David Frederick Ross

Distribution Planning and Control

Managing in the Era of Supply Chain Management

Third Edition

EXTRA MATERIALS springerlink.com

Springer

Distribution

Planning and Control

Distribution

Planning and Control

Managing in the Era of Supply Chain Management

Third Edition

David Frederick Ross

Springer

David Frederick Ross
APICS
Chicago, IL, USA

ISBN 978-1-4899-7577-5 ISBN 978-1-4899-7578-2 (eBook)
DOI 10.1007/978-1-4899-7578-2

Library of Congress Control Number: 2015934905

Springer New York Heidelberg Dordrecht London

Printed on acid-free paper

Springer Science+Business Media LLC New York is part of Springer Science+Business Media (www.springer.com)

CONTENTS

FEATURES OF THE THIRD EDITION

The third edition is marked by several major enhancements. The text follows the same basic objectives as the first two editions. It is written primarily for use by practitioners, instructors, students, and consultants involved in supply chain management (SCM), logistics and distribution channel management courses, seminars, supply chain certification programs, and internal company development programs, as well as professionals seeking a handy up-to-date reference text. Although broad enough to encompass all the management activities found in today's logistics and distribution channel organizations, the text is detailed enough to provide the reader with a thorough understanding of essential strategic and tactical planning and control processes, as well as problem-solving techniques that can be applied to everyday operations.

Changes to this edition include:

- Each of the 15 chapters comprising the book was reviewed and errors occurring in the second edition were corrected.
- Each chapter underwent significant updating to include new developments in supply chain management over the past 10 years.
- A new chapter was added to the text. Chapter 4 *Designing Channel Networks* discusses how companies can effectively design supply chain strategies and configure channel networks that capture marketplace advantage.
- In many chapters, statistical-based problems have been inserted into the text to stimulate learning and provide practical exercises. Each problem is a mini-case study and the reader is provided with detailed information needed to solve the problem.
- Summary questions and problems found at the conclusion of each chapter have been expanded. The goal is to challenge readers as to their knowledge of topics presented in each chapter and to offer a tool for learning reinforcement.
- For instructors, each chapter has a test databank of true/false and multiple choice questions and analytical problems that can be used to gauge learner understanding of the materials. In addition, most chapters have accompanying Excel spreadsheets to assist in problem solving and simulation. Finally, each chapter has a full PowerPoint visual presentation deck that can serve as a basis for classroom presentation.

PREFACE

In the decade since the publication of the second edition of this text, the concept and practice of supply chain management (SCM) has come to dominate discussion on all levels of business. Whether it is producing custom machine tools, delivering pizzas, or utilizing the Internet to browse for unique products and services, SCM is being applied by today's top companies to not only provide customers with a superlative buying experience but also enable enterprises to be more connected and agile in their mission to create new sources of value across a global supply chain. Terms such as "multi-channel," "omni-channel," "demand-driven networks," and "next-day delivery" are the current buzzwords driving fresh approaches to delivering goods and services to an increasingly demanding customer. As these new dimensions of supply chain management have arisen, the attention of supply chain managers has migrated away from traditional concerns with cost management, logistics, operations management, and lean business models to leveraging the power of big data, analytics, social networking, and collaborative supply chains in their search for new avenues of competitive advantage.

This view of the innovative, networking nature of supply chain strategies has driven the success of high-profile businesses as diverse as Walmart and Dell Computer and is at the core of the disruptive success of Amazon.com. Unilever credits its supply chain for assisting in doubling the size of its marketplace footprint while reducing its environmental impact. Inditex, the Spanish parent of Zara clothing retail outlets, uses supply chain strategies to accelerate design, production, and delivery of cutting-edge apparel at low prices to a mass clientele. These and other top companies have succeeded by using SCM to create more agile channel networks capable of rapid organizational change, collaborative decision making, and the reengineering of roles and responsibilities on all supply chain levels in the search for greater flexibility, agility, and sensing of customer demand.

This tremendous growth in the science and application of SCM calls for a revision of the second edition of *Distribution: Planning and Control*. The purpose of the third edition is twofold: the first is to integrate today's newest supply chain theories and business practices into what is basically a solid text. The text has been rewritten, and in many cases expanded with additional subject matter. The second objective is to significantly expand the ancillary materials available to instructors and students. The end result is a text that will provide professionals, students, and practitioners with the latest thinking in the field of SCM. For instructors, an array of educational and testing tools have been added to the third edition that will significantly assist in making the text easy to use in a classroom environment.

The third edition of *Distribution Planning and Control* follows closely the original structure of the first two editions. Part 1 of the text, *The SCM and Distribution Management Environment*, sets the background necessary to understand today's supply chain environment. Chapter 1 defines the principles and practices of modern logistics and SCM. Main topics include defining logistics and SCM, the evolution of SCM from its roots in the logistics concept, and designing competitive supply chain structures. Chapter 2 describes the nature and functions of the distribution industry. Main topics include exploring the role of distribution channels, mapping distribution channel transaction and inventory flows, and exploring new trends in reverse logistics and environmental sustainability.

Part 2, *SCM Strategies, Channel Structures*, *and Demand Management*, reviews the activities involved in performing strategic planning, designing channel networks, forecasting, and managing channel demand. Chapter 3 sketches the basics of supply chain strategy development. Key topics include defining business strategy, crafting the supply chain strategy, achieving strategic supply chain "fit," and managing supply chain risk. Chapter 4 explores the tasks associated with structuring supply and distribution channel networks. Topics of discussion are defining channel networks, networking configuration, channel network design processes, channel selection, and implementing channel structures. Chapter 5 provides a review of forecasting in the SCM environment. Forecasting topics include a review of forecasting techniques, time series analysis, associative (correlation) forecasting, and managing forecast performance. Chapter 6 concludes Part 2 with an exploration of how demand management plans are developed and used to drive the tactical strategies of the supply chain. Focal points include defining supply chain demand management, creating the demand plan, creating the supply plan, and balancing demand and supply plans through the sales and operations planning (S&OP) process.

Part 3, *Inventory Management in the Supply Chain Environment*, centers on translating the tactical plans arising out of the demand management process into detailed supply chain inventory requirements, logistics capacity plans, and distribution channel resources deployment. Chapter 7 describes the role of inventory in the supply chain environment. Main topics include understanding inventory management basics, components of inventory decisions, inventory costs, inventory control, and performance measurement. Chapter 8 continues the discussion on inventory management by examining how inventory is replenished in an independent demand environment. Main topics include a review of statistical inventory replenishment concepts and techniques, order point systems, order quantity techniques, and lean inventory management. Chapter 9 discusses inventory replenishment in a multi-echelon channel environment. Main topics include working with inventory "push" and "pull" concepts, using statistical replenishment techniques, understanding the basics of DRP, the DRP calculation, stocking multi-echelon supply channels, and supply chain capacity planning.

Part 4, *Supply Chain Execution*, traces the translation of the strategic supply chain plans into detailed customer and supplier management, warehousing, and transportation operations activities. Chapter 10 examines how pursuing superior customer service requires order processing and customer service functions that provide for the speedy and accurate transference of goods, value-added services, order information, and financial settlement. Chapter 11 focuses on today's supply chain procurement and supplier management functions. Chapter 12 explores the role of warehousing as a facilitator of the smooth flow of inventory through the supply chain system. Chapter 13 details the principles and scope of transportation. Discussion focuses on the interaction of transportation with other enterprise functions and with supply channel strategies. The various legal forms, performance characteristics, modes, and types of transportation are examined in depth.

Part 5, *International Distribution and Supply Chain Technologies*, concludes the text by exploring the role of two integral elements of SCM: international distribution management and the deployment of information technologies in the supply chain environment. Chapter 14 explores the role of global trade and distribution. Major topics include understanding the impact of the globalization of the world economy, development of supply chain global strategies, managing global trade networks, international purchasing, and international transportation and warehousing. Chapter 15 provides an overview of the impact of the information technology revolution on SCM. Key topics include outlining the foundations of information technology, technology architecture basics, information system foundations, the array of available SCM business technologies, standard SCM business systems, advent of SCM internet technologies, and SCM technology implementation issues.

Chicago, IL, USA David Frederick Ross

ACKNOWLEDGEMENTS

The author is greatly indebted to the many individuals and companies that have provided over the decades the insight and understanding of logistics and supply chain management fundamental to the writing of this text. Of particular importance are the comments of the many students gleaned from countless hours spent in the classroom in a variety of settings. I am particularly grateful to APICS for their support and understanding during the writing of this text. The magnificent library of texts, monographs, courseware, articles, white papers, and other sources owned by APICS was always at my disposal. Also I would like to thank APICS for the use of the SCOR® framework materials. The author would also like to especially thank Mr. Daniel Martin, CPIM, CIRM, and CSCP for his very thorough and meticulous reviews and suggestions for the text. His efforts have significantly contributed to a first rate and very readable text. I would also like to thank the staff at Springer Science + Business Media for their keen support in drafting the third edition and finishing it through to completion. The author would especially like to thank Matthew Amboy, who was with the project from the beginning, and Christine Crigler, who shepherded the manuscript through to completion. Finally, I would like to express my loving thanks to my wife Colleen who had to bear yet again another period of lost afternoons and long evenings but who receives little of the rewards.

ABOUT THE AUTHOR

David Frederick Ross A recognized thought leader in enterprise resources planning (ERP) and supply chain management (SCM), David Frederick Ross has spent over 35 years in the field of operations management as a practitioner, consultant, and educator. During his 13 years as a practitioner, he held line and staff positions in several manufacturing and distribution companies. Over 22 years of his career was spent in ERP and SCM software project management, application software and education courseware development, and consulting and professional development for several technology companies. Currently, he is Senior Manager, Professional Development for APICS headquartered in Chicago, Illinois, USA (e-mail: dross@apics.org).

Dr. Ross has also taught operations and supply chain management in several academic settings. These include Oakton Community College, Easter Illinois University, Elmhurst College, and the Kellogg School of Management at Northwestern University. He is a long-time instructor in several of APICS's education and certification programs and is a certified APICS instructor. Dr. Ross holds a Ph.D. degree from the University of Chicago and is recognized as a CFPIM and CSCP by APICS.

Besides articles and industry white papers, he has published six books in SCM. *Distribution Planning and Control* (1996, 2nd ed. 2004) is used by many universities and is a foundation book for APICS's *Certified in Production and Inventory Management* (CPIM) program. *Competing Through Supply Chain Management* (1998) is one of the very first complete texts on the science of supply chain management. *Introduction to e-Supply Chain Management* (2003) merged the concepts of e-business and SCM. A second edition of this book, entitled *Introduction to Supply Chain Management Technologies*, was released in 2010. This book has been adopted by APICS as a primary resource in the *Certified Supply Chain Professional* (CSCP) program. *The Intimate Supply Chain* (2008) explores the interrelationship between SCM, customer relationship management (CRM), and customer experience management (CEM). He also contributed a chapter entitled "Supply Chain Management: Principles and Structures" for the *Manufacturing Engineering Handbook* (2015).

PART 1

THE SCM AND THE DISTRIBUTION MANAGEMENT ENVIRONMENT

CHAPTERS

Part 1 squarely positions the reader in today's supply chain management (SCM) and logistics business environment. As discussed in the Preface, the pace of change brought about by the power of the customer, information technology, and globalization have forced companies to critically re-examine the operating values and cultures of their organizations, the way their businesses and processes are structured, and the strategies and tactics by which they compete in the marketplace. The ability of businesses to continuously realign their supply chains to meet these changes constitutes the foremost challenge before their organizations. Companies that can leverage the dramatic breakthroughs in information technologies, channel partnerships, and global trade will be those that gain market share and thrive in the twenty-first century.

Chapter 1 begins the text by defining SCM, modern logistics, and the organization of the distribution function. Next, the chapter traces SCM from its origins in the logistics concept to today's Internet-enabled "virtual" supply chain network. Following, the chapter examines four different models of supply chain structure: the SCOR® model; the lean supply chain; the adaptive, demand-driven supply chain; and the supply chain maturity model. The chapter concludes with a review of the trends and goals shaping today's SCM concepts and practices.

Chapter 2 explores the nature and function of channel *distribution*. The chapter opens with a detailed discussion of the characteristics of distribution management followed by a review of the role of the three major entities constituting the product and service distribution cycle: producers, channel intermediaries, and end-use customers. Main topics covered are understanding the need for channels of distribution, the functions performed by channel distribution intermediaries, and the inbound and outbound materials and information flows found within the typical distribution organization. The chapter concludes with an overview of new SCM concerns associated with reverse logistics and environmental sustainability.

1

Introduction to Supply Chain Management

Supply chain management (SCM) is perhaps the premier operations management strategy for companies seeking to establish and maintain competitive advantage in today's global marketplace. SCM is important because businesses have come to recognize that their capacity to continuously reinvent competitive advantage depends as much on their ability to look *outward* to their channel partners as it does leveraging their internal capabilities.

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_1) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_1, © Springer Science+Business Media New York 2015

Channel partners assist companies to generate the innovative ideas and resources necessary to assemble the right blend of competencies that will resonate with their own organizations and the wants and needs of their marketplaces. Today, no corporate leader believes that their organization can survive and prosper acting independently of its suppliers and customers. In fact, perhaps the *ultimate* core competency an enterprise may possess is not to be found in a temporary advantage it may hold in a product or process, but rather in its ability to continuously assemble and implement market-winning capabilities arising from collaborative alliances with their supply chain partners.

Companies have always known that leveraging the strengths of business partners could compensate for internal resource deficiencies, thereby enabling them to expand their marketplace footprint without expanding their costs. Still, there were limits to how robust these alliances could be due to the resistance of companies to share market and product data, limitations in communication mechanisms, and inability to network the many independent channel nodes that constitute supply chains. In addition, companies were often reluctant to accept partner dependences for fear of losing leverage when it came to working and negotiating with channel players. Today, the myth of the self-sufficient corporation, vertically organized, has been largely exploded. In reality, companies have always been interconnected with their supply chain partners. Once considered a strategic prohibition, creating chains of supporting channel partners has become one of a successful company's most powerful competitive attributes.

This chapter is focused on defining and exploring the opportunities and challenges to SCM in the early twenty-first century. The chapter begins with definitions of logistics and SCM. The goal is to detail the principles underlying SCM as a business strategy and logistics as a set of operations functions. Next, a short history of the evolution of SCM will be explored. Following, the chapter will review the basic entities composing any supply chain structure, the three main supply chain strategies (stable, reactive, and efficient reactive), and the two types of channel integration (vertical or horizontal). Once these basics have been covered, four different views of supply chain structure will be explored: the SCOR® supply chain model; the lean supply chain; the adaptive, demand-driven supply chain; and the supply chain maturity model. The chapter concludes with a discussion of the trends and goals of today's supply chain.

1.1 DEFINING LOGISTICS AND SUPPLY CHAIN MANAGEMENT

From the beginnings of industrialized economies, businesses have been faced with the twin problems of sourcing materials and dispersing their goods and services to the marketplace. When suppliers and customers are in close proximity to the producer, demand and supply signals are easily communicated, and materials and products can quickly make their way through the supply chain. As the time and distance separating production and the points of supply and consumption widen, however, the ability of companies to easily access materials and deliver to markets correspondingly diminishes. Without the means to effectively move product rapidly from the supply source to the customer, producers find their ability to expand their businesses restricted and the array of goods and services available to the marketplace limited.

Bridging the distance gap between demand and supply requires companies to perform two critical functions. The first is the management of *logistics*. The role of logistics is to efficiently and cost-effectively deploy inventory, warehousing, and transportation resources that enable companies to satisfy the day-to-day product and service requirements of their supply chains. The second function is *supply chain management*. The role of SCM is to generate unique sources of customer value through the creation of collaborative partnerships that leverage the resources, capabilities, and competencies of channel members to increase the competitive advantage of the entire channel system.

1.1.1 Defining Logistics

Over the past 50 years, logistics has evolved from a purely operational function focused on inventory, delivery, and cost performance to a competitive weapon providing today's enterprise with the capability to link supply resources at the farthest regions of the supply chain with demand found across widely dispersed geographical marketplaces. In the age of the global supply chain, modern logistics has become a critical competitive resource, creating value by enabling businesses to span geographical barriers, delivering product in as quick and cost effective a manner as possible, and linking channels of trading partners.

The sheer size and complexity of logistics bears witness to its central position in the global economy. According to the Council of Supply Chain Management Professionals (CSCMP) *25th Annual State of Logistics Report* [1], the cost of U.S. logistics for the year 2013 exceeded US$1.39 trillion. Of this total, interest, taxes, obsolescence, depreciation, insurance, and warehousing totaled 469 billion; all forms of transportation totaled 852 billion; shipper related costs totaled 10 billion; and logistics administration totaled 53 billion. Altogether, logistics costs were the equivalent of 8.2 % of the U.S. gross domestic product (GDP) measured in nominal dollars. A summary of the *Logistics Report* appears in Figure 1.1.

	$ Billions
Carrying Costs-$2.459 Trillion All Business Inventory	
Interest	2
Taxes, Obsolescence, Depreciation, Insurance	320
Warehousing	137
Subtotal	469
Transportation Costs	
Motor Carriers:	
Truck – Intercity	453
Truck – Local	204
Subtotal	657
Other Carriers:	
Railroads	74
Water (International 27, Domestic 7)	37
Oil Pipelines	13
Air (International 13, Domestic 20)	33
Forwarders	38
Subtotal	195
Shipping Related Costs	10
Logistics Administration	53
Total Logistics Costs	1,385

FIGURE 1.1 Total logistics costs – 2013.

Simply defined, logistics management is the process whereby suppliers, manufacturers, and distributors store and move products through the supply chain to their customers. The *APICS Dictionary* defines logistics as “the art and science of obtaining, producing, and distributing material and product in the proper place and in proper quantities” [2]. The Council of Supply Chain Management Professionals (CSCMP) defines logistics as “that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers’ requirements” [3]. These definitions imply that logistics creates competitive value by optimizing logistics operations costs and productivity, high capacity and resource utilization, and close integration with customers and suppliers. Furthermore, the success of these objectives depends upon the close collaboration and integration of logistics partners that populate the supply channel system. Logistics creates competitive advantage by flawlessly executing customer service objectives, achieving conformance to quality standards, and increasing marketplace value.

Perhaps the best way to define logistics is to divide it into three closely integrated sets of management functions as illustrated in Figure 1.2. The first is *warehouse management*. This function is responsible for the storage and handling of inventories beginning with supplier receipt and ending with dispersion to internal or external customers. Critical concerns are the pursuit of lean philosophies, environmental sustainability, reduction of wastes, use of third party logistics (3PL) partners, utilization of warehouse management systems (WMS), integration with transportation, and pursuit of flow-through techniques for storage and picking.

The second function of logistics is *transportation management*. This function is defined as the movement of product from one node in the supply chain to another, ending with delivery

FIGURE 1.2 Logistics management components.

to the customer. Critical concerns are management of private fleets and 3PL partners; audit, payment, and claims; transport routing, tracking, and optimization; government regulation, security, and compliance; and the utilization of transportation management systems (TMS). The third and final function of logistics is *performance measurement*. Because of the size of the capital invested in warehousing and transportation, managers must keep a close accounting of the performance of these functions through the deployment of logistics administration and analytic modeling techniques capable of providing full visibility to logistics costs and operational performance.

1.1.2 Detailed Logistics Activities

Logistics management centers on the daily execution of several business activities. The goal is to pursue the highest customer service at the lowest possible cost. These functions are separated into the following operations areas:

- *Order management*. This activity is concerned with the navigation of the customer order through the inventory allocation, picking, packing, shipping, and backorder cycles. The fundamental performance target is ensuring product shipment based on quoted lead times, order quantities, and quality specifications.
- *Production and procurement*. Providing information to production and purchasing concerning the status of channel inventories is essential to high-performance logistics. Logistics is also responsible for the inbound flow of materials into production and the outbound flow of finished goods into the distribution channel.
- *Freight cost and service management*. These activities consist of managing inbound/outbound freight, third-party carrier management, total cost control, operations outsourcing decisions, and execution of administrative services. Superior logistics performance is achieved by optimizing inbound materials and outbound product movement, warehousing, and administrative services that utilize the most cost effective yet efficient transportation methods and transportation service partners.
- *Warehouse management*. The effective management of inventory in the supply chain requires efficient and well-managed warehousing techniques. Key activities are inventory storage, material handling, equipment and labor utilization, receiving, put away, and returns.
- *Transportation routing and scheduling*. The movement of product to its destination is a primary function of logistics. Activities performed are optimization of shipping capacity utilization, decreasing less-than-truckload shipments, and applying postponement strategies. Another important function is selection of third-party transportation providers. An often overlooked area is shipment documentation and compliance. Accurate documentation is necessary to effectively manage country quotas, tariffs, import/export regulations, product classification, and letters of credit.
- *Fleet management*. It is the responsibility of logistics to ensure the utilization of company-owned transportation fleets. The goal is to determine the optimum use of transportation assets, whether internal or through a third party supplier, without compromising service levels.
- *Load planning*. Utilizing transportation assets to achieve maximum fulfillment optimization requires detailed load planning. Critical activities are packaging and

labeling, load building and consolidation, and possible third party transfer point or cross-docking functions.

- *Special functions*. Often logistics must manage a range of miscellaneous functions. Managing service parts inventories and working with return goods are examples. A function growing in importance is *reverse logistics*. This process involves managing customer returns and the reclamation of packaging materials and other wastes and backhaul to a central collection point for recycling. The object is the coordination of both the forward and reverse processes necessary to fully utilize products and materials during the different stages of their life cycles.

While the effective management of each of these areas is essential to logistics success, their benefits dramatically increase when the entire logistics channel network is integrated in the pursuit of supply chain optimization and development of robust, flexible sourcing, warehousing, transportation, and delivery capabilities that unify total logistics capabilities.

1.1.3 Detailed Logistics Performance Measurements

Logistics performance is composed of three important metrics. The first, *logistics productivity*, provides information concerning productivity standards, level of logistics cost optimization, integration of quality management processes, and broadening of logistics service levels. The second metric, *logistics service performance*, tracks customer service goals, such as product availability, order cycle time, logistics system flexibility, depth of service information, utilization of technologies, and breadth of post-sales service support. The final performance component, *logistics performance measurement systems*, details the content of performance metrics, how performance data are captured, and the systems used to track and report on performance.

Superior logistics performance pursues the following seven operating objectives:

- *Service*. High performance logistics functions possess the following customer service attributes: high levels of service and inventory availability, self-service order entry, order delivery status management, order configuration flexibility, and short recovery time after a performance failure.
- *Fast flow response*. Rapid response requires highly agile and flexible logistics resources capable of quickly adding or reducing capacities based on expected demand. Besides accelerating the order-to-delivery cycle, this attribute also means migrating away from a dependence on stagnant pools of buffer inventory driven by forecasts to a demand-pull model enabling rapid response to each customer order on a shipment-by-shipment basis.
- *Reduction of operating variances*. Since logistics productivity increases when variances are minimized, high performance logistics continuously pursues the architecting of supply channels dedicated to the continuous elimination of all forms of supply chain variance and waste.
- *Minimum inventories*. Maintaining the necessary levels of channel inventories is an essential component of logistics' commitment to customer service. High performance logistics channels maintain the right levels of inventory demanded by the marketplace while continuously searching to reduce stagnant pools of excess, obsolete, and safety

stock inventories. Achieving this goal means pursuing high inventory turns velocity for the entire supply chain and not merely one trading partner.

- *Transportation reduction.* Transportation cost reduction is achieved by close inter-channel inventory planning and replenishment, assembling larger shipments traversing longer distances to achieve movement economies of scale, the effective use of third party service providers, and pursuit of sustainability objectives.
- *Quality management.* The pursuit of total quality management (TQM) is essential for effective logistics. It can be argued that the requirement for absolute quality is even more essential for logistics than anywhere else in the company. Logistics transactions often deal with transporting large quantities of inventories and performing services spanning large geographical areas. Once set in motion, the cost of a quality failure, ranging from incorrect inventories to damaged goods, requires lengthy and costly processes to be reversed.
- *Product life-cycle support.* The movement to increase environmental sustainability has mandated an increase in *reverse logistics* functions. Activities include recalls and returns, remanufacturing, repair, and disposition. An environmental sustainability strategy also provides companies with a wealth of information on product performance, ease of use, defects, and consumer expectation.

1.1.4 Defining Supply Chain Management

Companies have always known that by leveraging the capabilities and resources of their supply chain partners they could enhance their own core competencies and expand the footprint of their products and services. SCM began to gain traction when companies came to recognize the competitive value arising from the integration of logistics functions with those of other channel organizations. Soon it became apparent that using channel partners for logistics collaboration was barely scratching the surface of the potential for strategic advantage. In place of the opportunistic, tactical use of channel partners to achieve short term objectives, channel planners began advocating the transformation of these transient relationships into integrated, mutually enriching partnerships. By the early 1990s a new management concept began to gather traction to fill this gap: *supply chain management*.

The concept of SCM encompasses much more than simply the transfer of products and services through the supply pipeline. SCM is about a company *integrating* its process capabilities and marketplace objectives with those of its suppliers and customers on a strategic as well as tactical level. Integrative supply chains consist of many trading partners participating simultaneously in a collaborative network containing multiple levels of competencies and various types of relationships. SCM enables companies to activate the synergy to be found when a community of firms utilizes the strengths of each other to build superlative supply and delivery processes that provide total customer value.

SCM can be viewed from several perspectives. Definitions of SCM take into account a wide spectrum of applications incorporating both strategic and tactical objectives. For example, the *APICS Dictionary* defines SCM as

> The design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally.

The Council of Supply Chain Management Professionals (CSCMP) defines SCM as encompassing the

> planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. [3]

The collaborative, network-building attributes of SCM have revolutionized the role of the supply chain and infused channel constituents with innovative ways of providing total customer value. Instead of a focus on just logistics operations, SCM enables supply chains to collectively work to activate an array of strategic competencies as illustrated in Figure 1.3 [4].

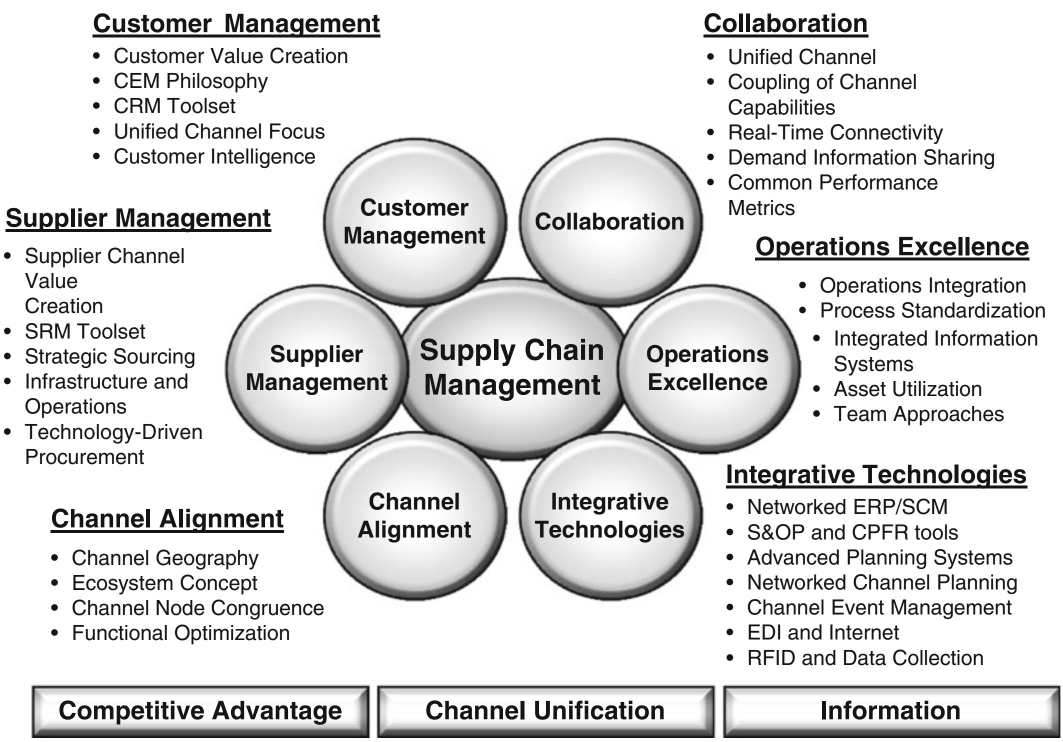


FIGURE 1.3 Supply chain management competencies.

A detailed discussion of each of the six competencies is as follows:

- *Customer management*. Managing the customer has taken on added significance in the era of supply chain management and is termed customer relationship management (CRM). CRM is founded on the recognition that as customers demand to be more involved in product/service design, pricing, and order configuration, companies must focus their efforts beyond brand and marketing-based strategies to establish enriching customer relationships. The goal of CRM is to provide complete visibility to all aspects of the customer, from facilitating the service process and collecting data concerning customer buying history to optimizing the buying experience. CRM provides companies with the ability to architect a mosaic of processes for the generation of fast flow, flexible, and synchronized delivery systems that enable customer self-service; configuration of customized, individualized value-solutions; and fulfillment functions providing the highest levels of service and value.

CRM enables supply networks to respond to three critical customer requirements:

1. *Superior service*. The goal of CRM is to provide the customer with an unbeatable buying experience that exceeds price, product availability, delivery, and service expectations. Creating high service levels requires two critical value chain attributes: *speed of response* and *attention to reliability*. CRM technologies realize speed of response by passing demand information not serially, but simultaneously to channel partners through advanced shipping notices, bar coding and RFID, on-line delivery tracking, event-management technologies, and real-time fulfillment information. Reliability means executing the *perfect order* each and every time. Reliability requires supply chains to be flexible enough to respond to last minute changes while never compromising high service levels.
2. *Convenient solutions*. Today's customers are searching for supply chains capable of providing them not just with products and services but *solutions* to their business needs. In addition, customers want to search, configure, create, and review their orders in as convenient a manner as possible. Visibility to customer requirements in turn provides each channel partner with the opportunity to use core competencies that ensure each customer can make individualized choice of product and service solutions.
3. *Customization*. Today's customers are no longer content to purchase standardized goods and services, but instead require the ability to configure solutions that meet their own individual needs. To realize these objectives, suppliers can deploy strategies that postpone and place actual product differentiation at the channel delivery point that actually touch the end-customer. Another strategy is to utilize Internet-enabled ordering that permits customers to place orders and receive delivery from multichannel sources. Channel synchronization is crucial: customization requires direct linkage of demand and supply at all points in the channel with the goal of minimizing cost and accelerating total channel throughput.

- *Supplier management*. Businesses have always known that the relationship between buyer and seller, and not just product price and quality, determines the real value-add component of purchasing. This viewpoint has spawned a new concept and set of business practices termed supplier relationship management (SRM). The mission of SRM is to activate the real-time synchronization of the requirements of buyers with channel supplier capabilities. The goal is a customized, unique buying experience while simultaneously pursuing cost reduction and superior quality. SRM seeks to fuse supplier management functions into an efficient, seamless process driven by relationships founded on trust, shared risk, and mutual benefit. The key components of SRM include:

- *Strategic sourcing*. Strategic sourcing not only provides for technology-enabled sourcing from a universe of suppliers, but also reveals the depth of supplier competencies, availability of value-added services, level of desired quality, capacity for innovative thinking, and willingness to collaborate on new product development.
- *SRM technology toolsets*. Use of technologies that facilitate the communication of purchasing requirements; negotiation of quality, pricing, and delivery objectives; product sustainability; and financial settlement. The Internet has enabled purchasers to activate new forms of procurement, such as on-line catalogs, interactive auction sites, spend analytics, and trading exchanges. These integrative technologies provide purchasers with tools for the real-time, simultaneous synchronization of demand and supply from anywhere, anytime across a global network of suppliers.
- *Integrated procurement infrastructures*. A goal of SRM is the establishment of organizational infrastructures that link channel capabilities and performance objectives directly with the customer. A SRM-driven organization is capable of expanding traditional purchasing functions to include new players, such as trading exchanges, consortiums, and other e-commerce service support partners providing payment, logistics, credit, shipping, and other procurement-related processes.

• *Channel alignment*. The structure of a supply chain is composed of its supply and delivery nodes and the links connecting them. In the past this network was characterized as a series of trading dyads. In this model, channel partners created trading relationships one partner at a time without consideration of the actual extended chain of customers and suppliers constituting the entire supply chain ecosystem. In reality, a company like Wal-Mart deals literally with thousands of suppliers and their supply chain resembles more a networked grid of business partners rather than a linear pipeline-like structure (Figure 1.4). Maintaining a strategy of trading partner dyads as the supply chain expands, risks decay of cost management objectives, leveraging resource synergies, and maintaining overall marketplace competitiveness.

To counter the inertia inherent in the *trading partner dyads* strategy, effective SCM requires a continuous focus on network node congruence. This means that each channel constituent must construct an individual supply chain strategy and set of operational objectives that simultaneously provides for competitive advantage for both the firm and the collective channel network. This step also reveals the gaps and regions of potential conflict existing between the strategies and metrics of individual partners. Without strategic and operational alignment, the supply chain will have weak links that easily break as the pressure of demand variability and missing partner capabilities appears at times of channel stress.

As supply chain convergence matures, the number of nodes occupying peripheral positions are more closely integrated into the direct channel. The goal is to increase the length of the contiguous supply chain, thereby expanding opportunities for collaboration, customer value, and operations excellence while at the same time minimizing conflict and increasing compromise over costs, performance metrics, service value

FIGURE 1.4 The supply chain as a network grid.

propositions, and delivery velocity targets. Achieving supply chain congruence can be contentious as companies find themselves working with several separate channel networks as their business ecosystems evolve in new directions.

- *Integrative technologies.* The convergence of integrative information technologies and SCM constitutes a key theme in the evolution of SCM. Earlier, it was pointed out that it is virtually impossible to think of SCM without the power of the enabling technologies that have shaped and driven its development into a powerful management science. In today's highly competitive global marketplace having the best product or service is simply not enough: now, having the best *information* has become the decisive differentiator between market leaders and followers. Supply channel transparency consists of a single view of the supply chain and requires information technologies that facilitate the collection, processing, access, and manipulation of robust repositories of data necessary for determining optimal supply chain design configurations.

Information networks also provide companies with the necessary insight so that channel resources and competencies can be synchronized to provide superior customer service. On the marketing side, information networks enable companies to integrate customers directly into their fulfillment systems thereby assisting in executing a perfect order every time. On the shop floor, information networks improve planners' visibility into supplier resources to smooth capacity spikes and improve throughput. In the supply channel, information networks provide a window into inventory availability so that companies can align their resources with the demand pull of the marketplace.

- *Operations excellence*. Ideally, operations excellence compels every firm in the channel network to optimize both their own performance and, by extension, the performance of the entire supply chain. By acting as a single integrated team, the supply chain has access to an expanding range of processes and competencies individual companies would be incapable of achieving acting on their own. In addition, integrated supply chains have a better chance to increase performance by standardizing processes and leveraging shared information technologies.
- *Collaboration* [5]. The keystone of SCM is found in the willingness of supply channel partners to engage in and constantly enhance collaborative relationships with each other. As displayed in Figure 1.5, the intensity of collaborative content can vary. On the lowest level, it is internally-focused on the achievement of local objectives. On the next level, SCM collaboration consists in linking inter-channel partner logistics functions to optimize channel operations. In level three, channel partners seek to develop collaborative strategies to link core competencies and resources to generate joint product and service value for the supply chain's customers. Finally, in level four, SCM leverages web-based interoperability technologies to create a completely integrated supply chain focused on executing a common business strategy by presenting customers with a seamless supply engine.

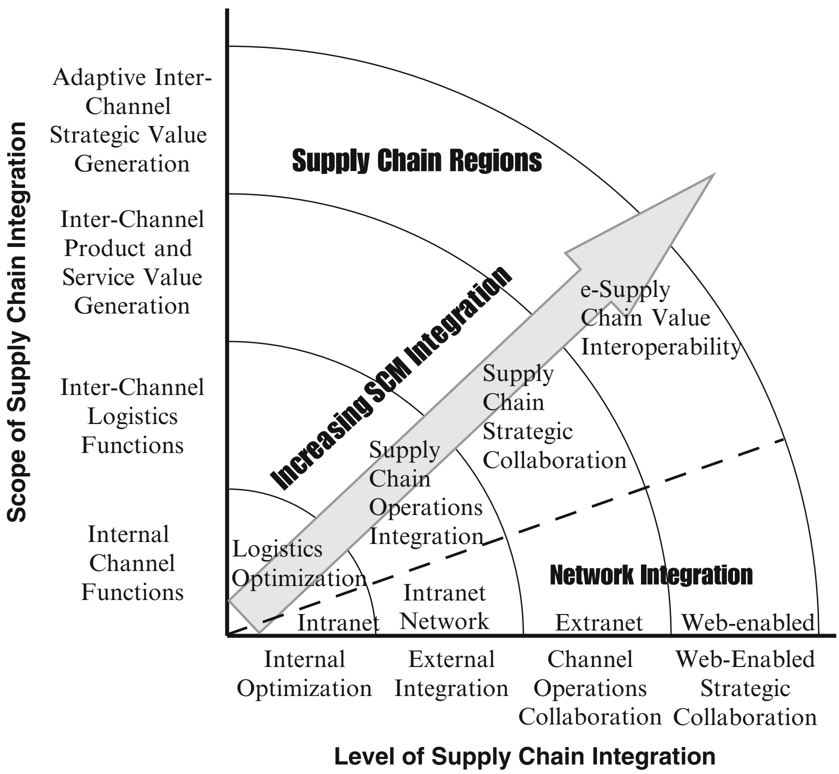


FIGURE 1.5 Span of SCM collaboration.

While no one can disagree on the efficacy of collaboration, there are many barriers inhibiting implementation. A significant impediment is overcoming existing corporate cultures. Long-tradition and internal performance silos often pose an almost insurmountable barrier to espousing an environment encouraging openness, communication, and mutual-dependence. Another barrier is *trust*. Companies fear that proprietary information will be used for unfair negotiating advantage or passed on to competitors. Finally, today's technology presents real barriers. The incompatibility of channel computer systems poses a serious deterrent to shared communications. Collaborative relationships normally take years of good will, investment in resources, and proof of mutual benefit.

The six SCM competencies enable companies to realize the three success factors shown at the bottom of Figure 1.3. By architecting highly integrated supply networks, companies achieve continuous *competitive advantage* by jointly developing and delivering winning products and services that capture the customer before the competition. Second, by converging the collective resources and innovative capabilities found among supply network partners, SCM enables companies to act as if they were a single *unified channel* capable of delivering customer value seamlessly across intersecting supply chains. And finally, by deploying connective technologies, such as the Internet and social networking, companies can leverage *information* to lead marketplace change, preserve brand integrity, effectively identify customers, and provide total customer value and overall profitability.

1.2 THE EVOLUTION OF SUPPLY CHAIN MANAGEMENT [6]

As portrayed in Table 1.1, the SCM concept evolved through four distinct stages. The first stage is described as the era of logistics decentralization. In the second stage, logistics moved from functional decentralization to organizational centralization driven by increased requirements for cost optimization and customer service. Stage three witnessed the dramatic expansion of logistics from a passive operational function to a strategic resource centered on the linkage of internal operations with analogous functions performed by channel trading partners. As the concept of channel collaboration grew, the old logistics concept gave way in stage four to full-blown SCM.

1.2.1 Stage 1: Basic Logistics

The first stage of SCM occurred in the period extending from the early twentieth century to the mid-1960s. Considered essentially as an operations execution function concerned with warehousing and transportation, it was felt that logistics was purely a cost center with minimal effect on competitive advantage. As such, logistics was considered unworthy of serious capital investment, accorded little management status, and assigned less professional staffs. Often companies fragmented logistics into stand-alone activities and placed control under different company departments. Not only were functions such as procurement, transportation, and inventory management, separated from one another, but local departmental performance measurements actually pitted logistics functions against each other. What is more, the whole field of logistics was woefully ill-defined as a management science. The result was a disjointed, relatively uncoordinated, and costly management of logistics activities.

TABLE 1.1. SCM Evolutionary Stages

SCM Stage	Management focus	Organizational Design
***Stage 1* to 1960s** **Decentralized logistics management**	Operations performance Support for sales/marketing Warehousing Inventory control Transportation efficiencies Physical Distribution Management concept	Decentralized logistics functions Weak internal linkages between logistics functions Little logistics management authority
***Stage 2* to 1980** **Total cost management**	Logistics centralization Total cost management Optimizing operations Customer service Logistics as a competitive advantage	Centralized logistics functions Growing power of logistics management authority Application of computer
***Stage 3* to 1990** **Integrated logistics management**	Logistics concept founded Support for JIT, quality and continuous improvement Use of logistics partners for competency acquisition	Closer integration of logistics and other departments Closer integration of logistics with supply partners Logistics channel planning Logistics as a strategy
***Stage 4* to 2000+** **Supply chain management**	Concept of SCM Use of extranet technologies Growth of coevolutionary channel alliances Collaboration to leverage channel competencies Application of the Internet to the SCM concept Low cost networking of channel databases e-Business SCM synchronization	Trading partner networking Virtual organizations Market coevolution Benchmarking and reengineering Integration with ERP .coms, e-tailers, and market exchanges Organizational agility and scalability Multi-channel delivery Omni-channel retail delivery

In an era when lead times were long, global competition practically non-existent, and the marketplace driven by mass production and distribution models, logistics decentralization was a minor problem for most companies. By the early 1960s, however, changes in the economic climate were forcing corporate strategists to re-think the role of their logistics functions. Expanding product lines, demand for shorter cycle times, and growing competition began to expose the dramatic wastes and inefficiencies of logistics decentralization. Second, executives were finding themselves handcuffed by the lack of a unified logistics planning and execution strategy. Logistics responsibilities were scattered throughout the organization and no single manager was responsible for the development of a coherent logistics plan. Finally, decentralization had made it impossible to pursue a comprehensive program to reduce logistics costs and improve productivity.

1.2.2 Stage 2: Total Cost Management

By the early 1970s, problems associated with decentralized logistics management had become so evident that a sea change was necessary. Several facts were apparent:

1. The impact of decentralized logistics costs on enterprise profits was greater than most managers had previously thought. Logistics costs constituted as much as 50 % or more of the selling price of a product. A well-run logistics organization could actually have a significant impact on the corporate bottom-line.
2. Opportunities for logistics cost improvement were largely unexplored because they had for so long resided in a managerial no-man's-land, outside the scope of responsibility of any single executive.
3. Standard cost-cutting measures were woefully inadequate in reducing logistics costs. Although improvement measures reduced local departmental costs, they were piecemeal and had a relatively low effect on total logistics costs.
4. The splintering of logistics functions had made corresponding logistics cost reporting incomplete. Concise statistics on total logistics costs were difficult to attain and often hidden inside local departmental agendas.

These deficiencies were at the core of the total cost strategy for managing logistics. The goal was to structure logistics so that total costs, and not just the cost of one logistics activity, are minimized. Effective total cost management occurs when cost improvement initiatives are formulated based on an integrated view of logistics. By the mid-l970s, companies began to merge logistics functions formally under a single manager. It was this manager's responsibility to make decisions that would benefit the whole logistics system and not just local departmental optimization. Achieving such a synergy would involve not only reengineering the logistics organization but also repositioning the role logistics had when working with other organizational functions.

In *Stages 1* and *2*, logistics was perceived as internally and externally *neutral* in providing competitive advantage. The role of logistics was considered as defensive in nature and concerned purely with the daily management of inventories, delivery, and cost-containment. When making logistics decisions, the goal of planners was to keep logistics flexible and reactive so that products and services were always available for customer-facing functions to meet any type of demand. In the business environments of the 1960s and early 1970s, companies simply ignored the potential of logistics to provide competitive advantage. By the end of the period, however, logistics managers had come to realize that logistics could enhance competitive advantage by optimizing the flow of goods occurring both within the boundaries of the company and, more importantly, through the supply chain right up to the customer's receiving dock. Such thinking cut-across traditional company departmental boundaries and existing views of supply chain systems. Logistics was on the verge of its next evolutionary step.

1.2.3 Stage 3: Integrated Logistics Management

During the 1980s, strategists became increasingly aware that focusing solely on total cost management represented a passive approach to logistics' potential. In place of a focus on logistics cost minimization, managers began integrating logistics with other corporate departments in an effort to both reduce total enterprise costs and enhance customer value.

It was becoming apparent that operational processes, such as speed of delivery, value-added services, and product availability, realized when the entire enterprise was closely integrated together, could in themselves provide a powerful facilitator of competitive advantage beyond brand and price leadership.

In addition to the change in executives' perception of the strategic role of logistics, powerful challenges from the business environment were further fueling the growth of the integrated logistics model. If the 1980s could be compressed into two quintessential catchwords, they would be *competition* and *quality management*. Competition came in the form of global companies, often deploying radically new management philosophies and organizational structures that were realizing unheard of levels of productivity, quality, and profitability. The second driver of change came from the deployment of new management concepts, driven by just in time (JIT) and total quality management (TQM) philosophies, that were providing competitors with tools to compress time out of product development cycles; engineer more flexible, "lean" processes; tap into the creative powers of the workforce; and generate entirely new forms of competitive advantage.

Businesses responded first to these challenges by revamping their organizations. According to a 1990 survey conducted by Ohio State University, traditional areas of logistics responsibility, such as warehousing, transportation, and inventory management, were almost 100 % under the control of a single logistics manager, along with a high percentage of additional functions such as customer service and order management, purchasing, and product planning. Second, companies began using logistics as a competitive weapon. Logistics became a source enabling an enterprise to differentiate itself from its competitors. Recognizing its strategic value, businesses drafted plant charters and mission statements to guide logistics development and ensure alignment with other enterprise functions. The concept of integrated logistics also afforded logistics an equal position alongside marketing, sales, and operations in the formulation of strategic plans, determining the allocation of enterprise resources, and defining the scope of customer service objectives. By closely aligning logistics capabilities and marketing, sales, and operations objectives, the enterprise could present customers with a unified approach, enhancing product, price, and delivery competitiveness.

1.2.4 Stage 4: Supply Chain Management

By 1990, companies began to enhance the logistics concept to tackle the new realities of the marketplace. The acceleration of globalization, the explosion in Internet technologies, business process reengineering, increased outsourcing, and the growing power of the customer were forcing companies to look beyond the boundaries of their own core competencies to the capabilities and resources of their supply channel partners to remain competitive. Responding to these new challenges compelled companies to implement what can only be called a dramatic paradigm shift from *Stage 3* logistics to *Stage 4* supply chain management. In place of the informal, short-term, tactical use of supply chain partners, corporate planners were now advocating strategies that sought the development of close channel collaborative partner relationships with the objective of optimizing and synchronizing the productive competencies of the entire supply chain. The logistics concept was to be replaced by *supply chain management*.

The SCM paradigm that has emerged consists of three distinct elements:

1. *Expanded view of logistics operations management.* SCM requires companies to move beyond a focus on optimizing internal logistics activities, to one where all enterprise functions are closely integrated to realize order-of-magnitude breakthroughs in product design, production, delivery, and value-added services before the competition. SCM also requires that logistics performance be measured against total supply chain objectives. This external orientation enables organizations to focus their strategic planning, organizational structures, and performance metrics around the strength of their logistics functions.
2. *Extension of integrated logistics management to encompass opportunities for competitive advantage occurring outside company boundaries.* In its most basic form, a focus on external integration enables business functions to search for productivities and new competitive space by leveraging innovative relationships with their suppliers, customers, and third-party alliances. Through the use of channel networking technologies, SCM enables companies to integrate their supply chain partners with their business strategies to realize radically new directions in the creation of sources of marketplace value.
3. *New strategic view of channel management.* Although *Stage 4* companies seek to optimize logistics performance and total cost management objectives, the real strength of this level of channel maturity is found in its strategic dimensions. The external orientation and networking capabilities of *Stage 4* organizations enable whole channel ecosystems to establish a shared competitive vision, structure co-evolutionary channel alliances providing for order-of-magnitude advances in product and service delivery, and manage complex channel relationships enabling businesses to lead market direction, generate new associated businesses, and explore new opportunities.

1.2.5 Summary

Supply channel management today is no longer the loose combination of business functions characteristic of the early stages of logistics. New networking technologies and management models have not only blurred internal departmental boundaries, but also the boundaries that separate supply chain partners, transforming once isolated channel players into unified, "virtual" supply chain systems. Today's top companies are using SCM to reassemble and energize channel structures by tapping into the core competencies of their channel partners and accelerating cross-enterprise collaborative processes. They are also using technology enablers to activate new methods of providing customer value by opening new marketing channels as they migrate from individual sources of supply to networks of channel partners capable of servicing the customer across global space and time.

1.3 SUPPLY CHAIN STRUCTURES

According to the *APICS Dictionary* a *supply chain* is a "global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash." This definition considers the supply chain as consisting of a network of channel entities and processes. A supply chain network has many forms. Regardless of whether it is a product or service chain or how many channel entities are involved, an effectively structured supply chain will enable firms to guarantee the flow of goods and services, reduce channel costs, and pursue competitive leadership in their market space.

1.3.1 Basic Supply Chain Structures

Figure 1.6 illustrates the three basic entities of a supply chain: a producer with one supplier and one customer. The figure could also refer to internal entities within an organization: supply chains can be internal to an enterprise as well as external. The producing entity is responsible for the production of products (or services). The role of the supplier is to provide production inventories to the producer who, in turn, produces finished products that are then sold to the customer. As indicated by the arrows on Figure 1.6, channel networks have four basic flows that connect the three channel entities together. The first flow is concerned with the transfer of *information* up and down the channel. The second flow represents the movement of inventory as it is transformed from materials into finished goods and final sale to the customer. The third flow tracks financial settlement at each entity in the channel. The final flow reflects today's growing concern with environmental sustainability and is centered on reverse logistics, recycling, conservation, and waste disposal.

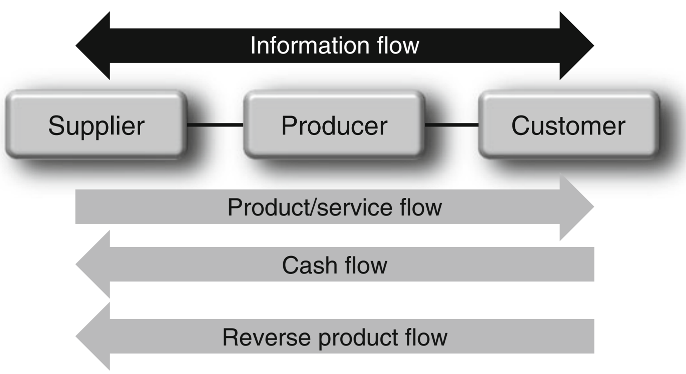


FIGURE 1.6 Basic supply chain structure.

Figure 1.7 presents a more complex view of the integrated supply chain [7]. Perhaps the most important aspect about the framework is the networking of various levels of primary and secondary suppliers, delivery intermediaries, and customers into a single, seamless supply chain system. The exact structure of any supply chain depends on the range of specialized functions required of channel partners, the intensity of channel collaboration, the number of *echelons* (or tiers) in the channel, and the number of channel intermediaries used in the delivery process. The integrated supply chain perspective transforms the traditional channel structure from a loosely linked association of independent businesses into a networked, virtual organization focused on common supply chain value, market impact, overall efficiency, and continuous improvement.

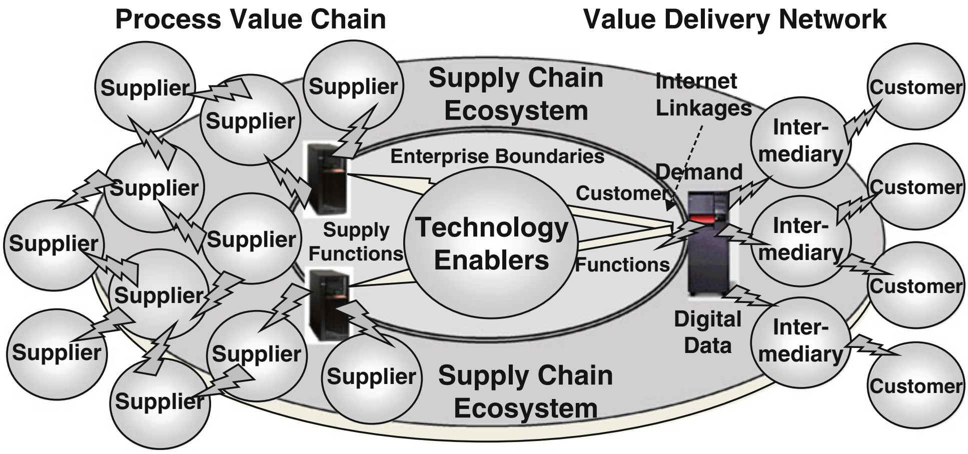


FIGURE 1.7 Integrated supply chain framework.

A supply chain network consists of two segments. The first segment is the *process value chain*. This component is composed of networks of materials, components, and resource suppliers that are used by channel integrators to produce the product. The role of the *process value chain* is to receive information in the form of product requirements, and then to translate that demand into the products and services demanded by the customer. Once the anticipated portfolio of goods and services has been produced, they then enter the second segment of the supply chain, the *value delivery network*. The goal of this component is the structuring of delivery channels that facilitate the effective distribution of products and services reflecting as closely as possible the service values demanded by the customer. The actual structure of the delivery channel is the responsibility of the integrators and intermediaries that constitute the channel and will be dictated by the nature of demand and the respective capabilities of the channel network constituents.

1.3.2 Basic Supply Chain Strategies

There are three main supply chain strategies that could be followed in channel management: stable, reactive, and efficient reactive. A *stable* supply chain is characterized by a long trading history between channel entities; a heavy focus on execution, efficiencies, and cost performance; and the use of simple connectivity technologies with little need for real-time information sharing. An example is a fastener supply chain that competes using scale production, stable pricing, and readily available inventories. A *reactive* supply chain is one where channel entities act to fulfill the on-demand requirements from customers. Such supply chains are perceived as cost centers, use minimal networking technologies, and regard throughput as the main goal of the channel structure. An example is a make-to-order producer of computer equipment, such as Dell, that offers customers the ability to customize their orders. An *efficient reactive* supply chain acts as an efficient, low-cost provider of goods and services. This channel entity focuses on efficiency and cost management to keep total delivered costs low and regards connectivity technologies and internal process automation as the key to increasing profits, expanding capacities, and increasing channel product and information velocities. An example is a retail chain that uses point-of-sale (POS) and collaborative planning, forecasting, and replenishment (CPFR) to broadcast demand to various levels of upstream channel suppliers.

Supply chains are managed using one of two types of channel integration: vertical and horizontal. A *vertically* managed supply chain is characteristic of businesses that seek to absorb as many channel entities as possible inside the organization to create a monolithic supply chain. The classical example is the early Ford Motor Company which pursued a strategy of owning as many tiers of supply channel entities as possible. The advantages of this strategy are direct management control of the supply channel, close materials and operations cost control, and high interaction with the customer. Issues regarding supplier instability and capacity gaps are eliminated and focused economies of scale are gained. Drawbacks are heavy management and facilities costs, the expense involved in building new competencies, and the risk of not being responsive enough to marketplace changes. Most companies today pursue a strategy where key core competencies are integrated vertically, while non-essentials are outsourced to channel partners.

Horizontally managed chains all but replaced the traditional vertical approach. In this strategy, corporate managers seek to outsource as many administrative, production, and distribution functions as possible to supply network partners while retaining ownership of core competencies. In place of direct control, channel flows are regulated by transaction and long-term contracts. The advantages of this strategy are leveraging partners to achieve local economies of scale and scope, concentrating company focus on internal core competencies by outsourcing non-essential functions, gaining quick access to key productive resources held by channel partners, and leveraging technology networking to share and access information from anywhere across the global supply chain. Drawbacks center on loss of control of functions, increased risk due to possible channel partner failures, the hollowing out of internal competencies, increased burden to manage channel complexities, and possible compromise of proprietary information to competitors.

1.3.3 The SCOR® Supply Chain Framework [8]

An important alternative method to evaluate a supply chain structure is the *Supply Chain Operations Reference (SCOR®)* framework developed by the APICS Supply Chain Council. The SCOR® framework was created to assist in understanding, describing, and evaluating supply chains. SCOR® defines the supply chain as "the integrated processes of Plan, Source, Make, Deliver, Return, and Enable spanning from the suppliers' supplier to the customers' customer." The framework reflects the collective wisdom of years of field-based practices and combines elements of business process engineering, metrics, benchmarking, best practices, and people skills into a single management framework for designing and managing the supply chain.

As illustrated in Figure 1.8, the SCOR® framework is composed of the viewer's own company at the center and tiers of suppliers and customers extending in either direction. To the immediate right of the company are first tier customers that are either internal or external. To the left are first tier suppliers that, again, are either internal or external. The model also displays a second tier illustrating suppliers' suppliers and customers' customers. In actuality, the SCOR® framework represents more than one external tier but only two are shown.

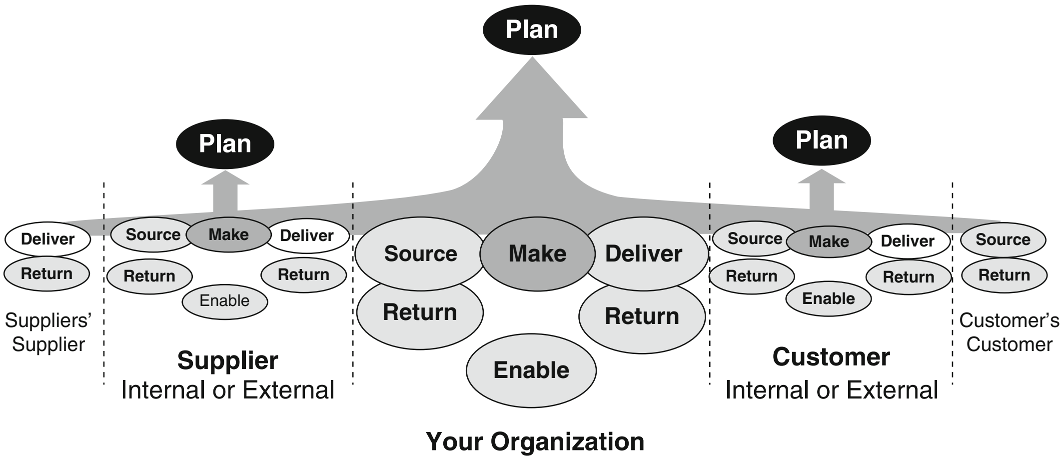


FIGURE 1.8 SCOR® supply chain framework (Source: Adapted from APICS Supply Chain Council).

The SCOR® framework is composed of four major sections. The first is *performance*, which consists of five standard attributes and accompanying metrics to describe process performance and define strategic goals. The first attribute, ***reliability***, addresses the ability of the supply chain to perform processes as expected. Key metrics are perfect order fulfillment, percent of orders delivered in full, and delivery performance to customer commit date. The second attribute, *responsiveness*, refers to the velocity at which processes are performed. Key metrics are order fulfillment, source, make, and deliver cycle times. The third, *agility*, refers to how quickly a supply chain can respond to changes in the external environment. Key metrics are upside and downside supply chain flexibility, adaptability, and value at risk (VAR). The fourth, ***cost***, refers to the cost of operating a supply chain. Key metrics are total supply chain management cost, cost of goods sold, and costs to plan, source, make, deliver, and return products. The final attribute, *assets*, describes the ability of supply chain participants to effectively manage assets. Key metrics are cash-to-cash cycle time, return on supply chain fixed assets, and return on working capital.

The second section in the SCOR® framework is *processes*, which consist of a set of six primary management processes: Plan, Source, Make, Deliver, Return, and Enable. By referencing these macro processes, SCOR® can be used to describe supply chains that are very simple or very complex by applying a common set of definitions. The framework is also designed to support supply chain process analysis at four linked levels. The SCOR® framework decomposes the six primary Level-1 processes into Level 2 *process categories*. In turn, Level-2 categories are further decomposed into Level-3 *process elements*. For example, Plan is decomposed into five *process categories* (supply chain, source, make, deliver, and return). Category *supply chain* is then decomposed into four *process elements* (identify, prioritize, and aggregate supply chain requirements; identify, prioritize, and aggregate supply chain resources; balance supply chain resources with supply chain requirements; and establish and communicate supply chain plans). Level-4 consists of company specific supply chain management practices decomposed from Level-3 designed to achieve competitive advantage and to enable the company to rapidly adapt to changing business conditions. The content of these improvement processes are company-dependent and are outside the scope of the SCOR® framework.

The third section is *practices*, which provides a collection of industry-neutral "best practices" linked to Level-2 and Level-3 processes. SCOR® 11 recognizes 21 classifications of practices, such as customer support, distribution management, inventory management, and manufacturing/production. Each practice is accompanied with a relevant set of performance metrics. The fourth section of the SCOR® framework is *people*. This section provides a standard for describing skills required to perform tasks, manage processes, and mange talent in the supply chain. The key elements of the people section are skills, experiences, aptitudes, and training.

Figure 1.9 illustrates a supply chain thread diagram that uses the SCOR® process framework to describe a supply chain consisting of two suppliers, one producer (following a make-to-order strategy), and two channel intermediaries. The goal is to use the SCOR® framework to identify the major processes needed to run the supply chain, select the process categories, and structure the supply chain. Finally, the SCOR® process elements from Level 3, the SCOR® process metrics, and the SCOR® practices from each process category are then used as a framework to continuously evaluate and compare supply chain activities and performance. To help in the diagraming, SCOR® uses a simple code to describe each process. For example, Level-1 Plan is coded as sP; the five Level-2 categories of Plan are coded as sP1 . . . sP5; the four Level 3 process elements as sP1.1 . . . sP1.4, and so on for the remaining Level-1 processes. The full detail of the four levels is found in the SCOR Model Reference manual available from the APICS Supply Chain Council.

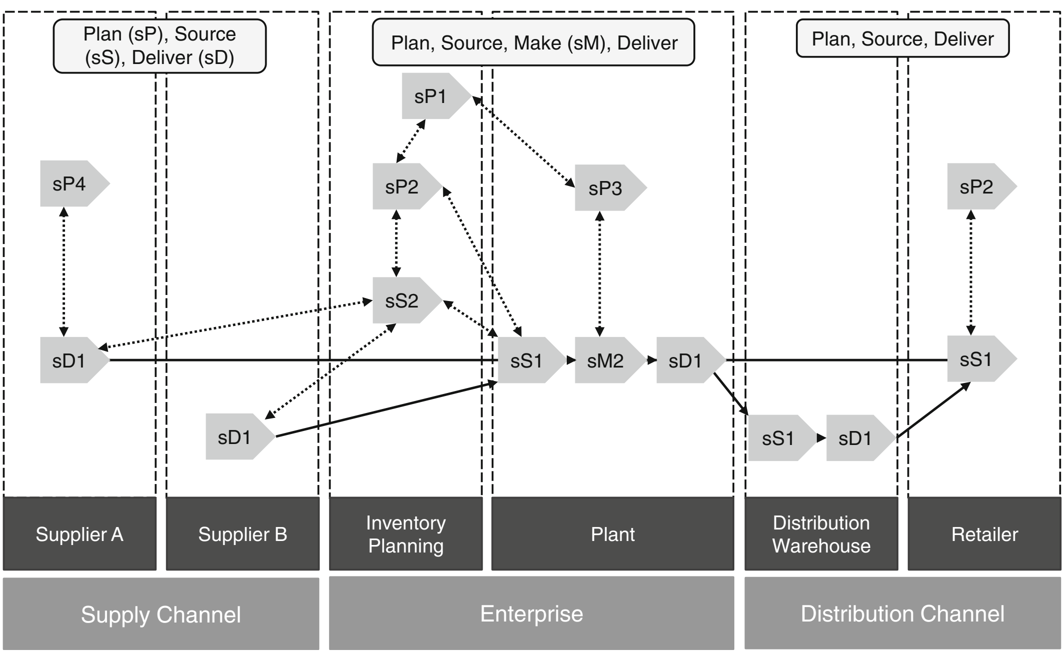


FIGURE 1.9 Creating a SCOR® supply chain thread diagram.

The supply chain thread diagram in Figure 1.9 provides a simplified application of the SCOR® framework. Only two of the four SCOR® levels are used. The dotted lines represent the flow of information and the solid lines the flow of inventory through the supply chain. Planners using the SCOR® framework would start by identifying the actual segments of the supply chain. In this case they are the supply channel, the production enterprise, and the distribution channel. Next the Level-1 macro-processes (which appear in boxes at the top of the diagram) would be assigned to each entity found in the three supply chain segments (note some will repeat).

The next step is to determine the Level-2 *process categories*. Planners would start by picking an important gateway process. For example, inventory planning at the plant would be an excellent opening process. Using the SCOR Model Reference, *sP1* (Plan Supply Chain) is chosen. Next, *sP2* (Plan Source) is selected which describes the sourcing plans. Next, *sS2* (Source Make-to-Order) describes the production strategy and determines the nature of the sourcing effort (Note that the dotted lines from the warehouse *sS2* stretch to the two suppliers and are connected to the *sD1* (Deliver Stocked Product) process category). Finally, the inventory is shipped and received at the Plant under category *sS1* (Source Stocked Product) and moved to production in *sM2* (Make-to-Order). The other entities in the supply chain would undergo the same *process category* review.

The real value of using the SCOR® framework is the ability not only to decompose processes into more detailed activities, but also to identify specific performance metrics. Each one of the metrics in the SCOR Model Reference contains a full description and, where applicable, the statistical formula. SCOR® recognizes three levels of pre-defined metrics:

- Level-1 metrics provide strategic metrics and key performance indicators (KPIs) assessing the health of the over-all supply chain. Using the performance attributes previously detailed, SCOR® recognizes 10 strategic metrics:

Performance attribute	Level-1 metric
Reliability	Perfect order fulfillment
Responsiveness	Order fulfillment cycle time
Agility	Upside flexibility
	Upside adaptability
	Downside adaptability
	Overall value-at-risk
Cost	Total cost to serve
Asset management efficiency	Cash-to-cash cycle time
	Return on fixed assets
	Return on working capital

- Level-2 metrics serve as diagnostics for the Level-1 metrics. The diagnostic relationship helps to identify the root cause of Level-1 metrics performance gaps. For example, for Make process categories, the metrics are Total Cost to Serve, Production Cost, and Cost of Goods Sold.
- Level-3 metrics serve as diagnostics for Level-2 metrics. For example, for process category sM2 (Make-to-Order), there are 20 metrics that include Perfect Order Fulfillment, Yield, Make Cycle Time, and so on.

Once the SCOR® framework is fully populated with the processes, metrics, and practices describing the supply chain, the current channel configuration and performance is documented. The next step is to begin a SCOR® improvement project to align the existing supply chain with the configuration detailed in the SCOR® framework. A significant advantage of SCOR® is that the production company can use the metrics from across supply chain members to gauge the overall performance of the supply chain. For example, (providing the information is shared), the plant can use the metrics attached to the sD1 process category to determine total supplier channel delivery performance.

1.3.4 Lean Supply Chain Model

Another important supply chain model involves the blending of lean concepts and practices with SCM. The story of lean process management is well known to all professionals in the field of operations management. Springing out of the teachings on quality management of W. Edwards Deming and the assembly-line practices of the Ford Motor Company, the concept was adopted by Japanese manufacturers and nurtured to maturity in the 1980s in the *Toyota Production System (TPS)*. Over the decades, the concept has migrated from *just in time (JIT)* to lean and was enhanced by the addition of total quality management (TQM), *six sigma*, and *theory of constraints (TOC)* management methods. Lean has emerged as a business *philosophy* preaching the total elimination of all wastes, the optimization of productive resources, building and delivering products to the *demand-pull* of the customer, a *toolbox* of techniques for process improvement, and a *system* through which companies and their business partners can deliver continuous improvement and customer satisfaction everywhere in the supply chain.

What makes a supply chain lean? To begin with, the mission of a lean supply chain is to reduce waste found anywhere in the supply network, standardize processes across organizations, and optimize core resources. Lean supply chains seek to achieve high levels of customer value at the lowest cost through the real-time synchronization of product and service needs with the optimum channel supplier. Achieving such objectives requires supply chains to be *responsive* (capable of rapidly responding to changes in customer requirements for quality, delivery, and satisfaction) and *flexible* (agile to adapt assets, pursue outsourcing, and deploy dynamic pricing and promotions to meet marketplace requirements). Finally, lean supply chains are dedicated to the continuous improvement of people and processes throughout the extended supply chain. A lean supply chain is defined as *a network of organizations that collaboratively work together to synchronize products, services, and information while continuously reducing waste to meet the demand-pull of the individual customer.*

Lean supply chains contain six core competencies [9].

- *Lean improvement tools.* Lean advocates have identified a toolbox of methods designed to attack wastes anywhere in the company or the supply chain. Important methods are the *"five S" system of improvement* (sort, set in order, shine, standardize, and sustain work management); *SMED/quick change over* (reduce operational lead times inhibiting process performance in the supply chain); *process flow analysis* (linkage of processes and removal of barriers between channel nodes enabling the acceleration of the flow of goods to the customer); *total productive maintenance* (TPM) (ensuring the availability of productive equipment in the supply chain); and *six sigma* and *statistical methods* (performance metrics to ensure total quality across the supply chain).

- *Process standardization.* A fundamental objective of lean SCM is the elimination of waste through the standardization of business processes. Standardization enables companies to effectively apply improvement methods to any process and track, measure, and demonstrate improvement results. Standardization also enables identification of inhibitors of flow, such as batch and queue processing and unnecessary transportation and product storage. Standards should not be limited solely to products and processes, but should also be expanded to determine how information is shared across the supply chain. Industry standards should be used whenever possible, and supply channel partners should participate in confirming the common standards to be used.
- *Lean SCM technologies.* Today's supply chain has access to a wide spectrum of technologies for the implementation of lean practices. Technologies such as ERP and SCM business systems; point technologies such CRM, APS, and global trade management (GTM); bar coding and RFID devices; and Internet connectivity applications are fundamental in the creation of a common information platform. These systems enable channel partners to link systems to form an information network providing real-time, channel-wide visibility to demand and supply, unplanned channel events and risks, and common performance measurements.
- *Cross-enterprise collaboration.* The broad elements of supply chain collaboration were illustrated in Figure 1.5. The commitment of channel participants to the level of lean involvement mirrors the general intensity of cross-enterprise collaboration. At the lowest level, *internal optimization,* channel entities engage in lean initiatives focused on reducing local internal costs and cycle times to enhance customer satisfaction, but rarely will pursue lean improvement outside the four walls of their companies. Businesses at level two, *transactional/informational collaboration,* will pursue lean with channel partners to establish and monitor common channel performance metrics. These companies normally use *extended value-stream mapping* to illuminate the process flows with other channel players to quantify areas for improvement. Additional lean tools are conducting joint Kaizen events, lean accounting and problem solving, and statistical methods charting channel performance. Lean initiatives at this level seek to reduce wastes in cross-channel functions such as transportation, warehousing, and inventory.

  In level three, *shared processes and co-development*, network partners seek to more deeply integrate lean by creating cross-channel lean project teams to effectively establish consensus on improvements to common performance and planning processes. Finally, in the fourth level, *linked competitive vision*, channel partners will utilize lean improvement as a common lever to activate new dimensions of joint strategy and marketplace collaboration, compliance and transparency, performance and risk management, sustainability, and shared resources. On this level of collaboration, cross-channel lean practices and metrics enable executives to determine the overall performance and health of their own organizations and that of the supply chain in general and illuminate new areas for continuous improvement.
- *Sustainability.* Environmental sustainability is a natural extension of lean and it resides at the heart of a lean supply chain. By standardizing and rationalizing productive processes to remove wastes and excess inventories, lean improvement teams can

reduce the use of materials, redundant and meaningless labor, pollution, and power. Lean sustainability directly targets all forms of channel *waste*. Making processes more efficient removes wastes caused by poor product and process design, inaccurate documentation, scrap, and poorly used people skills, knowledge, and capabilities. An important consideration is planning for the recycling or disposal of defective products and packaging materials.

The importance of environmental sustainability to organizations and their supply chains is found in the concept of the *triple bottom line* [10]. This strategy implies that companies that design processes that preserve the environment will also add to their financial bottom-lines. The three advantages are:

– *Economic*. This component is concerned with the application of sustainable business practices and how they contribute to the financial well-being of supply chain firms.
– *Environmental*. This component is concerned with a supply channel's sustainability practices aimed at controlling and regulating the production, transportation, and use of toxic, dangerous, wasteful, and hazardous products.
– *Social*. This component is concerned with how organizations act and operate in a socially responsible manner, including human rights, labor practices, and the environment.

As supply chains become more sustainable, business *operations* become more agile and flexible and capital and assets are better focused to further structure business practices that continually enhance the triple bottom line for everyone in the supply channel network.

- *Demand management*. A central principle of lean is the *demand-pull*. The demand pull is set in motion at the time of sale. Once triggered, inventory replenishment is then pulled from upstream delivery channel partners, node-by-node, back to the producer. The demand-pull requires lean processes that are:

1. *Visible and transparent*. Lean supply chains need to be immediately alerted when out-of-bounds events occur that will increase costs and cause wastes to appear anywhere along the supply channel continuum.
2. *Demand-driven*. Demand in the supply channel is no longer driven by forecasts but only occurs when inter-channel or customer demand is present.
3. *Instrumented*. Information about marketplace conditions needs to be driven by information technology applications that alert not just the next node but the entire channel simultaneously of impending demand changes.
4. *Integrated*. Lean supply chains are organized around demand management process teams whose activities are focused on creating optimum value for the customer.

Lean concepts and practices enable the structuring of supply chains that build and sustain a *stream of value* to the customer. Lean supply chains enable cross-channel teams to broaden and enrich channel communications concerning quality, change management, collaboration opportunities, and joint metrics that keep supply chains focused on continuous improvement as they drive toward network competitiveness and profitability.

1.3.5 Adaptive, Demand-Driven Supply Chain Model

Managing today's supply chain requires businesses to confront the problem of risk. Much of the concern is an outgrowth of the complexity involved in managing global channels of supply. As the footprint of supply chains expands, the disruptions caused by natural disasters and man-made events have heightened the exposure of supply networks brought about by a decades-long mandate to decrease supply chain inventories and costs. Suddenly, companies that had formerly sought to make their supply chains as lean and as streamlined as possible were having second thoughts. Although it was true that implementing lean principles had dramatically cut channel inventories, drained away much of the waste found in production and logistics, and dramatically increased throughput velocities, managers were now beginning to worry that, while the fat had gone, supply chain pipelines were perhaps too thin, that they had actually become too brittle to withstand even small negative events, much less a major disruption.

To counter the growing sense of risk, businesses have turned to two new channel strategies: supply chains need to be *adaptive* and *demand-driven* if they are to remain resilient. Adaptive channel networks counter market uncertainty by being able to rapidly restructure processes and even whole supply chains to meet changes in customer requirements while remaining efficient. Adaptive supply chains are able to quickly reconfigure themselves in response to disruptive events, such as the introduction of a radically new product or service, information technologies, regulatory and environmental policies, financial uncertainty, and massive market restructuring, without compromising on operational efficiencies.

Besides flexibility, supply chains also need to be demand-driven. Being demand-driven means that companies must move beyond internal operational optimization and restructure their supply chains to sense and proactively respond to demand signals arising from customers rather than just reactively countering emerging disruptions in the supply network. Demand-driven organizations are more *demand sensing*, capable of more *demand shaping,* and able to execute a more profitable *demand response* than companies that are simply supply-centered. A demand-driven strategy centers on the configuration of supply chain processes, infrastructure, and information flows that are driven by the demand channel rather than by the constraints of factories and distribution intermediaries located upstream in the supply network. In the end, being demand-driven is more than just filling orders: it is using demand signals to scale processes and resources quickly across the entire supply network.

1.3.6 Components of Adaptive Supply Chain Management

In contrast to conventional supply chains, which depend on forecasting and inventory buffers to manage risk, adaptive networks can be quickly reconfigured to meet changing marketplace requirements. As illustrated in Figure 1.10, adaptive networks possess information tools that permit them to *sense* changing conditions in the channel network wherever they occur. Illuminating potential or actual network supply problems requires technologies that provide instant visibility to threats occurring concurrently to channel partners. Data is crunched to reveal systemic patterns of actions causing channel disruptions. Awareness of the level of potential risk is then used by preconfigured system *alerts* to generate detailed action messages to all network participants. Exception messaging provides warnings on both tactical and strategic levels. Strategically, alerts may reveal emerging challenges that endanger the fundamental assumptions upon which the supply chain is structured. Tactically, alerts may indicate that market conditions have altered the supply chain's ability to execute detailed marketplace functions.

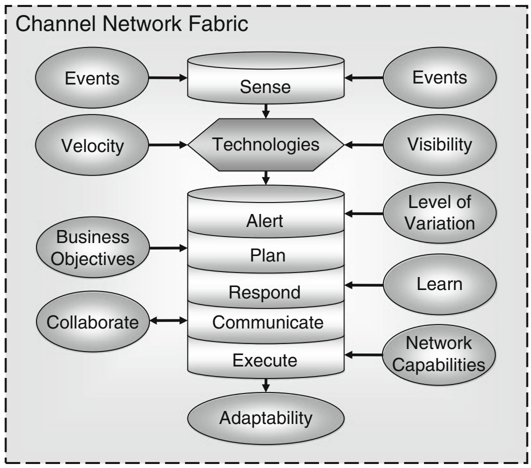


FIGURE 1.10 Components of adaptive SCM.

Exception messages enable channel planners to assess the degree of required *plan* revision. For example, a simple plan is needed to correct an internal out-of-balance process. A more complex plan involves re-planning a channel supply point in order to put the channel plan back on track. The goal is to ensure that events occurring anywhere in the supply network are visible to all participants so that they can *respond* effectively to the impending disruption. As an example, action to correct a tactical problem, such as an inventory shortage at a network supply node, results in an emergency effort to relocate stocks from other channel warehouses to the affected location. A major disruption at a critical upstream supplier might require a revision of the entire supply chain strategy. In all cases, event data should be complete enough so that standard operating procedures and planning optimization can rapidly and accurately assess the resulting impact on channel performance as a result of a fundamental change in plans.

As mitigation plans are developed, possible solutions must be *communicated* to affected supply network participants. The speed of response by channel partners to plan revision is driven by two factors: the level of existing network *collaboration* and the availability of communications tools. The more integrated and collaborative the channel relations, the quicker alternative plans are communicated and consensus reached. Once solutions are agreed upon, plan *execution* follows. Disruptions are handled by applying an alternate solution to the problem area. Quick adaptation by the supply chain permits event obstacle resolution without adversely disturbing and destabilizing standard processes occurring at other network points. If the volume or magnitude of tactical adaptive planning becomes too great over time, fundamental change to the overall supply network is probably warranted.

Adaptive supply chains assist companies to effectively manage risk by possessing the following operational characteristics:

- *Demand Flexibility*. Utilization of demand-gathering, planning, and execution technologies to capture real-time information that enables planners to sense both planned and unplanned demand events as they occur. Such intelligence in turn enables them to rapidly adapt and synchronize *marketing factors*, such as inventory substitution, promotions, pricing, and auctions and exchanges, and *operations factors*, such as network substitution, outsourcing, and logistics, to meet new demand patterns, and activate visibility, collaborative, and analytical toolsets enabling every node in the network to keep the right products flowing to the right customers.
- *Supply Flexibility*. Ability of channel partners to link themselves together into networks focused on collaborative integration. Suppliers that are 'seamlessly' integrated can focus their special competencies on accelerating joint product development, sourcing, order management, and delivery flexibility that enables rapid deployment of inventories and transportation capabilities to respond to demand as it actually happens at each point in the network.
- *Delivery Flexibility*. This characteristic enables supply chains to overcome disruptive events by shrinking cycle times; synchronizing all logistics, transportation, and fulfillment operations; deploying sense-and-respond technologies enabling rapid response; and utilizing technologies that pinpoint in real time information arising from people and physical objects.
- *Organizational Flexibility*. At the core of the adaptive supply chain stands organizations agile enough to rapidly alter resources and competencies in response to the threat of channel disruption. Flexible organizations are capable of *adaptive planning* whereby affected supply chain areas can rapidly devise and deploy risk and response alternatives by recalibrating inventories, suppliers, logistics services providers, and carriers to optimize possible financial and operational trade-offs. *Adaptive execution* enables organizations to quickly implement and guide alternative plans by monitoring events as they occur, coordinating understanding and assessment alternatives, and ensuring rapid joint action for optimal recovery while minimizing the impact on supply chain areas unaffected by the disruption.

1.3.7 Demand-Driven Supply Network (DDSN) [11]

A *DDSN* is defined as "a system of technologies and business processes that sense and respond to real-time demand across a network of customers, suppliers, and employees" [12]. DDSNs have emerged in response to the significant risks inherent in today's extended supply chains and consist of the following competencies (Figure 1.11):

- *Demand-Driven*. DDSNs succeed by creating *value* for their customers and supply chain partners through the continuous re-alignment of all channel resources, infrastructures, and information flows to serve the downstream source of demand rather than the upstream constraints of factories and distribution systems. Supply chains that can react quickly to customer needs, present unique buying experiences, and continuously provide innovative product and service mixes will be those who will be able to lock in brand awareness, create an exceptional customer service benchmark, and be recognized as the supplier of choice among peers.

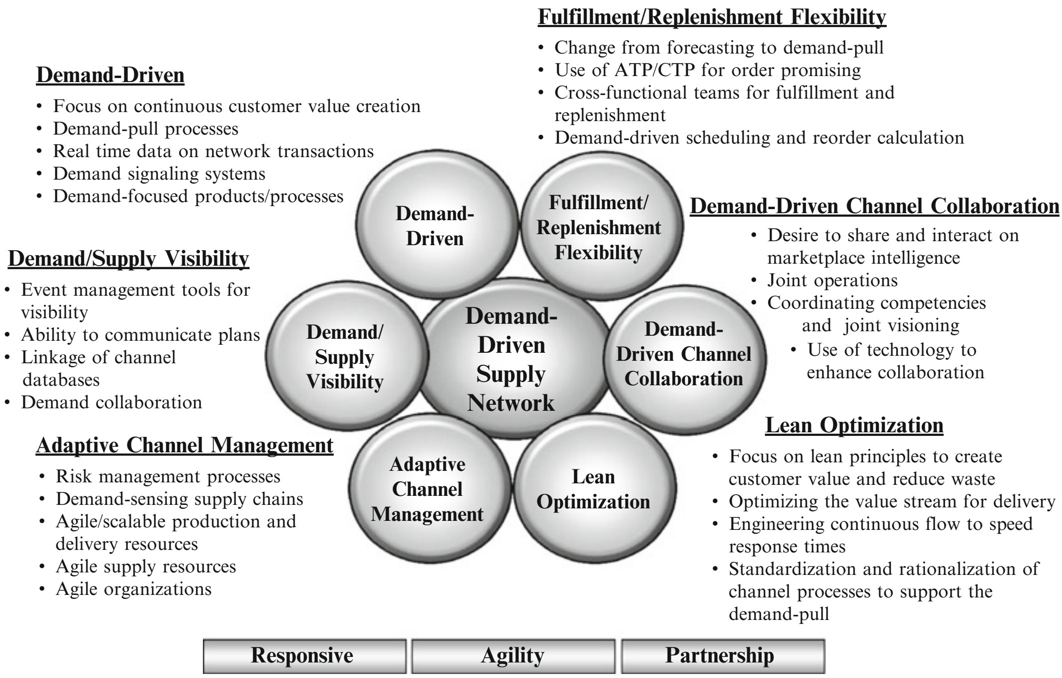


FIGURE 1.11 Demand-driven competencies [13].

- *Demand/Supply Visibility*. A key priority of a DDSN is improving *visibility* to demand as it occurs anywhere in the supply channel. Agile supply networks excel in deploying demand-gathering, planning, and execution technologies that reveal events as they actually occur. At the heart of supply chain visibility is found technology tools that *connect* supply network partners and focus them on customer value delivery. These technologies provide for the merger, harvesting, and analysis of channel intelligence associated with critical data such as demand forecasts, order status, production schedules, and finished goods levels essential to effective demand management. Performance-wise, companies with highly visible supply chains have customer service levels of at least 96 %, reduced inventory levels of 20–30 %, and are twice as likely as their competitors to have an on-time delivery rate of 95 % or higher [14].

  According to the Aberdeen Group [15], the top strategic actions designed to promote channel supply and demand visibility are:

  – Improved internal cross-department visibility and integration into supply chain transactions and costs.
  – Streamlined processes for easier monitoring, enhanced usability, or efficiency.
  – Improved timeliness and accuracy of data exchange about supply chain transactions.
  – Increased business-to-business (B2B) connectivity/visibility into supplier-side processes, 3PLs, and trading partners.
  – Networked use of predictive analytics and simulation to capture, analyze, and simulate actual supply chain performance.

As examples, companies such as P&G, Wal-Mart, and Cisco are taking demand and supply visibility beyond just receiving forecasts from their customers. Utilizing techniques such as shopper loyalty cards and point-of-sales (POS) data, these companies are tapping into enormous data reservoirs revealing customers' real-time buying habits. Wal-Mart, for example, provides P&G access to its huge database of POS information. Other organizations are working closely with key suppliers and customers to develop linked sales and operations planning (S&OP) tools so they can feel the pulse of supply and demand in the supply channel. P&G calls this ability to "sense" demand as it happens "joint value creation.... The new challenge for the supply chain is in fact getting and translating real demand data" [16].

- *Adaptive Channel Management*. Supply chains cannot hope to leverage the demand-pull signal without agile infrastructures, scalable resources, and speed of information transfer. Adaptive organizations effectively use global visibility and demand intelligence to make informed, reality-based judgments affecting everything from major channel realignment to disaster recovery strategies. Agile organizations also use demand intelligence to rapidly and collaboratively assess an array of possible "what-if" marketplace alternatives. Connective technologies enable action teams to then communicate simulation details to channel areas at risk of demand disruption so that alternatives are jointly reviewed and optimal courses of action pursued. Finally, adaptive organizations deploy a comprehensive performance scoring mechanism that accurately predicts the impact of possible demand management responses and weighs alternatives against emerging demand requirements so the best course of action can be taken that meets overall channel customer service and profitability.
- *Lean optimization*. Lean assists supply chains to be "demand-driven" by providing the *value* desired by customers, engineering continuous *flow* to speed response times, enabling the customer to *pull* value from the supply chain, and engaging channel partners in an endless search for perfection. Such demand-driven objectives are achieved when supply chains continuously clear away constraints, collapse processing times, remove redundant operations steps, and even eliminate entire channel levels in order to optimize marketplace response. By applying "lean" principles, companies can effectively pursue *waste reduction* at all supply chain levels; leverage supply chain partnerships and technology tools to continuously build and sustain a high-velocity *stream of value* to the customer; and finally, deploy cross-channel metrics for effective quality, change management, and collaboration to maintain a focus on network *continuous improvement*.
- *Demand-driven channel collaboration*. Leveraging lean, adaptive, DDSN models requires companies to transform their supply chains from linear, sequential processes into collaborative networks. Demand-driven collaboration streamlines the flow of joint product design, cross-channel information regarding marketplace events and ongoing customer management, and integrated logistics functions. Supporting collaborative demand networks are a variety of technology tools. Point-of-sale (POS), EDI, and RFID technologies enable companies to directly input marketing events, such as promotions and deals, as well as disruptions and last minute changes, directly into their supply chain partners' demand-management systems to ensure optimal customer service. Application interoperability enables channel planners to assess in real-time

the impact of excess demand, out-of-stock, and over-stock information; apply the information for sales forecast revision; drive replenishment scheduling; and communicate results to channel partners. DDSNs can also deploy collaborative planning, forecasting, and replenishment (CPFR) and sales and operations planning (S&OP) systems to directly export demand requirements, production performance statistics, and available inventories directly into the planning systems of channel partners.

- *Fulfillment/Replenishment Flexibility*. DDSN replenishment is defined as the synchronization of supply channel sourcing, production, and distribution with the demand-pull of the customer. DDSN requires that supply chains move from customer fulfillment plans based on fixed forecasts to a demand pull-based strategy that leverages the sensing and cascading of the demand signal down through the supply channel and its translation into a replenishment signal to guide the priorities of channel production and distribution. Steps to building effective DDSN fulfillment are:
  - Integration of the demand-pull with channel business systems (ERP/SCM) so that demand signals are driven all the way back through the supply chain.
  - Replenishment processes capable of sensing impending stock-out conditions and then feeding the data automatically into downstream ERP and advanced planning systems to make demand-driven replenishment a reality.
  - Demand management teams that have access to metrics and scorecards providing visibility to cross-channel fulfillment performance.
  - Replenishment resources (assets and labor) designed for flexibility and responsiveness.
  - Demand team visibility to cross-channel production and distribution performance, thereby promoting joint channel ownership of replenishment decisions.

The effective execution of the six demand-driven network competencies enables supply chains to effectively pursue three critical performance drivers. Demand-focused technologies provide the depth of visibility necessary for channel participants to sense real-time information about demand and supply events that, in turn, enables them to be *responsive* to demand as it occurs at each node along the channel network continuum. Productive resource and replenishment flexibility promote *agility* by endowing supply chains with nimbleness, simplicity, and speed to rapidly execute adjustments to demand and supply capabilities as demand shifts over time. Finally, collaboration and optimization intensify visibility and agility and help foster effective supply chain *partnership* that enhances and optimizes the channel network's competitiveness and profitability.

1.4 SUPPLY CHAIN MATURITY MODEL

All supply chains strive for three performance objectives: customer responsiveness, profitability, and reduced costs by optimizing asset utilization. These objectives are measured by a handful of key indicators:

- Perfect order attainment
- Demand management accuracy
- Time to value

- Cash-to-cash cycle time
- Supply chain cost

Achieving these high performance objectives requires that companies transform their supply chains from static, insular organizations to dynamic networks providing customers with a totally integrated value solution.

Supply chain maturity is measured by assessing performance against the following four critical attributes:

- *Flexibility*. This attribute places agility and nimbleness as the central operating features of the mature supply chain. The flexible supply chain contains three operating principles: management of *visibility* (access to and broadcast of critical supply chain information); *velocity* (speed by which intelligence and inventories are moved through the supply chain); and *variability* (management of change occurring in the marketplace and in supply chain capabilities).
- *Predictability*. This attribute seeks to dampen the effect of supply chain disruption by using risk management methods that make the channel environment more predictable. The goal is making supply chains more resilient to disruptions by identifying and profiling risk variables, quantifying risk for business decision making, and activating mitigation alternatives so that supply chains are adjusted intelligently to meet the challenges of today's changing global economic and market conditions.
- *Resiliency*. This attribute is defined as the ability of a supply chain to recover from disruptions of any type. Mature supply chains use metrics such as time-to-recovery, value-at-risk (VAR), and *resiliency* indexes to provide visibility to impending disruptions and enable the establishment of comprehensive preventive and mitigation plans that ensure a company's viability in the wake of disruptive events.
- *Sustainability*. The keynote of a world-class supply chain is its ability to sustain high levels of performance regardless of changes in supply channel structures, the trauma of disruptive events, and the pressure of the competition. Mature supply chains overcome the negative challenges of the marketplace by leveraging the core competencies of the internal organization and the deepening collaboration of channel partners to build superior demand-driven supply networks.

As illustrated in Figure 1.12, there are four levels of maturity. The first level, *internal channel functions*, is fairly immature. Goals are driven by the efficient performance of internal functions only; commitment to the four supply chain maturity attributes is minimal. Supply chain strategy is splintered with each channel node often pursuing separate objectives. There is minimal to no global sourcing and no formal supplier relationships. The logistics network and infrastructure is insular and transaction based.

The second level, *inter-channel logistics functions*, is marked by horizontal integration of logistics functions across the internal supply chain. Supply chains at this level of maturity focus on integrating internal channel profitability, responsiveness, and cost reduction. Concerns with the four maturity attributes are directed at internal channel entities. Supply chain strategies are integrated across internal functions; orders and inventory are visible across the enterprise; purchasing is involved in cross-functional leveraged buying; outsourced logistics and contract manufacturing are shared across the internal supply chain; internal network assets are shared.

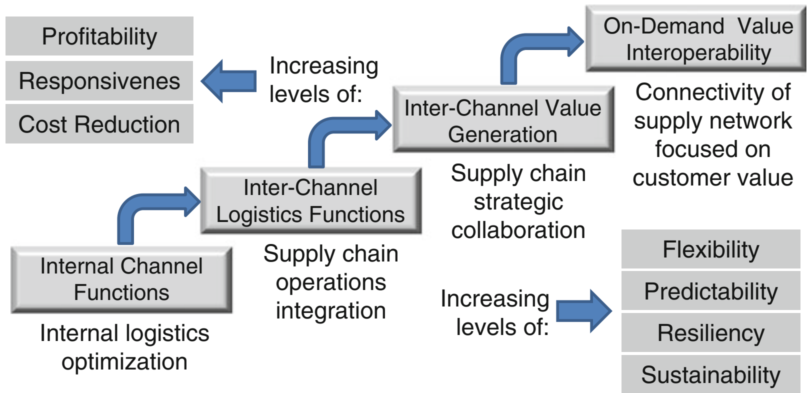


FIGURE 1.12 Supply chain maturity model.

Supply chains at level three maturity (*inter-channel value generation*) grow profitability by integrating customers and suppliers with the objectives of the core business. Supply chains compete by espousing the attributes of flexibility and resiliency. A concerted effort is made to standardize processes across channels, develop risk management mitigation alternatives designed to ensure the flow of information and materials, and foster a common commitment to sustainability practices. Strategies extend across supply channel partners; the distribution network is oriented to be closely integrated with customer requirements; visibility to customer demand is available across channel nodes; the supply network is integrated across upstream channel partners.

Supply chains displaying the highest level of maturity (*on-demand value interoperability*), understand that leadership in profitability, responsiveness, and cost control exponentially grows when channel partners are closely integrated and their value generating competencies are interoperable. Mature supply chains leverage each other to provide high levels of flexibility, use risk management tools to ensure disruptive events are minimized throughout the supply chain, link disruption recovery plans to ensure the continuous flow of goods and services, and leverage environmental sustainability as a way to provide a valuable triple bottom line advantage for the supply chain as a whole. Mature supply chains see themselves as a single virtual network, collectively focused on superior customer services. Strategic resources are capable of rapid reconfiguration and are rationalized and managed according to common performance measurements.

1.5 TRENDS IN SUPPLY CHAIN MANAGEMENT

Today's supply chains are experiencing a number of trends that pose distinct challenges. Some of these trends mark changes occurring within the organization while others are part of new directions occurring on a global scale. The most important of these trends are:

1. *Multichannel and omni-channel fulfillment*. Today's customer wants products and services that are available at the shortest possible delivery time. This "buy from anywhere, ship from anywhere" attitude requires supply chains to be able to respond across multiple channels and delivery systems. *Multichannel* fulfillment refers to the practice of selling goods through multiple channels, such as stores, distributors,

e-commerce, mobile, and so forth. The term *omni-channel* fulfillment refers to a form of multichannel strategy practiced by retailers who sell goods both through stores and over the Internet. The aim of these retailers is to offer multiple avenues of sales to provide customers with a seamless shopping experience.

2. *Service chains will become more important than product chains*. As product sourcing continues to expand on a global basis, pre- and post-sales service, rather than products, will be the criterion for competitive advantage. Companies that couple superior service with innovative products will emerge as the winners over their solely product-centric competitors.
3. *Leveraging social media*. The use of public social media (Facebook, LinkedIn, Twitter, and other sites), company-level chat rooms, blogs, and social networking vendors (Yammer, Jive, Moxie Software) will continue to have an important impact on supply chain management. In a 2013 survey [17], almost 70 % of respondents felt that social networks will either transform supply chain processes in ways unimagined today or will make supply chain processes more efficient, respondent, and effective. Tomorrow's winning companies will be able to deploy robust feedback loops allowing supply chains to proactively respond to customer concerns.
4. *Managing "big data."* Today's technology has enabled supply chains to capture enormous amounts of data. According to IBM, businesses create 2.5 quintillion bytes of data per day: so much that 90 % of data in the world today have been created in the last two years alone [18]. The concept of "big data" encompasses creating, enabling, and operating data storage, processing, and reporting structures that provide comprehensive insight arising from the analysis of all available data. An emerging challenge is effectively abstracting valuable intelligence from these massive databases. Big data enables supply chains to quickly spot new trends; gain faster access to important results; grow confidence, accuracy, and precision in data management; and glean more accurate data for strategic decision making.
5. *Managing business analytics*. An important tool in leveraging supply chain information is business analytics. *Predictive analytics* (an integrated framework that uses quantitative methods to derive insights from data) enables supply chains to identify possible patterns in channel demand and supply before they occur. *Descriptive analytics* enables supply chain to determine why something has or is happening now; predictive analytics provide insight into what will happen next. Predictive analytics enables companies to produce more realistic and detailed channel structure models, cope with missing and substandard data, and apply complex methods and algorithms to channel data. Predictive analytics can quickly validate proof of value for supply chain decisions, create a core analytical framework around which new processes can be built and standardized, and explore cross-channel analysis of supply chain issues to enable complex and integrated problem solving.
6. *Growth of cloud computing and mobile networking*. As the need for more sophistication supply chain technologies grows, new deployment trends have emerged that reduce the time to benefit and lower the cost of ownership. Migration to cloud computing and the increased adoption of mobile technologies are expected to expand. As multichannel and omni-channel fulfillment becomes more important, supply chains are expected to leverage mobile technologies to ensure demand is fulfilled

from anywhere in the supply chain, while cloud-based applications continue to reduce the cost of information systems ownership while improving the efficiency of channel players.

1.6 GOALS OF TODAY'S SUPPLY CHAINS

SCM enables channel businesses to function as an integrated, customer-centric supply ecosystem that delivers goods and services to the marketplace at the lowest possible cost. By leveraging the resources and competencies of channel partners, supply chains function as a seamless supply system focused on total customer satisfaction. At the foundation of market-winning supply chains are the following five success factors:

1. *Value-generation.* Effective supply chains add value to their customers and stakeholders. A *value chain* links the products and services originating in the supply chain starting from the origination point and continuing through delivery to the final customer. The goal is to add value at each step in the supply chain. A commitment to the *triple bottom line* requires that supply chains understand that value should be measured in three dimensions: economic, social, and environmental in additional to the traditional benchmarks of profitability and cost reduction.
2. *Improved customer service*. The best supply chains are configured to deliver customer value by segmenting and matching customer needs (products, services, and geographical access points) with supply chain strategies focused on optimizing total cost across network structures, operational parameters, and processes. Resources and investment are centered on configuring agile and scalable delivery networks by establishing integral processes that drive the overall value proposition with metrics and ownership defined at each channel point that touches the customer.
3. *Use of information technology*. Information technologies assist channel value creation by optimizing supply chain processes. Today's technologies provide value by establishing data architectures capable of synchronous information flows needed by channel members to develop and execute joint strategies. Supply chain technologies enable a shared inter-enterprise vision; channel business and process modeling capable of structuring the best supply chains; a means by which channel participants are seamlessly integrated to provide a common point of information; and a definition of what the networked structure should look like, how network resources are accessed, the sources and types of data, and how operational conflicts are to be resolved.
4. *Leveraging partner strengths.* The size of a supply chain's footprint is measured by how well it leverages channel partner collaboration. The *value* of collaboration is gauged by how well it results in supply chain profitability, reduces redundant functions and wastes, promotes a common supply chain strategy, and constructs the technical and channel architectures that win the customer's business. Collaboration enables the convergence of individual channel partner objectives so that a common channel vision, integrated planning and execution processes, and shared performance measurements can be constructed. Collaboration enables companies to far exceed individual company capabilities by providing for the connectivity of all channel

nodes, visibility to supply chain information and real-time data transfer, acceptance of common performance metrics and benefits, and access to demand patterns and expectations as they stream across the supply chain.

5. *The intimate supply chain*. Supply chains enable channel constituents to achieve a high level of intimacy about what constitutes a successful customer experience when they interact with channel products and services. Intimate supply chains are able to meet customer expectations for total value, provide an ultimate buying experience, and cement close relationships. These objectives are achieved by leveraging common demand databases enabling channel nodes to sense demand signals as they occur in the supply network, optimize demand fulfilling operations by reducing costs and wastes at each channel touch point, and leverage channel-generated intelligence not only to respond but to shape demand by opening new opportunities to reach the marketplace ahead of the competition.

1.7 SUMMARY

Managing today's supply chain has its roots in the ages-old struggle of producers and distributors to overcome the barriers of space and time to acquire production materials from suppliers and deliver products and services to the customer. Bridging this gap between demand and supply requires companies to perform two critical functions. The first is the management of *logistics*. The role of logistics is to efficiently and cost-effectively deploy inventory, warehousing, and transportation resources that enable companies to satisfy the day-to-day product and service requirements of customers. The second function is *supply chain management*. The role of SCM is to generate unique sources of customer value through the creation of collaborative partnerships whereby the resources, capabilities, and competencies of channel partners are leveraged to increase the competitive advantage of the entire channel system.

Logistics management centers on the daily execution of several foundational activities. These functions are separated into the following eight areas: customer order management, procurement and production, freight cost and service management, warehouse management, transportation routing and scheduling, fleet management, load planning, and dealing with special functions such as reverse logistics and waste recycling. The goal is to pursue the highest levels of customer service at the lowest possible cost.

SCM is about a company integrating its capabilities and marketplace objectives with those of its suppliers and customers on a strategic level. Integrative supply chains consist of many trading partners participating simultaneously in a collaborative network containing multiple levels of competencies and various types of relationships. SCM enables companies to activate the synergy to be found when a community of firms utilizes the strengths of each other to build superlative supply and delivery processes that provide total customer value. Instead of a focus on just logistics operations, SCM enables supply chains to collectively work to activate six key competencies:

- *Customer management*. The use of technologies and customer relationship management (CRM) concepts and practices to provide the customer with a superior buying experience.

- *Supplier management*. SCM uses supplier relationship management (SRM) to activate the real-time synchronization of the requirements of buyers with channel supplier capabilities to simultaneously achieve cost reduction and superior quality.
- *Channel alignment*. Effective SCM requires a continuous focus on network node congruence that simultaneously provides for competitive advantage for both the firm and the collective channel network.
- *Integrative technologies*. Information networks provide companies with visibility into channel resources and competencies so that they are harmonized and synchronized to provide superior customer service.
- *Operations excellence*. By acting as a single integrated team, the supply chain has access to an expanding range of processes and competencies individual companies are incapable of achieving acting on their own.
- *Collaboration*. The keystone of SCM is found in the willingness of supply channel partners to leverage web-based interoperability technologies to share resources and create a supply chain focused on executing a common business strategy by presenting customers with a seamless channel supply engine.

SCM emerged from its foundations in logistics management. The evolution of SCM occurred in four distinct stages. The first stage is described as the era of logistics decentralization. In this stage, logistics was broken into several distinct functions and assigned to different organizational departments. In the second stage, logistics began the evolution from functional decentralization to organizational centralization driven by requirements for cost optimization and customer service. Stage three witnessed the dramatic expansion of logistics from a passive operational function to an active integrative resource centered on the linkage of internal operations with analogous functions performed by channel trading partners. As the concept of channel collaboration grew, the old logistics concept gave way in stage four to full-blown SCM.

SCM today is viewed from multiple structural perspectives. A basic supply chain structure consist of at least one producer, one supplier that provides materials for production, and one customer who receives finished goods from the producer. This basic product/service flow is accompanied by three other critical channel flows: information, cash settlement, and reverse product flows. A more complex view extends the reach of the supply chain beyond local trading dyads to encompass a long chain of suppliers' suppliers linked forward to the producer/seller and a chain of customers' customers linked backward to the producer/seller.

To these basic models, several SCM approaches have been developed. An important model is the Supply Chain Operations Reference (SCOR®) framework. The SCOR framework clarifies the base supply chain structure by assigning the management of six key processes to entities in the channel structure: plan, source, make, deliver, return, and enable. These processes in turn are driven by five performance attributes: reliability, responsiveness, agility, cost, and asset management.

Another important supply chain model involves the blending of lean concepts and practices with SCM. The mission of a lean supply chain is to reduce waste found anywhere in the supply network, standardize processes across organizations, and optimize core resources. Lean supply chains are *responsive* (capable of rapidly meeting changes in customer requirements) and *flexible* (able to easily adapt resources to meet marketplace requirements). Finally, lean supply chains are dedicated to the continuous improvement of people and processes throughout the extended supply chain. A lean supply chain is defined as a network of organizations that collaboratively work together to synchronize channel products, services, and information while continuously reducing waste to meet the demand-pull of the individual customer.

Managing today's supply chain requires business to confront the problem of risk. As the global footprint of supply chains expands, the probability of natural disasters and man-made disruptions has heightened the exposure of supply networks to risk. To counter market turbulence, businesses have turned to two new strategies: supply chains need to be *adaptive* and *demand-driven* if they are to remain resilient. Adaptive channel networks counter market uncertainty by being able to rapidly restructure processes and even entire supply chains to meet changes in customer requirements without compromising on operational efficiencies. Being demand-driven means that companies move beyond operational optimization and restructure their supply chains to sense and proactively respond to actual demand signals arising from customers rather than just reactively countering emerging disruptions in the supply network. In the end, being demand-driven is more than just filling orders: it is using demand signals to scale processes and resources quickly across the entire supply network.

How well a supply chain responds to today's business challenges is revealed by using the supply chain maturity model. The model seeks to assess a supply chain's level of maturity by referencing four critical attributes: *flexibility* (the level of agility and nimbleness); *predictability* (the application of risk management methods to dampen the effect of uncertainty); *resiliency* (the ability of a supply chain to rapidly recover from disruption); and *sustainability* (the ability of supply chains to maintain high levels of performance). The maturity of a supply chain is demonstrated by how closely it is integrated. At the lowest level, *internal channel functions*, the supply chain is immature with performance splintered among channel members. In level two, *inter-channel logistics functions*, channel entities integrate logistics functions only. In level three, *inter-channel value generation*, supply chain members seek strategic collaboration with their customers and suppliers. In the highest level of maturity, *on-demand value interoperability*, channel partners are closely integrated and their value generating competencies are interoperable.

Competing and succeeding in today's global business environment requires supply chains to focus on channel performance, develop a disciplined culture, structure agile and flexible operations, strive to provide the customer with the ultimate buying experience, and forge strong internal and external partnerships. Only by working together can supply chains effectively manage volatility, dampen the impact of channel disruption, and remain ahead of the competition.

DISCUSSION QUESTIONS

1. Define the science and practice of logistics.
2. What are the components of logistics management?
3. Define the concept and practice of supply chain management (SCM).
4. What is meant by channel network node congruence?
5. What are the three basic channel entities and what is their role in the supply chain?
6. What are the basic inventory flows found in every supply chain?
7. Describe the basic supply chain strategies.
8. What are the competency attributes necessary to achieve a lean supply chain?
9. World-class companies can be described as being "demand-driven." Describe the operational attributes necessary to being demand-driven.
10. Supply chains can be said to possess levels of maturity. Describe the key attributes supply chains can use to gauge their level of maturity.

REFERENCES

1. Wilson, Rosalyn. (2014). *25th Annual State of Logistics Report: Ready for a new route*. Oakbrook: Council of Supply Chain Management Professionals.
2. All references to the APICS Dictionary in this chapter are from the 14th ed.
3. This definition can be found at www.cscmp.org/resources-research/glossary-terms.
4. Parts of this section have been adapted from Ross, David Frederick. 2011. *Introduction to supply chain management technologies*, 2nd ed, 23–31. Boca Raton: CRC Press.
5. See the detail in Finley, Foster, and Sanjay Srikanth. 2005. 7 imperatives for successful collaboration. *Supply Chain Management Review* 9(1):30–37.
6. For a more detailed review of the evolution SCM see Ross, David Frederick. 1998. *Competing through supply chain management*, 72–107. New York: Spencer.
7. Figure 1.7 is adapted from Ross, David Frederick. 2011. *Introduction to supply chain management technologies*, 2nd ed, 6. Boca Raton: CRC Press.
8. This section is based on the *SCOR Model Reference*, Revision 11.0, APICS Supply Chain Council, August 2013.
9. These competencies have been defined in greater detail in Ross, *Introduction to supply chain management technologies*, 123–131.
10. The concept of the *triple bottom line* was introduced by sustainability advocate Elkington, John in his book. 1994. *Cannibals with forks: Triple bottom line of 21st century business*. New York: John Wiley.
11. The concept of the demand-driven supply network (DDSN) was introduced in 2003 by AMR Research.
12. Cecere, Lora, Debra Hofman, Roddy Martin, and Laura Preslan. 2005. The handbook for becoming demand driven. *AMR Research White Paper*, July 2005, 1.
13. Adapted from Ross, David Frederick. 2008. *The intimate supply chain: Leveraging the supply chain to manage the customer experience*, 154. Boca Raton: CRC Press.
14. This analysis is found in The supply chain visibility roadmap. *Aberdeen Group White Paper*, Aberdeen Group, November 2006, 2.
15. Heaney, Bob. 2013. Supply chain visibility. *Aberdeen Group White Paper*, Aberdeen Group, May 2013, 4.
16. Harbert, Tam. 2009. Why the leaders love value chain management. *Supply Chain Management Review* 13(8):12–17.
17. Gonzalez, Adrian. 2013. The social side of supply chain management. *Supply Chain Management Review* 17(8):16–21.
18. Quoted in APICS. 2013. *The big data folio: Exploring the big data revolution*, 4. Chicago: APICS.

2

The Distribution Management Environment

In Chapter 1, the supply chain is described as a network consisting of suppliers, producers, channel intermediaries, and customers. Classically, each supply chain entity performs a detailed set of channel functions. The mission of suppliers is to provide materials to producers who make finished goods that in turn are warehoused and distributed by channel intermediaries to the end-customer. This compartmentalized view of the supply chain, while providing recognizable silos into which channel businesses are easily grouped, does not correspond to how channel processes actually work. Many manufacturers bypass the use of intermediaries and perform distribution functions such as finished goods storage, channel management, and delivery to customers. In turn, many channel intermediaries pursue light manufacturing and postponement strategies. Instead of rigid boundaries, the performance of channel functions are not the preserve of anyone channel entity but depend on the way a company responds to the challenges driven by business objectives and strategies, marketplace requirements, the nature of the product and the production process, and the expectations of the customer.

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_2) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_2, © Springer Science+Business Media New York 2015

The focus of this chapter is exploring the nature and function of channel *distribution*. Since the functions of distribution often cut across the roles traditionally assigned to supply chain entities, the discussion will take a wide view of the distribution management environment. The chapter opens with a detailed discussion of the characteristics of distribution. Following this introduction, the chapter turns to a review of the three major channel entities constituting the distribution cycle: integrators (producers), channel intermediaries, and end-use customers. Particular attention is paid to the various types of channel intermediaries, ranging from wholesalers, brokers and agents, and manufacturers' and retailers' branches and offices, to exporting and importing distributors. Next, the role of distribution channels is described. Among the topics covered are distribution channel service outputs, bulk-breaking, spatial convenience, length of waiting and delivery time, and product variety. The chapter then moves to a discussion of the ten marketing flows that guide the performance of channel transactions. The chapter also describes the forward flows of inventory from channel intermediaries to the end-customer, substituting information for inventory, reverse logistics, and the movement for "green" or sustainable supply chains.

2.1 DEFINING THE DISRIBUTION FUNCTION

References in the previous chapter to "distributor" and "distribution" assumed a general knowledge on the part of the reader as to the content of these terms. The objective of this section is to arrive at a comprehensive definition of both terms that will serve as the groundwork for the discussion to follow. To begin with, it is important to separate the term *distributor* from the term *distribution*. Classically, distributor refers to the channel entities that act as intermediaries between manufacturers and end-use customers. The *APICS Dictionary*, for example, describes a distributor as "A business that does not manufacture its own products but purchases and resells these products" [1]. The Council of Supply Chain Management Professionals (CSCMP) similarly defines a distributor as

> A business and industry that acts as a third party local representative and distribution point for a manufacturing firm. These firms may perform some light assembly or kitting of goods, but generally provides a buffer for finished goods. Distributors typically purchase the goods in quantity from the manufacturer and ship to customers in smaller quantities. [2]

The essential role of a distributor is to facilitate the flow of finished goods from channel producers to end-use customers.

In contrast to the role of the distributor, *distribution* refers to a process and not a channel entity. Using the *APICS Dictionary*, distribution is defined as

> The activities associated with the movement of material, usually finished goods or service parts, from the manufacturer to the customer. These activities encompass the functions of transportation, warehousing, inventory control, material handling, order administration, site and location analysis, industrial packaging, data processing, and the communications network necessary for effective management. It includes all activities related to physical distribution, as well as the return of goods to the manufacturer. In many cases, this movement is made through one or more levels of field warehouses.

The key points of the definition are:

1. Distribution is a set of activities performed by various supply chain entities associated with the movement of finished goods from producer to the customer.
2. Distribution includes the functions performed by inbound and outbound logistics.
3. Distribution processes include the structuring of communications networks that keep the supply channel alerted to disruptive events, inventory availability, and customer delivery status.
4. Distribution often involves the use of field warehouses that make channel inventory management and delivery to the customer more efficient.

Distribution systems are also characterized either as *direct delivery* or *echelon-delivery* based. In direct delivery, products are delivered directly from the manufacturer to the customer, bypassing warehouses and channel intermediaries. Advantages of this strategy are the manufacturer retains close control over product branding and pricing, the customer is dealt with directly, the expense of operating channel warehouses is avoided, and marketplace information is quickly made available. The most serious disadvantage is the cost of outbound transportation of small truck loads to diverse locations. This approach to distribution is often employed by manufactures pursuing a make-to-order strategy.

In an echelon-delivery system, the product is moved and stored using a hierarchical channel structure consisting of various levels of company-owned or independent distribution centers, warehouses, and retailers before it is delivered to the customer. The advantage of this strategy is that products are available to the customer on an on-demand basis with minimal delivery times. A disadvantage is the high cost of running and stocking the echelon channel. This approach to distribution is often employed by manufactures pursuing a make-to-stock strategy.

Distribution systems are also either *centralized* or *decentralized*. In a centralized system, all decisions are made at a central location for the entire supply chain. Centralized systems employ fewer channel warehouses, contain minimal safety stocks, have reduced operating overheads, pursue economies of scale, have decreased inbound transportation costs, and realize targeted service levels while minimizing total system cost. Decentralized distribution possesses the opposite attributes: decisions are made on the echelon level, businesses must assume responsibility for increased costs to support channel warehouses, warehouses must bear the cost of local safety stocks, inbound transportation costs increase, and total system costs increase. Perhaps the critical deciding factor between a centralized and decentralized system is maintaining targeted customer service levels. In a centralized system, lead times are longer as products must traverse long distances from the storage site to the point of delivery. Often the outbound delivery cost have to be absorbed by the shipper or the customer. On the other hand, since decentralized systems are closer to the customer, delivery lead times are short and outbound delivery costs are decreased.

2.2 REVISITING THE SUPPLY CHAIN

Before a full discussion on distribution begins, it is useful to revisit the placement of the various entities constituting the supply chain network. As Figure 2.1 illustrates, the primary channel constituents are organized into six groups that reflect the basic movement of goods through the channel. The first group, *suppliers*, provides the supply chain with raw materials and components. In the second group are *integrators/producers* that are concerned primarily with the development and production of products. Although it is true that some raw materials, such as wood, coal, and grains move directly into the supply channel, the role of the product integrator places it at the opening stage of the distribution process. As previously noted, some manufacturers, such as Ford Motor Company, Sony, and Dell, assume the responsibility of managing a distribution channel, whereas other manufacturers depend on trading partners to perform that role.

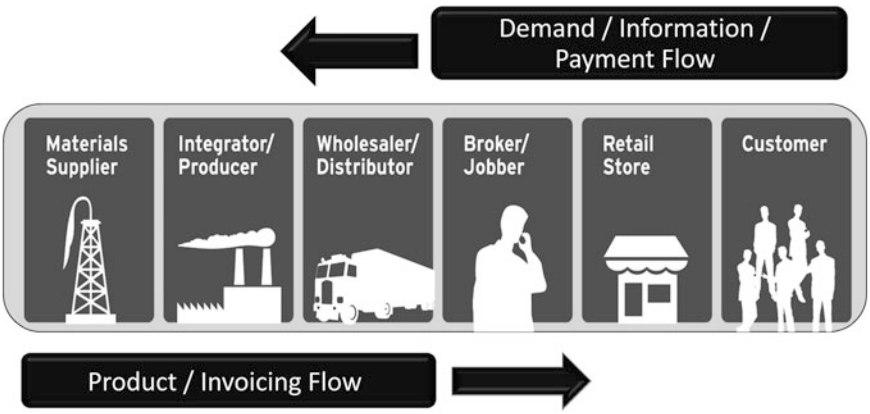


FIGURE 2.1 Supply chain constituents.

The third entity in the supply chain consists of three types of *intermediary*. The first is the *wholesale distributor*. Because this entity assumes a number of different forms, *wholesaling* is difficult to define. The classical role of wholesalers is to serve as middlemen, providing other intermediaries with products originating from manufacturers. Wholesale distributors exist because of their ability to act as aggregators, assembling and selling merchandise assortments. Today, technology applications like the Internet, electronic catalogs, and the ability to sell products from multiple channel outlets have enabled manufacturers and retailers to expand their role to encompass many of the functions traditionally performed by wholesale distributors. Although these practices seem to portend the "disintermediation" of the wholesale distributor, successful companies such as Burgen Brunswig, SYSCO, McKesson, and ACE Hardware, indicate the continuing strength of the wholesale distributor.

The second group of intermediaries found in the supply chain are *brokers and jobbers*. These intermediaries are distinct from wholesalers in that they do not take ownership of inventory and offer a limited number of services. Their role, for the most part, is to facilitate the buying and selling process between suppliers and customers. The third group of intermediaries, *retailers*, comes in many forms from giants like Wal-Mart to on-line retailers like Amzon.com. The central purpose of retailers is to sell inventories received from manufacturers and wholesale distributors directly to companies or individual customer end-users.

Finally, it is important to note the *end-use customer* residing at the end point in the supply chain. Whether business customers or individual consumers, this channel entity is the focus of the entire supply chain, its strategies, and its functions. Customers are included in the supply chain because they often perform some of the functions of distribution. Instead of passive recipients of channel outputs, customers, for example, that buy large quantities of paper towels at a mass-merchandiser, such as Costco, perform distribution activities such as physical possession, inventory storage, ownership, and financial transaction. A customer shopping over the Internet performs the distribution activities of product search, aggregation, order management, delivery selection, and financial transaction.

The various members of the supply chain can be combined in many ways to create a variety of different channels of distribution. The range and number of channel members is determined by the nature of end-use customer demand, the production processes used, and the power of the channel master and varies from channel to channel.

2.2.1 Basic Supply Chain Distribution Formats

Commensurate with their channel roles, manufacturers, wholesalers, and retailers are organized for distribution differently. Manufacturers with distribution functions are organized according to one of three possible methods. The first and most popular strategy is *processed based*. In this model, the manufacturer operates as a single value-added delivery chain. Whether delivering factory direct or through company-owned warehouses, the objective of this strategy is to achieve optimal efficiencies and productivities by directly managing production and distribution functions as a single integrated system. The second strategy is *market based*. This strategy is concerned with managing a limited set of logistics functions across a multidivisional or a multiple-enterprise channel. The object is to execute joint product shipments to customers originating across the enterprise or to facilitate sales and logistical coordination by a single-order invoice. The final manufacturing strategy is *channel based*. In this strategy a manufacturer seeks to manage the distribution process by forming alliances with wholesalers and retailers. Enterprises that employ this strategy typically have large amounts of finished goods in the supply channel [3].

The organizational structure of wholesale distributors reflects their position as the link connecting manufacturers with retailers. Because wholesalers do not produce products, the focal point of operations is centered on two critical functions: sales and the execution of logistics activities. Wholesalers are often much more conscious of marketing and sales issues than manufacturers. Like retailers, the life blood of wholesaling is merchandise and promotion oriented, centered on inventory availability, strong order processing functions, exceptional customer service, and a robust accounts receivable balance. In addition to warehousing and delivery, wholesalers today are organized to provide value-added services such as ease of product search, EDI, Internet transactions, and postponement processing.

At the end point of the distribution process, retailers are organized around meeting the needs and expectations of the end-customer. Similar to, but to a much greater degree than wholesalers, retailers are organized around store location, advertising, promotions, pricing, selling, customer service, and inventory stocking and availability. Typically, retailers stock a very broad assortment of products. A large grocery chain, for example, inventories over 11,000 products; mass merchandisers and department stores carry even more. The supply channels of retailers characteristically are geographically focused, with central supplying warehouses generally located one or two day's delivery distance from a cluster of stores. To facilitate this process, retailers are constantly restructuring and integrating their organizations. For example, the traditional dependence on central warehouses and transportation functions has been giving way to leveraging manufacturing and wholesale channel partners, or even to using third-party service providers. Finally, today's retailers have accelerated the process of buying direct from the manufacturer. Techniques such as EDI, the Internet, and centralized retailing, buying offices that facilitate the process of cost-effective shipment consolidation, and "milk-run" delivery practices result in lower retailer logistics costs while maintaining high levels of customer service.

In addition to these three structures, hybrid combinations are possible. Of the possible combinations, that of wholesaler and retailer is the most common. An example of a typical hybrid organization is a large food-service company identified by Bowersox [4].

> This company operates a number of regional distribution centers, each serving approximately 5,000 restaurants or other food-service establishments. Products are sold at wholesale prices to these traditional customers. Over the past ten years, this firm has begun to open retail stores which sell wholesale products at discount retail prices directly to consumers. Typically, the firm operates a single retail location in a given city. The image maintained at retail is one of a large, institutional package size store with few conveniences. The appeal is price, unusual products or large sizes, coupled with the feel of shopping at wholesale.

Another example is Costco which presents customers with a wholesale look and feel in a retail environment. Regardless of the mix of retail structures, hybrid operations pose special organizational challenges. Among the most important is the logistical capability of the company to support supply channel positions occurring on multiple levels.

Because of the great variety of distributors, there is no optimal organizational structure that fits all channel members. The actual structure of a distributor is dependent on a number of factors, such the goals of the business strategy, availability of capital, extent of international involvement, nature of the product, number of echelons, capacities of transportation, capabilities of information technologies, and predilections of enterprise management. Often companies occupying similar positions in the supply chain have radically different organizations. Bowersox, for example, found two large mass merchandisers with different views of the supply channel. One company was heavily committed to maintaining an extensive distribution channel, whereas the other sought to eliminate their channel structure, preferring to pursue direct shipments from the manufacturer/wholesaler to retail outlets [5].

2.2.2 Alternative Distribution Channel Formats

The previous section outlined the four basic delivery channel formats: manufacturers, wholesalers/distributors, service organizations, and retailers. In this section, these formats are expanded to reveal the wide variations distribution formats can take.

2.2.2.1 Manufacturer-Based Channel Formats [6]

The first series of channel formats are manufacturers who perform the functions of sales and distribution themselves without the assistance of an independent wholesale distributor. Organizations in this category operate as both wholly-owned and operated divisions of a manufacturing company or as independent businesses belonging to a large, multicompany corporation. Manufacturer channel formats are described as follows:

- *Factory direct*. In this format, product is shipped and serviced directly from the factory's finished goods warehouse. Product is sold through company catalogues, an internal sales force, independent agents, or the Internet. This distribution strategy is often used by make-to-order manufacturers who build custom products per customer request.
- *Sales branches and offices*. In this format are manufacturers who distribute their own products through simple or complex matrices of sales offices and channel warehouses. Sales offices do not carry inventory but are responsible for regional marketing, pricing,

promotion, customer order processing, and customer service. In contrast, some distributors will establish wholly-owned regional warehouses that receive finished goods from the plant and then sell and distribute to a local market.

- *Manufacturer-owned full-service wholesale distributor*. This format describes an acquired wholesale distribution company serving the parent's markets. Typically, these enterprises form the connecting link between a company's manufacturing and distribution operations. When synergies warrant, these distribution formats will also distribute the products of other manufacturers. Examples are found in the food and apparel industries.
- *Manufacturer's outlets*. This format consists of manufacturer-owned retail outlets located in high-density markets. These stores are primarily used to liquidate seconds and excess inventory, such as designer clothing and athletic wear. Examples range from brand outlets like Nordstrom Racks to electronic product retail stores like Apple.
- *License*. In this format, a manufacturer contracts with an independent distributor or retailer, granting product and marketing exclusivity for a specific period of time. This distribution method is often used for products in the development stage of their life cycles. Examples would be Mattel, Disney, and various forms of importers.
- *Consignment-locker inventories*. In this format, the plant ships finished goods to a point of consumption, but title does not pass until the goods are consumed. A drawback of this format is possible obsolescence and damage that must be borne by the manufacturer. Examples would include service repair parts and tool cribs.

2.2.2.2 Merchant Wholesaler Channel Formats

Merchant wholesalers are independent enterprises that buy finished products from producers and other wholesalers and sell to companies for resale or production consumption. This type of distributor format performs the bulk of the work of distributing finished goods through the distribution channel. Merchant wholesalers can be further divided into full-service and limited-service wholesalers.

- *Full-service wholesalers*. This distribution format provides a wide range of products and services to the customer. Besides stocking inventory and maintaining a sales force, they perform other value-added functions such as sales order management, credit, transportation, EDI, and Web communications. In this grouping are found the following sub-formats:
  – *Wholesale merchants*. This format generally provides products and a full range of value-added services to the retail industry. Wholesale merchants are further categorized by the robustness of the product lines they offer to the marketplace. *General merchandise wholesalers* normally stock a targeted range of products within several merchandise lines in an effort to service both multi-line and single-line retailers. In contrast *general-line wholesalers* carry an extensive assortment of products in one or multiple product lines. Auto parts, drug store, and clothing wholesalers are examples. Finally, *specialty wholesalers* focus on carrying an extensive inventory of the products of a single line. Examples include produce, meat and fish, and fashion apparel wholesalers.
  – *Industrial distributors*. This type of format is composed of wholesale merchants who sell products exclusively to manufacturers. Similar to retail distributors, they

carry a multitude of products lines (often called a mill supply house), a general line, or a specialty line. Industrial distributors also focus on MRO items (maintenance, repair, and operating supplies), OEM items (original equipment supplies), or industrial equipment (such as machinery).

- *Limited-service wholesalers*. Distributors in this type are characterized by the fact that they offer a limited range of products and services to their customers. There are several kinds of distributor formats in this sub-group.
  – *Cash-and-carry wholesalers*. This distributor format normally stocks a limited line of fast-moving products that are sold to small retailers. This format requires the customer to pick up and pay for the goods at the point of transaction. An example would be a produce distributor that delivers, or makes available for pick-up, vegetables and fruits to small local grocers.
  – *Truck wholesalers*. Often termed a *truck jobber*, this distribution format performs primarily a selling and delivery function only. They normally carry a limited line of products (such as milk, bread, and soft drinks) that they sell for cash to supermarkets, small groceries, restaurants, business and institutional cafeterias, and hotels.
  – *Drop Shippers*. This channel format operates in industries associated with commodities handled in bulk, such as building materials, coal, lumber, and paper-based products. Drop shippers normally do not inventory or transport the product. When they receive a customer order, they will locate a suitable supplier who, in turn, delivers the product to the customer. Drop shippers assume title and risk for the inventory from the moment the order is placed with the supplier until the time it is delivered to the customer.
  – *Rack Jobbers*. This format normally provides highly advertised, brand-name nonfood products and accompanying services to grocery, convenience, and drug stores. Examples of products supplied by rack jobbers are toys, paperback books, greeting cards, hardware items, and health and beauty aids. Rack jobbers are responsible for delivery of the product to the retailer, product setup and display, pricing, item rotation, effectivity dating, and inventory maintenance. Inventories are stocked in consignment: that is, the rack jobber retains title to the inventory, billing the customer only for the goods sold since the last visit.
  – *Mail-order wholesalers*. This type of distributor depends on the sale of products from a catalog. Customers range from industrial and retail to institutional. Products are selected from the catalog by the customer. Once the order has been placed with the wholesaler, it is then delivered by mail, truck, or other means of transportation from a centralized distribution center. The main customers of this format are located in rural or geographically isolated regions. Lands' End, Spiegel, and Fingerhut are examples of this format.

2.2.2.3 Distribution Service Channel Formats

This channel format differs from merchant wholesalers in two important regards: they do not take ownership of inventory and they offer their customers a limited number of services. For the most, part their function is to act as middlemen, who for a commission, facilitate the buying and selling of products between suppliers and customers. Similar to merchant wholesalers, they generally specialize by product line or customer segment.

- *Brokers*. The primary role of brokers is to serve as intermediaries, matching buyers with sellers and assisting in price, product, and delivery negotiations. They are usually contracted by manufacturers and their sales forces focus on a specific product line and a narrow customer market segment. Brokers do not take possession of inventories, assume risk, or provide financing. They are usually paid for their services by the party that contracted them.
- *Agents*. There are several types of buyer and seller agents who represent or are contracted to represent either the producer or act in the role of a buyer.
  - *Manufacturer's agents*. Also termed *manufacturers' representatives*, these independent agents usually represent two or more manufacturers that produce complimentary product lines. Normally, they enter into a formal written agreement with each manufacturer relating to exclusivity, pricing policies, territories, order handling procedures, delivery service, warranties, and commission rates. Most manufacturers' agents are small firms composed of highly skilled sales people who have an extensive knowledge of the products they represent and the best marketplaces in which to sell them. They are often contracted by small manufacturing firms that cannot afford an extensive sales force, or large manufacturers who wish to explore new marketplaces but which as yet do not generate sufficient revenue to support a full-time sales staff. Manufacturers' agents are used to sell such products as furniture, apparel, and electrical goods.
  - *Selling agents*. Selling agents are contracted by a manufacturer to sell the firm's entire production output. In most cases, the manufacturer does not wish or is incapable of employing a sales staff. Functioning as the de facto marketing and sales function of the company, selling agents have a significant influence over prices, buying terms, and conditions of sale. This type of distribution format is found in such industries as textiles, industrial machinery and equipment, coal and coke, chemicals, and metals.
  - *Purchasing agents*. This type of agent is normally a product expert who, besides obtaining for the customer the best goods and prices available, provides consultative services. Purchasing agents generally have a long-term relationship with their customers, often purchasing, receiving, inspecting, warehousing, and shipping the goods to customers based on agreement with company buyers.
  - *Commission merchants*. Also termed *commission houses*, this type of agent takes possession of goods from the producer and then sells them in the marketplace for the best price. After deducting a fee covering the commission and miscellaneous expenses, the balance is then passed back to the producer. They are most often used in agricultural marketing by farmers who do not wish to sell their own produce or who do not belong to a producers' cooperative.
  - *Value-added reseller (VAR)*. A company employing designers, engineers, or consultants that joint venture or have arrangements with manufacturers to sell and service equipment or products. VARs often get a commission or discount to service the product later and often carry inventories of high-turn finished goods.

2.2.2.4 Distribution Retail Formats

This distribution format consists of retailers who perform the functions of sales and distribution with the assistance of a manufacturer or independent wholesaler. Organizations in this category operate either as wholly owned and operated storefronts or belong to a large corporation. Retail channel formats are described as follows:

- *Franchise*. In this format, product, brand recognition, and marketing expertise are sold to small entrepreneurs who in turn execute the functions of sales and delivery. Various distribution and other services are provided by contract to franchisees for a fee.
- *Buying clubs*. Although largely consumer oriented, this format provides manufacturers with the opportunity to penetrate certain niche markets or experiment with product variations. Normally, selection is limited and products are usually sold in bulk quantities.
- *Mail order/catalog*. In this format, non-store selling is performed through catalog literature. A central or regional distribution center is usually responsible for warehousing and shipping direct to the customer.
- *Food retailer*. This type of retailer sells a wide range of foodstuffs, health and beauty aids, and general merchandise bought from manufacturers and wholesalers. Warehouses are used as consolidation points to reduce transportation costs and facilitate receiving and inventory deployment.
- *Department stores*. These types of national retailers stock a broad mix of soft goods (clothing, food, and linens) and hard goods (appliance and hardware). Having stores on a national basis motivates these types of retailers to structure their own distribution channels. These distribution centers act as receivers and consolidators, often with a direct link with the manufacturer. JCPenny, Macy's, and Nordstrom are examples of retailers in this space.
- *Mass-merchandisers*. This type of retailer is similar to department stores, except product selection is broader and prices are usually low. Examples include Wal-Mart, Kmart, and Target.
- *Specialty stores*. This type of retailer offers a deep selection of merchandise in one line, such as women's apparel or electronics. Because the product line is often seasonal, close relationships with manufacturers or upstream distributors is essential. Suppliers normally ship in predetermined store assortments and usually price the goods. The retailer in some cases has joint ownership with the manufacturer.

2.2.2.5 Exporting and Importing Channel Formats

Cutting across supply chain participants are exporting and importing formats that specialize in international distribution. The strategy of some multinational organizations is to develop and maintain their own international supply channels, complete with foreign sales offices and warehouses. Others choose to engage in global trade by using an international distributor. Distributors in this category are described below.

- *International Trading Company*. This type of distribution format performs functions such as the purchasing and selling of goods, arrangement of logistics services between exporters and importers, managing currency conversion and rate fluctuations, providing consulting advice, and other marketing and logistics issues.

- *Export Merchants*. Export merchants act as a form of international wholesaler. Similar to domestic merchant wholesalers, they purchase goods from manufacturers and wholesalers and then ship them to distribution points in foreign markets. Although some export merchants have facilities located in foreign countries close to the target market, they mostly deal with foreign distributors in the country of destination.
- *Resident Buyers*. Large international firms often locate their own buyers directly in an exporting country. Their responsibility is to locate, purchase, and ship goods back to their home country or to company distribution facilities across the globe.
- *Export Commission House*. This type of channel format performs the same functions as a *resident buyer*, except that the buyer is not a company employee but rather a contracted agent empowered to negotiate, buy, and ship products located in foreign markets. In return, the agent is paid a commission by the buyer.
- *Allied Manufacturer*. In this format, firms export and import products by using a foreign business partner. Normally, both companies will negotiate to "piggyback" their products through the international distribution channel. There are a number of advantages. By carrying each other's products, both firms can improve market share by presenting markets with extended product lines and achieving high logistics utilization. The end result is that both companies can enjoy the benefits of a mature global distribution system without the investment.
- *Export Management Company*. This channel intermediary acts as a product line or foreign market specialist who represents that export for one or a group of noncompeting manufacturers and/or distributors. Although most act as selling agents for the companies they represent, some of the larger firms will stock inventories for resale.

2.2.2.6 Buyer-Initiated Formats

In this area are distribution channel formats that do not neatly fit into traditional supply chain structures. This group of intermediaries is based on sellers grouping together to sell in large quantities to gain better prices and reduced logistics costs such as storage, transportation, and marketing to sellers. Examples include the following:

- *Producers' cooperatives*. This type of channel intermediary is formed by companies, usually in the same industry, that create an organization in which each member is a shareholder. The organization uses the combined strength of the members to leverage economies of scale so that smaller companies can compete with larger businesses. An example is a group of agricultural producers who assemble food products from co-op members for sale in local markets. An important goal of these organizations is the promotion of brand names, such as Sun Maid raisins or Sunkist oranges, and increased product quality. The profits from sales are distributed to the members at year's end.
- *Buying groups*. This channel format is similar to a producer's co-op, with the exception that it is less structured. Members can belong to multiple buying groups. A group can buy direct through manufacturers or through wholesale distribution channels. Buying groups use this format to purchase low volume items.

2.2.2.7 e-Business Formats

The rise of Internet-driven distribution formats have become so important that they deserve to be identified as a major category. Historically, distributors have existed because of their ability to serve as intermediaries, providing retailers with products originating from producers or performing direct sales to the end-use customer. With the advent of e-business, this traditional role has come under attack. In the high-flying days of the dot-com revolution, it was even suggested that the wholesale distributor would eventually be “disintermediated” from the supply chain. The argument was compelling. By combining the advertising and ordering capabilities of the Web, even the smallest of companies could now by-pass costly channel intermediaries, present its products to a global audience, and process orders from anywhere in the world, at any time. In addition to the growth of direct sales, the Internet also provides the opportunity for the birth of a new type of “electronic marketplace” where buyers and sellers are brought together through auction sites, private exchanges, buyer/seller matching, and other functions. The Internet seemingly had provided all companies with the power to continuously reconfigure their supply networks, eliminate costly channel partners, streamline the flow of information and products, and enable the creation of radically different types of customer value.

Major distributors have responded by launching multi-channel strategies. According to Tompkins International [7], there a five pillars to achieving multichannel excellence:

1. *Competitive pricing* that wins and retains the customer’s business.
2. *Product breadth* that presents a broad selection within a product group that provides customers with the best value solution for their needs.
3. *Availability* so that the customer can execute the perfect order each and every time.
4. *Speed of delivery* that moves toward same-day or next-day delivery as the standard.
5. *Technical support* that enables customers to explore a range of technical resources, whether for a simple search, finding detailed product specifications on a supplier’s website, or participating in end-user forums.

For example, W.W. Grainger cites e-commerce as its fastest growing segment, with 25 % of 2013 sales online. The percentage is expected to rise to 40–50 % by 2015. More ominous to the traditional wholesaler is the entry of giant e-commerce organizations into the industrial supplies arena. Termed the *Alibaba Effect*, after the monster Chinese e-marketplace, challengers from across the world are fine tuning inventories, leveraging quick-response delivery propositions, and structuring new solutions. The prospect of Amazon.com firmly establishing itself in the MRO marketplace is bound to severely shake traditional stalwarts such as W.W. Grainger and McMaster-Carr in this marketspace.

e-Business formats are described as follows:

- *Business-to-business (B2B) channel formats*. These channel intermediaries are concerned with the sale of goods and services between businesses. They are grouped into three major types:
  - *Independent Trading Exchanges (ITX)*. These formats are described as many-to-many marketplaces composed of buyers and sellers networked through an independent intermediary. ITXs are further divided into *vertical exchanges* focused on providing Internet trading activities to a particular industry and *horizontal exchanges* that facilitate e-business functions for products and services common to multiple industries.

  - *Private Trading Exchanges (PTX).* These formats are Web-based trading communities hosted by a single company that recommends or requires trading partners participate as a condition of doing business.
  - *Consortia Trading Exchange (CTX).* These formats are described as a some-to-many network consisting of a few powerful companies organized into a consortium along with their trading partners.
- *Business-to-customer (B2C) channel formats.* These channel intermediaries are any business that uses the Internet to sell products and services directly to the customer. Channel formats include:
  - *e-Stores or e-tailers.* The goal of this format is to simulate an actual shopping experience where consumers browse through catalogs or use search mechanisms to locate, price compare, and order goods to be shipped directly to their homes. *Pure play* e-tailers, like Amazon.com, or *bricks-and-clicks* e-tailers, like Barnes & Noble, belong to this format.
  - *Third-party catalog services.* This channel format is composed of multiple suppliers that provide a catalog for a group of customers frequenting a certain place, such as airline in-flight magazines and catalogs and in-room hotel publications.
- *Consumer-to-consumer (C2C).* This model applies to Internet sites that allow customers to buy from each other. C2C's are consumer-driven and consist of online communities that interact via e-mail groups, Web-based discussion forums, or chat rooms. Currently this area is undergoing dramatic change as *social network* gains traction. An example would be eBay.com. Issues associated with this area are financial settlement and timely shipment and delivery.
- *Consumer-to-business (C2B).* This model applies to any consumer that utilizes the Internet to sell products or services directly to a business. This area is also expected to be dramatically impacted by the growth of online tools like *Facebook, twitter, and U-Tube* that allow consumers to directly communicate with businesses. An example is Priceline.com that sells products and services to individuals or to companies.

2.2.2.8 Miscellaneous Channel Formats

In addition to the categories detailed above, there also exist specialized distributors found in certain sectors of the economy, such as agricultural assemblers, petroleum bulk plants and terminals, and auction companies.

2.2.2.9 Delivery Network Facilitators

While all of the above channel functions provide for the smooth and seamless transfer of products and services through the delivery network, they are not always performed by a single network entity. Those channel types that do take direct ownership of inventories and assume financial risk are called *primary delivery network intermediaries*. However, if network intermediaries choose not to assume direct responsibility for one or multiple functions, they can employ the services of a *delivery network specialist*. In short, the role of a channel specialist is to perform specific functions for primary channel entities for a fee. The use of a specialist, therefore, can be considered as a form of *outsourcing*, where a third-party specialist, who possesses special competencies beyond the core competencies of the contracting firm, is employed to perform key logistics operations. Among delivery network specialists are found the following businesses.

- *Financial Institutions.* This type of specialist provides a wide-range of banking functions ranging from cash management and lending to taxes, currency exchange, and payment. Other specialists in this area handle other services like insurance, freight rating, and inventory buying and selling.
- *Marketing and Advertising Agencies.* Many small distributors, wholesalers, and retailers simply do not have the competency to drive major marketing, advertising, and promotional campaigns. By contracting a specialist, network intermediaries gain access to sophisticated marketing analysis and media outlets without direct investment in such resources.
- *Technology Services.* With the advent of the Internet and company-to-company networking, delivery channel intermediaries must deploy increasingly sophisticated technology tools that support ease of information transmission through the availability of wide-band data, voice, video, and text information transfer. Rather than support these often expensive resources internally, network businesses can turn to "on-demand" technology companies who will provide these computer solutions for a fee.
- *Logistics Service Providers.* In today's fast-paced distribution channel, intermediaries simply cannot stay competitive by providing end-to-end delivery network management without the support of *logistics service providers* (LSPs), often termed *third-part logistics* (3PL) providers. LPS services are divided into five service areas:
  1. *Logistics* – global trade services, inbound/outbound delivery, supplier management, inventory management, and payment.
  2. *Transportation* – small package delivery; intermodal transportation; ocean, rail, and bulk transport; track and trace; fleet management; and equipment and personnel leasing.
  3. *Warehousing* – storage, pick/pack functions, assembly, cross-docking, customer order management, and delivery fulfillment.
  4. *Special services* – direct delivery to customer (UPS), import/export/customs functions, reverse logistics, market and customer management, consulting, and financial services.
  5. *Technology* – electronic data interchange (EDI), satellite/wireless communications, web enablement, and software solutions hosting.

In the past, channel businesses sought to utilize LSPs to outsource non-core functions that quickly realized cost savings. Today, many managers see their LSPs as constituting a critical cornerstone of their logistics strategies, providing additional sources of value to attain channel information, reductions in fixed assets, and reductions in overall channel costs.

2.3 ROLE OF DISTRIBUTION CHANNELS

Distribution channels are formed to solve three critical distribution problems: *functional performance, reduced complexity,* and *specialization.* The problem of increasing the efficiency of time, place, and delivery utilities is the central focus of channel functional performance. When product availability and delivery is immediate, the functions of exchange and fulfillment can be performed directly by the producer. As the number of producers and the size and geographical dispersion of the customer base grows, however, so does the need for internal and external intermediaries who can facilitate the flow of products, services, and information through the distribution process. In fact, an intermediary can substantially reduce the number of transactions, information, and product flows between producers and customers. For example, a small marketing channel exists where three producers trade directly with five customers. To calculate the number of trading links, the number of producers is multiplied by the number of customers. As illustrated in Figure 2.2, this means that there is a maximum of 15 exchange transactions in the channel. The presence of an intermediary, however, would reduce the number of transactions from 15 to 8.

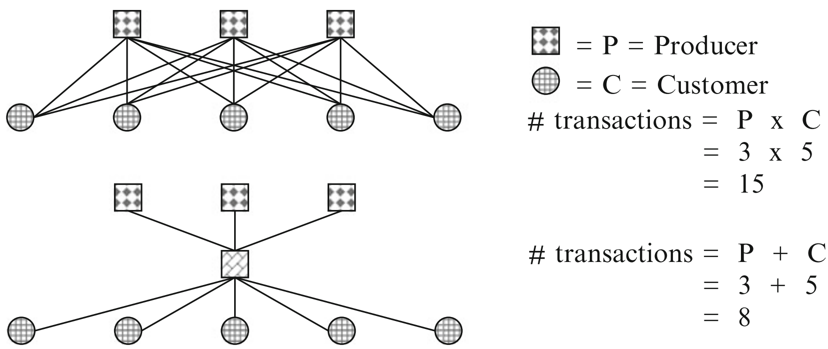


FIGURE 2.2 Role of channel intermediaries.

Supply chain intermediaries also increase functional performance by facilitating channel product and service *search*. Depending on the nature of the product and the location of the producer, buyers as well as sellers can be uncertain about goods and services search. If distributors did not exist, producers without an established brand would be unknown to buyers; similarly buyers might find it hard to locate specialized sellers or to trust the nature and quality of their products and services. Instead of searching the marketplace, buyers can go to a recognized distributor and rest assured of their purchases.

Distribution channels decrease channel complexity in other areas. Channel intermediaries assist in the *routinization* of business functions and product *sorting*. Routinization refers to the establishment of policies and procedures that provide channel members with common goals, channel arrangements, and expectations that enable supply network exchange mechanisms to facilitate transactional efficiencies. Sorting is defined as a group of activities associated with transforming products and product quantities acquired from producers into the assortments and lot sizes demanded by the marketplace. The "sorting" process can be broken down into four primary functions:

- *Sorting out*. This process is defined as separating a heterogeneous group of products, often acquired from multiple suppliers, into homogeneous subgroups. An example would be a poultry distributor that sorts eggs by grade and size and then assigns them to inventory lots.
- *Accumulation*. In this form of sorting, the channel intermediary combines homogeneous stocks of products into larger groups of supply. An example is a home electronics distributor who combines the televisions of different manufacturers into a single product line.

- *Allocation*. This form of sorting breaks down large lots of products into smaller lots for sale. A hardware distributor may, for example, purchase fasteners in kegs and then repackage them into a variety of small lot quantities.
- *Assorting*. In this form of sorting, distributors mix similar or functionally related items into assortments to meet customer demand. For example, an automotive distributor may package the components necessary for brake repair into a kit.

Few producers wish to perform the sorting and consolidation functions undertaken by channel intermediaries. In addition, most producers are extremely reluctant to carry and market similar products produced by competitors alongside their own inventories.

The final reason why distribution channels are formed is to solve the problem of *specialization*. As the supply chain grows more complex, costs and inefficiencies tend to grow in the channel. To overcome this deficiency, many channels contain intermediaries that specialize in one or more of the elements of distribution, such as cross-docking or transportation. The net effect of specialization is to increase the velocity of goods and value-added services that flow through the distribution pipeline by reducing costs associated with selling, sorting, transporting, carrying inventory, warehousing, order processing, and credit. Sometimes a dominant channel member, such as the manufacturer, may seek to eliminate a specialist partner by absorbing the function into its own operations. Vertical integration can be beneficial if it seeks to facilitate the flow of product, decrease cycle times, decrease costs, and eliminate redundancies.

One school of thought, on the other hand, feels that not only will companies move away from vertical organization and focus most of their attention on core competencies, but channels will be structured around “virtual” networked organizations. According to this model, the distribution channel, supported by the integrative power of the Internet, will be composed of temporary alliances of independent specialists, ranging from suppliers to possible competitors that rapidly coalesce to form a marketing unit to satisfy a customer need, and then disbands when the need is satisfied. The concept underlying this theory is that the optimization of the core competencies of each partner in the network provide the best value to both customer and to the supply chain. Regardless of the form of the arrangement, the goal is the same: the integration of each of the parties’ operational strengths to obtain mutual benefit.

2.3.1 Channel Service Outputs

Proposed by Louis P. Bucklin as a basis for determining channel structures [8], distribution channels exist because they perform four critical *service outputs*. The argument is that the higher the level of service outputs, the more readily buyers will purchase from that supply chain. Bucklin identified four generic service outputs: (1) bulk-breaking, (2) spatial convenience, (3) length of waiting and delivery time, and (4) product variety (assortment).

- *Bulk-breaking*. This service output is one of the fundamental reasons for the existence of distributors. The term refers to the fact that whereas manufacturers normally produce large quantities of a limited number of products, channel intermediaries, like retailers, normally require only a small quantity of a large number of diverse products. Take, for instance, a candy manufacturer who must produce large lots of product due to cooking and ingredients requirements. The retailer, however, needs only a fraction of this lot, thereby forcing channel aggregators to perform bulk-breaking and repackaging activities designed to fit their customers' stocking requirements. In addition, by combining confectionery-type products from several manufacturers, aggregators can offer a wider assortment to the retailer in the desired quantities than can a single manufacturer. In today's competitive environment, lean manufacturing techniques are continuously seeking ways to reduce lot sizes and produce exactly to customer demand. Manufacturers who use such techniques have been able to eliminate channel middlemen by selling just the right quantity of products as demanded by the retailer.

- *Spatial convenience*. A fundamental service output of distribution is to shrink time and geographical distance between producer and buyer. By locating products and services close to the customer, channel intermediaries, such as retail stores, neighborhood supermarkets, and convenience stores, satisfy customers' requirements for reduced search time and transportation cost. An example is W.W. Grainer's boast that 70 % of U.S. businesses are within 20 miles of a Grainer branch.
- *Length of waiting and delivery time*. This service output is concerned with the length of time spanning the point when a customer enters an order and when it is received from the supplier. The longer the order replenishment time, the more it is inconvenient for the buyer who must plan for replenishment and even acquire excess safety inventories in advance of actual need. Usually, the longer buyers wait, the lower the price or shipping charge they receive.
- *Product variety (assortment)*. This function is extremely important to retailers. Unless they are a highly specialized business selling products made by only one or a few manufacturers, most retailers prefer to deal with suppliers that provide a wide assortment of products that closely fit their merchandizing strategy. The reason is simple: the more products that are sourced from a single supplier, the less the cost involved in searching, purchasing, transportation, and merchandizing. Wholesalers are particularly structured to serve this requirement. By purchasing related product families from multiple producers, they have the ability to assemble the right combination of products and lot sizes to meet the requirements of the retailer and deliver it in a cost-effective manner.

The service outputs of channel distributors are not provided without a cost. Bulk-breaking and building inventory assortments, locating nearby distribution facilities and storefronts, and offering immediate demand response are reflected in higher customer prices. For example, online grocery deliver Peapod charges more for their products than what would be found in a neighborhood grocery chain. Simply, the less the customer participates in the channel marketing flows, the more expensive their buying will become.

2.3.2 Other Functions of Distribution Channels

While comprehensive, the four service outputs do not exhaust the range of functions performed by channel distributors. The following additional service outputs also need to be discussed.

- *Selling and promoting*. This function is extremely important to manufacturers. Whereas retailers develop complex place and promotion strategies to reach the marketplace, manufacturers have only a limited number of delivery locations and have great difficulty in executing sales, promotions, and fulfillment to customers located at a geographical distance from the home factory. To counter this deficiency, manufacturers can pursue two strategies. In the first, the manufacturer establishes its own marketing and direct sales staff responsible for channel marketing. The manufacturer may also locate finished goods warehouses close to wholesale and retail customers. The advantages of this strategy are direct control over products, branding, pricing, and marketplace identity. Disadvantages include increased costs for people, physical plant, and inventory carrying costs associated with the maintenance of internal distribution channels.

The second strategy involves the use of a wholesale distributor to perform channel selling and promoting. Wholesalers have direct-selling organizations, are often marketing experts in their industry, and have a detailed knowledge of local customers and their expectations. What is more, because of the scale of operations and specialized skills in channel management, most wholesalers can significantly improve *place, time,* and *possession* utilities by housing inventories close to the target market. The advantages of using a wholesaler are reaching many small, distant customers at a relatively low cost; keeping the manufacturing organization focused on core product development and production competencies; and improving finished goods carrying costs. Disadvantages include loss of price and promotion control, disruption in the direct flow of marketplace information, and possible gaps in customer expectations regarding products and services.

- *Postponement*. Distributors today are increasingly involved in transforming semi-finished goods derived from the producer into their final form through the processes of sorting, labeling, blending, kitting, packaging, and light final assembly. Stocking and transportation cost savings are attained by keeping semi-finished product at the highest level possible in the pipeline and by moving them through the supply channel in large, generic quantities that are customized into their final form as close as possible to the actual sale. A large apple juice producer, for example, bottles product in nine different unmarked container sizes. This unlabeled product is then shipped to distribution warehouses across the Midwest. As orders from grocery retailers and wholesalers are received, the appropriate brand and store labels are fixed on the containers. This practice enables the company to carry a great deal less product in the pipeline, shrink warehousing and handling, and significantly reduce product obsolescence.

  Postponement provides the following advantages:

  - *Reduced Channel Costs*. As products move from the producer into the distribution pipeline, value is often added by channel partners who perform sorting, packaging, or other activities. The problem is that at each value-added node, the cost of processing is added to the product. In an effort to reduce total price to the customer, many companies have eliminated costly downstream channel partners and perform these value-added processes themselves in their own supply chains. Although they will have to bear additional costs for plant, equipment, and personnel, the expense is more than offset by reductions in channel-wide finished goods inventories and lower outbound transportation costs.
  - *Lead-Time Reduction*. As finished goods no longer have to proceed through costly and time consuming processes as they pass from one channel level to the next,

delivery time to the customer from the originating producer is significantly reduced.

- *Inventory Reduction*. Because products are stored in the channel in a semi-finished state until final differentiation by the customer order, there is much less finished goods in the supply pipeline. Besides reducing channel carrying costs, reduced inventories enable better control of product obsolescence and spoilage.
- *Customer Response and Flexibility*. Because downstream channel network nodes can receive products in bulk or in an unassembled state, their ability to respond to customer requests increases. By moving semi-finished goods to downstream distribution facilities, customer response flexibility is expanded without increasing inventory investment.
- *Material Handling*. Postponement targeted at *unitization* helps reduce labor and material handling costs while accelerating product movement. Unitization is defined as the consolidation of product into units of measure that facilitate warehouse and transportation handling. An example is palletizing many small units to reduce the number of pieces handled.

• *Transportation*. The movement of goods in the supply chain is one of the most important functions performed by the distributor. The ability to move goods from one node in the supply channel to another is fundamental in achieving time and place utilities. Simply, no matter how sophisticated the marketing and warehousing system, if a product is not available at the time and place wanted by the customer, the result will be a lost sale, faltering customer confidence, and possible increased costs resulting from order expediting. Transportation attempts to solve this problem by ensuring that goods are positioned properly in the channel by moving them as quickly and cost-effectively as possible from the point of origin to the point of consumption. Some manufacturers and retailers maintain their own transport fleets, whereas others use common and contract carriers. Because of their close proximity to the customer, possession of transport fleets, and expertise, many wholesalers can move product to the customer much quicker than distantly located manufacturers.

• *Warehousing*. The purpose of warehousing is to ensure that the supply channel possesses sufficient stock to satisfy customer requirements and to act as a buffer guarding against uncertainties in supply and demand. Warehousing exists because demand for products are often geographically located far from the place where they are produced. Most channel supply points perform some form of warehousing in order to assure the even flow of goods in the supply channel. In place of company-owned warehousing, channel entities can use a wholesaler. Because of their specialized logistics capabilities and knowledge of local markets, wholesalers can provide products to a wide range of marketplaces that producers, functioning independently, cannot possibly penetrate. By serving as middlemen, wholesalers provide retailers with access to a wide assortment of products while simultaneously minimizing inventories.

• *Sequencing*. As finished goods move closer to the customer, some distributors perform product sequencing. Sequencing consists in sorting goods into unique configurations necessary to fit customer requirements. The goal is to reduce customer receiving, sorting, and put-away activities by combining a mix of products into single lots or arranging components in the sequence in which they are to be used by the customer. For example, Continental Freezers of Illinois sequences mixed lots of frozen foods that allows direct delivery to Jewel Foods grocery stores. This process shrinks the amount of handling and storage costs in the channel by eliminating other echelon supply points. Another important form of sequencing is driven by lean production. Production order sequencing is typically provided by channel distributors who will combine components acquired from one or multiple suppliers into kits sequenced to match the assembly schedule. Because of the cost and highly customized nature of delivery sequencing, recent trends have been to contract with distributors who specialize in such services.

- *Merchandizing*. In some cases, product available from the producer is not ready to be delivered directly to channel intermediaries without additional handling and modification. Some of this value-added service involves bulk breaking quantities into smaller lots that are easily digested through the supply chain. In other instances, product is placed into special packaging or assembled in a display unit determined by marketing and sales campaigns. One of the most visible forms of merchandizing performed by a distributor is the assembly and maintenance of specialized point-of-sale display units found at the check-out counter of every grocery store. Distributors work closely with retailers to ensure the best mix of product and service displays in response to special promotions. Another example is the promotional pack that is assembled by the distributor to meet the needs of a special sale hosted by the retailer or wholesaler. The pack normally consists of a product family or related products. The promotional pack has the advantage of offering the customer a volume discount while enabling the retailer or wholesaler to transact volume quantities and avoid restricted labeling.
- *Marketing information*. A severe problem encountered by the producer without a strong supply channel is the quality and timeliness of product availability and quality feedback from the customer base. Producers who depend on intermediaries to sell to a geographically dispersed marketplace often must rely on the scant information arising from customer complaints and voluntary product assurance cards. In contrast, producers with close linkages with downstream distribution points receive information regarding product, marketplace issues, and competitors' activities directly from the channel.

2.4 DISTRIBUTION CHANNEL TRANSACTION FLOWS

Supply chain intermediaries participate in the performance of transaction flows linked to products and information as they move through the channel network. Executing channel transaction flows not only produces a valued service output but also is associated with a cost. For example, many producers who transact directly with a retailer or end-use customer will perform all of the transaction flows and bear the total costs. Similarly, some buyers in large retail and industrial firms will bypass channel intermediaries altogether and purchase directly from the producer. These *dominant buyers* seek to control channel transaction functions in an effort to control quality, lot size, delivery, and price economies.

Channel distributors, on the other hand, exist because of their ability to perform transaction efficiencies and economies of scale better than other channel members. Often these intermediaries are used because of their expertise in managing marketing, sales, logistics, and finance activities for their channel partners. Surrendering parts of the channel transaction flow enables companies to remain focused on their core competencies instead of expanding their organization's resources and shifting their business focus, organization, and available resources to performing non-value added functions.

Regardless of who performs them, the following transaction functions must be performed by one or multiple supply channel entities [9].

- *Product possession*. This transaction flow refers to channel activities associated with product warehousing and transportation. The goal of product possession is to provide targeted levels of customer service at the lowest carrying cost at all channel echelons. For example, McMaster-Carr pursues a strategy of same or next day delivery and bears the cost of warehousing over 500,000 items stored in five distribution centers from which all orders are filled.
- *Selling and Promoting*. Distribution channels provide an expanded opportunity for sales and promotion. By providing national and localized marketing and sales forces, channel intermediaries can sell to a global marketplace as well as target specific local market segments. In addition, distributors can increase market share, educate customers about product values and features, and expand brand awareness by deploying promotion campaigns using special pricing, product assortments, and value-added services such as short delivery cycles, financing, and transportation economies. Finally, supply chain sales and marketing efforts are augmented by the broadcast to channel members of transactional data, sales plans, and upcoming promotions.
- *Ownership*. Ownership of goods in the supply chain must be assumed by one or multiple channel supply points. It is important to note that ownership is not necessarily the same as possession. For example, merchant wholesalers take both possession and ownership of inventory. On the other hand, in *consignment selling*, a retailer will take possession of the goods but title to the inventory is held by the producer or upstream channel intermediary. Change of ownership occurs when the goods are sold to the customer.
- *Risk*. Companies in the supply chain taking ownership of goods incur risk. As channel entities expand stocks of product, the possibility of financial loss caused by shifts in demand, customer tastes, carrying costs, obsolescence, and spoilage grow proportionally. In addition, channel members also assume responsibility for product failures, warranties, and price fluctuations. In some cases, they will even guarantee product satisfaction, accepting returns for full credit. Strategies for mitigating risk include reducing excess pools of inventory in the supply channel, reducing the number and quantities of SKUs, centralize warehousing of slow selling inventory, and accelerating inventory flows of inventory by deploying technologies or engaging in multichannel selling.
- *Negotiations*. The transfer of ownership of goods from one business in the supply chain to another usually involves attaining agreement on price and other sales terms. The costs involved are mostly composed of the cost of personnel performing the

negotiations. Sometimes the negotiations are performed by a channel member specializing in this transaction function. Negotiation should always be supportive of the overall competitiveness of the channel system.

- *Ordering Flow*. The placement of customer and channel replenishment orders, as well as the gathering of information concerning marketplace trends, occur at all echelons levels in the supply chain. With the dawning of the Internet Age, channel members have expanded their order management capabilities by enabling customers to place and maintain their own orders through the use of personal computers, tablets, and mobile devices. The transaction functions involved in channel stock replenishment have similarly been streamlined by the use of point-of-sale (POS) and automated replenishment systems.
- *Payment Flow*. The flow of payment proceeds through the distribution channel from the customer back to the producer. While many channel companies perform financial settlement functions, often banks and other financial institutions are used to facilitate channel payment flows. Many companies have also implemented financial management software that allows direct electronic payment from buyer to seller, thereby eliminating slower methods, such as bank drafts and checks.
- *Financing*. Supply chain members are often involved in financing the distribution process by purchasing inventories, providing for transportation, managing accounts receivables, and extending credit to their channel customers. When a wholesaler or retailer assumes ownership of inventory, they are, in effect, financing the producer by exchanging capital for inventory. Often channel sellers will receive assistance in the form of financial advice and investment from sellers who might also use commercial banks, brokerage houses, and finance companies.
- *Information services*. The explosion in information technologies has required some channel companies to contract with channel specialists who possess the necessary equipment and technical skills to manage multiple facets of channel information management. These services exist on several levels. Some channel sellers provide equipment, such as telephones, computers, leased lines, and facsimile machines, essential to the maintenance of sales and logistics continuity. In recent years, more complex communications technologies and accompanying channel specialists have appeared. Perhaps the most critical has been the growth of the Internet and cloud-computing services. Many channel sellers supply these networking tools to channel partners who do not have the funding or technical expertise and equipment.
- *Management Services and Consulting*. In some instances, companies assist their channel partners rationalize transaction processes by providing expert advice to enhance their operations or provide important services. For example, distributors assist retailers by training their point-of-sales staffs, helping with stores and stockroom layouts, building and arranging displays, and setting up inventory and accounting systems.

Channel transaction functions, such as physical possession, ownership, sales, and promotion, are usually characterized as *forward flows*, describing the movement of goods and services from the supplier to the end-customer. Inventory, for example, flows "down" through the distribution network until it reaches the end-customer. On the other hand, functions, such as ordering and payment, are *backward flows* moving from customer to supply source. Finally, marketing information, negotiating, finance, and risk taking move in *both* directions up and down the channel. In addition, negotiation and ordering are grouped under the term *exchange flows* because they facilitate the buying and selling of goods. Inventory possession is described as a *logistics flow* because the activities of transportation and storage occur with the transfer of the ownership of goods. Finally, financing, risk, payment, and information services flows collectively are termed *facilitating flows* because their performance is necessary to complete financial exchange and logistic transfer [10].

Supply channels are designed to facilitate and make as efficient as possible the execution of each of the transactional flows. Regardless of the physical structure of the distribution network, each of these functions *must* be performed at some point in the distribution channel by either a single or multiple businesses. Channel members can be eliminated or substituted; the transaction functions, however, cannot be eliminated and must be assumed by remaining channel participants. A producer, for example, may elect to sell direct to the end customer, bypassing channel intermediaries. Such a channel strategy requires the producer to perform all channel transaction flows. When a channel member is "disintermediated" from the transaction flow and its functions transferred to remaining channel members, it is termed *channel absorption*. Conversely, when functions are transferred to one or more intermediators, it is termed *channel functional spin-off*. In the final analysis, the real value of the structure of a particular distribution system is that it provides a form of synergy, permitting individual channel partners to reach objectives they would otherwise be unable to achieve acting individually.

Channel transaction flows can be performed multiples times depending on the number of echelons in the supply chain system. Figure 2.3 illustrates several different supply channels. In a *zero-echelon channel*, producers sell directly to the end-customer from the factory. The producer performs all transaction flows. A *one-echelon channel* consists of one intermediary business unit between the producer and the customer. In this environment the transaction flows are split between the two entities. A *two-echelon channel* contains two intermediaries, and so on. As the number of echelons in the supply channel grow, it becomes more difficult to maintain transactional efficiencies due to a lack of timeliness and accuracy of information and the cost incurred to move and store inventory in the pipeline.

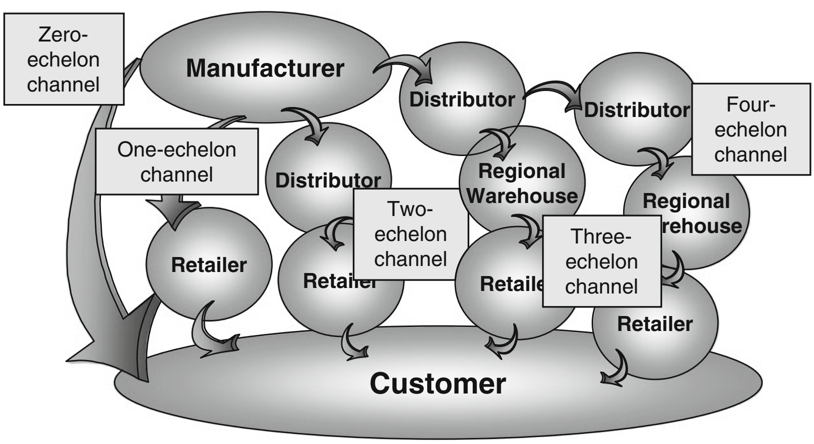


FIGURE 2.3 Levels of channel structures.

2.5 DISTRIBUTION CHANNEL INVENTORY FLOWS

An important role of supply chains is managing the flow of inventory. The decision to stock inventory at any particular channel echelon is a serious management decision that must be carefully considered by cost and service trade-off analysis. Decisions will be different by supply chain and are affected by the use of management methods such as lean, make-to-order production, structure of the channel warehouse system, outsourcing of operations, and other factors.

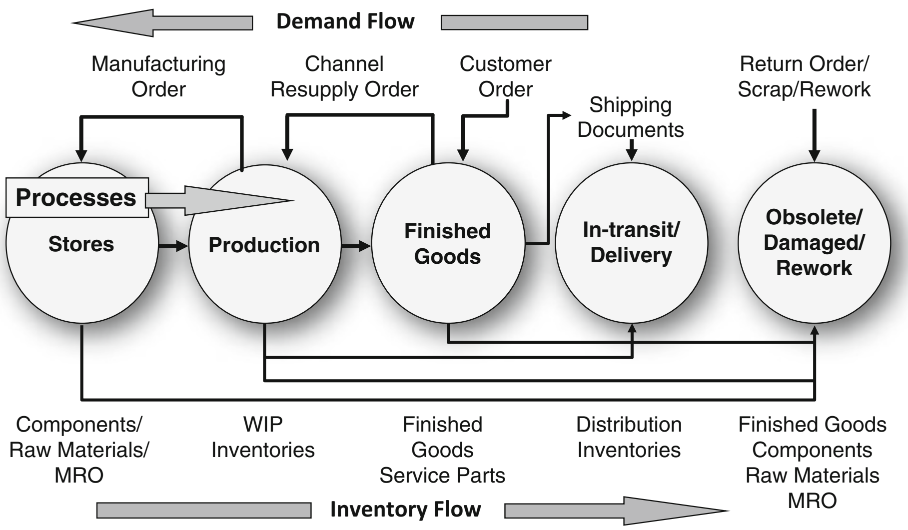


FIGURE 2.4 Channel inventory flows.

Figure 2.4 displays the flow of inventory as it moves through the internal organization. The diagram consists of three major areas: the customer *demand flow*, the five possible *process* stages that inventory passes through, and the type of item found at each process stage in the *inventory flow*. The demand flow is normally initiated with a customer order. If stock is available, the product is picked and packed and shipping documents authorize the delivery. If inventory is not available, the customer order continues its backward flow and initiates a replenishment order. This backward flow is always the case in a make-to-order (MTO) production environment where no finished goods are inventoried. For a make-to-stock (MTS) production environment, as demand consumes stock, a planned replenishment order is created when stocking levels in individual finished goods reach a predetermined reorder level. Once planners examine the replenishment order, they release it as a production order to be built in the plant. For a distributor, a finished goods shortage would trigger a resupply order that would in turn trigger the generation of a move order to be shipped from supplying warehouses upstream in the supply channel to the linked satellite warehouse. When the order is ready for shipment, shipping documents authorize the movement of finished goods into in-transit/delivery as they move to the satellite warehouse.

The final inventory flow is managing obsolete and damaged inventories. For products that are to be repaired, a rework order is generated authorizing product teardown and rebuilding. These products are then returned to finished goods inventory. For items that are damaged or obsolete, inventory management would generate a disposal order indicating that the products are salvaged.

Inventory is found in various organizational processes. For a typical production company, inventory is located in *stores* (where production inventories received through a purchase order are kept), *production* (where the product is made), *finished goods* (where the finished goods are staged waiting for customer orders), *in-transit/delivery* (orders moving to the customer or to downstream channel warehouses), and *obsolete/damaged/rework* (inventory waiting for disposition). For a distributor, stores and production stages are eliminated unless postponement processing occurs. Finished goods inventories are purchased and staged in the distribution pipeline. The inventories located in these various processes are considered as *inventory at rest*: no movement occurs unless activated by the demand pull.

The bottom portion of Figure 2.4 reveals the type of items typically found at each process stage. Items could be raw materials, components, finished goods, distribution inventories, service parts, damaged goods, and MRO inventories depending on organizational processes. Note that distributors would normally not stock production inventories, such as raw materials and components.

Figure 2.4 described the flow of inventory *inside* the typical production or distribution company. Figure 2.5 displays the flow of inventory *outside* the organization as it moves across the various companies found in its supply and delivery channels. In the past, the management of channel inventories stopped at the shipping dock. Today, the ability to link the inventory of channel partners back through the supply chain to the raw materials supplier is one of the central objective of the science of supply chain management.

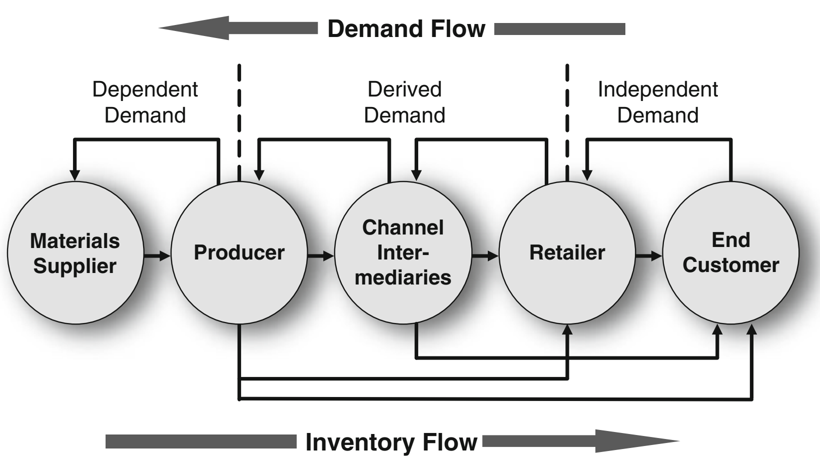


FIGURE 2.5 Supply chain inventories and demand flows.

As illustrated in Figure 2.5, the supply channel is divided into three segments based on the type of inventory and demand flow [11]. The key to understanding the management of supply chain inventories is recognizing that inventory demand assumes very different characteristics depending on where in the channel it occurs. All channel demand has one point of origin and that is *independent demand* for finished goods coming from the end-use customer positioned at the end of the supply chain. While classically a retailer, the purchase point could be a distributor, catalog sales, Internet sales, or a producer. In all cases the end-use customer determines the true demand for the inventory. The channel entity that serves the end-use customer directly experiences this independent demand.

Channel businesses located in the end-use customer segment of the supply chain normally view inventory as a short-term risk. In this environment, the goal is managing the *velocity* of buying and selling of inventories. As a rule, the greater the variety and quantity of products stocked, the greater the risk. But, while the variety a company stocks can be very high (a typical Macy's department store can stock more than 50,000 items; W.W. Granger stocks almost a half a million items), the organization's commitment to stocking large volumes is not very deep. These channel entities depend on high levels of sales and very short supplier delivery times to keep turnover rates as high as possible. Discount dealers will carry much less variety, but assume the risk of storing large volumes, which they sell in bulk. Finally, specialty dealers have narrow product variety and depth, but must assume high risk with respect to the duration they will be holding inventory.

Supply chain entities usually manage independent demand from end-use customers by developing some form of forecast of future sales. This forecast, which is passed upstream to channel intermediaries, is termed *derived demand*. Unlike independent demand, which is random, derived demand consists of the aggregated demand of upstream channel entities placed on the second major area of the supply chain: *channel intermediaries*. The role of channel intermediaries is to acquire finished goods from producers and then pass the inventory to downstream distributors and retailers concluding with the end-use customer. While it is true that the demand a channel intermediary receives is said to originate from its "customer," such demand is not considered as *independent* but rather as *derived* from the inventory replenishment plans stemming from the channel entities directly servicing the end-use customer.

Channel intermediaries view inventories as a medium-term risk. They buy products (usually in large lot sizes and varieties) from many sources to create a broad assortment which they in turn sell to other distributors or retailers, usually in smaller lot sizes. Intermediaries may attempt to reduce stocked finished goods by embarking on a post-ponement strategy. Sometimes, to meet seasonal requirements, intermediaries assume increased risk by holding large quantities over a medium-range time period. In general, however, the goal of intermediaries is to stock as broad a variety as possible acquired at the lowest possible cost, while accelerating product turn-over and reducing stocked volumes.

In the third segment of the supply chain is found the *producers* of finished goods and the *materials suppliers*. The demand the producer experiences is either derived (when it is received from channel intermediaries) or independent (when it involves direct sales to the end-use customer). The total demand is determined by combining the derived and inde-pendent demand placed on the producer's finished goods. This total demand, in turn, is used in the producer's material requirements planning (MRP) system to determine the production inventories required for production. The requirements for production inventories constitute the third and final form of demand: *dependent demand*. The demand is dependent because the producer knows exactly the production items and quantities that must be ordered from suppliers based on the bill of material explosions occurring in the MRP system.

Companies in this segment of the supply chain view inventories as a long-term risk. Even though they offer a limited variety of finished goods, producers must stock a wide variety of raw materials and components that often spend a long time in inventory before they pass through the production process. Make-to-stock companies must also store a significant amount of finished goods. Make-to-order companies reduce risk by not stocking finished goods, but must be prepared to invest in a wide variety and quantity of production inventories and the flexible production processes needed for customer order-driven end-product configuration.

Companies positioned along the process value chain continuum must be careful to develop the optimal supply and delivery networks commensurate with the type of demand they receive. This decision can be difficult if companies service multiple types of demand. For example, a business that sells movie CDs to retailers as well as directly to customers through the Internet needs to develop inventory stocking, order fulfillment, and purchasing policies that reflect independent demand coming from the direct Internet sales and derived demand stemming from sales to retailers.

An important activity in channel design is determining the rate by which inventory flows through a channel system. The principle for calculating this flow is known as *Little's law*. This principle says there is a distinct relationship between channel inventory, throughput rate, and flow time. Little's law is expressed as:

$$\textit{Inventory } (I) = \textit{Throughput rate } (D) \times \textit{Flow time } (T)$$

Little's law assumes that inventory moving through the channel pipeline occurs in a "steady state." This means that the throughput rate of inventory is the long-term average rate that items are flowing through the channel system and flow time is the time that it takes a unit to move through the system from beginning to end. Over a long enough period of time, input rate of inventory moving into the supply channel is equal to the output rate of sales to the customer. The principle also assumes that the throughput rate is equal to average demand and production or purchase processes are not resulting in excess inventories or shortages.

Applying Little's law requires measuring inventory in individual units, flow time in days, and throughput in units per day. For example, a company sells 100 units of a product a day and it takes 12 days for orders to flow through the company's distribution channel. Using the base formula, the size of the inventory in the channel is calculated as 100 units $\times$ 12 days $=$ 1,200 units. *Little's law* is also used to determine inventory value. For example, a company has just received a purchase of 2,000 units. Currently, the distribution center has 200 units in stock and the downstream satellite warehouse that sells to a local retailer currently has 400 units in stock. The throughput rate is 250 units per day. The cost of the unit is \$12.50. The cost of the inventory in the channel is calculated by adding all of the units and multiplying the quantity by \$12.50, or 2,600 units $\times$ \$12.50 $=$ \$32,500. The flow time is then calculated as the inventory divided by throughput, or 2,600 units/250 units per day $=$ 10.4 days' supply of inventory in the channel system.

2.5.1 Substituting Information for Inventory

A fundamental postulate of channel management is that as demand and supply uncertainty grows, so do pipeline inventories. The roots of channel uncertainty are found in such conditions as unreliable suppliers, poorly developed and communicated forecasts, ineffective scheduling, poor quality, process variability, long cycle times, inaccurate performance metrics, and others. These problems cascade through each level of the supply network, adding buffer stocks at each channel node, the infamous *bull whip effect*. The solution to breaking this cycle of using inventory as a means to counteract uncertainty is to increase the timeliness and bandwidth of the information about what products are really needed and when. The principle is simple: The more information channel nodes have about total network demand, the better they are able to produce and stock products in the quantities and at the time they are needed that match the pull of channel demand. Simply, timely and accurate information concerning supply channel demand becomes a substitute for inventory buffers.

For supply networks to effectively substitute information for inventory, several conditions are necessary. To begin with, every company in the supply channel must do its part to optimize channel inventories by effectively managing the total investment of material and process costs for every channel product, from raw materials to finished goods. Second, supply chains must gain “real-time” visibility to supply network demand and supply conditions. In the past, trading partners rarely communicated with each other concerning inventory needs except when a replenishment order was launched. Today, breakthroughs in supply chain planning and event management technologies provide channel partners with Internet tools that activate the potential to share demand and supply information within and across enterprises in real-time, along with exception messaging capabilities.

Third, channels can utilize alternative methods of stocking inventories that link suppliers and customers more closely together. For example, various forms of vendor managed inventory (VMI) enable suppliers to placed consigned inventories at the customer site where they hold ownership until the moment of sale. Another method is to utilize Web-based procurement and trading exchange systems to buy and sell online. Finally, channel partners can station planners and supply storerooms at the customer’s site to eliminate the time necessary for the communication of inventory replenishment needs.

Viewing supply chain inventories as if they were a single integrated supply function is the foremost challenge of channel inventory management. Realizing this challenge requires meaningful responses to the following issues:

- *Supply chain integration*. Not just point-of-sale nodes, but the strategies and processes of channel intermediaries and producers, must be integrated and made responsive to the demands of the marketplace. Achieving strategic and tactical integration is, by far, the most difficult of the challenges facing channel constituents.
- *Increased flexibility*. The effective management of inventories requires flexible and agile processes that accelerate and add value to materials as they flow through the channel network. Flexibility goals are achieved by reducing the size of the channel pipeline, eliminating bottlenecks, shrinking production and distribution lot sizes, building to customer order, and enhancing postponement strategies.
- *Lower costs*. By considering all channel inventories as belonging to a single supply pipeline, unnecessary supply chain buffers that add carrying costs and risk obsolescence are removed. Supply chain planning and event management technologies assist in

matching channel supply exactly with demand and reducing finished goods overstocks and distribution point stocking imbalances while increasing product variety.

- *Time-based competition*. Response to today's customer is measured not in weeks, but in days and sometimes hours. Every day that inventories spend in the channel pipeline adds carrying costs. Every day of lead time required to get the right product to the right place means slower response to customer requirements and larger order quantities. As the importance of delivery speed in today's global environment increases, the combination of high costs and lack of responsiveness risks competitive disaster.
- *Telescoping the supply pipeline*. Competitive supply chains are concerned about the length of the supply pipeline. As channel networks grow in length, so inevitably do transit times and buffer inventories. Today's best supply chains seek to continuously shrink channel pipeline size and shave time and inventory from the channel network through the use of lean, supplier management, and information technology techniques.
- *Channel performance measurements*. Metrics that document independently the performance of each channel supply node yield little information about the performance of the channel as a whole. Customer service metrics should primarily be based on how responsive and cost effective the entire channel is from raw materials acquisition to customer delivery.

2.5.2 Reverse Logistics

The return of products and disposable wastes has become a critical part of supply chain management as issues surrounding lean processes and sustainability grow in importance on a global basis. This channel function is termed *reverse logistics* and it is defined in the *APICS Dictionary* as "a complete supply chain dedicated to the reverse flow of products and materials for the purpose of returns, repair, remanufacture, and/or recycling." Reverse logistics can be visualized by reversing the forward distribution channel flow as illustrated on Figure 2.6. Reverse logistics processes consist of customer service (marketing in reverse); the movement of products back through channel warehousing and transportation; and unpackaging, disassembly, and recycling (a return to raw materials). Products are returned for many reasons including: poor quality; damaged or defective products; surplus, seasonal, or out-of-date inventories; and product remanufacturing and refurbishing.

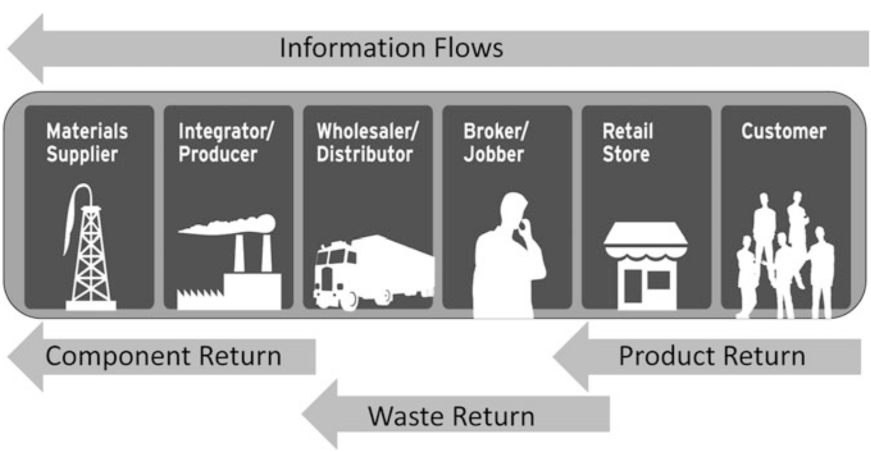


FIGURE 2.6 Reverse logistics flows.

Far from being considered as purely a cost, today's enterprise recognizes reverse logistics as a source of profit and good environmental stewardship. According to the Reverse Logistics Association, the volume of annual product returns is estiamted at between US $150 and US$200 billion. This value represents approximately 0.7 % of GNP and 6 % of the U.S. Census Bureau's figure of US$3.5 trillion annual retail sales. It has been estimated reverse logistics average between 7 and 10 % of supply chain cost of goods [12].

There are a number of motivating factors driving companies to construct reverse logistics core competencies.

- *Aftermarket savings*. Returned products can be "mined" to recover precious metals, such as gold, cooper, and zinc. Products can be repaired for continued use, refurbished for resale, and disassembled for their usable components, as well as conscientiously recycled.
- *Competitive edge*. Ease of return, repair, and recycling may add to a product's value and provide a competitive advantage. In addition, a growing "green" consciousness among customers adds to a supplier's promise of good service and environmental stewardship.
- *Pressure*. Consumer and shareholder groups, governmental legislation, and requirements of foreign trade are pressuring companies to make their products, processes, and distribution channels more sustainable. Savvy companies have sensed an opportunity to turn such sentiments into sources of increased customer loyalty and sales.
- *Growing market for environmentally safe products*. Today's consumer is increasingly demanding products that are simple, clean, and less threatening to the environment. Some customers will pay a premium for products that promise to protect their health and their world.
- *Environmental awareness*. Today's logistics function must develop strategies that capture a growing sense of environmental awareness, love of nature, and desire to preserve the health of the nonhuman world.

Reverse logistics functions can be considered as a hierarchy consisting of five possible options. Figure 2.7 illustrates the reverse logistics hierarchy in the form of a pyramid with the most desirable actions for managing returned and damaged products at the top and the least desirable at the base of the pyramid.

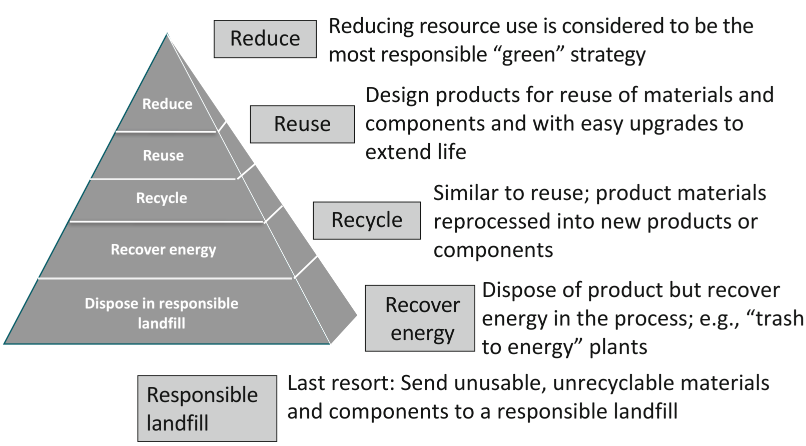


FIGURE 2.7 Reverse logistics hierarchy.

- *Reduce*. Reducing the use of resources is considered the most responsible option in the reverse logistics hierarchy. Reducing resources is accomplished through such actions as redesigning products and packaging that use physical resources more efficiently; reducing the amount of energy needed to run productive processes; and increasing the efficiency of resources and energy needed to run channel warehouses and transportation.
- *Reuse*. This strategy looks to the design of products so materials and components are more easily separated for reuse. In addition, intelligently designed product upgrades can extend the life of durable products if they are easy to install.
- *Recycle*. Similar to reuse, recycling seeks to capture wastes in the form of packaging materials, containers (bottles, barrels, drums, etc.), scrap materials, and so on, and to reprocess them into other products. Recycling reduces disposal costs.
- *Recover energy*. "Trash to energy" refers to the harvesting of forms of energy contained in products that are no longer usable in their physical form.
- *Responsible landfill*. Some products and wastes must go to the incinerator or landfill, but this is the least desirable option. A responsible landfill that prevents degrading items from leaching into a water source or polluting the air is preferable.

To monitor progress in using the reverse logistics hierarchy, companies need measurements that track the financial impact of returns management. Key metrics are: amount of product reclaimed and resold, percent of material recycled, amount of waste recycled, percentage of cost recovered, energy used in handling returns, and total cost of ownership.

Some of the benefits of a carefully designed reverse logistics channel are:

- potential for highly lucrative customer service contracts and extended warranties to manage end-of-lifecycle products
- mitigation of the unprofitable effects of high-volume returns
- enhanced customer loyalty and corporate reputation
- extraction of valuable raw materials for other industrial users
- development of more efficient products and logistical tactics
- profits from resale of refurbished products and parts that would otherwise go into landfills at a cost to the company
- creation of new types of jobs
- more efficient use of energy
- conservation of resources for future generations
- reduced emission of many greenhouse gases and water pollutants
- development of "greener" technologies
- reduced need for new landfills and incinerators

2.5.3 Sustainability

Companies have become aware in recent years of the global movement for "green supply chain management." Sustainability has its roots in the expansion of the traditional supply chain focus on cost, quality, and service to include environmental performance. Sustainability requires supply channels to move beyond a concern only with corporate profits and accept social responsibility for their marketplace actions in response to demands from consumers and stakeholders. This movement is encapsulated in the United Nations Global Compact which defines sustainability as

> The management of environmental, social, and economic impacts, and the encouragement of good governance practice through the lifecycles of goods and services. The objective of supply chain sustainability is to create, protect, and grow long-term environmental, social, and economic value for all stakeholders involved in bringing products and services to market.

Today's concern with sustainability is manifested in what is termed the *triple bottom line* introduced at the end of Chapter 1. Developed by the Bruntland Commission in 1987 and popularized by environmental activist John Elkington [13], the triple bottom-line consists of three perspectives: economic, environmental, and social. The basis of the triple bottom line is the theory that if companies are to remain economically viable over time, they must reinvest and track their contributions and impact on the environment and social capital as well as traditional markets, products, and profitability.

Taking an *economic perspective* means that companies should integrate environmental concerns into each step of business strategy and operationally into supply chain processes. Incorporating sustainability into supply chain strategies means that channel entities must implement environmental technologies that enable them to shape their businesses in a way that assists supply chains to find practical solutions to the environmental problems facing the global community. Sustainability potentially has a significant impact on economic decisions for the following reasons:

- *Good environmental management and sustainability concerns*. These concerns focus on organizational efforts to conserve energy, reduce waste and carbon footprints, and pursue the recycling of useable products and wastes.
- *Public opinion and the power of consumer choice*. These concerns center on heightened consumer awareness about protecting the environment, preserving the earth's finite natural resources, and increasing demand for green products.
- *Potential for competitive advantage*. This concern focuses on the use of sustainability practices to increase resource efficiency and reduce costs that improve the financial bottom line across multiple supply channel partners, build a reputation for eco-friendliness, attract talented employees, and inspire customer loyalty.

An economic perspective on sustainability requires companies to carefully consider, research, and track the impact of environmental issues on their supply chains and how sustainable business practices contribute to the business's long-term financial success.

An *environmental perspective* is concerned with how a company and its supply chain controls and regulates the production, transportation, and use of toxic, dangerous, and hazardous products and other wastes. Measurements focus on how well these concerns are part of an organization's environmental sustainability practices. Factors influencing the environmental perspective are:

- *Government and regulatory pressures*. These pressures consist of a growing number of laws, regulations, and treaties related to pollution prevention and control to prevent the dissipation of harmful materials into the environment. An example is the European Union's Waste Electrical and Electronic Equipment (WEEE) regulation mandating suppliers to take back electronic products as they complete their lifecycles and ensure components are properly recycled.

- *International Organization for Standardization (ISO)*. While a voluntary decision, ISO standards (especially the ISO 14000 series of environmental management standards) have been adopted by many countries and assist companies to identify standards assisting them to comply with governmental and environmental requirements.
- *Impact on supply chain decisions*. The decision to pursue environmentally sound practices are manifested in such actions as choosing only suppliers that are certified; designing products and processes that reduce hazardous materials and wastes; using warehousing and transportation modes that reduce carbon footprints; and dealing only with companies that have a solid reverse logistics process in place.

A *social perspective* provides a structure for companies to devise policies that enable them to act in a socially responsible manner. These initiatives are manifested in such guidelines as organization governance, human rights, labor practices, the environment, fair operating practices, consumer issues, and community involvement and development. Assuming a comprehensive commitment to social responsibility enables companies to weigh the impact on such factors as competitive advantage; local and international reputation; employee morale and commitment; the opinions of its many stakeholders; and relationships with customers, suppliers, the media, the community, and other companies.

While there are as yet no global standards governing sustainability practices, it is becoming evident that the maturing of environmental supply chains standards is likely to continue to grow. The results can only be seen as good for both businesses and the environment. The economic perspective enables companies to measure in the short-term the impact of sustainability to their financial performance. The social and environmental perspectives will take a longer-term to mature, but, none the less, will have an increasing incremental effect on social good and environmental sustainability.

2.6 SUMMARY

As the pace of global competition and demands for flawlessly executed customer service accelerate in the opening decades of the twenty-first century, the requirements for effective and efficient distribution functions is expected to grow accordingly. Far from being associated with a narrow segment of industry, the dynamic nature of today's supply channel requires expanding the definition of the distribution channel by describing it broadly as any organization that sells goods and services to retailers; industrial, institutional, and commercial users; and end-use customers. From this analysis, several types of distribution channel formats can be identified: manufacturers' branches and offices; merchant wholesalers; channel service formats such as brokers and agents; retailers; exporting and importing distributors; e-business channel formats; and specialized distributors.

Whether carried out by the sales and distribution division of a manufacturer, an e-tailer, or an independent merchant wholesaler, there are a number of critical functions performed in the distribution channel. To begin with, distributors solve three critical supply channel problems: *functional performance, reduced complexity,* and *specialization*. The goal of distribution is to increase the efficiency of time, place, and delivery utilities by acting as intermediaries focused on facilitating and rationalizing the flow of products, services, and information through the supply chain pipeline. In addition, distribution functions facilitate the performance of *forward flows* (physical possession, ownership, and promotion), *backward flows* (marketing information, negotiating, and risk taking), *exchange flows* (buying and selling), *logistics flows* (transportation and storage), and *facilitating flows* (financing and payment).

Perhaps the most important role of channel distribution is the effective and efficient management of the flow of inventory through the supply chain. Supply channels can be divided into three segments characterized by the type of demand they serve. Channel formats that service the end-use customer experience *independent demand*. Inventory in this segment is considered a short-term risk driven by concerns associated with sales velocities and forecasting. The second segment consists of intermediaries who receive *derived demand* coming from the aggregated demands of upstream channel entities. These channel formats consider inventory as a medium-term risk and will strive to stock as broad a variety of goods as possible. In the third segment is found materials suppliers and producers. This segment receives demand from upstream channel formats and coverts the requirements into *dependent demand* used by company MRP systems. Companies positioned along the process value chain continuum must be careful to develop channel structures commensurate with the nature of the demand they receive.

While attention is normally paid to the forward flows of inventory through the supply chain, in recent years issues surrounding reverse logistics and sustainability have grown in importance. Reverse logistics is defined as a complete supply chain dedicated to the reverse flow of inventory for the purpose of returns, repair, remanufacture, and recycling. Accompanying reverse logistics is the growing awareness of the concept of economic, environmental, and social sustainability. The concepts of "sustainability" and "green" are used synonymously with a growing movement for supply channels to move beyond a concern with corporate profits and accept social responsibility for their marketplace actions in response to demands from consumers and stakeholders. Reverse logistics and sustainability have become one of the newest frontiers in the effective and responsible management of today's supply chain.

DISCUSSION QUESTIONS

1. What is the difference between a “distributor” and “distribution?”
2. Describe the difference between a *centralized* and *decentralized* distribution system?
3. Identify the channel players that constitute the typical supply chain.
4. Describe some manufacturer-based channel formats.
5. Describe the main players in the e-business channel format.
6. What are the three critical distribution problems solved by effectively designed distribution channels?
7. Describe the four channel service outputs.
8. What is the function of postponement and what are its main advantages?
9. What are the channel transaction flows performed by supply chain entities?
10. Describe the nature of supply chain inventories and demand flows.
11. According to *Little’s law*, if it takes 30 days for inventory to cycle through a company’s supply chain and daily sales average 50 units, what would be the size of the inventory in the supply channel?
12. Describe the options in the environmental sustainability reverse logistics hierarchy.

REFERENCES

1. All reference to the *APICS Dictionary* in this chapter are from the 14th edition (2013).
2. This definition can be found at www.cscmp.org/resources-research/glossary-terms.
3. Bowersox, Donald J., Patricia J. Daugherty, Cornelia L. Droge, Dale S. Rogers, and Daniel L. Wardlow. 1989. *Leading edge logistics: Competitive positioning for the 1990s*, 34–35. Oak Brook: Council of Logistics Management.
4. Ibid., 41.
5. Ibid., 83–84.
6. These alternative channel formats have been attained from the *North American Industry Classification System* located at www.census.gov/eos/www/naics/; Kotler, Philip, and Kevin Lane. 2006. *Marketing management*, 12th ed, 520–522. Englewood Cliffs: Prentice Hall; Bowersox and Cooper, *Strategic marketing channel management*, 40–44; and Coughlan, Anne T., Erin Anderson, Louis W. Stern, and Adel I. El-Ansary. 2001. *Marketing channels*, 6th ed, 19–27. Upper Saddle River: Prentice Hall.
7. Tompkins International. 2013. Industrial distribution at a crossroads. *Tompkins International White Paper*, January 2013.
8. Bucklin, Louis P. 1978. *Productivity in marketing*, 90–94. Chicago: American Marketing Association.
9. For further discussion on these points see Kotler, *Marketing management*, 570; Bowersox and Cooper, *Strategic marketing channel management*, 74–79; and Coughlan, *Marketing channels*, 88–92.
10. These divisions of channel transactions are further discussed in Bowersox and Cooper, *Strategic marketing channel management*, 15–16.
11. The three-part division of demand was introduced by Mentzer, John T., and Mark A. Moon. 2004. Understanding demand. *Supply Chain Management Review* 8(4): 38–45.
12. These figures are detailed in Rogers, Dale S., Ron Lembke, and John Benardino. 2013. Reverse logistics: A new core competency. *Supply Chain Management Review* 13(3): 42.
13. Elkington, John. 1997. *Cannibals with forks: Triple bottom line of 21st century business*. New York: John Wiley & Sons.

PART 2

SCM STRATEGIES, CHANNEL STRUCTURES, AND DEMAND MANAGEMENT

CHAPTERS

Part 2 is concerned with formulating supply chain strategies and channel structures and managing channel demand. Chapter 3 begins this unit with a review of the business strategic planning process. Of primary importance is the formulation of comprehensive supply chain goals and their translation into the tactical and operational plans that will guide the supply chain's business functions. Main topics include defining business strategy, crafting the supply chain strategy, achieving strategic supply chain "fit," and supply chain risk management. The success of the supply chain strategy consists in the ability of top management to develop flexible organizations to meet the ever-changing needs of the marketplace; implement information, communications, and automation technologies capable of networking the whole supply chain; and leverage strategic alliances with channel partners that facilitate operational agility and reduce channel costs.

Chapter 4 explores the tasks associated with structuring supply and distribution channel networks in the pursuit of high levels of collaboration, profitability, and customer service. Main topics include defining channel networks, designing network configurations, channel design selection, and channel design implementation considerations. The chapter also introduces a *channel network matrix* tool that enables channel designers to determine how supply and demand channel structures should be constructed that support the firm's supply chain strategy. An important output is the identification and selection of one or several channel network structures that will fit the findings arising from the channel network matrix exercise.

Chapter 5 examines the role of forecasting in the supply chain planning process. Perhaps no other activity has as much effect on the supply chain as forecasting. Long-range forecasts enable top management to analyze the impact of strategic discussions on the supply chain's resource capabilities and marketplace opportunities. Forecasts assist tactical managers to match channel demand plans with departmental capacities. Finally, short-range forecasts enable operations managers to plan and control everyday activities and keep them aligned with the long-terms goals of the supply chain. Main topics included in this chapter are a detailed review of forecasting techniques, time series analysis, associative (correlation) forecasting, alternatives to forecasting, and managing forecast performance.

Part 2 concludes with a review of the demand management process. Chapter 6 explores how the demand and supply plans are developed and eventually merged in the sales and operations planning (S&OP) process. The demand management process is portrayed as having two correlated parts: the identification and quantification of demand and the calculation of the supply chain's resource capability to meet the demand plan. The culmination of this process is the monthly S&OP meeting where the demand and supply plans are reconciled and then driven down into the supply chain's tactical and operations plans.

Each of the four chapters comprising Part 2 provide supply chain managers with the essential strategies and planning processes to effectively respond to the challenges posed by expanding product and service lines, intensified competition, requirements for purposeful communication and networking, and the pace of changing marketplace needs characteristic of business in the twenty-first century.

3

Crafting Business and Supply Chain Strategies

The strategic role of supply chain management is summarized as the management of supply chain assets, products, information, and financial flows to maximize company profitability. In more detail, effective supply chain strategies grow business value by seeking to: (1) increase customer *responsiveness*; (2) increase the *efficient* use of supply chain resources; and (3) decrease the *cost* of supply chain operations. These objectives are realized by the design of supply chain strategies that define the physical configuration and capabilities of the supply chain network; how the execution of aggregate and detailed demand and supply

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_3) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_3, © Springer Science+Business Media New York 2015

planning will maximize business value; and how the daily performance of supply chain operations realizes customer responsiveness, efficiency, and low cost goals. There is little doubt that the success of companies like Wal-Mart, Amazon.com, and Home Depot are due in large part to how their supply chain strategies have shaped their supply channel design, planning, and operations.

This chapter is concerned with the basics of business and supply chain strategy development. The chapter begins with an overview of the nature and components of corporate strategic planning. Key discussion points center on defining the enterprise's strategic vision, mission, and goals. Following, focus shifts to the decomposition of the corporate business plan into the concrete strategies that are to drive business unit, functional business unit, and business unit operating strategies. The business planning process concludes with the establishment of the roles the major business functions (market/sales, supply chain, engineering/design, human resources, and finance) will play in support of each business unit's strategic goals. At this point, the chapter shifts to a full discussion on how to craft an effective supply chain strategy. Major points include defining a supply chain's performance attributes, performance process drivers (demand, channel configuration, inventory, sourcing, manufacturing, transportation, and technology), ensuring strategic "fit" with the business plan, and use of performance measurements to gauge supply chain strategic success. The chapter concludes with an overview of managing supply chain strategic and operational risk.

3.1 DEFINING BUSINESS STRATEGY

The objective of all business enterprises resides in providing products and service value that enables them not only to compete, but to continually win the customer's order. Whether it is a manufacturer of toasters or a travel agency, successful companies develop winning strategies and execute finely-tuned operations plans that assure the customer that the product or service received possesses outstanding and unique value. Before planners begin to develop a supply chain strategy, however, they must first define the strategy that will be used to run the business. The business strategy defines what the company is today, where it wants to go, and what will it take to get there. The output of this process is the mission statement and the business goals that provide a single, consistent, and coherent direction guiding and coordinating the company's activities. The business plan enables strategists to firmly establish the enterprise's identity, define the objectives and values by which the company competes, set realistic goals, and determine how it will measure success.

3.1.1 Scanning the External and Internal Business Environments

As illustrated in Figure 3.1, crafting business strategy begins by identifying the marketplace issues driving the firm's *external environment*. This process reveals the enterprise's competitive strengths, the forces driving marketplace change, the actions of competitors, opportunities for future success, and attractiveness of the firm to customers. An effective understanding of the marketplace enables planners to understand how closely the business's strategies, value propositions, products, services, and supply channel delivery systems match the needs of the customer. Finally, the firm's operational functions (sales and order processing, logistics, production, and finance) are then examined to measure how effectively they execute the business strategy at a level that not just meets, but far exceeds the competition.

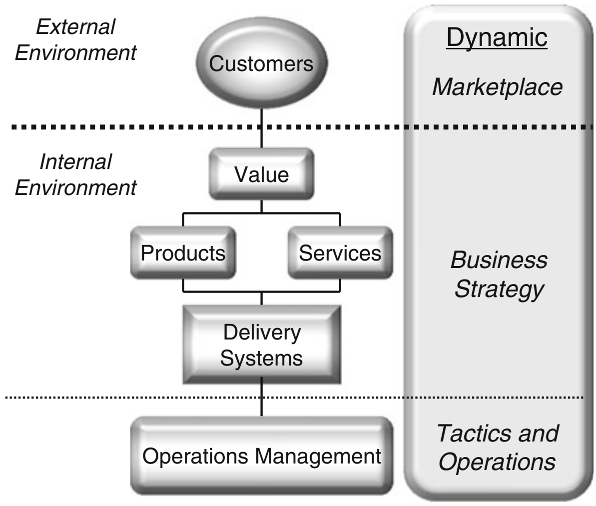


FIGURE 3.1 Strategic dynamics.

3.1.1.1 Scanning the External Business Environment

All enterprises operate within a much larger business or external environment. A revealing way to describe this macro environment is to call it a *business ecosystem* [1]. The concept of a business ecosystem considers every enterprise as part of a matrix of intersecting business systems composed of intricate, mutually supportive webs of customers, products, and information played out on a global scale. The idea that companies can develop and become successful independent of the ecosystems to which they belong is a myth. Today, companies around the globe understand that survival requires cooperation as well as competition with other ecosystem members that together shape the destiny of the world's economic system. In other words, today's global market system is being driven not by individual companies but by clusters of allied business partners who contest, and sometimes cooperate, with other business ecosystems in the search for competitive advantage.

Understanding a company's business ecosystem requires identifying the relevant factors and influences constituting the macro environment. These factors and influences define not only how a company competes for survival, but how its relation to other ecosystem members is leveraged to overcome the risks arising from changing marketplace environments and the threats of competitors. Figure 3.2 illustrates seven critical factors to be considered by business strategic planners [2].

- *Economic features*. The economic features of a marketplace varies by industry, but there is a measure of significant commonalty. A marketplace's economic features consist of such factors as the overall size and growth rate of the markets, global size, number and strength of competitors, needs and expectations of suppliers and customers, nature and life cycle of products being sold, use of technologies, use of economies of scale, and learning and experience curves. It is critical for strategists to respond to the dominant economic features of their marketplaces if they are to develop effective strategies that emphasize company strengths and competitive positioning.

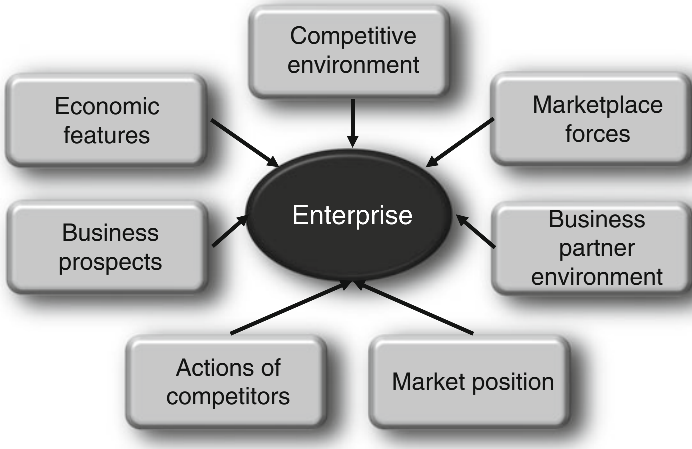


FIGURE 3.2 External environmental scanning.

- *Competitive environment*. The competitive environment in which a business operates varies by industry. An effective tool for understanding the competitive environment is Porter's *five-forces model of competition* [3]. The five forces consist of pressures on a business emanating from the following marketplace areas:
  1. The natural competition (pricing, market share, product/service value, advertising, delivery, and others) that occurs between rival companies competing with similar products for the same customer community.
  2. The threat to business ecosystem equilibrium caused by the arrival of a new player or a disruptive technology or product.
  3. Attempts of companies from other ecosystems to capture marketplace share by introducing substitute products/services currently not found in the ecosystem.
  4. Pressures stemming from the strength of suppliers. Supplier power occurs when buyers find that the cost of switching suppliers is very high, certain products possessed by the supplier are hard to get from alternative sources, there are only a few suppliers of the product, and suppliers threaten to forward integrate into the businesses of customers.
  5. Pressures stemming from the power of the customer. Supplier power diminishes to the extent that buyers can easily switch to alternate suppliers, there are a small number of buyers, buyer demand is weak, buyers have control over what and when they will purchase, and buyers threaten backward integration into the business of suppliers.

  Understanding a company's strengths and weaknesses relative to the five-forces model enables planners to gauge the intensity of the competitive environment. Analysis will yield not only the likelihood of the company's success but also how to design strategies to enable it to align strengths with the competitive character of the marketplace.
- *Marketplace forces*. All business ecosystem members (customers, suppliers, and competitors) experience trends and changes to their products, services, and value propositions. Some of these changes are a result of the migration of companies from

one position in their strategic life cycles to another. Other changes are driven by important forces that destabilize the competitive equilibrium of the ecosystem or a company's immediate industry and competitive environment. Examples include such forces as technology (the Internet and computer networking), globalization, product innovation, changes in costs and efficiencies, increases in uncertainty and risk, changing social concerns and attitudes, and others. Leveraging these changes to increase strategic competitiveness requires planners to identify the changes most applicable to their ecosystems, determine the cumulative effect on the strengths of competitive forces, assess their impact on business profitability, and highlight areas needing strategic change.

- *Business partner environment*. The central feature of business ecosystems is the opportunity for the coevolution of companies coalescing around commonly shared strategic visions and mutually supportive competencies. Two essential dynamics emerge. The first involves companies looking continuously for innovative ways not just to penetrate existing markets, but to create new sources of value that, in turn, geminate whole new markets. The second essential dynamic is the development of strategic relationships with other organizations in the search for the vision as well as the competencies and resources necessary to sustain competitive survival. An effective business strategy must contain a mechanism to enable planners to continuously adapt the business to leverage the best ecosystem partners.
- *Market position*. All companies face the threat posed by competitors in their market segment. Understanding the position a company occupies in the same space as competitors is an essential component in external business environment scanning. An effective technique that can be used to map competitive positioning is *strategic group mapping* [4]. An example of a strategy map is illustrated in Figure 3.3 for the fast food/restaurant industry.

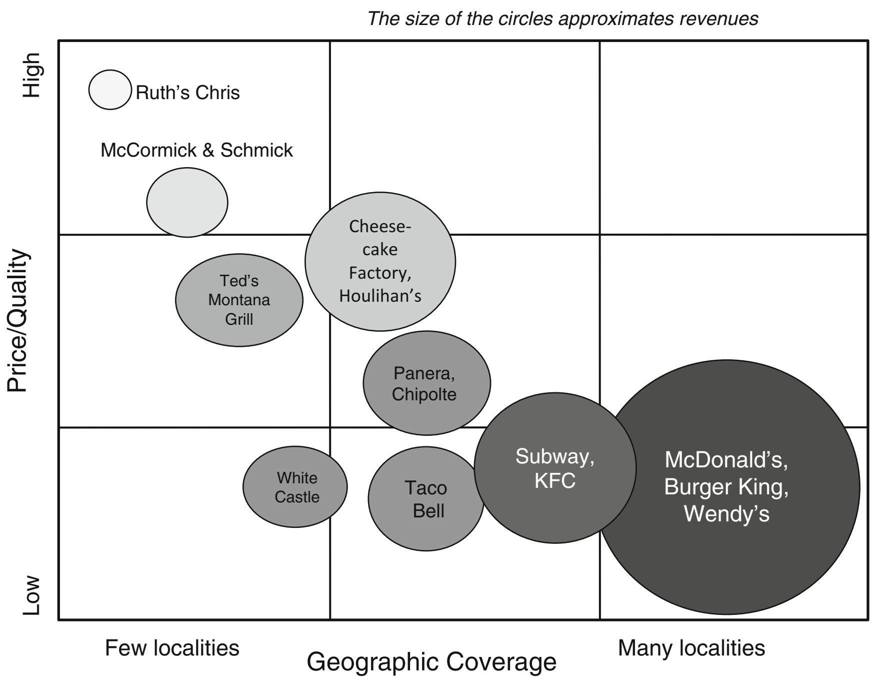


FIGURE 3.3 Strategic group mapping.

Constructing the strategic group map begins with identification of the competitive attributes, such as geographical range, breadth of product line, depth of service, and others, held by businesses in the company's competitive space. In Figure 3.3, the competitive attributes are *price* and *quality* on the vertical axis and extent of *geographical coverage* on the horizontal axis. The map is populated by positioning each rival company (in this case, fast-food and higher quality restaurants) in a strategic group and then plotting them (in the form of a circle) onto the grid. To emphasize the competitive value of each group, the circles are expanded in proportion to the relevant competitive attributes. Next, the company's market position relative to other companies in the strategic group is entered onto the grid. Once completed, the goal is to detail the strengths and weaknesses of each group, determine if market forces or competitive pressures favor one company over others, and identify the depth of competition by seeking how close is the competitive space.

- *Actions of competitors.* The object of this component of external environmental scanning is to evaluate competitors in each market area. This step focuses on three main objectives:
  1. Evaluating the content of a competitor's market strategy.
  2. Determining competitors' resource strengths and weaknesses.
  3. Predicting the next moves competitors are likely to make to gain advantage.

  This information enables strategists to determine which competitors have the best and who the weakest strategies, which have strong incentives to make major strategic changes, which are poised to gain and which to lose market share, which have clearly defined competitive advantages, and which are likely to enter new geographical markets. Strategists who fail to closely study competitors risk being disrupted by the strategic moves of market segment rivals.
- *Business prospects.* The final area to be explored in external environmental scanning is defining the competitive factors possessed by an enterprise that enable it to flourish in its business ecosystem. A starting point is identifying the *key success factors (KSFs),* such as level of technology expertise, logistics networking, products, productive resources, core competencies, competitive capabilities, past marketplace achievements, and others, that define the firm's competitive strengths and weaknesses. These metrics enable the enterprise to establish strategic factors such as
  – The business's and the industry's growth potential
  – The effect of the competition on the firm's current and future profitability
  – The impact of market forces on profitability
  – The level of risk and uncertainty in the industry's future
  – The ability to capitalize on the vulnerability of competitors

3.1.1.2 Scanning the Internal Business Environment

Most enterprises possess certain competitive attributes in which they excel and other attributes in which they are weak. The purpose of *internal business scanning* is to identify these internal strengths and weaknesses and to understand how companies can capitalize on the strengths while marginalizing the weaknesses. For example, a business may have strong R&D and innovative products, but lacks marketing and sales expertise. It makes sense for such a firm to concentrate on their design and product strengths in the short run. However, the firm must be careful to continuously search for ways to increase competencies in marketing and sales if they are to remain competitive in the long run. Of primary importance is assessing the degree to which the enterprise's current internal capabilities match the needs of its market strategies. Often, the failure of companies to survive and prosper in their business ecosystem is the result of the failure of their productive resources (people competencies, capital, plant and equipment, and other assets) to execute the strategies the firm has elected to pursue in the marketplace. In the end, the goal of internal business scanning is to measure how far the organization's resources and internal strategies are out of synchronization with their external business strategies.

Internal environmental scanning consists of six assessments as illustrated in Figure 3.4 and detailed below.

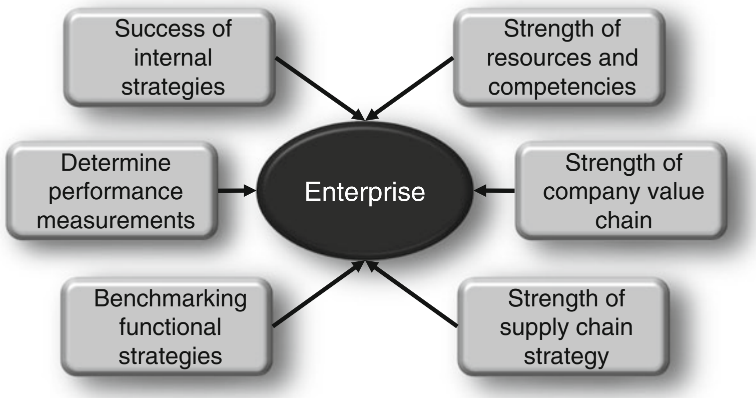


FIGURE 3.4 Internal environmental scanning.

- *Success of internal strategies*. In this assessment, planners seek to address several critical competitive factors driven by the existing internal strategies. The most obvious is asking whether the internal strategies are succeeding in building competitive advantage. This assessment asks how well internal competencies enable the company to outperform competitors; are functional strategies agile enough to react to marketplace changes; is the company growing strong collaborative partnerships and strategic alliances; and are detailed strategies driving business functions by providing the support necessary to execute the business plan. The assessment should point out synergies as well as gaps in the internal strategies.
- *Strength of resources and competencies*. An effective process for determining the strengths and weaknesses of internal resources is to perform a *SWOT analysis*. A SWOT analysis consists of three steps. The first is to identify the *strengths, weaknesses, opportunities*, and *threats* to the organization's future well-being. Strengths are attributes such as superior products and services, excellent financial condition and access to capital, strong brand recognition, and a highly integrated supply chain. Weaknesses are deficiencies, such as no clear strategic direction, heavy debt, mature product lines that lag behind competitors, ineffective supply

chains, and poor R&D and technology know-how. Opportunities are potentials such as growing demand, expansion into new markets, and alliances with partners in new geographical markets. Threats are risks such as growing competition, loss of sales to substitute products, governmental restrictions, and increased supplier and customer power.

- The second step in the SWOT analysis is to use the findings from the first step to draw preliminary conclusions about the relative strengths and weaknesses of the business, competitive attributes that make it particularly attractive to the marketplace, and deficiencies that could threaten its competitive position in the business ecosystem. Finally, in step three, planners translate the findings and conclusions into an action plan for improving the company's marketplace position. Courses of action include enhanced synchronization of internal resources with the company's business strategy; identification of marketplace opportunities exhibiting the highest potential; reducing company weaknesses and the magnitude of risk; and limiting the impact of external threats. The end result should be a clear definition of how the enterprise's resources and capabilities are aligned with marketplace profitability and compare with the strengths of competitors.
- *Strength of company value chain*. The *APICS Dictionary* defines a company's *value chain* as "The functions within a company that add value to the goods or services that the organization sells to customers and for which it receives payment" [5]. Borrowing from the work of Porter [6], the value chain consists of two broad categories of value-producing activities a company performs internally. The first consists of the firm's *primary activities*, such as supply chain management, operations, logistics, sales and marketing, and customer service that directly create customer value. The second category consists of *support activities*, such as product R&D, technologies, human resources, and general administration that facilitate and enhance the primary activities. A detailed value chain analysis enables managers to identify how effectively primary and support functions contribute to the success of the business strategy, the actual cost structure of internal functions, and resulting profit margins.
- *Strength of supply chain strategy*. Internal environmental scanning enables managers to assess the strength of their supply chain strategy and its contribution to the company's value chain. The supply chain strategy consists of two sets of attributes. The first focuses on the performance of operational functions, such as purchasing costs, use of productive assets, responsiveness of logistics and delivery, and effectiveness of sales and marketing strategies. The second set of attributes is associated with more strategic objectives such as the level of channel network flexibility, operational predictability, resiliency in the wake of disruptions, and the ability to sustain high levels of performance regardless of changes in the supply chain environment.
- *Benchmarking functional strategies*. Another element of internal environmental scanning is benchmarking. Benchmarking permits a company to compare its costs, products, and services to those of a company thought to have superior performance. The benchmarking target is often a competitor. It can also be a company with similar competitive characteristics in a different industry. There are several goals of the benchmarking process. One goal is to identify how closely company value-chain

activities match acknowledged leaders. Other goals are learning how best-in-class companies are achieving lower costs and higher profitability. The end result is to use the findings to improve the competitiveness of the company's primary and supporting value chain activities.

- *Determine performance measurements*. Performance measurements indicate whether an internal process is meeting the objectives that have been assigned to it by the business strategy. Primary and secondary internal activities are measured by applying the following five generic performance attributes from the SCOR reference model: reliability, responsiveness, agility, costs, and asset management efficiency. These objectives can be further decomposed into specific measurements, such as *order fulfillment cycle time*, or aggregated into higher-level metrics such as *customer satisfaction* or *operations flexibility*. Detailed metrics provide managers visibility into the daily operations of processes, while aggregate measurements are more strategic and enable managers to compose an overall picture of company performance. The goal of internal environmental performance is to uncover gaps between actual and targeted performance. Possible improvement paths followed are business process re-engineering, breakthrough (radical improvement), and continuous improvement.

The purpose of external and internal business scanning is to assess the enterprise's existing competitive strengths and weaknesses. The findings that emerge enable managers to effectively establish exactly what competencies and resources the enterprise possesses and what competitive gaps have been uncovered. With this information in hand, planners can then move to establish the goals and strategies that are likely to promote the firm's ongoing competitive success in the external environment.

3.1.2 Defining the Enterprise Vision, Mission, and Goals

Knowledge of the enterprise's external and internal environments is the prelude to the development of the corporate business strategy, which in turn, will drive the development of the supply chain strategy.

3.1.2.1 Establishing the Enterprise Vision

As illustrated on Figure 3.5, the strategic planning process begins with the formulation of the business's *strategic vision*. The *APICS Dictionary* defines the strategic vision as "the shared perception of the organization's future – what the organization will achieve and a supporting philosophy. This shared vision must be supported by strategic objectives, strategies, and action plans to move it in the desired direction." The strategic vision establishes the future direction the firm's management wants the business to go, details how the firm will leverage its core strengths and competitive advantages to realize marketplace goals, and shapes organizational identity.

For example, Coca Cola defines its vision as "serving as the framework for our Roadmap and guides every aspect of our business by describing what we need to accomplish in order to continue achieving sustainable, quality growth.

- **People:** Be a great place to work where people are inspired to be the best they can be.
- **Portfolio:** Bring to the world a portfolio of quality beverage brands that anticipate and satisfy people's desires and needs.

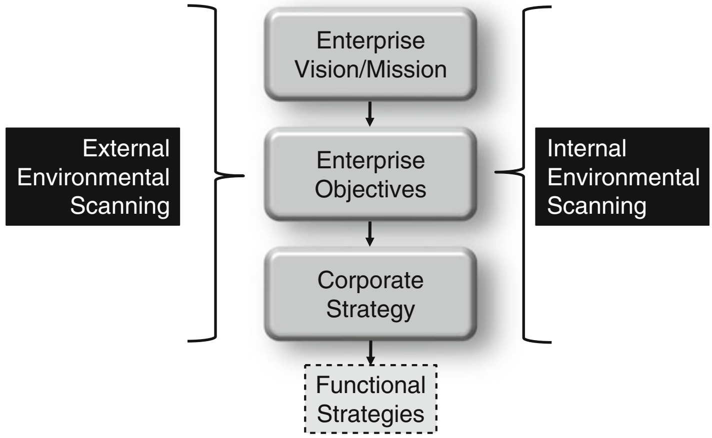


FIGURE 3.5 Corporate strategic model.

- **Partners:** Nurture a winning network of customers and suppliers, together we create mutual, enduring value.
- **Planet:** Be a responsible citizen that makes a difference by helping build and support sustainable communities.
- **Profit:** Maximize long-term return to shareowners while being mindful of our overall responsibilities.
- **Productivity:** Be a highly effective, lean, and fast-moving organization."

Toyota's vision proclaims that it

> will lead the way to the future of mobility, enriching lives around the world with the safest and most responsible ways of moving people. Through our commitment to quality, constant innovation and respect for the planet, we aim to exceed expectations and be rewarded with a smile. We will meet our challenging goals by engaging the talent and passion of people, who believe there is always a better way.

According to Thompson, et al., a successful strategic vision

> must provide understanding of what management wants its business to look like and provide managers with a reference point in making strategic decisions and preparing the company for the future. It must say something definitive about how the company's leaders intend to position the company beyond where it is positioned today. A good vision always needs to be a bit beyond a company's reach, but progress toward the vision is what unifies the efforts of company personnel. [7]

3.1.2.2 Establishing the Enterprise Mission

In contrast to the enterprise vision, the *enterprise mission* consists of the matrix of values, beliefs, and cultural attitudes that define the company's present business scope and purpose. The development of the enterprise mission takes place over long periods of time, requires the acceptance of all functions within the company, and is difficult to change once in place. Hayes and Wheelwright [8] term these vague but powerful attitudes and values an enterprise's *business philosophy,* and define it as "the set of guiding principles, driving forces, and ingrained attitudes that help communicate goals, plans, and policies to all employees and that are reinforced through conscious and subconscious behavior at all levels of the organization." These foundational enterprise *values* provide the framework for purposeful action and the grounds upon which competitive, marketplace, governmental, community citizenship, and environmental norms are developed.

The enterprise mission statement usually consists of multiple goals. Some are obvious financial goals such as profitability, corporate growth targets, and return on investment. Others focus on providing quality of work life, service commitment, the furthering of community and societal objectives, the minimization of risks to promote orderly growth, and so on. Such slogans as SAP's "The best-run businesses run SAP" and UPS's "We love logistics" are targeted at communicating basic enterprise values and product and service commitments to the marketplace. The following are examples of mission statements:

> To build shareholder value by delivering pharmaceutical and healthcare products, services, and solutions in innovative and cost effective ways. We will realize this mission by setting the highest standards in service, reliability, safety, and cost containment in our industry. (AmerisourceBergen, a pharmaceutical distributorship)

> We are a market-focused, process-centered organization that develops and delivers innovative solutions to our customers, consistently outperforms our peers, produces predictable earnings for our shareholders, and provides a dynamic and challenging environment for our employees. (Ashland, a chemical, distribution and refinery company)

> At Microsoft, our mission and values are to help people and businesses throughout the world to realize their full potential. We consider our mission statement a promise to our customers. We deliver on that promise by striving to create technology that is accessible to everyone—of all ages and abilities. Microsoft leads the industry in accessibility innovation and in building products that are safer and easier to use. (Microsoft)

> Apple designs Macs, the best personal computers in the world, along with OS X, iLife, iWork and professional software. Apple leads the digital music revolution with its iPods and iTunes online store. Apple has reinvented the mobile phone with its revolutionary iPhone and App Store, and is defining the future of mobile media and computing devices with iPad. (Apple)

The combination of the enterprise vision and the values detailed in the mission statement serve a multitude of purposes. They help focus corporate, business unit, functional business area, and supply chain strategies on a common game plan. They provide the basis for operational decisions and establish the boundaries of available strategic options. Finally, enterprise vision and values assist managers in making trade-off decisions among performance measures such as cost, inventory investment, customer service, and between short-term and long-term strategies.

3.1.2.3 Setting Enterprise Objectives

Formulating the enterprise's vision statement and fundamental operating values is an interactive, iterative exercise, culminating in the formulation of the objectives management wants to achieve as well as serving as the basis for tracking the company's progress and performance. The key to effective enterprise objectives are that they are quantifiable and contain a deadline for achievement [9]. These objectives support the enterprise vision and mission and consist of the direction management wishes the firm to take; the policies to be followed by the organization relating to customers, products, services, and business partners; the structure of the supply and distribution channel network; and the sense of community of purpose and enthusiasm guiding everyone in the organization in their endeavors to realize personal and, by extension, company goals.

As illustrated in Figure 3.5, enterprise objectives are not created just to guide company-level direction and performance: they also need to be decomposed and applied to each separate business unit and functional area as well as to the supply channel network. Often, pursuit of this objective is difficult to achieve. Different parts of the business may have established objectives that are in conflict with other functional areas. Enterprise-level objectives best succeed when each business unit, function, and the entities comprising the supply channel network strive to produce results that contribute to achievement of the enterprise vision, mission, and performance targets. This top-down, goal-setting process ensures that the objectives and performance targets being pursued are directly integrated with the enterprise vision, mission, and corporate strategies. The integration of objectives produces a sense of cohesion between operational and enterprise objectives and serves as a uniting force linking all facets of the business and channel network together.

3.1.2.4 Crafting Corporate Strategy

Corporate strategic planning is described as the process of establishing the courses of action an enterprise must follow if it is to realize the organization's mission and objectives. Strategies differ from objectives in several important ways. To begin with, objectives are defined as broad, long-term statements of what the enterprise would like to achieve. Strategies, on the other hand, consist of a set of specific actions designed to realize the enterprise's objectives. Strategies provide answers to such questions as; "How are enterprise resources to be used to achieve competitive objectives?" "How should the firm's portfolio of products be marketed to customers?" "What are the business's growth targets for a specified time frame." Collectively, strategies encompass the general action plans directing the enterprise, and, as such, will remain in effect for long periods of time.

The strategic planning process is an iterative task that involves the identification of threats and opportunities, problem solving to arrive at the best possible courses of action, evaluation of the consequences of possible solutions, and selection of the direction the firm will take. Kotler defines strategic planning as

> the managerial process of developing and maintaining a viable fit between an organization's *objectives* and *resources*, and its changing *market opportunities*. The aim of strategic planning is to shape and reshape the company's businesses and products so that they continue to produce satisfactory profits and growth. [10]

Much in the fashion of a mechanical gear train, strategic planning provides the mechanism to drive the tactical plans of the organization's business functions. These gears, in turn, drive the execution of operational activities. The goal of the whole process is to answer the central challenge facing the enterprise: *how to improve profitability by increasing productivity and optimizing the application of resources to capitalize on the "best" marketplace opportunities*.

The development of business strategies has four boundaries: *enterprise goals, opportunities, constraints,* and *risks and uncertainties*. When crafting the business strategy, corporate planners must weigh the impact of each of these factors. As illustrated in Figure 3.6, the development of the business strategy occurs on four levels. The first level is termed *corporate strategy*. Depending on the nature of the business, planning at this level focuses on five critical strategies as detailed in Table 3.1. Business planning begins with concise definitions of the competitive positioning, profit, ROI, and growth strategies that are to govern enterprise direction. These goals in turn are supported by product mix and volume, services, channel distribution, and technology enabler strategies that will describe the market potential and the products and services that will mature the revenue plan. The competitive values chosen by the firm will determine how orders are to be won in the marketplace, and in turn will influence process and channel structure choices. For example, if a company chooses to compete by offering a commodity-type product centered on minimal product variation, then low price, processes supporting agile make-to-stock strategies, low cost, and lean will be the optimal value choices. In addition, strategists would craft the supply chain strategy. This strategy defines the nature of the product sourcing and delivery processes and the configuration of the channel network structure. The corporate strategy is normally orchestrated by the firm's CEO and top executive team.

FIGURE 3.6 Enterprise strategic hierarchy.

The second level of corporate strategic planning is focused on the business units that make up the enterprise (*Note:* in the case of a single-business company, there would only be three levels, the business unit strategy being eliminated). Corporate business units assume a variety of forms, each requiring its own strategy. For example, General Electric is divided into 49 separate business units each with their own functional and operating strategies. Based on the above overview discussion on establishing the corporate business mission, external and internal scanning, goal creation, and strategy formulation, the crafting of business unit strategy should proceed according to the following steps:

TABLE 3.1. Strategic Framework

			Supply chain strategy	
Corporate strategy	Market strategy	Competitive values	Process decisions	Channel network configuration
Competitive differentiation	Marketing plan	Price	Make-to-stock	Single echelon
Profit plan	Product life cycles	Quality	Assemble-to-order	Multiple echelon
Asset plan	Product range, volume, mix	Delivery	Make-to-order	Use of 3rd party intermediates
Earnings plan	Distribution strategy	Image	Outsourcing intensity	Postponement strategy
Capital budgets	Service goals	Reliability	Collaborative intensity	Intensity of channel dependence
	Order customization/ configurability	Flexibility	Resource/capacity management	Intensity of channel integration
	Use of technology enablers	Product design	Lean/demand-driven/ agility	Basic service outputs definition
		Service	Cost improvement	Globalization
			Globalization	Risk management

- First, the *business unit mission*, which defines its marketplace position and role within the broader corporate mission, is formulated.
- Next, a SWOT analysis is performed to evaluate the business unit's *external* strengths and opportunities and *internal* weaknesses and threats. Planners in each business unit measure its product, market, and channel strengths and weaknesses; ensure that the strategies formulated provide sufficient growth opportunities; and are in support of the objectives of the corporation as a whole. Factors to be measured are business unit overall market size, annual growth rate, historical profit margins, technology requirements, competitive intensity, energy requirements, and marketplace impact.
- Following, specific *goals* are set for each business unit. Business units often pursue a mix of goals including profitability, sales and revenue growth, customer service, improvement in market share, risk containment, and innovation. Business unit goals should be arranged hierarchically, from most to least important; expressed using quantitative metrics that are easily measured; realistic in that they document what the business unit will and can do; and are consistent with each other.
- As mentioned previously, *goals* constitute what a company wants to achieve, while *strategies* comprise the specific steps defining how the goals are to be realized. Effective strategies enable business units to establish the basis by which a competitive advantage is achieved and maintained. Porter [11] identifies five generic competitive strategies that could be implemented.
  – *Low-cost provider*. In this strategy, the business unit pursues tactical and operational strategies that enable it to achieve low production and distribution costs so that it can capture competitive price leadership and win market share. The source of cost advantage may focus on economies of scale, proprietary technologies, supply chain efficiencies, geography, outsourcing of processes, or other factors. This strategy is effective when there are rival sellers with similar pricing and products, product differentiation is hard to achieve, buyers can easily switch,

and buyers have the power to bargain down prices. Wal-Mart, Best Buy, and Home Depot are examples of companies who pursue this strategy. The downside to this strategy is that competitors will also be searching to build core expertise that enable them to offer even lower prices.

– *Broad differentiation.* In this strategy, the business unit seeks to offer some product or service that is unique and highly valued by a broad base of customers. Differentiation can be based on products; the delivery systems by which the product is transacted; the marketing approach; and intangible features of the product or service, such as image and prestige, the buying experience, and service. As with the low-cost provider strategy, this strategy depends on having a unique strategic competency in product, distribution, design and engineering quality, innovation, or technical superiority that protects the differentiation strategy. This strategy is effective when there are many ways to differentiate the product and customers perceive these differences as providing value; customer wants and needs are diverse; and there are few competitors possessing a similar product/service differentiation. Toyota and Honda separate themselves from other automobiles by offering superior quality, image, service, and safety at a competitive price.
– *Best-cost provider.* In this hybrid approach, a company seeks to blend high differentiation products with a lower cost than what competitors can match. The product offered is significantly better than competing low-cost products and sometimes almost as good as a high-cost alternative. The customer base is value- and price-conscious and constitutes a sizeable part of the overall market. The danger of this strategy is that a company could get edged out of the market by competitors using product differentiation strategies at competitive cost. Lexus and Audi are examples of companies using this strategy to compete with BMW and Mercedes.
– *Focused low-cost provider.* In this strategy, the business unit focuses its product and service offerings on a well-defined, but narrow market segment and seeks to underprice competitors by utilizing operations that have lower production, services, and distribution costs. Market focus is characterized by geographical uniqueness, specialized requirements, or special product/service attributes appealing to a small market niche. Examples include generic label goods for retail grocers and replacement printer cartridges for branded printers.
– *Focused differentiation.* In this strategy, the business unit offers highly differentiated products with customized attributes to a well-defined, but narrow market segment. The product/service appeals to specialized customer wants and needs. Customers normally are willing to pay a premium for the product or service. For example, Gucci, Michael Kors, and Prada seek to penetrate the high-end apparel market by marketing high-quality goods and services that discount stores do not offer.

A business unit has a viable strategy when it describes how it produces value in the marketplace using processes that are hard to copy and provides clear differentiation separating it from its competitors. Business unit strategies are normally crafted by the general managers of each of the corporation's business units.

Level-three of strategic planning is concerned with the development of *functional business unit strategies*. Once business unit strategies have been formulated, the functional departments found in most companies, such as marketing, sales, finance, production, and logistics, must each have a strategy that details how the department is to deploy its competencies and resources in performing strategy-critical activities in support of the overall business unit strategy. For example, decisions concerning the location, size, staffing, inventory capacities, and costs of the distribution channel network must promote competitive advantages specified in the business unit strategy. Effective strategic planning occurs when the objectives of each strategic planning level are executed in alignment with and in support of one another. Effective functional-level strategic planning is an iterative process in which performance measurements link each level together and assure that overall enterprise goals are being accomplished.

The final level of corporate-level planning is the creation of *business unit operating strategies*. Operating strategies are concerned with the management of operating units, such as plants, distribution warehouses, and transportation, and specific operating activities such as logistics, marketing campaigns, product development, production, and budgeting. The objective of operating unit strategies is to ensure that the resources and capabilities of the organization realize the competitive advantages being sought by the business unit and detailed function. Operating strategies are created by the operating managers of plants, distribution centers, marketing, sales, finance, and other relevant business functions. Porter [12] identifies five generic categories involved in business unit operating strategy creation and execution.

- *Inbound logistics*. This category is associated with the acquisition, movement, and storage of materials, components, and products into the business. External activities in this category are associated with supplier sourcing, negotiations, order management, supplier scheduling, and delivery. Internal activities are comprised of receiving, quality management, material handling, warehousing, inventory control, and supplier returns.
- *Operations*. This category is associated with the conversion of production inventories into finished goods. This category includes the management of costs and productive assets. An important component of this category for distributors is *postponement*. Activities consist of bulk breaking, kitting, labeling, packaging, light assembly, and facilities operations.
- *Outbound logistics*. This category is associated with the movement of finished goods through the distribution channel. External activities in this category focus on wholesale and retail channels, delivery, and transportation. Internal activities are concerned with finished goods warehousing, material handling, replenishment planning, delivery vehicle operations, and scheduling.
- *Marketing and sales*. This category is associated with marketing and product sales. Activities include advertising, promotion, pricing, sales force management, order management, and distribution channel selection.
- *Service*. This category is associated with pre- and post-sale services. Activities in this category focus on product enhancement, maintenance, information, and training, and includes installation, repair, training, warranty, and service parts.

Although the development of business unit operating strategies are at the bottom of the planning hierarchy, they are of extreme importance. To be effective these strategies must be synchronized with each other. For example, if marketing runs a promotion to increase sales, it is imperative that operations receive prior warning so that resources can be assembled to ensure product is available. In addition, the activities of each operating strategy must match the overall business unit strategy.

3.2 CRAFTING THE SUPPLY CHAIN STRATEGY

As described in Chapter 1, up until the mid-1990s companies did not regard the management of their supply chains as requiring a strategy. The focus was on the day-to-day operation of logistics and the effective execution of the desired level of customer responsiveness at the lowest possible cost. The focus of supply chain management centered on doing things well so that more important functional strategies could be successfully executed. With the rise of the concept and practice of supply chain management (SCM), the construction of an effective business strategy has increasingly been perceived as incomplete without the development of a comprehensive supply chain strategy. The supply chain not only contributes to the success of other strategies, such as marketing, sales, and production, but is in itself a source of competitive advantage.

3.2.1 Defining Supply Chain Strategy

Supply chain strategy has arisen in response to a multitude of factors ranging from globalization, new technologies, and outsourcing to the growth of channel partnerships and the “leaning” of channels of supply that affect the business on a strategic level. Because of the impact of these and other factors, three key facets of the importance of the supply chain to the success of the business strategy have emerged. First, the scope of supply chain management is much larger than just the execution of daily operations functions – it is also concerned with the strategic coordination and collaboration of the business with supply channel partners. Second, supply chain management is not limited to just optimizing the performance of logistics functions – it also is a powerful strategy that both supports and is capable of driving sustainable competitive advantage. The objective of this dynamic is creating net value, building a competitive supply and delivery infrastructure, synchronizing supply with demand, and measuring performance globally. And third, supply chain strategy is the function where the business’s objectives and the capabilities of the supply chain network are reconciled. This dynamic is, in fact, perhaps the central goal of supply chain strategy.

As illustrated in Figure 3.7, a supply chain strategy is one of the major five functional strategies of a business unit (assuming a multiple business unit environment). Based on the mission, objectives, and strategies formulated at the business unit level, planners will need to establish what role the five functions will perform by crafting individual *functional strategies* that detail how each will support the business unit’s marketplace goals. The task of overall functional strategy integration is performed as part of the general business unit strategy. While the strategies of each of the five functions are critical and must be closely integrated, this chapter will focus on the development of supply chain strategy.

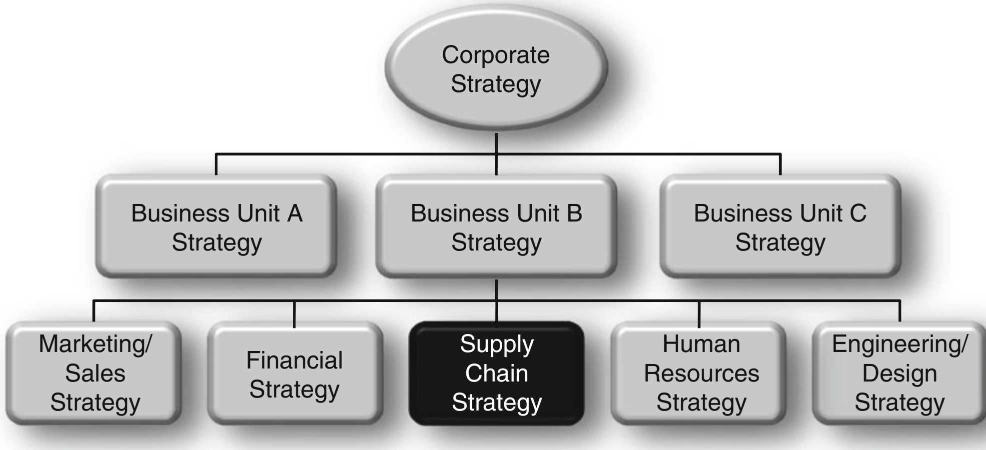


FIGURE 3.7 Business unit strategie.

What is the purpose of a supply chain strategy? Overall, the supply chain strategy describe how the firm's capabilities and resources contribute to the attainment of the business unit strategy. This objective consists of three processes. First, a supply chain strategy should contain a clear definition of the *performance attributes* that will enable other functional strategies and, by extension, the business unit, to compete successfully in the marketplace. Second, it should identify the broad *strategic decisions* that will be used to assemble supply chain operational competencies, capabilities, and resources. Finally, the supply chain strategy should establish the *performance metrics* that indicate the overall health of the supply chain. Collectively these supply chain strategic elements articulate how the marketplace requirements detailed in the business unit strategy are reconciled with the supply chain's productive and delivery capabilities and assets.

Reconciling a business unit's strategy with supply resources is not, however, a simple task. As implied in Figure 3.7, in the process of strategic planning the business unit mission and objectives are passed down to the functional level where operating managers must in turn develop the tactics determining how functional resources are to be used in support of business unit strategies. This conventional, reactive, "top-down" model, however, is in opposition to today's view that supply chain resources constitute a *proactive* competitive strategy. This means that actual supply chain competencies, capabilities, and experiences enable the business through time to explore alternative competitive paths than the ones stated in the initial "high-level" strategy or to embark on entirely new marketplace opportunities. Ideally, the best supply chain strategy is the one that reconciles the two approaches. A corporate level strategy would be ineffective that does not recognize the constraints and capabilities of its supply chain function (or indeed of the other four functional areas); a supply chain strategy would be neutral that does not enable the business to expand beyond its original goals. Achieving reconciliation between these two strategies is perhaps a central motif of a well-crafted supply chain strategy.

A proactive supply chain strategy begs the question as to how it is to create value. According to the research of Lee et al. [13], supply chain strategy creates value through five functions.

- *Operating cost reduction.* The research indicated that 97 % of respondents felt that operating cost reduction through effective supply chain management was crucial to the success of the business strategy. Value creation levers include supply chain efficiency in old and new markets, response time to react, risk management plans, and suppliers willing to accept favorable financial terms.
- *Value creation through increasing revenues.* According to the survey, just over half of the respondents felt the supply chain had a very important role in increasing revenues, with 93 % in total considering this function as an important role. Value creation levers include differentiation from the competition with value-added services and increasing customer loyalty.
- *Competitive advantage through differentiated customer service capabilities.* Scoring almost as equally high is competitive advantage through differentiated customer service, with almost 90 % of respondents identifying this function as a means to enhance customer service. Value creation levers include customer value of on-time, dependable delivery; quick response; flexibility in executing schedule and order changes; and influencing the customer's purchasing decisions.
- *Competitive advantage through strategic supplier engagement.* Eighty-four percent of the respondents felt this function to be important or very important. Value creation levers include strength of collaborative relationships, strength of supplier loyalty, product development cycle time reduction, on-schedule product introduction, and fast production ramp up.
- *Value creation through long-term equity improvement (*e.g. *brand equity).* Finally, 77 % of respondents assigned significant importance to the supply chain's ability to grow the company's equity in the eyes of the marketplace.

In summary, supply chain strategy performs two crucial roles. The first, and more historic, is that it provides a *supportive* role to the overall business strategy by performing operations functions at the highest efficiency, defined as cost and time. Second, and a much more contemporary viewpoint, is that the supply chain provides a *proactive* role that enables the business to set even higher goals and to expand its strategic directions. An effective supply chain strategy defines the following requirements:

1. The performance objectives by which the supply chain both responds to the business strategy and contributes to increased competitive advantage.
2. How decisions concerning the deployment of supply chain resources will realize corporate strategies while at the same time drive new areas of enterprise competitive space.
3. How integrating supply chain performance objectives and decisions regarding resources provides a roadmap detailing the direction the firm should be moving.

Based on these dynamics, supply chain strategy is defined as

> a matrix of policies and procedures through which the requirements of the firm's corporate strategy are reconciled with the totality of its supply chain productive and delivery capabilities in the pursuit of superior competitive advantage.

Figure 3.8 contains a flow chart illustrating the connection between the business and the supply chain strategies. In turn, the connection between the supply chain strategy and the supply chain network and its associated processes and resources is shown. As a summary, the goal of the supply chain strategy is to segment the business into supply chains networks and then to determine their expected performance. Next, the supply chain strategy seeks to optimize each channel network by determining their strategic performance requirements. Finally, each supply chain network manages their processes to achieve strategic network goals and seek to continuously align channel resources to meet performance goals.

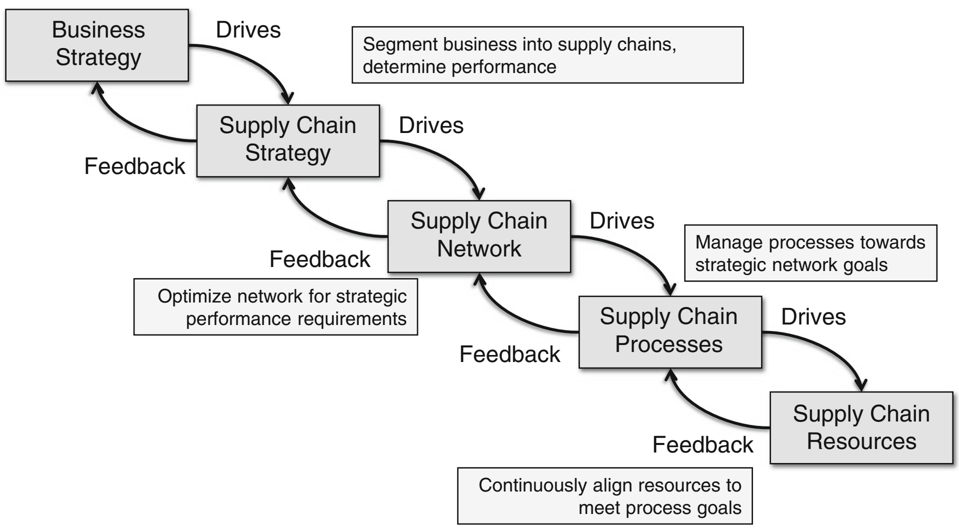


FIGURE 3.8 SCM strategic journey.

3.2.2 Stages of Supply Chain Strategy

Similar to the *supply chain maturity model* introduced in Chapter 1, supply chain strategy is separated into four stages of development. The goal of the exercise is to determine the size of the impact the company's supply chain has on the overall strategy of the business. A simple model that can be used is the Hayes and Wheelwright *four-stage model* [14]. The model enables companies to assess the importance of their supply chain strategies relative to their corporate strategy. At one end of the scale, a real supply chain strategy has yet to emerge and the supply chain function is thought to have a neutral effect on business strategy. At the other end of the spectrum, the supply chain strategy is perceived as a competitive advantage and actually assists in driving the overall business strategy. A schema of the four stage supply chain strategy is illustrated in Figure 3.9.

The steps required to move from stage 1 to stage 4 are as follows [15]:

Stage 1: Functional supply chain management. In this stage, supply chain strategy is very immature. The role of supply chain strategy is reduced to the execution of internal logistics operations such as inventory management and product delivery. Functions are inward-looking and reactive to marketplace challenges. There is minimal to no interaction with logistics functions performed by other business units or external logistics partners. Inventory and capacity levels are unbalanced leading to poor customer service and high total costs. The rest of the organization perceives it as purely operational and considers it as contributing little or nothing to company strategic advantage. What objectives *stage 1*

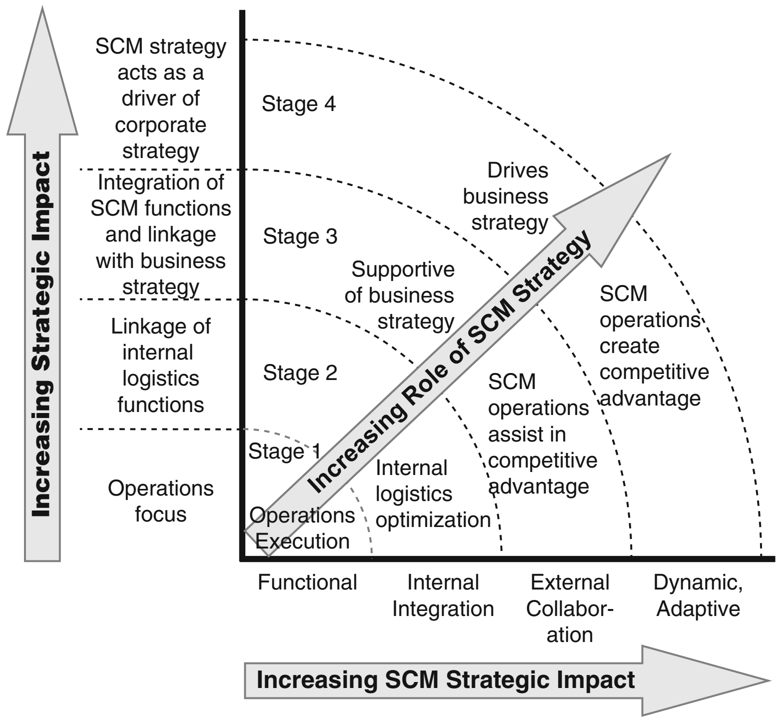


FIGURE 3.9 Four stage supply chain model.

supply chain strategies pursue are *internally neutral*, and concerned with transaction management and avoidance of operational mistakes.

Stage 2: Internal supply chain integration. The migration from *stage 1* to *stage 2* supply chain management occurs when logistics functions seek to benchmark their performance with other organizations in the marketplace in the search for "best practices" and higher levels of performance. Operations managers begin to implement basic *business unit operating strategies* associated with the pursuit of efficiencies and opportunities arising from the horizontal integration of plants, inventories, distribution warehouses, and transportation across the internal supply chain. Resources are jointly managed and there is a higher level of alignment between performance objectives. The goal is the optimization of internal supply channel profitability, customer responsiveness, and cost reduction. Other business functions begin to see the *stage 2* supply chain strategy as positive factor in the execution of their strategies.

Stage 3: External supply chain collaboration. *Stage 3* strategies are marked by a significant leap from being externally neutral to the pursuit of cross-functional and cross-supply channel strategies that elevates them from being logistics-bound to supply chain-enabled. At this level of strategy, supply chain managers seek to optimize profitability and cost reduction by integrating customers and suppliers with core business functions. Strategies extend across supply channel partners; the distribution network is oriented to be closely integrated with customer requirements; visibility to customer demand is available across channel nodes; and the supply network is integrated across upstream channel partners. Information sharing is extensive and visibility is high. Key activities such as product design and inventory management are integrated between supply chain partners.

Stage 3 supply chain strategies seek to leverage their operations competencies to excel in those areas that assist business strategies to compete effectively in the marketplace.

Stage 4: Dynamic, adaptive supply chain. In Stage 4, SCM moves beyond being supportive to providing the *foundation* for competitive success. Supply chains deploying this level of strategy understand that leadership in profitability, responsiveness, and cost control constitutes a fundamental driver central to market-winning business strategies. Companies are fully aligned with their supply chain partners on the key value dimensions across the extended enterprise. Supply chains are fully flexible to interact and adapt to complex dynamic environments. Instead of being reactive to business strategies, the supply chain is perceived as a creative and proactive force continuously adapting operations, products, and services to remain one step ahead of the competition.

3.2.3 Supply Chain Strategy Performance Attributes

As pointed out above, the development of supply chain strategies consists of three major components:

- *Performance attributes:* This component consists of the attributes that describe the performance of supply chain resources.
- *Performance drivers*: This component consists of the fundamental activities performed by supply chain resources that enable it to drive competitive advantage for the business.
- *Performance measurements*: This component consists of the performance metrics that indicate the success of the supply chain strategy. These measurements are also known as strategic metrics and key performance indicators (KPIs).

This section will examine supply chain *performance attributes*.

Supply chain performance attributes are briefly defined as a set of values and actions that guide the efficient use of supply chain resources to satisfy the demand requirements of the business. Exactly what these performance attributes are can be debated and various alternatives have been proposed [16]. Despite the differences, there are many areas of commonality. This text will use the five performance attributes defined in the SCOR® body of knowledge [17]. These attributes are defined in the following table (Table 3.2).

Reliability, responsiveness, and *agility* are considered customer-focused performance attributes. *Cost* and *asset management efficiency* are considered internally-focused performance attributes. The exact meaning and priority of these performance attributes varies by supply chain. Should the supply chain concentrate on reliability, responsiveness, agility, reducing costs, or optimizing resources or some combination? For example, *reliability* for Costco's supply chain brick-and-mortar strategy has a different meaning, set of execution processes, and performance measurements than it does for Amazon.com's online strategy. In addition, these attributes can be bundled together in pursuit of a broad supply chain strategy. McMaster-Carr Supply Company's overall strategy is to pursue *reliability, responsiveness*, and *asset management* efficiency simultaneously. Finally, supply chains servicing more than one customer group may have to develop a separate set of competitive factors and, therefore, different performance objectives for each customer market. For example, reference the differences in the content of the performance strategies for Barnes & Noble retail and online sales detailed in Table 3.3. The performance attributes reveal distinct strategies for managing bricks-and-mortar stores and for online sales where business partners are an essential component of success.

TABLE 3.2. SCOR Supply Chain Performance Attributes

Reliability	The ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of the delivery process. Metrics include delivery on-time, with the right quantity and the right quality performance
Responsiveness	The speed at which a supply chain provides products and services to the customer. Metrics include short order fulfillment and delivery cycle times. Responsiveness and reliability are often linked together as key marketplace measurements
Agility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage. Variations include *product or service flexibility* (speedy introduction of new products and services), *mix flexibility* (ability to quickly change products or services offered), *volume flexibility* (ability to service large order quantities), and *delivery flexibility* (ability to quickly change delivery dates to meet new requirements)
Costs	The cost of operating supply chain resources. Costs include labor, materials, transportation, and management. This cost can be broken down into operating expenditure, capital expenditure, and working capital. Metrics include cost of goods sold and total supply chain management costs
Asset management efficiency	The ability to efficiently utilize supply chain assets to support demand. This includes the management of all assets: fixed and working capital. Metrics include inventory days of supply and capacity utilization

3.2.4 Process Drivers of Supply Chain Performance

The development of the supply chain strategy centers on the pattern of decisions governing how supply chain resources are used to drive targeted levels of market responsiveness and efficiency at the lowest possible cost. As illustrated in Figure 3.10, supply chain strategy consists of six resource drivers defined as follows:

- *Customer focus*. This resource driver contains the strategy as to how supply chain resources support market requirements. Being responsive to the market strategy requires that the supply chain possesses the ability to meet both the daily requirements as well as the long-term needs of the customer by developing a distinct set of competencies and capabilities that supply the market strategy with a unique source of competitive advantage. As advocated by Hill [18], a useful way of assembling a market focus is to distinguish between *order winners* and *order qualifiers*. Order winners are those distinct actions or capabilities that enable a company to win business over the competition. The goal of supply chain strategy is to enhance these winning characteristics. Order qualifiers are those actions or capabilities that the customer expects the business to possess which "qualifies" its products and services to be considered alongside the competition. Table 3.4 provides some examples of how order winner and qualifier criteria would be applied to the supply chain strategy.

  The partial list of order winners and qualifiers in Table 3.4 must also be tempered by the fact that different market segments may require different supply chain strategy solutions. In the end, the customer focus of the organization may require both a broad and a segmented supply chain strategy whereby the other decision components of

TABLE 3.3. Comparing Barnes & Noble Retail and Online Sales Performance Attributes

Performance attributes	B&N retail sales	B&N online sales
Reliability	• Store hours meet expectations • Availability of product • Friendly staff • Returns accepted	• Order filled 100 % • Deliveries arrive in quoted time • Orders arrive without damage • Returns accepted
Responsiveness	• Short cycle time to acquire, merchandise, and sell • High product turns • Speedy customer checkout • Speedy inbound delivery	• Same as competition or faster delivery time • Short delivery from specialty and used books partners • Fast and easy order entry, shopping cart, and payment
Agility	• Ability to quickly rebalance store inventory imbalances • Short cycle time for deliveries from supplying warehouse network • Ability to use multiple sources of supply	• Quick shipment of any product from any warehouse or partner at lowest cost
Costs	• Maintain low cost using selective stocking strategy • Reduced store cost of goods • Reduced costs to source • Reduced costs to return	• Maintain low cost using selective stocking strategy • Reduced costs to source • Reduced costs to deliver • Reduced costs to return
Asset management efficiency	• Fast cash-to-cash cycle • High return on store assets and operating costs • Low total supply chain asset costs • High return on working capital	• Fast cash-to-cash cycle • Low total supply chain asset costs • High return on working capital • Low technology costs • Centralization of stocking points

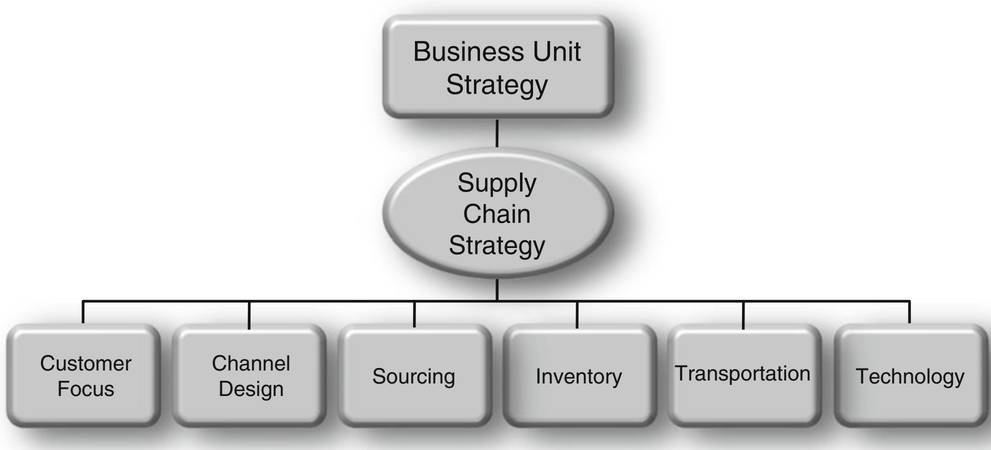


FIGURE 3.10 Supply chain strategic decision components.

TABLE 3.4. Select Order Winners and Qualifiers and Supply Chain Strategy

Market criteria	Description
Price	Based on the nature of the product and its position in the product life cycle, competitiveness may depend on price-sensitivity. In high margin markets, price is not an order winner. However, in low margin markets, price is an order-winner. The supply chain's role in this type of market is to improve on order qualifying criteria while reducing costs to keep prices low while increasing margins. Supply chain strategy focuses on accelerating delivery speed and reliability, increased product variety, and low-cost distribution
Product	If the firm is a manufacturer, there are several production strategies that directly affect market positioning. Products can be made-to-stock, made-to-order, assembled-to-order, or engineer-to-order. The main criteria in the selection of one of these strategies is cost and delivery time. For example, for a make-to-stock choice the supply chain strategy must establish the number of echelons in the distribution network, how many facilities are needed, use of third party services for storage and delivery, and the efficient management of inventories and transportation
Quality	While quality has pretty much become an order qualifier, the supply chain must deliver the level of quality matched to the customer strategy. For example, manufacturing must produce products that conform to competitive specification. The supply chain must facilitate ease of product servicing and speed of after-sales services (returns and warranty)
Cost reduction	An important market strategy is keeping costs as low as possible to keep prices low and margins high. A typical list of activities to be performed by the supply chain includes eliminating waste, improved product design, quality at the source, process redesign, full-truckload transportation, lean production control systems, setup reduction, overhead reduction, and the involvement of the workforce in cost reduction efforts
Product range	A key marketplace differentiator is the depth and breadth of a firm's product range. As companies increasingly incorporate customer preferences into product design, supply chains must be prepared to source, produce, and distribute an increasing number of product variations and assortments
e-Business	A decision to move to the Internet for sourcing and sales opens a new window for the utilization of supply chain resources. The supply chain will have to migrate to a new set of performance measurements that accentuate short delivery cycles, consolidation of ship-from warehouses, small shipping quantities, facility locations that reduce delivery time, standardized pricing and costing, use of channel intermediaries, and changes to the variety of available inventories

channel design, inventory, sourcing, and technology will develop multiple strategic paths.

- *Channel design*. The design of the supply channel is a fundamental component in structuring strategies related to responsiveness and efficiency. Design decisions are important because they determine the overall performance of the supply chain configuration. Several design decisions must be taken into consideration.
  - Channel planners must decide what role each facility is to play in the supply chain strategy. Included are decisions regarding what processes, inventories, and transportation functions are to be performed by each channel node. These decisions are

critical because they determine the level of flexibility the channel network possesses to quickly adapt to changes in costs and customer service. Options include whether facilities are to be storage, consignment, or cross-docking warehouses or a combination.

- Effective channel network design requires balancing efficiency with responsiveness. As the number of supply chain facilities are reduced and inventories consolidated, supply chain efficiency increases. The reduction in cost, however, comes as a result of a reduction in customer responsiveness as customers must be serviced from distant supply locations. The opposite of this dynamic is also true.
- Decisions regarding the number and location of facilities are very critical since they represent a long-term commitment. Important decisions consist in determining whether to centralize in order to gain efficiencies or to decentralize to gain customer responsiveness. An important consideration is the establishment of the transportation links ensuring timely and cost effective movement of inventory in the supply channel.
- A final major consideration is the availability of capacity. Decisions in this area determine the types and capacities of supply chain resources needed to meet strategic performance targets. Excess capacities enable the supply chain to be flexible and scalable to meet changing demand patterns. On the negative side, excess capacities reduce supply chain efficiencies. On the other hand, high-utilization supply chains, while being efficient, lack adaptability to respond to changes in marketplace demand. Planners will have to make thoughtful trade-off decisions between efficiency and responsiveness when formulating supply channel design strategy.

Chapter 4 will deal exclusively with the elements and strategies associated with supply channel design.

- *Sourcing*. Companies generally acquire inventories from two sources. The first is finished goods that are purchased. The decision to purchase inventories is the result of cost trade-off analysis where it is found that outsourcing production is more competitive, provides access to missing core competencies, increases capacities, and decreases overall plant and operations costs than performing production using company-owned resources. Purchasing strategy involves establishing a portfolio of suppliers, negotiating on such elements as price and quality, supplier selection and contracting, and the execution of purchase orders. Once purchasing processes have been established, supply chain planners must search for ways to continuously improve efficiencies and coordination with the supplier channel.

The second type of sourcing is to produce the needed goods and services. When developing the production strategy, planners must consider both "hard" and "soft" production structure choices. *Hard* choices affect the physical structures of production such as:

- *Plant*. The two major decisions associated with production plants are *location* and *focus*. Location decisions are made infrequently and are divided into cost and qualitative factors. Cost factors include size, operating costs, taxes, utilities, transportation, and others. Qualitative factors, such as proximity to customers and suppliers, community, legal, and others, must also be considered. Plant focus is concerned with the process design needed to build the firm's range of products; types of production equipment, technologies, and volumes; and markets served.

– *Process choice*. An important strategic structural choice is determining what production process choices and technologies are to be implemented. Alignment of current process capabilities and marketplace objectives to the current and expected varieties and output volumes of the firm's product offerings is absolutely critical. The decision to use job shop, batch, mass, or continuous production processes and the implementation of advanced information technologies involves significant changes to production resources.
– *Capacity*. Supply chain strategies cannot be authorized without consideration of the available capacities of the plant's productive resources. A decision to pursue a *lead* (capacity is added in anticipation of increased demand), *lag* (capacity is added or reduced after demand volumes are known), *tracking* (capacity is added in small increments to meet corresponding changes in demand), or *outsourced* capacity strategy involves a thorough cost-benefit analysis of existing resources, the cost of new investment, and the development of supply chain outsourcing partnerships.
– *Vertical integration*. This structural decision determines how far the firm wishes to assume ownership of activities that extend its footprint into the supply side (backward integration) or into the channel distribution side (forward integration) of the supply chain. Decisions to assume control of actions currently performed by suppliers and customers must be closely integrated with capacity decisions and the effect such a strategy will have on the physical structure of the business.

Soft choices affect the firm's production *infrastructure* and are detailed below:

– *People*. Staffing and personnel-related decisions must be coordinated with process-choice decisions and other structural considerations. Defining job content and worker tasks relate to matching process choices with the technical and functional skills needed, depth of knowledge and understanding about products and processes, and level of employee empowerment desired. Other decisions beyond process selection relate to the need for worker training, education, and skills enhancement.
– *Organization*. Organizations are categorized as either centralized or decentralized depending on the targeted level of production planning and control. In a *centralized* organization, all support functions are performed by one central authority. These organizations tend to be vertical with multiple levels of reporting. In a *decentralized* organization all support functions are performed locally. These organizations tend to be horizontal and have matrix management styles with a small number of reporting levels.
– *Quality systems*. Regardless of the type of production strategy, quality is a *requirement* not an option. The type, cost, and degree of inspection; process measurement and improvement; process control; and design for quality must match the parameters for competitive advantage desired in the supply chain strategy.
– *Manufacturing planning and control (MPC) systems*. The information systems of the firm coordinate business information and make it accessible to all functions

quickly and accurately so that plans and processes can be integrated effectively. Systems such as enterprise resources planning (ERP), advanced planning systems (APS), forecasting, supply chain, demand management, and lean techniques, provide comprehensive information management tools necessary for executing the day-to-day plans of the production strategy.
  - *Technology systems*. Technology tools enable the effective collection, management, and retrieval of information necessary to run the firm's information systems. Depending on the production process choice, applications like shop floor controllers, automated and web-based data collection, manufacturing execution systems (MES), electronic data interchange (EDI), and RFID can be used to support the production strategy.

  Considered in an aggregate sense, supply chain sourcing strategies are focused on the need to balance the firm's capacities and costs with the market requirements stated in the business plan.

- *Inventory*. The fourth supply chain strategic decision component is the management of inventories. Inventories exist in the supply chain basically as a form of buffer between demand and supply. If a company had access to a magic machine that could produce any item, in any quantity, at any time, there would be no need for inventory – much less the need for supply chains! Since this situation is not possible, inventory has two important roles: it increases responsiveness by having products available when customers want them and it reduces cost by leveraging economies of scale in sourcing and distribution.

  Inventory contributes to supply chain strategy in several ways. For example, if the marketing strategy requires high levels of responsiveness, the supply chain can locate a complex supply network with quantities and delivery points close to the customer. On the other hand, for a firm pursuing a low-cost strategy, inventory costs are reduced by centralized stocking. Inventories are also driven by production strategies. Make-to-stock production results in potentially large finished good and safety stock inventories. Assemble-to-order and make-to-order strategies results in almost no finished goods but potentially extensive amounts of production inventories. The basic trade-off when designing supply chain inventory strategy is establishing the cost of a level of desired inventory against potential lost customer sales.

- *Transportation*. The *APICS Dictionary* defines transportation as "The function of planning, scheduling, and controlling activities related to mode, vendor, and movement of inventories into and out of an organization." Transportation is important because it enables companies to bridge the problem of distance between producers and customers. It is concerned with the selection of the proper mode of transportation to match the products being transported. If the company does not have its own transportation fleet, transportation management is concerned with the selection of the most reliable and cost-effective for-hire transportation providers. It is also concerned with the protection, security, and timely delivery of products to all business partners in the supply chain.

  The availability of inexpensive, efficient, and easily accessed transportation activates several critical drivers of competitive advantage. To begin with, transportation enables companies to bridge the geographical gap between the place where products are produced and the place where they are consumed. A supply chain's transportation network defines the use of transportation modes (motor, rail, air, water, and pipeline), locations, and routes whereby product is delivered to the market. Transportation can deliver products direct to the customer or they could be delivered through intermediate consolidation points. Second, the more developed the transportation system, the greater the ability of businesses to compete with other companies in distant markets on an equal footing. Third, the wider the product distribution and the greater the demand, the more producers can leverage economies of scale in production and channel transportation costs. Finally, the more efficient and the lower the cost of transportation, the lower the selling price. Because transportation costs to the producer are normally calculated into the price of products, as costs decline and delivery capabilities rise, producers and distributors normally pass on the savings to their customers in the form of lower prices, thereby increasing marketplace advantage.

The transportation strategy is driven by two important trade-offs. The first involves measuring the costs of channel inventories and transportation costs. Generally, the more inventory is centralized in a few locations the higher the transportation costs. For example, compare the different transportation costs between Barnes & Nobles' retail and online strategies. For the retail side of the business, Barnes & Noble incurs only *inbound* transportation costs to replenish store inventories. The online business, on the other hand, incurs both inbound and outbound transportation costs. While it is true that the online business will be able to reduce inbound costs due to the fact that inventories will be centralized in a few warehouses, outbound cost will be extremely high due to the many small shipments using premium delivery services.

The second trade-off involves measuring the cost of transportation and customer responsiveness. If a firm's supply chain strategy is centered on high responsiveness, such as McMaster-Carr, which promises same or next-day delivery, the cost of transportation will be very high. Using fast modes of delivery, such as air and parcel post, increases transportation efficiency and the speed with which deliveries are made (responsiveness). On the other hand, if a company chooses to pursue a strategy of *temporal aggregation,* whereby delivery is delayed in order to combine orders into larger shipments, responsiveness will decline but so will transportation costs. Determining transportation trade-off costs is a central decision in the development of a sound supply chain strategy.

- *Technology.* Technology enables supply chains to perform two essential tasks. The first is the collection and application of information to facilitate the efficiency and responsiveness of supply chain resources and assets. The value and utility of information is dependent on the supply chain structure and the markets served. Information enables supply chains to position inventory at the optimal points in the supply channel (W.W. Grainger), ensure inventory is available to meet customer demand at the lowest cost (Wal-Mart), and source product from the most appropriate suppliers (Amazon). Technology enables companies to share vital information with their customers and suppliers, develop forecasts to project demand into the future, and validate the availability of productive capacities. The second task of technology is to either directly drive or provide the supporting infrastructure for supply chain transformational, marketing, sales and service, financial, and distribution processes. For example, technologies associated with inventory can be divided into *direct processes*, such as production, purchase, and physical storage systems, and *support processes*, such as enterprise resource planning (ERP) databases, customer ordering systems, and online search and inquiry.

At the heart of technology as a driver of supply chain strategy is the trade-off between flexibility and cost. Classically, large scale, heavily automated, and tightly integrated processes are considered as optimal for producing high volume, low variety products at the lowest cost but with little flexibility. In reverse, low volume, high variety products are marked by low tech equipment and high cost, but high flexibility. Today, the need to achieve high levels of performance in both flexibility and cost has challenged the traditional role of technology. Increasing market fragmentation, product proliferation, and demand for more customization, is placing increased pressures on traditional views of supply chain technology, flexibility, and cost.

Supply chain strategies seek to overcome the flexibility/cost barrier by expanding the concept and application of technologies to supply chain process drivers. Three dimensions are highlighted as follows:

– *Using technology to move from scale to scalability*. By expanding the information content and deploying transformational technologies capable of quick changeover and adaptation, supply chains can increasingly respond to changes in the marketplace and unforeseen opportunities. Technologies such as electronic data interchange (EDI), automated warehousing, ERP and supply chain management (SCM), supply chain event business systems (SCEM), radio frequency identification (RFID), Internet information networking, and others provide today's supply chains with increased visibility into the balance between channel demand and supply, advanced warning of supply chain disruptions, and demand-pull processes that enable supply chain resources to be more responsive.
– *Using technology to move from automation to information* [19]. The basis of the application of technology to the workplace is to incorporate the human knowledge necessary to perform productive tasks directly into the machine. The benefits of automation are substantial: unwavering precision, accuracy, and speed; improvements in productivity and efficiencies; working nonstop 24/7; and standardization of processes to name a few. The use of technology, however, not only enables more cost effective and more responsive processes, it also produces information that can be used to make other business decisions. For example, a purchase order launched in an ERP system makes available an array of new data that is used to monitor supplier performance, view accounts payable detail, gauge inventory values, schedule deliveries, and other activities. As technology makes this information more available across space and time, supply chain roles evolve into cross-functional, cross-knowledge teams, capable of further leveraging the data emerging from the performance of technology-driven work into new value-adding possibilities.
– *Using technology to move from 'informating' to networking*. With today's breakthroughs in technology connectivity, supply chains have the capability to move to the next level characterized by the integration and networking of knowledge and information. Peer-to-peer networking enables workers from all points in the supply chain to combines their talents and skills to work more efficiently and productively. Networking technologies enable workers existing at different points

in the supply chain to have access to and manipulate vast storehouses of data and to activate new joint opportunities to generate radically new processes and products and then to present them to the marketplace.

Supply chain technologies enable companies to be more *reliable* in the tasks they perform, *responsive* to the demand pull of the marketplace, and *agile* to rapidly respond to marketplace changes while reducing the *cost* of operating supply chain resources and efficiently utilizing supply chain *assets* to support demand.

3.2.5 Applying the Supply Chain Strategy Matrix

An effective way of developing supply chain strategy is to load a supply chain's performance attributes and drivers into a decision matrix [20]. An example of a strategy matrix is illustrated in Figure 3.11. The purpose of the matrix is to make visible the intersection of a supply chain's performance attributes with its operational performance drivers. The performance attributes are portrayed down the vertical portion of the matrix and they describe *what* goals the supply chain is to achieve. In the matrix, the five SCOR performance attributes have been selected. The performance drivers are found across the top of the matrix and they describe *how* the supply chain's capabilities and resources are to support attainment of the performance attributes.

Performance Attribute	Customer Focus	Channel Design	Sourcing	Inventory	Transportation	Technology
Relaibility						
Responsiveness						
Agility						
Costs						
Asset Management						
	Strategic Performance Drivers					

FIGURE 3.11 Supply chain strategy matrix.

The objective of the matrix is to provide planners with a visual map of the content of each performance driver needed to achieve each performance attribute in the vertical column. Depending on the nature of the business and marketplace objectives, the meaning of each strategic performance driver could change. For example, a distributor would consider *sourcing* differently than a manufacturer; an e-tailer that sells only through the Internet would have a different perspective of *transportation* than a bricks-and-mortar retailer. Also, it is unlikely that all business would consider each performance driver as of equal importance. Drug store chain Walgreen's strategy of establishing multiple stores in every community makes the channel design driver of extreme importance, while Prime Therapeutics, LLC, that uses only online sales from centralized distribution centers using the U.S. Postal Service for delivery, considers channel design as a less important part of their supply chain strategy.

For a large and multi-faceted company like Apple, it is possible to find complex performance objectives in each of the matrix grid cells. In order to highlight how the matrix is used, Figure 3.12 describes some of the more critical objectives a supply chain strategy would focus on for Apple Corporation. The level of importance to the supply chain is indicated as "High," "Medium," and "Low." The most important distinction is how Apple's multichannel market approach impacts the use of its supply chain strategic performance drivers. For example, Apple treats its *reliability* performance attribute very highly. Key competitive advantages the supply chain will need to support in this area are high product differentiation and quality, high sales and post-sales services, availability of easy to reach retail stores, 100 % inventory availability, and ease of online ordering technologies.

Performance Attribute	Customer Focus	Channel Design	Sourcing	Inventory	Transportation	Technology
Reliability	High product differentiation and quality, high service content (**High**)	Retail stores close to major markets (**High**)	Close supplier partnerships (**Medium**)	100% inventory availability, minimize obsolescence (**High**)	Use of 3rd party parcel post for online delivery (**Low**)	Easy to use online ordering (**High**)
Responsiveness	Store availability, quickly online sales delivery (**High**)	Facilities enable quick delivery of online sales (**High**)	Short restocking cycles (**Medium**)	Forecasting accuracy, push and pull replenishment (**High**)	Short cycle times for online deliveries (**High**)	Easy to use online order follow-up and returns (**Medium**)
Agility	Product availability (**High**)	Quick distribution of new products to all channels (**Medium**)	Utilize global supply chain, close linkage of R&D (**High**)	Reduce channel inventory rebalancing (**Low**)	Optimization of inbound and outbound transportation modes (**Medium**)	Total information systems (**Low**)
Costs	High cost for store inventory availability (**High**)	Locate online warehouses in low-cost areas (**Medium**)	Outsourcing to reduce production costs (**High**)	Pricing that optimizes profits, high retail store turnover (**Low**)	High cost for outbound online delivery (**Medium**)	World-class online ordering and order management technologies (**Low**)
Asset Management	Convenient store locations (**Medium**)	Control cost for retail facilities, high utilization of online facilities (**Medium**)		Close alignment of inventory with demand (**Low**)		Optimization of replenishment and online ordering technologies (**Low**)
	Strategic Performance Drivers					

FIGURE 3.12 Strategic supply chain performance matrix at Apple.

3.3 ACHIEVING STRATEGIC SUPPLY CHAIN "FIT"

The overall objective of the strategic supply chain performance matrix is to enable planners to attain a "fit" between the marketplace strategies identified at the business planning level and the capacities and resources available in the supply chain. The marketplace strategy details how customers are expected to view the channel's portfolio of products and services in terms of price, delivery time, variety, and quality. For example, Costco provides customers with a limited variety of commonplace products sold in bulk at low prices. The products Costco stocks can be purchased at any large grocery chain. What Costco focuses on is applying its performance drivers to maintain market share by enabling customers to shop at discount prices. Costco's business strategy succeeds because there is a close fit between the goals of its competitive and supply chain strategy goals.

3.3.1 Concept of Supply Chain Strategic Fit

The concept of strategic fit is illustrated in Figure 3.13 [21]. The vertical line represents the market requirements identified in the business plan. This dimension is composed of elements from the marketing strategy such as product/services differentiation, product life cycles, product variety and volume, distribution, brand recognition, pricing, order management, service expectations, and others. The horizontal line represents the capabilities and capacities of the firm's operations resources and processes. This dimension is composed of the supply chain's performance drivers and their ability to provide competitive advantage, efficient use of resources, and responsiveness to the business's market challenges.

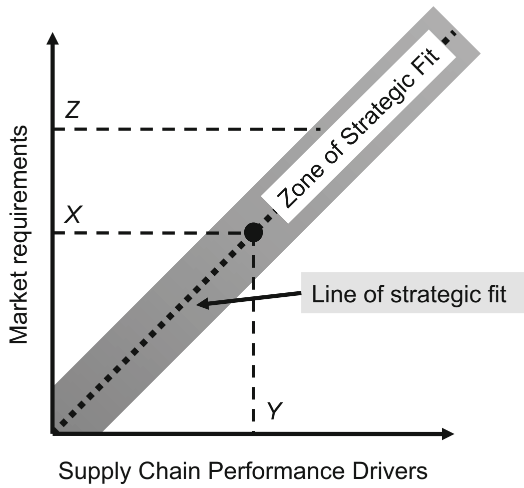


FIGURE 3.13 Concept of strategic fit.

If the market requirements and the supply chain performance drivers are in alignment they are strategically "fit." In Figure 3.13, the point where the degree of market requirements (indicated by "*X*") and the capabilities of the performance drivers ("*Y*") meet falls within the *zone of strategic fit*. A point that falls on either side of the *line of strategic fit* indicates that either resources are insufficient to realize marketplace objectives or resources are in excess of market requirements. Note that if the market requirements in a supply chain increase (position "*Z*"), it is imperative that the capabilities of the performance drivers increase proportionality if supply chain performance "fit" is to be maintained.

Establishing strategic fit can be undertaken from two directions. The first direction implies there is a low level of existing fit between market requirements and supply chain capabilities. In this environment, market requirements drive supply chain resources. Achieving strategic fit begins with a comprehensive definition of the market requirements and competitive positioning. Next, the market requirements must be translated into meaningful content that describes how the performance attributes of the existing supply chain resources will respond to market objectives. Finally, gaps occurring in supply chain performance drivers must result in the enhancement of resource capabilities to meet responsiveness targets. The second direction implies, on the other hand, that the supply chain possesses unique and strategic competitive capabilities and that markets should be shaped that fully exploit these core capabilities. For example, the product innovation capabilities of a company like Apple enable planners to build markets versus trying to fit products into existing market segments. In any case, the direction of achieving strategic fit is not absolute: the ongoing interplay between markets and supply chain resources continually exposes the company to new challenges and opportunities.

There are many obstacles inhibiting the achievement of strategic fit. Some of these obstacles are the result of growing uncertainty in demand and supply caused by market decisions. For example, a company may decide to increase its market responsiveness by reducing delivery lead times. Such a decision will require potentially significant changes to supply chain performance attributes and resource drivers. Possible responses are developing postponement processes to delay product differentiation, increasing production capacity flexibility, increasing buffer inventories to deal with growing demand and supply uncertainty, expanding the number of locations, and selecting transportation functions based on speed, flexibility, reliability, and quality. Other obstacles are increases in customer demand for shorter delivery times, lower cost, and higher product performance; globalization of the supply base; changing business and technology environments; and the development of new business and marketplace strategies.

3.3.2 Supply Chain Strategy Performance Metrics

Earlier it was stated that an effective supply chain strategy was composed of three components: the supply chain's performance attributes, drivers, metrics. This section turns to a discussion of the supply chain performance metrics. Adapting the metrics from the SCOR® body of knowledge, the key metrics corresponding to the five performance attributes are detailed as follows [22]:

- *Reliability*. The ability of the supply chain to perform tasks as expected.

Metric	Description
Perfect order fulfillment	The percent of orders meeting delivery performance (all items and quantities at the specified delivery time) with complete and accurate documentation and no delivery damage. *Calculation:* Total perfect orders/Total number of orders
% of orders delivered in full	The percent of orders in which all of the items received by the customer match the quantities ordered. *Calculation:* Total number of orders delivered in full/Total number of orders delivered
Delivery performance to customer commit date	The percent of orders that are received by the customer on the originally scheduled due date. *Calculation:* Total number of orders delivered on the original commit date/Total number of orders delivered
Documentation accuracy	The percent of orders with accurate documentation supporting the order, including packing slips, bills of lading, etc. *Calculation:* Total number of orders delivered with accurate documentation / Total number of orders delivered.
Perfect condition	The percent of orders delivered in an undamaged state that meet specification, have the correct configuration, and are faultlessly installed. *Calculation:* Total number of orders delivered in perfect condition/Total number of orders delivered

- *Responsiveness*. The speed at which tasks are performed.

Metric	Description
Order fulfillment cycle time	The average actual cycle time consistently achieved to fulfill customer orders. The metric spans the time for each individual order from the moment of order receipt until delivery and acceptance by the customer. *Calculation:* Sum of actual cycle times for all orders delivered/Total number of orders delivered
Source cycle time	The average time it takes to purchase items selected for replenishment. *Calculation:* Order release date/Various scheduling, receiving, payment cycle times
Make cycle time	The average time it takes to produce (make-to-stock, make-to-order, engineer-to-order) items for replenishment. *Calculation:* Order release date/Various scheduling, production, testing, packaging, staging, put-away cycle times
Delivery cycle time	The average time to deliver products. *Calculation:* Total number of orders delivered with accurate documentation/Total number of orders delivered
Perfect condition	The percentage of orders delivered in an undamaged state that meet specification, have the correct configuration, and are faultlessly installed. *Calculation:* Total number of orders delivered in perfect condition/Total number of orders delivered

- *Agility*. The ability to respond to external influences; the ability to change.

Metric	Description
Upside supply chain flexibility	The number of days required to achieve an unplanned sustainable targeted percent increase in flexibility in delivered quantities without a significant increase in cost per unit. Increase in percent of increased delivered quantity flexibility includes raw materials, production, quantity delivered, return of raw materials to suppliers, and return of finished goods from customers. *Calculation:* The least time required to achieve the unplanned sustainable percent increase when considering Source, Make, and Deliver. For example, if it requires 60 days to increase delivery by 5 %, the upside supply chain flexibility would be 60 days
Upside supply chain adaptability	The maximum sustainable percentage increase in adaptability of delivered quantities achieved in a targeted number of days. The metric includes quantity of raw materials, production, quantity delivered, return of raw materials to suppliers, and return of finished goods from customers. *Calculation:* Supply chain adaptability is the least resource sustainable when considering Source, Make, Deliver, and Return components
Downside supply chain adaptability	The maximum sustainable percentage reduction of ordered quantities at a targeted number of days prior to delivery without inventory or cost penalties. Reduction in percent of ordered quantities without penalties includes raw materials, production, and quantity delivered. *Calculation:* None identified
Supply chain value at risk	The probability of supply chain failures and their financial impact on supply chain functions (e.g. Plan, Source, Make, Deliver, and Return). *Calculation:* VAR (\$) = VAR (\$) Plan + Source + Make + Deliver + Return

- *Cost*. The cost of operating supply chain resources.

Metric	Description
Total supply chain management cost	The sum total of the costs required to execute SCOR Plan, Source, Make, Deliver, and Return processes. *Calculation:* Total sales minus profits – administrative costs
Cost of goods sold	The costs association with the procurement and production of supply chain inventories. The cost of goods sold calculation is composed of direct costs (materials, labor, and machine operations) and indirect costs (overhead). *Calculation:* Direct materials costs + direct labor (and machine) costs + indirect costs involved in procurement and production processing
Supply chain risk mitigation costs	The costs associated with managing non-systemic risks arising from non-predictable disruptions in the marketplace caused by such events as natural disasters, the competition, marketplace tastes, and technology. *Calculation:* Sum of costs to mitigate disruptions in SCOR Plan, Source, Make, Deliver, and Return processes

- *Asset management efficiency*. The ability to efficiently utilize assets.

Metric	Description
Cash-to-cash cycle time	The total time it takes for cash to flow back into the company after it has been spent on resources needed for production or finished goods stocking. The longer it takes to convert cash spent on production resources and accounts receivables, the more net working capital is required. Measurement is determined by converting into days the value of stocked inventories and the number of days outstanding for accounts payable and receivable. Inventory days are added to receivables days outstanding and then subtracted from days payable outstanding. *Calculation:* Inventory days of supply + days receivables outstanding – days payables outstanding
Return on supply chain fixed assets	Measures the return on capital invested in supply chain fixed assets. The measurement must first determine the supply chain revenue, cost of goods sold, and supply chain administrative costs. This amount is then divided by the supply chain fixed assets to determine the supply chain return on assets. *Calculation:* (Supply chain revenue – cost of goods sold – supply chain administrative costs)/supply chain fixed asset
Return working capital	A measurement that determines the size of the investment in supply chain fixed and variable assets relative to the supply chain's working capital position. Measurement is determined by monetizing supply chain profit and dividing it into the supply chain working capital position. *Calculation:* (Supply chain revenue – cost of goods – supply chain administrative costs)/(Inventory plus accounts receivable – accounts payable)

3.3.3 Balanced Scorecard Approach

Another tool for managing supply chain performance is the *Balanced Scorecard*. Developed by Kaplan and Norton [23], the concept is designed to provide strategic planners with a performance management methodology based on four perspectives: *financial results* (return on capital employed, asset utilization, profitability, growth), the *customer* (viability of the value proposition), *business processes* (effectiveness of the quality, flexibility, productivity, and costs accumulated by each business process), and *innovation and learning* (core competencies and skills, access to strategic information, organizational learning and growth).

While not directly created for supply network business planning, the method can be easily adapted to a supply chain environment. According to Brewer and Speh [24], implementing a supply chain balanced scorecard requires the following steps:

- *Step 1: Formulate strategy and build consensus*. The first step is for each channel partner to define their supply chain strategic objectives and understand where the strategies of each network participant converge or diverge. This activity will drive the metric selection process that will permit definition of the parameters detailing optimal performance for each supply chain participant.
- *Step 2: Select metrics in alignment with the supply chain strategy*. The performance measurements selected should support the four scorecard perspectives described above. For example, supply chain *financial* targets, such as increased market share, *customer* targets, such as on-time delivery, *business process* targets, such as facilitating the value chain from design through production, distribution, and delivery to the end customer, and *innovation and learning*, such as integrating cross-enterprise design functions to ensure the efficient development of the next generation of products, are defined and agreed upon by channel network partners.
- *Step 3: Integrate and communicate the metrics*. The general statements of desired performance must be decomposed into detailed, understandable, and actionable metrics that can guide internal and well as cross-channel daily operations. The use of the SCOR framework is an excellent source of metric definition to complete this step.
- *Step 4: Drive the organization to maintain and optimize the desired results*. This step ensures that the metrics detailed at the strategic and operational level of the supply chain scorecard are performed. The step includes accepting accountability for performance, targets for improvement, action plans, performance progress reviews, and linkage to individual performance and reward by all channel managers.

Figure 3.14 illustrates a supply chain balanced scorecard where network partners have selected increased *channel flexibility* as the critical success factor. The *financial* perspective opens the scorecard. The objectives to be pursued are centered on total channel cost reduction and revenue growth by leveraging materials and conversion strategies. It has been determined that a more flexible supply channel will reduce finished goods inventories, improve product throughput, and increase gross margins. Realizing this goal requires measures that demonstrate how well channel partners' operating costs and gross margins are progressing.

Supply Chain Objective: ***Increase Channel Flexibility***			
Measurement	Strategic Theme	Strategic Objective	Strategic Measure
Financial	Increased supply chain flexibility	Channel cost reduction Increased profit margins Revenue growth High return on assets	Increased cash flow Reduced channel inventory Improved fixed asset utilization
Customer	Perception of flexible response to customers	Customers drive product finalization Service individualization Increased product variety	Flexibility and agility of the supply channel Ability to deliver customized solutions
Business Processes	Postponement and value-added strategies	Increased synchronization Increased communication Fast flow of invent tories Multi-purpose facilities	Channel finished goods reduction Increased invent tory turns Processing efficiencies and utilizations Optimize transportation Warehouse storage reduction
Innovation and Learning	Increased material handling and processing capabilities	Increasing core competencies Motivating workers Skilling workers	Employee survey Personal balanced scorecard Total supply chain competency available

FIGURE 3.14 SCM balanced scorecard.

The purpose of emphasizing flexibility as the critical success factor is to gain *customers* by permitting them to configure and order products in real time and receive individualized service. Meeting this criteria rests on the capabilities of the *business processes*. Increased postponement will place a burden on channel nodes to increase the variety of products available while simultaneously maintaining or decreasing the time it takes for order configuration support. Realizing this goal requires measures that indicate the productivity of processing operations, total dollar value of finished goods, and how well warehousing and transportation costs are being optimized. Finally, the *innovation and learning* perspective is critical to the execution of the flexibility strategy. Increased postponement requires a higher level of workforce skill from each channel partner. Core competencies might have to be built or attained from outside the organization. New incentives and motivational programs might have to be enacted.

Architecting a supply chain balanced scorecard provides strategic planners with radically new challenges. Successful execution of the methodology requires companies to move beyond simply measuring the progress of the internal business to a perspective that considers channel collaboration, consensus, and total supply chain performance as the cornerstone of success. According to Brewer and Speh [25], the following eight critical hurdles must be spanned to make supply chain balanced scorecards a reality: *trust* among channel members in sharing data and measuring performance; *understanding* concerning the impact of how multi-organizational measurements might involve individual company negative consequences; lack of *control* over measures that depend on inter-channel partner efforts; presence of *different goals and objectives* among channel members; incompatible *information systems* that inhibit data transfer and visibility; varying definitions of the format, structure, and measurement approach to *performance measurements;* difficulty in *linking measures to customer value*; and *deciding where to begin*.

While a daunting task, the complexity should not dissuade supply chains from taking up the challenge: there is just too much to be gained by harnessing the productive power of collaborative supply chain performance measurement. The first place to start is to form cross-enterprise performance design teams. These teams need to move beyond a concern with local department-based measurements, which tend to splinter the performance development effort, and focus on cross-functional processes and accompanying metrics that crystallize objectives designed to increase cross-network channel integration. The goal is not to eliminate function-based measurements, but rather to broaden their effectiveness by integrating them with supply chain-level metrics that reveal how well each network business node is individually working toward goals that improve not only their own performance but also the overall performance of the entire supply chain. In addition, teams must be strong enough to tackle several other critical problems inherent in determining supply chain metrics. The measures decided on must be in synchronization with individual company and total supply chain strategies. The tendency to capture too many measurements must also be avoided. Participating companies must be encouraged to provide meaningful information on their performance. And finally, supply chain measurements can be beset by problems in defining basic terminology necessary to ensure common understanding of performance standards.

3.4 SUPPLY CHAIN STRATEGY AND RISK MANAGEMENT

It is difficult to discuss the crafting of supply chain strategy without a consideration of *risk*. All forms of business strategy involve the element of risk. It is simply not enough to make strategic decisions by considering the fit between performance attributes and operational drivers alone: strategists must also weigh the probability of internal and external disruptions that can doom even the best formulated strategic plan. In fact, the more complex the reach of the business strategy, the more it is exposed to negative risk events. As supply chains grow more global, they are exposed to a variety of unplanned risks, including supply disruption, supply delays, demand and price fluctuations, government regulation interference, and natural disasters. If appropriate risk management plans are not in place, these risks can significantly damage supply chain performance. The flooding in Thailand in 2011 exemplified how disruption in one geographical area affects companies all around the world. Thailand is the world's second largest computer hard drive manufacturer, so the flooding spread fear of parts shortages among global computer manufacturers. As analysts predicted that worldwide hard drive production would fall by as much as 30 % in the final quarter of 2011, computer manufacturers reacted by snapping up existing hard drive inventories. The long-term impact is still evident today in the increased cost of computer hard drives.

3.4.1 Defining Supply Chain Risk Management

Supply chain risk management has increasingly become an important subject and has become in many organizations the formal responsibility of a team of risk management experts. This trend stems from the rising visibility of channel risk. The natural disasters occurring over the globe in the last several years, as well as increasing information technology capability, have demonstrated to business management the rewards available through the practice of risk management. What is supply chain risk management (SCRM)? The *APICS Dictionary* defines SCRM as

> The variety of possible events and their outcomes that could have a negative effect on the flow of goods, services, funds, or information resulting in some level of quantitative or qualitative loss for the supply chain.

As implied by this definition, supply chain risk management is important for several reasons. To begin with, risk management stimulates supply chain best practices. For example, risk management is a key driver in the implementation of lean concepts and practices. Use of wasteful resources creates unnecessary risk to the organization and the supply chain and may potentially compound losses in other resources should a disruption occur. Second, risk management generally improves supply chain partner relationships as sharing of risk and risk information improves. It also increases trust among channel members since risk management demonstrates commitment and capability the supply chain can count on. Visibility to supply chain-wide risk stimulates recognition of the reality of the constant exposure of all organizations in the supply channel to the threat of unplanned disruptive events.

Third, risk management creates a heightened sense of the reality of soft risk (risk that is difficult to measure) and unintended consequences in business management. It underlines the need for constant awareness and vigilance toward decisions, practices, and goals that may unintentionally increase risk in the supply chain. Finally, every business decides on the tipping point of risk versus reward. Conventionally, earning a greater reward generally requires enduring a greater risk. Risk management ensures that risk exposure is minimized while the organization seeks optimal reward by efficiently and effectively leveraging its people, assets, capabilities, and resources.

3.4.1.1 Sources of Today's Evolving Supply Chain Risk [26]

Evolving changes in today's supply chain have accentuated the level of risk companies must face. The following are the major drivers of supply chain risk that must be considered by today's supply chain strategist.

- *Low-cost country sourcing*. With the opening of formerly closed economies in countries such as China, India, Viet Nam, and others, industrialized nations have eagerly sought to reduce their labor costs by relocating operations to low-cost countries. Against this cost advantage, however, companies have also had to weigh the impact of risk in the form of long lead times and exposure to political, security, regulatory, and currency instability that potentially can offset the cost benefits.
- *Outsourcing*. The search for lower costs for manufacturing products and performing operations by outsourcing them to emerging countries across the globe has become a commonplace strategy. Such a strategy, while improving cost levels and performance, also severely limits supply chain visibility and coordination. Literally, outsourcing has moved direct control and critical competencies out of the hands of local manufacturers and invested it with third-party suppliers.
- *Lean supply chains*. The growth of lean strategies for the removal of wastes in the supply chain has diminished buffer inventories everywhere in the supply channel. While fast flow operations counter many of the challenges posed by random channel disruptions, they also result in increased stock outs and further disruptions due to supply and delivery problems. The leaner the supply chain grows, the more it is exposed to unforeseen risks that normally are absorbed by inventory and process buffers.
- *Supply base rationalization*. A fundamental precept of lean is reduction of the supplier base and the growth of supplier partnerships. While this model is a reasonable approach to reducing the cost of managing suppliers and ensuring high quality and delivery, it also increases the risk of supplier non-performance and non-conformance, financial insolvency, and delivery disruption. Single-sourcing can result in buyers not having a viable supply alternative if disaster strikes their sole supplier.
- *"Siloed" business processes*. Risks also arise from faulty business processes *within* the organization. While lack of communication and disjointed business practices are normally outside business strategy, they do pose severe on-going risks to the organization. Poor organizational structures, adversarial corporate cultures, lack of communication and sharing of plans, and others all contribute to dysfunctional organizations that are as real a threat to company survival as an external competitor or natural disaster.

3.4.1.2 Basic Concept of Risk Management

Risk management is the process of identifying risk, analyzing exposures to risk, and determining how to best handle those potential exposures. A risk management strategy describes how an organization plans to address the vulnerabilities it has identified in its supply chain by controlling, mitigating, reducing, or eliminating the impact of risk events – the materialization of a seen or unforeseen adverse event. These basic characteristics of risk management are evident in Figure 3.15. Risk stems from uncertainty about the outcome of a strategy, a process, or an event. This uncertainty is heightened as the timing and accuracy about the information available concerning the event becomes unclear. As the risk grows, so does the potential for financial loss.

As indicated by the dotted line, risk managers must evaluate the risk to the enterprise relative to the potential cost exposure posed by the risk and the likelihood that it will actually occur. Points *X* and *Y* lie on a line representing a combination of risk and payoff that indicate the optimal choice for a decision. This line is also known as the *efficient frontier*. Effective risk

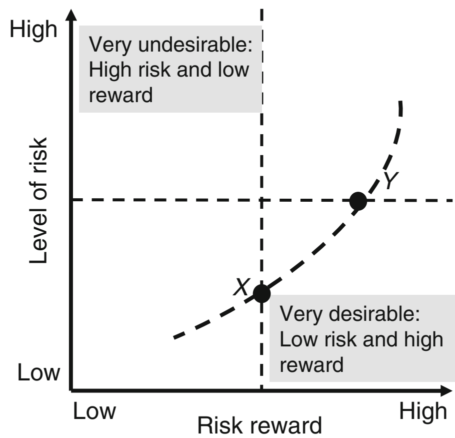


FIGURE 3.15 Basic concept of risk management.

management starts with an understanding that there is a trade-off between the cost of a disruptive event and the cost of preventing the risk from occurring. For example, to counter the risk that a top-selling item may stock out, extra safety inventory could be placed in the distribution channel. Determining how much the business is willing to pay in extra carrying cost to offset the possible risk of lost sales involves detailed analysis involving company performance objectives, financial targets, channel capacities, and marketing positioning.

Risk is generally defined as an uncertainty that endangers the accomplishment of business objectives or a hazard, source of danger, or possibility of incurring loss, misfortune, or injury. In general there are five forms of supply chain risk.

- *Supply*. This form of risk encompasses a range of possible disruptions originating with product and service suppliers. When inventories and services ordered do not appear as planned, a number of serious results can occur: plant shutdowns, inventory shortages, lost customer orders, excess expediting costs, loss of brand image, and others.
- *Process*. This form of risk occurs as a result either of a failure of a process or impact of a disruptive event on the performance of a process. Risk in this area arises from disruptions caused by quality problems, inventory shortages, late deliveries, capacity shortages, and equipment breakdowns
- *Demand*. This form of risk causes a disruption in the ability of the business to respond to customer or channel demand. Risk in this area arises from disruptions caused by problems in distribution flows, computer glitches, actions of competitors, and product quality failures.
- *Finance*. This form of risk causes disruptions to the ability of an organization to effectively manage financial issues. Risk in this area arises from disruptions caused by currency exchange instability, recession, financial failure, and stock market crashes.
- *Environment*. This form of risk is potentially the most disruptive since it often causes severe damage to facilities, productive assets, and logistics infrastructures. It is also the most difficult to predict. Risks in this area arise from disruptions caused by natural disasters such as hurricanes, floods, wind, draught, and earthquakes.

An effective method to investigate areas of possible risk is the use of a *supply chain risk map*. This map helps reveal concentrations and distributions of risk in a supply chain.

Risk map information facilitates mitigation planning, investigation, and implementation of risk management practices. It also helps prioritize supply chain risk efforts with partners. Another important benefit of a risk map is to integrate supply strategy with risk management. Risks that are inherent in the supply chain strategy, but that bring minimal to no reward for the risk incurred need to be addressed in both the supply chain strategy and supply chain risk management practice.

Figure 3.16 provides a very basic supply chain map and set of possible risks. Some of the risks affecting channel demand and supply are operational, such as lead times, quality, and capacity. Other risks are strategic, such as supplier financial stability, government regulation, and the actions of the competition. Still other risks are order of magnitude risks involving natural disasters, such as poor weather and global cyber threats. Drafting a supply chain map and then pinpointing the types and severity of the risks occurring in the supply channel is a fundamental way to begin assessing the risks a business faces. The supply chain risk map provides an excellent visual of where risk planners can begin to assemble the risk plans for the supply chain.

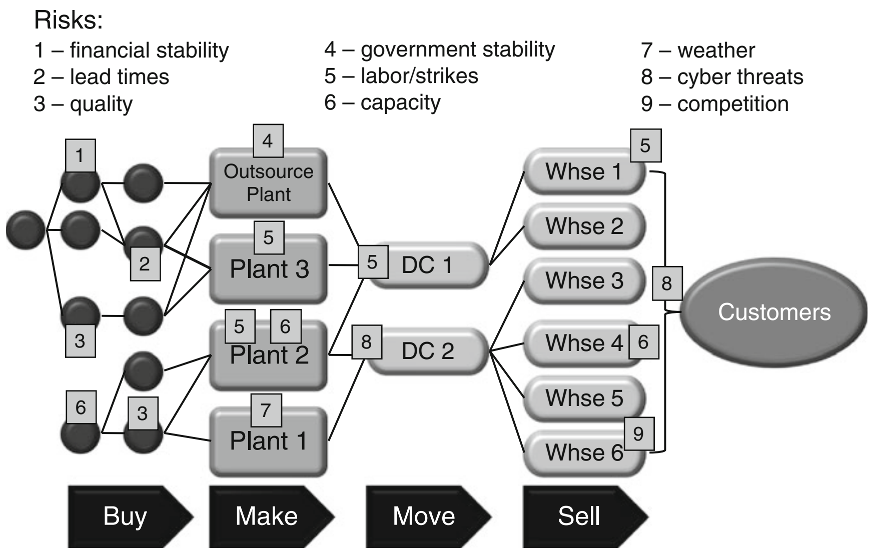


FIGURE 3.16 Supply chain risk mapping.

3.4.1.3 Supply Chain Risk Analysis Tools

Supply chain risk planners have several analytical tools they can apply to risk determination, probability of occurrence, and impact on the supply chain.

- *Value-at-risk (VAR)*. This risk management tool, which originated in the financial industry, converts risk to monetary value by multiplying the probability of risk times the financial exposure. The results of the VAR calculation assist planners to put a monetary or statistical value on the impact of a disruptive event or select the less risky of two possible courses of action.
- *Time-to-recovery*. This risk management process assesses how much time an organization (or supply chain) would need to fully recover from a specific disruptive event.

The smaller the time-to-recovery the less the impact the event has on a company's return to normal operations. A key component of time-to-recovery is ranking possible disruptive events and the possibility of their occurrence.

- *Statistical process tools*. Statistical models enable risk analysts to identify patterns of events occurring in the past that are then applied to the probability of their reoccurrence in the future. There are two general types of statistical modeling used in risk management. The first is *stochastic optimization*. This type involves evaluating risks by using algorithms incorporating probabilistic (random) sets of events either in the data or in the algorithm itself. The basis of stochastic modeling is that the problems considered involve *uncertainty*. The second statistical model that can be used is *deterministic modeling*. Deterministic modeling is used where the values are assumed to be exact and the computation is determined by the values sampled or observed. Since these models do not consider uncertainty, they do not use safety measures built into the decision model.
- *"Heat" Maps*. A *heat map* is a graphical representation of data where the individual values contained in a matrix are represented as colors or some other form. The object of a heat map is to convert a dataset into a graphical representation.
- *Resiliency index*. The purpose of the resiliency index is to quantify the level of risk posed by individual suppliers in the supply chain. Based on the resulting metrics, risk managers can develop a map showing where there are weaknesses in the channel, what types of weaknesses exist, and how severe is the risk.

An example of the application of VAR is calculating the level of risk in the wake of a possible supply chain disruption. A number of variables could be used, such as the type of risk, risk severity, the probability of the disruptive event occurring, time for the business to recover from the event, the area of the supply chain affected by the event, the estimated monetary value of the exposure, and others. Table 3.5 provides an example of a simple VAR calculation. There are two business functions used in the calculation: *sales* and *products*. To assist in understanding, the relevant elements in the VAR calculation have been placed in an Excel spreadsheet. The key values are:

- Sales monetary exposure (the base monetary value metric)
- Product monetary exposure (the base monetary value metric)
- Four possible risks to be considered (tornado/hurricane, fire, earthquake, and product quality)
- Estimated time to recovery from the disruptive event
- The estimated probability of the event occurring
- Any comments about the risk

Once assembled, these values are then used to calculate the VAR. The formula used is as follows:

$$\text{VAR} = \text{Exposure} \times \text{Probability of Occurrence}$$

The goal of the exercise is to determine the size of the VAR for each disruptive event. This value would represent the financial loss to the organization if the disruptive event actually occurred. For example, it is estimated that a tornado or hurricane would cause damage of US

TABLE 3.5. VAR – Sales and Product Exposure Example

Risk	Exposure (US$MM) ($)	Time-to-recovery (Months)	Probability (%)	VAR (US$MM) ($)	Comments
Tornado/ Hurricane	450	12	5	23	Total plant shutdown
Fire	450	6	12	27	Partial plant shutdown
Earthquake	450	12	1	4.50	Low probability
Product quality	700	3	15	26	Quality review and retooling

$450MM, take 12 months to recover from, and would have a 5 % chance of occurring. The VAR then is calculated as US$450MM times 5 % times percent of year (100 %), or a VAR of US$23MM (rounded). Even though the number is a rough calculation, it still provides risk planners with a benchmark they can use to prioritize supply chain risks and begin the task of developing risk avoidance strategies.

"Heat" maps provide a visual representation of the impact or possible impact of a disruptive event on a supply chain. Figure 3.17 provides an example of a heat map illustrating the various levels of risk to a company with a series of suppliers located in Japan and South Korea after the 2012 Japanese earth quake and tsunami. The heat map works as follows:

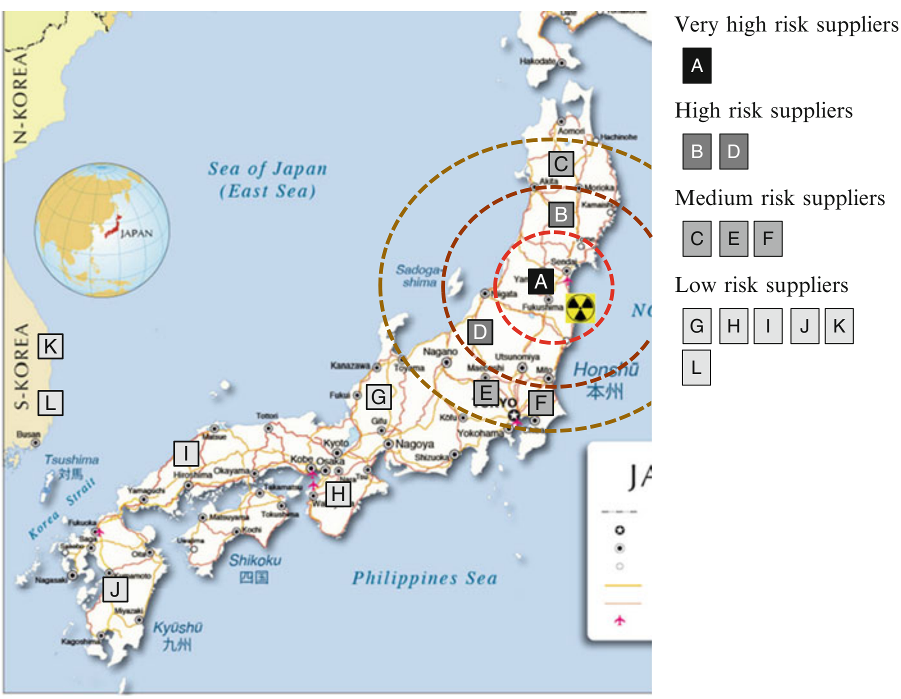


FIGURE 3.17 Heat map – Japanese earthquake (2012).

1. A map of Japan is used.
2. The epicenter of the disruptive event (the Fukushima nuclear power plant) is then located on the map. This point represents the area of the highest risk to a company with suppliers in Japan and South Korea. For the most part, these suppliers received crippling damage with a long-term rate of recovery.
3. The level of severity spreading out from the epicenter is determined. These levels are placed inside increasing-sized circles indicating the severity of the disruption.
4. All suppliers used by the company are then located on the map.
5. Each supplier is then rated as black (very high risk), dark grey (high risk), grey (medium risk), and light gray (low risk).

Once the heat map is completed, risk planners can plan for several actions to mitigate the impact of the disruption on their operations. The heat map enables planners to ask the following important questions: What products and services are supplied from the affected region. Which manufacturers and distributors of goods and services are impacted by the disruption? How much inventory is in the supply channel? What impact will this disruption have on the supply channel's ability to produce and sell products and services to the marketplace? How has the disruption inhibited shipping product from and to the affected region? What do supply chain planners do next to mitigate the disruption? Do planners have visibility beyond tier 1 suppliers in the region?

3.4.2 Managing Supply Chain Risk Resiliency

Figure 3.18 displays a template for the development of a SCRM strategy [27]. A risk management strategy describes how an organization plans to address the vulnerabilities it has identified throughout the supply chain by controlling, mitigating, reducing, or eliminating risk and the impact of risk events.

FIGURE 3.18 Template for SCRM strategy.

The proposed SCRM strategy template contains four core components:

- *Policy*. Government restrictions and regulations is a significant source of supply chain risk. At the same time, positive government intervention can shape better trade, security, investment, and other policies that directly or indirectly affect resilience. Governments should aim for maximum flexibility during times of disruption, while providing incentives for building resilience during times of stability. Governments can also act as conduits for information during times of crisis. Governments that are able to provide strong information flows play a critical role in protecting supply chains.
- *Strategy*. As time and conditions change, what was once a viable risk response strategy may be wholly inadequate in a period of increased volatility. While it is possible to create new strategies, it is perhaps the ability of existing SCRM strategies to adapt, rather than the strategies themselves, that creates resiliency. To make this attribute a core competency, supply chain risk managers, for example, should be able to synthesize external and internal data and rapidly take action to minimize the impact of any risk event. This also means that supply chain structures should be adaptable and agile, so that they can quickly adjust and respond to changing marketplace conditions.
- *Partnership*. As supply chain collaboration grows, companies are developing long-term partnerships with their suppliers. Partnership enables resilience to be built via improved security, information sharing, and knowledge exchange. Joint risk response strategies promote risk sharing, risk recovery, and understanding that buyer and supplier are facing supply chain risk as common partners.
- *Information*. The ability to network information significantly assists supply chain resilience by providing access to databases for analytics, data and information sharing, scenario modeling, and pre-programmed responses. Supply channel continuity is protected through access to real-time data, followed by rapid dissemination of data-driven solutions to emerging channel disruptions. Network information systems depend on a resilient core network, appropriate communication tools, and some redundancy. The foundation of effective SCRM technology strategy requires technology systems that are scalable, secure, and re-routable.

3.4.2.1 Strategies for Controlling Supply Chain Risk

Since the prospect of a disruptive supply chain event occurring is inevitable, risk managers can employ three basic strategies to counter a disruptive event when it does happen.

- *Prevention strategies*. The goal of these strategies is to pre-design solutions that completely prevent (or reduce the frequency of) a disruptive event from occurring. The classic approach to prevention strategies is to inspect and audit operations. By closely reviewing the output of operations to the established standards, risk managers can easily identify when process activities are exceeding their acceptable range and are moving toward failure. The more managers have control over a potential risk, the more preventive methods can be used. Prevention strategies have a limit to their usefulness. For example, preventive measures are not applicable to disruption caused by a natural disaster or outside forces the supply chain has no control over.
- *Event management strategies*. The goal of these strategies is to isolate an event and minimize its possible negative consequences. If the disruption is not too severe, the organization can accept the event and work through the problems. The impact of the

event could also be transferred to a business partner. Finally, the impact of the risk could be mitigated by using a contingency plan.

- *Recovery strategies*. The goal of recovery strategies is to accept the consequences arising from a disruptive event but then to minimize, alleviate, or compensate for the impaired processes. Recovery strategies normally start once avoidance and mitigation strategies no longer suffice to work through the disruptive event. Recovery strategies require well-developed procedures and methodologies if the recovery process is to remain in control.

Controlling risk is influenced by the organization's tolerances for risk, the specific risk level, the responses to each risk that are possible, and the cost of the risk response. Risk level is commonly described using the following equation:

$$\text{Risk Level} = \text{Probability of occurrence} \times \text{magnitude of loss}$$

Supply chain planners can respond to risk by using any of the following five basic responses.

- *Avoidance*. Risk avoidance is defined as changing a plan to eliminate a risk or to protect plan objectives from a disruptive event. The goal of avoidance is basically not to engage at all in a specific activity containing a certain level of risk. Avoidance is used when the probability of a disruptive event occurring far outweighs the economic advantage to be gained. For example, some pharmaceutical companies do not develop vaccines because of the risk of lawsuits from harmful side effects.
- *Acceptance*. Risk acceptance is defined as a decision to take no action to deal with a risk or an inability to format an effective plan to deal with the risk. Risk acceptance is often the strategy for low probability, low magnitude risks or risks that have high costs of transfer or mitigation. In other words, the risk is worth the potential gain. For example, sovereign risk includes the risk that a government could nationalize an entire industry. For each country an enterprise operates in, it will have to accept this risk. (If the risk is considered significant, a company could avoid or transfer the risk by not working in the country or by finding an outsourcing partner in that country.)
- *Transfer or share*. The enterprise can move the resource or financial effects of a risk to a third-party organization such as an insurance company or a supplier. This requires purchase of insurance, bonding, or contractually transferring risk to an outsourcing partner. However, not all risks can be transferred. For example, risks to production schedules caused by core competency activities that define part of the process's total end-to-end lead time cannot be transferred.
- *Mitigation*. Mitigation is useful to manage events that cannot be prevented. Mitigation often takes the form of a contingency plan that provides an alternative to the impaired processes so that business can be carried on. Mitigation strategies do not normally serve as a source of risk prevention. An example would be to have a secondary supplier available in case of failure at the main supplier.
- *Redundancy*. Building in redundancy means having back-up processes or resources in case of a failure or disruptive event. Redundancy is normally an expensive proposition and should only be used when a failure will result in a major problem. Redundancy means doubling or even tripling backup resources or processes so that these 'redundant' elements can be quickly put into action on the occasion of a disruptive event (see Table 3.6 [28]).

TABLE 3.6. Supply Chain Risk Redundancies

Approach	Strategies
Increase capacity	Build low-cost, decentralized capacity for predictable demand and centralized capacity for unpredictable demand
Acquire redundant suppliers	Multiple suppliers for high-volume and reduced number of suppliers for low-volume products in a few flexible suppliers
Increase responsiveness	Select cost over responsiveness for commodity products. Select responsiveness over cost for short life-cycle products
Increase inventory	Decentralize inventory of predictable, lower-value products. Centralize inventory of less predictable, higher value products
Increase flexibility	Select cost over flexibility for predictable, high-volume products. Select flexiblity for low-volume, unpredictable products. Centralize flexibility in a few locations if it is expensive
Aggregate demand	Aggregate customer order management and shipping as unpredictability grows
Increase capability	Select capability over cost for high-value, high-risk products. Select cost over capability for low-value commodity products. Centralize high capability in flexible source

The ideal risk management program is one that applies a comprehensive methodology to counter the possibility of a disruptive event before it actually occurs. Given a set of risks that are considered significant enough to warrant a risk response and an approved action plan to address the risks, risk teams should follow the following sequence of activities (Figure 3.19):

FIGURE 3.19 Supply chain risk response methodology.

- *Generate preventive action plans for each risk to be mitigated.* The primary function of the supply chain is to keep goods, information, and payments flowing through business channels. Significant risks to the supply chain are events that might disrupt these flows. Examples are listed on Figure 3.19. Responses to these risks include: vehicle preventive maintenance, backup power supplies, extra capacity, safety stock, use of third party logistics services, insurance, GPS tracking systems, supplier certification, backup suppliers, assessing supplier's economic viability, compliance to audits and new regulations, RFID devices, diversification of the customer base, and use of CRM tools. Preventive action can lead to easier implementation of contingency plans.
- *Implementing preventive action plans.* Failure to implement preventive plans is a risk in itself. Organizations need to assign to an individual the responsibility for turning a plan into a project. This entails defining the goals for all stakeholders and setting expectations (e.g. targets and what the plan will and will not address), winning final project approval and release of funds, and exercising project management to execute the project. The plan's relative level of success against its goals must be measured. The risk response plans should be periodically updated by removing old and adding new risks to the list, modifying risk probabilities, and other appropriate action.
- *Preparing contingency plans*. Contingency plans are ways to prepare the organization to respond quickly and effectively to identified and unforeseen disruptive events. Contingency planning involves designating specific individuals to take on specific roles during an emergency. Contingency plans are step-by-step instructions and plans that indicate priorities for restoring services such as communications, vital information systems, and key production processes. Contingency plans should be tested and employees and managers trained to understand and implement them in the event of a disruption.
- *Coordinating and sharing risks among supply chain partners*. Successful risk response plans are a formal and systematic process coordinated among supply chain partners to reduce the negative impact of disruptive events on the supply network. Plans should provide visibility and quantification of risk among supply chain members through processes such as joint risk identification and contingency planning. Risk response planning needs to be fully integrated into the supply chain's regular business processes for it to be effective. A way to achieve this integration is to perform regular progress reviews and risk response plan update meetings involving staff from a number of functions as well as supply chain partners.

3.4.3 SCRM Maturity Model

An important gauge of the preparedness of the supply chain strategy to thrive and prosper is weighing the maturity of the SCRM plans. Measuring the maturity of today's supply chain requires a different look at what traditionally made a supply chain successful. While it is true that mature supply chains are focused on collaborating with channel members to provide the highest levels of profitability, responsiveness to the customer, and efficiency on all channel levels, they must also assess the level of maturity of their risk management strategies and tactics.

As illustrated in Figure 3.20, plotting SCRM maturity moves across four key attributes.

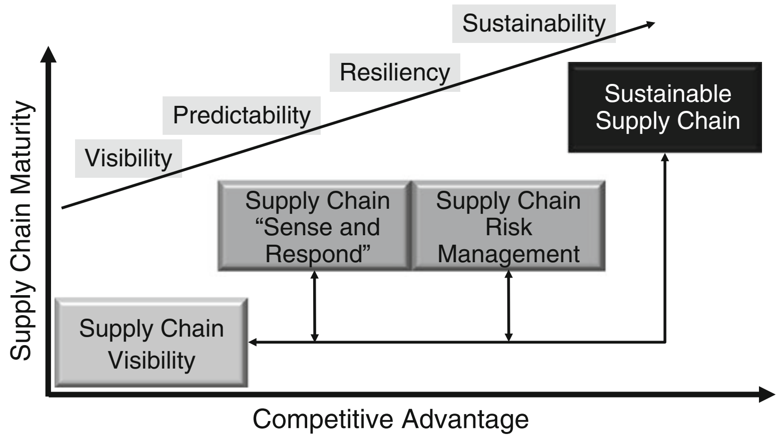


FIGURE 3.20 SCRM maturity model.

- *Supply chain visibility*. This attribute requires making supply chain risk visible by mapping who, where, when, and what. This attribute places agility and nimbleness as the central operating features of the mature supply chain. In turn, the flexible supply chain contains three operating principles: management of visibility (access to and broadcast of critical supply chain risk information); velocity (speed by which risk intelligence moves through the supply chain); and variability (management of change driven by disruptions occurring in the marketplace and in supply chain capabilities).
- *Predictability*. This attribute seeks to dampen the effect of supply chain disruption by using risk management methods that make the channel environment more predictable. The goal is to increase supply chain resilience by identifying and profiling risk variables, quantifying risk for supply chain strategy decision making, and activating mitigation alternatives so that supply chains are adjusted intelligently to meet the daily challenges of changing global economic and market conditions.
- *Resiliency*. This attribute is defined as the ability of a supply chain to recover from disruptions of any type. Mature supply chains use metrics such as time-to-recovery, value-at-risk (VAR), and resiliency indexes to provide visibility to impending disruptions and enable the establishment of effective preventive and mitigation plans that ensure a company's viability in the wake of disruptive events.
- *Sustainability*. The keynote of a world-class supply chain is its ability to sustain high levels of performance regardless of changes in supply channel structures, the trauma of disruptive events, and the pressure of the competition. Sustainable supply chains attempt to integrate bottom line capabilities (profitability, low cost, and responsiveness) with the emerging "triple bottom line" goals covering environmental, economic, and social trends. Mature supply chains overcome the negative challenges of the marketplace by leveraging the core competencies of the internal organization and the deepening collaboration of supply channel partners to build resilient supply networks.

Supply chain strategists perform several steps to enhance the maturity of their SCRM plans. To begin with they must look across their supply chains and gauge the level of SCRM maturity. Do risk planners have current SCRM plans from at least their most important channel partners? Are they sending their SCRM plans to their channel partners? Have they seized the opportunity to look at combined channel risk plans, time-to-recover estimates, and recovery road maps for important supply chain risks? Second, risk planners should then proceed to determine how well the SCRM plans align with supply chain risk tactics and strategies. Older supply chain strategies may not have fully contemplated today's supply chain risks. As supply chain strategies become closer aligned to actual practice, planners should see an improving risk-reward balance. For example, where the supply chain strategy calls for increased cycle-time speeds, it will correspondingly need to manage risks associated with higher costs for more flexible transportation, increased channel inventories, and more delivery locations. There might be specific risks that can be reduced, transferred, or shared so that worthwhile rewards are retained.

Third, SCRM plans must be kept current and relevant. Among plan components are maintaining realistic time-to-recovery estimates and paying particular attention to significant single point of failure channel risks. Over time, as contingency planning evolves in order to remain current and relevant, planners can more easily spot trends or gain insights that are useful to better manage a portfolio of risks. Risk teams may also find new metrics, leading indicators, or data points along the way that serve multiple risks. Finally, SCRM maturity can be increased by continuously identifying root causes of risk and ranking them by priority. What enablers, dependencies, or practices cause risks to become more probable? More damaging? Why does the supply chain tolerate this risk? Have less-than-optimal supply chain practices developed over time to try to mitigate the risk? Answering these questions not only helps to mature risk management strategies, it also reveals ways to improve supply chain performance. In a mature SCRM environment, an organization perceives risk management as a strategic, long-term function of supply chain planning and process management. Instead of a one-time effort to get a handle on the current risks facing their supply chains, the risk management process is seen as a foundational process for the business's financial, strategic, and operational plans and functions that enable managers to remain resilient in the face of possible disruptive events while enabling them to effectively measure risk against reward to take advantage of market opportunities.

3.4.4 Effect of Supply Chain Management on Resiliency

As supply chains evolve from an operational model – a pipeline for the efficient movement of goods – to integrated webs of fluid, responsive ecosystems of people, processes, and technologies, they have enabled businesses to be more resilient in the wake of disruptive events. Four key attributes make the resilient supply chain possible [29]:

1. *Agile execution*. The degree by which supply chains are able to rapidly change configurations, increase and decrease capacities at channel crisis points, leverage collaborative relationships with channel partners, formulate effective contingency plans, and implement advanced technologies, such as predictive analytics, the greater the chance they have of withstanding disruptive events. The objective is "flexible resource allocation" made possible by an elastic supply chain infrastructure.
2. *Adaptable channel structures*. Resilient enterprises have engineered highly adaptable products, processes, and systems capable of being easily modified to counter the impact of a disruptive event without compromising on operational efficiencies. Examples include flexible manufacturing systems that can be quickly retooled to

counter sudden demand shifts by changing volumes and mixes; multiple access to critical components to prevent supply disruptions; alternative transportation modes when normal routes are disrupted; and alternative distribution channels to deliver products around troubled geographical areas or failed channel partners.

3. *Visibility*. Resilient supply networks excel in deploying demand-gathering, planning, and execution technologies that reveal events as they actually occur. This information, in turn, enables them to rapidly reconfigure and re-synchronize supply and delivery resources in response to a disruptive event through automated exception handling, directed workflows, directed resolution, and overall network management. At the heart of supply chain visibility is found technology tools that *connect* supply network partners. Connectivity refers to a wide range of data transfer processes. These technologies provide for the merger, harvesting, and analysis of supply chain data intelligence associated with blockages in the supply chain, loss of suppliers, channel partner financial problems, and sudden shifts in marketplace demand. Once notification of supply channel abnormalities occurs, the close networking of trading partners provides for the efficient rebalancing of channel resources. Visibility tools include alert-driven signals revealing unplanned product shortages (or excesses), emergency plant shutdowns, process failures, unexpected outlier demand, and evidence of wide variance of actual demand and supply against the plan. Finally, the ability to capture, analyze, and simulate the impact of risk events on supply chain performance is essential to the selection of alternative paths enabling the company to avoid the worse effects of a disruption.
4. *Flexible innovation*. Increasing companies' abilities to respond to possible disruptions includes making product design and process development less rigid. Important tools are reducing product, component, and process complexity so that alternative materials and production processes can be easily plugged-in when normal operations are disrupted. Even operational issues such as reducing product changeover times, small lot-size production, order management tools that smoothly and rapidly rebalance customer demand and warehousing, and embracing multichannel networks and technologies provide significant levers in making companies more risk tolerant.

3.5 SUMMARY

The central challenge to today's enterprise is simply stated as the ability to establish and maintain competitive advantage in a global business environment. Perhaps the most critical dynamic in achieving this objective is the strength of the supply chain strategy. An effective supply chain strategy enables the business to grow value by increasing customer *responsiveness*, increasing the *efficient* use of supply chain resources, and decreasing the *cost* of supply chain operations. These fundamental objectives are realized by leveraging the configuration of supply chain channel capabilities, executing aggregate and detailed demand and supply plans maximizing business value; and optimizing the performance of supply chain operations to realize customer responsiveness, efficiency, and low cost goals.

Before supply chain strategies are developed, corporate planners must first seek to align corporate-level goals, strategies, and growth expectations with today's economic and marketplace realities. The first step in the corporate planning process is the crafting of a comprehensive strategic business plan. The process begins with an analysis of the external and internal business environments. The *external environment* reveals the enterprise's competitive strengths, the forces driving marketplace change, the actions of competitors, opportunities for future success, and attractiveness of the firm's products and services to customers. The *internal environment* reveals the internal strengths and weaknesses (resources, core competencies, capacities, and capabilities) and how they enable the enterprise to succeed in its competitive space.

The development of effective corporate-level plans involves five steps. The first is the definition of the enterprise's long-term vision and corporate mission culminating in the formulation of the objectives management wants to achieve as well as serving as the basis for tracking the company's progress and performance. The second step is concerned with determining the concrete courses of action the enterprise must follow if it is to realize the corporate mission and objectives. In the next step, the corporate strategy is translated into business unit mission, goals, and strategies. Business-unit strategies are separated into five generic types: low-cost provider, broad differentiation, best-cost provider, focused low-cost provider, and focus differentiation.

Step four is concerned with the development of functional business unit strategies. In this area, the functional business departments (marketing, sales, production, logistics, and so on) must each have a strategy that details how departmental competencies and capabilities support the business unit strategy. The final level of corporate-level planning is the creation of business unit operating strategies. Operating strategies are concerned with the management of operating units, such as plants, distribution warehouses, and transportation, and specific operating activities such as logistics, marketing campaigns, product development, and budgeting. The objective of operating unit strategies is to ensure that the resources and capabilities of the organization can realize the competitive advantages being sought by the business unit and detailed functions.

Supply chain strategy is one of the five major functional strategies (marketing/sales, financial, human resources, and engineering/design) of a business unit. Supply chain strategy creates value through five activities: operating cost reduction, value creation through increased revenues, competitive advantage through differentiated customer service capabilities, and competitive advantage through strategic supplier engagement. These competitive values are realized through three central components of supply chain strategy. The first is the establishment of the *performance attributes* that guide operational goals. The SCOR® model defines these attributes as reliability, responsiveness, agility, costs, and asset management efficiency. The second component centers on establishing how the supply chain *process drivers* (customer focus, channel design, sourcing, inventory, transportation, and technology) will be used in pursuit of targeted levels of resource responsiveness and efficiency. The final component of supply chain strategy is defining the *performance metrics* detailing business performance to plan.

An important tool to guide planners in supply chain strategy design is the *supply chain strategy matrix*. The purpose of the matrix is to make visible the intersection of a supply chain's performance attributes with its operational performance drivers. The goal of the process is to enable planners to attain a "fit" between the marketplace strategies identified at the business unit planning level and the capacities and resources available in the supply chain. Obstacles inhibiting strategic fit are the result of growing uncertainty in demand and supply; increases in customer demand for shorter delivery times, lower cost, and higher product performance; globalization of the supply base; changing business and technology environments; and the development of new business and marketplace strategies.

It is difficult to conclude a discussion on crafting supply chain strategy today without a consideration of *risk*. It is simply not enough to make decisions regarding supply chain strategies by considering the fit between performance attributes and operational drivers alone: planners must also weigh the probability of the emergence of internal and external disruptions that can doom even the best considered strategic plan. In fact, the more complex the reach of the business strategy, the more the supply chain strategy is exposed to disruptive events. As supply chains grow more global, they are exposed to a variety of unplanned risks, including supply disruption, supply delays, demand and price fluctuations, government regulation interference, and natural disasters. If appropriate risk management plans are not in place, these risks can significantly damage supply chain performance. All in all, supply chain resilience is improved by the following six best practices:

- Enhancing supply chain partner relationships
- Improving supply chain risk mapping
- Developing greater information system backup and redundancy
- Simulating or drilling risk contingency plans
- Developing greater diversity in supply chain materials, partners, and logistics
- Optimizing supply chain safety stock levels and locations

DISCUSSION QUESTIONS

1. What information do strategic planners expect to get from performing external and internal business environmental scanning?
2. Detail the steps used to craft a corporate business strategy.
3. Discuss Michael Porter's five generic competitive strategies.
4. Why is a supply chain strategy so important for an effective corporate business strategy?
5. How does supply chain strategy create value?
6. Explain the basic trade-off between responsiveness and efficiency for each of the supply chain performance drivers discussed in the text.
7. Explain the role of each of the supply chain performance drivers in supply chain strategy.
8. Establishing strategic "fit" can be undertaken from two directions. What does this mean?
9. What are some of the obstacles planners face when attempting to establish a strategic fit?
10. Why is supply chain risk management important?

REFERENCES

1. This concept of the external business environment was popularized by Moore, James F. 1996. *The death of competition*. New York: HarperCollins.
2. The seven external environmental factors are drawn from Thompson, Arthur A., A. J. Strickland, and John E. Gamble. 2005. *Crafting and executing strategy: Text and readings*, 14th ed, Chapter 3. New York: McGraw-Hill Irwin.
3. See Porter, Michael E. 1980. *Competitive strategy: Techniques for analyzing industries and competitors*, Chapter 1. New York: Free Press.
4. This process is detailed in Ibid., Chapter 7.
5. All references to the APICS Dictionary in this chapter are from the 14th edition (2013).
6. Porter, Michael E. 1985. *Competitive advantage*, 37–43. New York: Free Press.
7. These company vision statements have been gathered from Thompson, et al., 19.
8. Hayes, Robert H., and Steven C. Wheelwright. 1984. *Restoring our competitive edge*, 25. New York: John Wiley & Sons.
9. Thompson, et al., 27.
10. Kotler, Philip. 1988. *Marketing management*, 6th ed, 33. Englewood Cliffs: Prentice Hall.
11. Porter, *Competitive strategy*, 35–40.
12. See the analysis in Porter, *Competitive advantage*, 3.
13. Lee, Hau, Kevin O'Marah, and Geraint John. 2012. The chief supply chain officer report. *SCM Word White Paper*, 14–19.
14. Hayes and Wheelwright, 395–408.
15. This section references the analysis of operations strategy found in Slack, Nigel, Stuart Chambers, Robert Johnston, and Alan Betts. 2009. *Operations and process management*, 2nd ed, 38–40. New York: Prentice Hall.
16. For example, Slack, Nigel, and Michael Lewis. 2003. *Operations strategy*, 19. Upper Saddle River: Prentice Hall, define operations performance objectives as consisting of *quality, speed, dependability, flexibility*, and *cost*. These attributes could easily applied to performance objectives of supply chains.
17. The *SCOR: Supply Chain Operations Reference Model*, Version 11.0 (Supply Chain Council, 2013), 1.2.4–1.2.5.
18. Hill, Terry. 1994. *Manufacturing strategy*, 2nd ed, 43–76. Boston: Irwin-McGraw Hill.
19. For more on the concepts of automation and networking, see Ross, David Frederick. 2011. *Introduction to supply chain management technologies*, 2nd ed, 37–41. Boca Raton: CRC Press.
20. The concept of a strategic attribute and performance driver matrix is adapted from Slack and Lewis, 56–59.
21. The concept of strategic fit discussed in this text has been adapted from Slack and Lewis, 59–60 and Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operations*, 4th ed, 21–34. Upper Saddle River: Pearson/Prentice Hall.
22. These supply chain strategy performance metrics have been abstracted from The *SCOR: Supply Chain Operations Reference Model*, 2.1–2.5.14.
23. Kaplan, Robert S., and David P. Norton. 1992. The balanced scorecard: Measures that drive performance. *Harvard Business Review* 71–79; Kaplan, Robert S., and David P. Norton. 1996. *The balanced scorecard: Translating strategy into action*. Boston: Harvard Business School Press; and, Kaplan, Robert S., and David P. Norton. 2001. *The strategy-focused organization: How balanced scorecard companies thrive in the new business environment*. Boston: Harvard Business School Press.
24. Brewer, Peter C., and Thomas W. Speh. 2001. Adapting the balanced scorecard to supply chain management. *Supply Chain Management Review* 5(2):48–56.

25. Ibid.
26. See the excellent summary in the Kinaxis white paper entitled "Supply Chain Risk Management: Knowing the Risks – Mitigating and Responding for Success," *Kinaxis Corporation* 2012, 4–5.
27. Reference Wright, Jonathan. 2013. Taking a broader view of supply chain resilience. *Supply Chain Management Review* 17:25–31.
28. Reference the classic definition in Chopra, Sunil, and Manmohan S. Sodhi. 2004. Managing risk to avoid supply-chain breakdown. *Sloan Management Review* 46(1):53–61.
29. These points are found in Wright, 31.

4

Designing Channel Networks

A fundamental task of supply chain management (SCM) is structuring supply and distribution channel networks. As emphasized in Chapter 1, no business is an island. All businesses are suppliers of products and services to their customers as well as customers of some other business's products and services. But supply chains go much deeper. In reality, all businesses are members of supply chains consisting not only of their own customers and suppliers, but also of their customers' customers and suppliers' suppliers. Structuring effective supply chain systems is, therefore, fundamental to the ability of all organizations to effectively leverage the resources and competencies of their channel partners to achieve competitive success.

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_4) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_4,

The diversity and complexity of supply chain arrangements make it difficult to generalize the many decisions planners make when structuring an effective channel network. Planners must understand the possible outcomes of channel economic and business relations involved in any particular decision. They must also have a firm grasp of what customers want and expect from a supply channel, what it will cost to meet customer goals, and which channel partners will provide the right mix of resources and capabilities. Ensuring that a supply channel successfully satisfies the customer and increases the profitability of network participants requires considerable planning and negotiation. Even when a channel strategy is implemented, planners will over time make changes, modifying the network links to eliminate unforeseen costs and capture unexpected opportunities. The task of channel network design must address such questions as: How many echelons should be in the supply and distribution channel? Where should channel facilities be located? What level of customer service should be attained? What are the capacity levels of each channel facility? How deep is the ownership of supply and distribution channels and when should a firm use independent channel partners? What channel design models are available to assist channel planners in making critical decisions regarding channel network design?

Chapter 3 is concerned with how producers and distributors design effective supply chains that enable member companies to pursue high levels of collaboration, profitability, and customer service. The chapter begins with a definition of channel networks. A crucial distinction is made between *supply chains* (which consist of all organizations connected to the sourcing, production, and delivery of products and services to the customer) and *channel networks* (which consist of cooperative interrelationships of linked channel members built over time). Next, the chapter discusses the different forms channel networks can take: transaction-based, limited channel, federated, partnerships, and alliances. An important focus is placed on detailing why channel networks exist and what are the critical channel design considerations to be considered.

Following these introductory comments, the chapter introduces a five-stage model for executing channel design processes. Design planners are expected to first map the channel strategy; then segment the customer base; explore possible channel configurations; select the channel structures that best optimize channel customer service and cost objectives; and, finally, select channel members, define the boundaries of channel power, manage channel conflict, and achieve strategic collaboration.

4.1 DEFINING CHANNEL NETWORKS

Previous chapters used the terms "supply chain" and "channel networks" as basically equivalent. In reality, there is an important distinction between the two. The *APICS Dictionary*, for example, defines a *supply chain* as "The global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash" [1]. This definition describes a supply chain as being the totality of primary and secondary suppliers, producers, and customers used by a company to produce and sell its goods and services to the marketplace. The linkages between customers and suppliers in this supply chain model can be direct-collaborative, indirect, or impersonal-purely transactional. For example, the relationship between a manufacturer and the supplier of a critical component will be direct and collaborative. The manufacturer may also maintain an indirect relationship with the supplier's supplier that provides the necessary raw materials the first tier supplier uses to produce the component. Finally, the manufacturer has a purely transactional relationship with a number of suppliers for the purchase of non-essential commodity components governed by market price and convenience of ordering.

In contrast to a supply chain, a *channel network* is "an interconnection of organizations which relate to each other through upstream or downstream linkages between the different processes and activities that produce value in the form of products and services to the ultimate customer" [2]. There are several characteristic features of a channel network that differentiate it from the more general concept of a supply chain:

- Channel networks usually consist only of a company's *first-tier* suppliers and customers.
- A company rarely forms network relationships with suppliers and customers beyond the first tier.
- Channel members perceive their relationships as established on a long-term basis.
- The cooperative, often collaborative, relationships that exist are perceived by channel members as an essential component of their continued success in the marketplace.

As will be further explored, the nature of a channel network depends on a matrix of factors, such as the desired level of market penetration, how deeply forward and backward integration with channel partners is to extend, and how intensive is the targeted level of product and service distribution.

Of all the factors, perhaps the most critical in choosing a particular channel network is the degree of *functional dependence* involved. Is the channel to be characterized as purely transactional, unencumbered by channel dependencies, or is it based on a relational dependence among channel constituents? What are the required capabilities and costs of dealing with each network entity and how are they to be woven together? What is the distribution of power among channel players: who wields the most and who the least power? What are the strengths and weaknesses of the competition and how are existing channels responding to the initiatives of these alternative formats?

4.1.1 Exploring Channel Systems [3]

When crafting a network channel, strategists have a choice of four types of systems. In the first, *transaction-based systems*, there is minimal-to-no dependency between channel trading partners. Such systems, in fact, are formed for the performance of an often non-repeated transaction. The products or services are normally confined to commodity products or very expensive durable goods, such as machinery or other processing equipment, and the services rendered are usually customized around a unique event. Once the transaction is completed, the likelihood of continued interaction is remote. These companies are described as being minimally, if at all, part of a company's channel network.

In many ways the second type of delivery network system, a *limited channel*, is similar to a single-transaction system in that businesses only engage with other firms to capture a marketplace opportunity. Once executed, buyers and sellers do not seek to form extensive dependencies. Limited channels are defined as loose arrangements of businesses that intermittently and opportunistically coalesce with channel specialists in the buying and selling of goods. The overriding objective of such channels is achieving best selling price and short delivery time, and their longevity is directly dependent on the ongoing usefulness of the arrangement. There is little or no loyalty in a limited channel, minimal effort is expended to build collaborative partnerships, and there is minimal desire to improve channel efficiencies. Often channel relations are characterized as adversarial and arrangements can be dissolved at a moment's notice. Finally, limited channels do not view their success at providing value as stemming from the capabilities of their network partners. Each firm stands alone and autonomous, free to choose or disengage from any trading partner as long as they augment the internal objectives of the business.

In contrast, a *federated network system* is formed by businesses that acknowledge mutual dependencies and actively seek to integrate individual core competencies, resources, and market opportunities on a long-term basis. By pooling together the specialties of each channel member, a federated network realizes levels of efficiency, profitability, and customer value that could not be achieved by individual firms acting alone. A critical factor driving coalescence is that each participating member perceives the relationship as fair and equitable and that they will financially and competitively benefit in the short- and long-term from the arrangement. Unlike the first two types of delivery channels, where firms compete on their own, federated networks enable channel partners to compete as a unified delivery system.

Federated networks are not new. Collaborative relationships among channel members are found in a variety of forms, from partnerships, joint ventures, and strategic alliances to consortia, franchising, royalty, and licensing agreements. Several dynamics dictate how the federated channel will work. To begin with, the presence of a dominant channel player, who either owns or controls a channel network, like a Wal-Mart or a Home Depot, or possesses so much power that network partners have no alternative but to fully cooperate, result in networks that are driven by strong contractual arrangements where the channel master seeks to control partner behavior and diminish opportunities for conflict. Members benefit by participating in the economies of scale resulting from volume transactions, enhanced marketing exposure, and removal of system redundancies. This type of federated delivery network describes about 80 % of today's consumer market.

Another type of federated network is partnerships and alliances. *Partnerships* arise when two or more firms integrate core competencies and resources in the pursuit of an emerging market opportunity. Each participant in such an arrangement agrees to surrender some of its independence to achieve long-term benefits arising from cooperative marketing, operations, and information sharing. A serious drawback of a partnership is the inability of the relationship to withstand conflict stemming from differences in operations or go-to-market strategies. When businesses agree to move to the next level of cooperation by jointly undertaking to improve performance, cost effectiveness, and competitiveness, this type of federated network is called an *alliance*. While it can be voluntary, most alliances are centered on contractual agreements. Examples are franchises, dealerships, and warehousing and transportation service agreements. Contracts provide network partners with a sense of permanence where risks, profitability, and accountability are shared legally.

4.1.2 Basic Channel Networking Structures

The structure of any channel network is composed of supply and delivery nodes and the links connecting them. Perhaps the simplest way to portray a channel network is to see it as a series of linked trading dyads as exhibited in Figure 4.1. In this model, channel networks consist of series of primary and secondary trading relationships where supply and delivery functions are performed one channel partner at a time. Normally, the supply and demand relationships between trading dyads are closed to other members of the channel network.

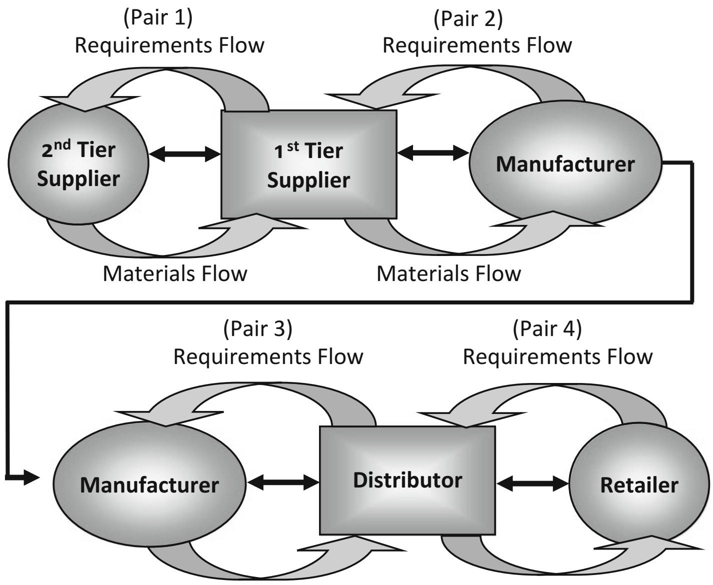


FIGURE 4.1 Channel dyads.

While this basic model is characteristic of some channels, it does not work well with today's multichannel strategies where companies buy from any supplier and sell to any customer. For example, a channel intermediary, such as a large retailer like Wal-Mart, could literally be dealing with hundreds of suppliers and customers, some of whom sell to each other. For most channel constituents, the supply chain looks less like a closed series of dyads and more like a power grid representing an extensive network of customers and suppliers, many simultaneously interacting with each other.

Since it is virtually impossible to form close relationships with each member of such large channel ecosystems, each channel node must clearly identify the supply and delivery channels it uses directly to acquire products and services and to drive delivery to the end-customer. This extended network should be constructed around a common strategy and set of operational objectives that support the channel's collective best interests. This step should also reveal incongruities between the strategies and metrics of individual partners and areas of potential conflict. The goal is to tightly integrate the various links that constitute the reach of the channel network. Without strategic and operational alignment, the channel will have weak links that easily break as the pressure of demand variability and limitations in network resources appear at critical points in product or marketing campaign lifecycles.

Finally, as direct convergence matures, the number of nodes occupying positions outside the channel network, both upstream and downstream, are brought in from the supply chain and integrated into the channel network. The goal is to increase the length of the contiguous channel network, thereby expanding opportunities for collaboration, focus on customer value, operations excellence, and supplier integration. For example, as illustrated in Figure 4.2, a large channel master (the Regional DC) receives products from various suppliers and sells to various stores, customers, and consolidators with which it has a direct channel relationship (channel nodes occupying positions in the solid colored space).

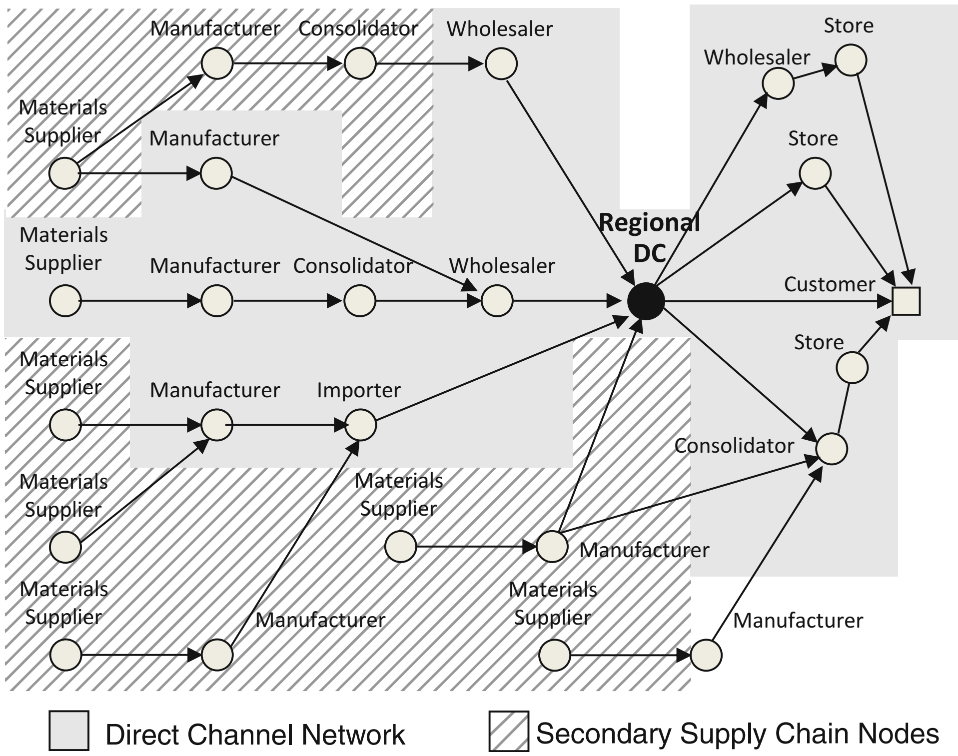


FIGURE 4.2 Channel network alignment structure.

The various companies out in the supply chain, which the Regional DC neither directly trades with nor treats as transactional partners, occupy positions in the diagonally striped spaces. While the goal is to absorb as many supply chain nodes into the network as possible, channel network strategists must be careful not to over expand a unified channel system to the point where resources and benefits are diluted by conflicts and compromises over costs, performance metrics, service value propositions, and delivery velocity targets. In fact, some companies may find themselves working with several separate supply chains and supply and delivery networks as their business ecosystems evolve in new directions.

4.2 NETWORK CONFIGURATION: DEFINITIONS

Configuring a channel network has a significant impact on performance because it determines the physical structure of the channel and sets constraints on the channel demand and supply drivers governing how it manages costs and pursues market opportunities. Channel configuration decisions affect the amount of flexibility the channel has to adapt to marketplace changes, how many facilities are needed and where are they to be located, what is the capacity of the channel, and what inventories and customers are assigned to each channel node. Finally, the channel configuration impacts total production, inventory, and transportation costs needed to satisfy the network’s customers.

4.2.1 Reasons for Channel Networks

If customers could be presented with the goods and services they want instantaneously, there would be no reason to build channel networks. Since there is often a lag between the time customers order a product or service and when it can be delivered, companies must establish distribution channels to facilitate their ability to reduce customer wait time and costs. Companies establish distribution channels to meet the challenges of the following critical drivers.

- *Customer service*. Servicing the customer drives the creation of channel structures in two ways. First, a business decides that the number of existing internal channel facilities or outside channel partners are insufficient to meet current or potential customer service levels. "Insufficient" is defined as limited plant capacity, length of lead times, or the existence of obsolete warehouse technology. By expanding the channel network, companies hope to trade the cost of an expanded channel network for additional sales gained by increasing response flexibility or improving logistics functions. The second reason driving channel expansion is a strategy that moves demand fulfillment resources closer to new markets. Because of the growth in products, services, and market share, businesses may wish to expand their reach into markets currently on the peripheral of their existing channel structures. Reasons for expansion could also include the establishment of new state-of-the-art facilities.
- *Relocation*. Often, shifts in such factors as product offerings, markets, population, transportation access, industries, technologies, availability of raw materials and energies, growth of competitors, environmental or governmental regulations, and general operational expenses will force a company to expand its channel network to include alternative geographical areas. These and other factors, for example, are found at the core of the historical shift of industry from its former stronghold in the U.S. Northeast to the South and Southwest.
- *Flexibility and scalability*. In today's global, fast-paced business environment, channel networks have increasingly been subjected to a state of perpetual change as they seek to be responsive to shifts in customer demand, costs structures, product innovation, new forms of technology, and corporate mergers. The solution is to design channel networks that are agile and flexible enough to be able to easily expand, contract, relocate, and outsource to channel partners. In a very real sense, companies often establish channel networks just to remove time and space differences between themselves and suppliers and customers.
- *Product diversification*. When a company diversifies a product line, it might prove advantageous to locate it in a new facility close to raw materials, product suppliers or producers, and/or customer markets. Diversification, driven by the acquisition of a supplier's or competitor's product lines, often requires the firm to assume the plant, distribution facilities, equipment, and personnel of the former company. In any case, the objective is to pursue a channel strategy that minimizes logistics expenses while enhancing customer service performance.
- *Rationalization*. An easy method to improve return on investment (ROI) and cash flow is to reduce the amount of capital needed to operate large assets such as plants, warehouses, and transportation assets. Employing the latest optimization tools, real

estate management expertise, and lean channel management strategies, companies can reduce costs and increase profitability by consolidating inventories and resources and eliminating unnecessary facilities. Often these activities will require companies to consolidate the channel network by centralizing functions or relocating facilities to provide better customer service at a reduced cost.

- *Decentralization.* The opposite channel network strategy is to expand the number of channel networks nodes and partners as a result of a decision to decentralize product lines and service delivery. The reasons for such a decision are optimization of outbound logistics responsiveness; tariffs and tax incentives; community zoning, government, or environmental restrictions; favorable exchange rates; greater specialization of activities; simplified administration; and increased customer response time and local presence.

4.2.2 Network Channel Design Considerations

Once it has been determined that a company will establish, reduce, or expand a channel network, several fundamental design decisions must be considered. Design decisions are critical because they determine the overall performance goals of the channel configuration. All network decisions affect each other and either increase or decrease channel cost and responsiveness to the customer. Collectively, the decisions made relating to channel design considerations should always support the business strategy and accurately reflect the channel's capabilities.

The following design decisions must be taken into consideration.

- *Facility role.* Channel planners must decide what role each facility and channel partner is to play in the channel network. Included are decisions regarding what processes, inventories, and transportation functions are to be performed by each channel node and partner. These decisions are critical because they determine the level of flexibility the channel network possesses to quickly adapt to changes in costs and customer service. Options include whether facilities are to be storage, consignment, cross-docking warehouses, or a combination.
- *Balancing efficiency with responsiveness.* Effective channel network design requires balancing efficiency (least-cost) with responsiveness (quick response to changing marketplace demand). Channels characterized by relatively stable demand and product and service offerings tend to focus primarily on efficiency. Channels with volatile or seasonal demand and short product life cycles tend to focus on responsiveness. As channel networks strive to improve performance, it is essential that they strike the right balance between efficiency and responsiveness.
- *Facility location.* Decisions regarding the number and location of facilities are very critical since they represent a long-term commitment on the part of the firm. A good location is one that enables the facility to keep operating costs low while realizing high levels of customer service. Among the other location decisions is determining whether to centralize in order to gain economies of scale or to decentralize to gain responsiveness to the local customer. An important consideration is the establishment of the transportation links ensuring timely and cost effective movement of inventory in the supply channel. Finally, location decisions must take into consideration

macroeconomic and regulatory factors such as workforce availability, quality of life, availability of utilities, and government restrictions and taxes.

- *Capacity allocation*. Decisions in this area determine the types and levels of capacities of channel facility resources needed to meet performance targets. Excess capacities enable a facility to be flexible and scalable to meet changing demand patterns. On the negative side, excess capacities render a facility less efficient. On the other hand, a high-utilization facility, while being efficient, will lack adaptability to respond to unplanned variations in marketplace demand.
- *Supply and distribution channel integrative intensity*. This decision area relates to the level of ownership a company decides to pursue relative to the different echelons of its external supply and distribution channel networks. A strategy that seeks to increase ownership of channel partners is normally driven by the desire of the channel master to increase channel control. The advantages of such a strategy are direct interaction with the customer, control of sources of vital production materials, and increased control over pricing, promotion, brand awareness, and inventory. The negative side to increased ownership of channel nodes is higher costs to manage an extended channel network.
- *Logistics costs*. Logistics costs in a channel network will change as the number of facilities, their location, and capacity allocation change. Logistics costs associated with inventory and facilities management increase as the number of facilities in the channel increase. Normally, transportation costs decrease as the number of facilities increases, but could reverse if inbound transportation economies of scale are lost. Total logistics costs are determined as the sum of facility, inventory, and transportation costs. The number of channel facilities should at least equal the number that minimizes total logistics costs. Addition of facilities beyond this point must be counter-balanced by increased sales driven by better customer response times.

4.3 CHANNEL NETWORK DESIGN PROCESS [4]

The purpose of the channel network design process is to ensure the channel configuration optimizes customer service at the lowest operating cost. Effective channel network design involves two major functions: (1) design of the best channels in terms of service and cost, and (2) channel design implementation. As illustrated in Figure 4.3, the channel design consists of four major steps: mapping the business strategy to basic channel alternatives; segmenting customers to match channel service outputs; review of possible channel configurations; and channel network selection. The final step, channel implementation, is concerned with managing channel power, conflict resolution, and adaptation of channel structures to meet changing conditions.

4.3.1 Map Channel Strategy

The first step in supply channel design is mapping the business strategy to alternative channel structures. Companies, for example, with strategies emphasizing cost leadership tend to locate production plants and distribution centers at least-cost locations, regardless of where their markets are. Strategies focusing on responsiveness tend to locate facilities close

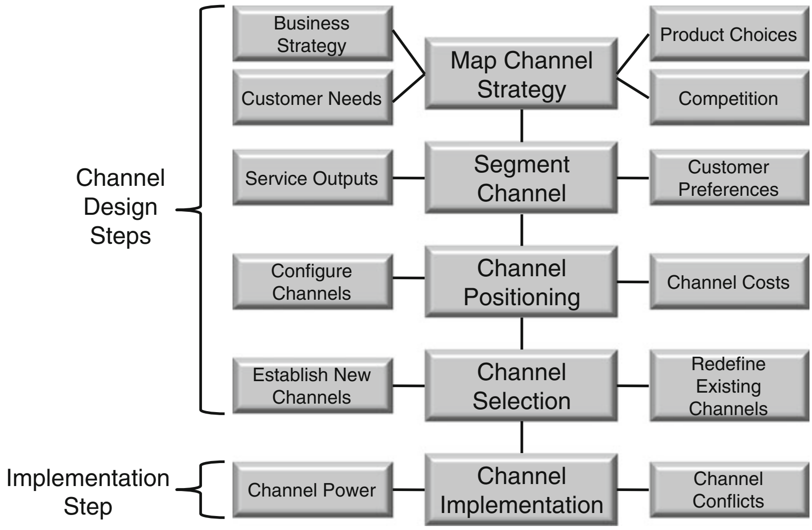


FIGURE 4.3 Channel network design process.

to the markets they serve, even if this means selecting high-cost locations. The goal is to be able to react quickly to the changing needs of customers. In addition to location, channel planners must be cognizant of capacities. Allocating too many resources to a location risks poor utilization, while allocating too little results in poor responsiveness. Channel planners must continuously review channel structures as the channel grows to adjust total production, inventory, warehousing, and transportation resources to meet new marketplace demands.

The McMaster-Carr Supply Company, for example, has chosen a quick-response strategy. This multi-billion dollar a year U.S. distributor stocks over a half a million SKUs which they can deliver within a 24-h window. To facilitate this strategy, McMaster-Carr has five distribution centers (DCs) positioned strategically across the U.S. Orders arrive at the main office in Chicago, and from there are routed to the closest DC for delivery to the regional customer. In contrast, Barnes & Noble Booksellers has chosen a very different distribution strategy. B&N has over 675 storefront locations throughout the U.S. that sell their products directly to the shopping customer. In addition, B&N has a multi-channel strategy. The company uses the Internet to sell books and other products directly to the customer. Orders are received at central sites and then routed to regional DCs for shipment using the U.S. Postal Service. For more esoteric titles and used books, B&N uses a partner network that receives the orders and ships directly to the customer. Recently B&N expanded its market reach by offering e-books bought online and read through their Nook device. Other companies might choose strategies that emphasize convenience, such as 7-Eleven, or low-cost warehouse sales models such as Costco and Sam's Wholesale Club. Each will require a specific channel structure to support their chosen business strategy.

4.3.1.1 The Channel Network Matrix

An important model used to assist companies design effective supply and demand channels is the *channel network design matrix*. All organizations must use supply partners to acquire production materials or finished goods and determine the role of channel distribution entities to deliver the product to the customer. As illustrated in Figure 4.4, companies must determine how supply and demand channel structures will support the business strategy by deciding on how the six channel design attributes will be leveraged to support the business strategy.

Supply Channel			Distribution Channel		
Supply Channel Complexity	Supply Integrative Intensity	Supplier Intensity	Market Penetration Intensity	Distribution Integrative Intensity	Distribution Intensity

FIGURE 4.4 Channel design matrix model.

Before practical use can be made of the matrix, it is important to first define the six design attributes illustrated in Figure 4.4. The three *supply channel attributes* are described as:

- *Supply channel complexity*. This attribute describes how many echelons deep in the supply channel a producer or distributor will extend their planning and acquisition of production or finished goods inventories.
- *Supply integrative intensity*. This channel attribute is concerned with how far back in the supply channel a company wants to control product sourcing. This could involve extending backward in the channel through ownership of supply sources or negotiated contracts with suppliers for exclusive or limited rights to products and services. Among the issues involved are ensuring specific levels of quality, quantity availability, and protection from the inroads of competitors.
- *Supplier intensity*. This channel attribute is concerned with how the production process choice affects the scope and depth of the partnerships existing with primary and deeper echelons of suppliers. Partnership will involve such issues as collaboration on product designs and specifications, shared cost, and mutual responsibility of total quality management.

The three *distribution channel attributes* are described as:

- *Market penetration intensity*. This attribute describes how many echelons deep in the delivery network producers or intermediaries must go to deliver goods to the customer. The desired level of penetration will require the formulation of strategies associated with capabilities and costs (executing delivery activities), channel power (distribution of influence among channel players), and competitive actions (presence of competitors and buying alternatives).
- *Distribution integrative intensity*. This channel attribute determines the level of forward integration a company chooses to pursue in the delivery channel. Forward integration identifies how much control a company seeks over downstream customer-facing delivery echelons. Horizontal integration refers to a level of control whereby a company acquires a former channel intermediary. According to the matrix map, the more a product or service is customized, the more intense is the control over downstream channel delivery functions. For example, a producer of highly configurable plant heating and cooling equipment will most likely control the entire channel from marketing, production, and delivery to onsite service. On the other hand, an electronics commodity producer like Sony will depend on a complex, multi-echelon delivery

network of third party distributors and retailers that assume responsibility for a wide range of functions from promotion and pricing, to delivery, merchandizing, and product warranty.

- *Distribution intensity*. This attribute determines the number of intermediaries needed to bring products to the end-customer. There are four strategies available. In the first, *single source distribution*, a producer performs all distribution activities. This strategy is chosen by producers who wish to retain control over marketing elements such as brand, delivery, price, promotion, and service. In the second strategy, *intensive distribution*, a company seeks to utilize a broad and deep distribution network to reach as many customers as possible. The third strategy, *limited distribution*, is pursued by companies who want to limit the number of intermediaries who deal with customers. This strategy takes two forms: *exclusive distribution*, in which a producer authorizes exclusive distribution rights to a select group of intermediaries, and *exclusive dealing,* where a producer restricts intermediaries to selling only its products. The final strategy, *selective distribution* permits select intermediaries, but not all possible intermediaries, to handle and sell its products.

A broad example of how the distribution channel design matrix is used is to match the different forms of production with the supply and distribution attributes on the matrix. The reasoning is that the nature of how products are produced influences how channel designers will use the matrix attributes to structure supply and demand channels. There are five production methods used in the matrix.

- *Project*. This process choice is used to produce a wide variety of large scale, highly unique products associated with a project. This type of process is highly flexible and can cope with a broad range of product designs and design changes. It is often used in shipbuilding, house construction, oil well construction, and in service industries such as motion picture production and IT application software implementation.
- *Job shop*. This process choice is associated with make-to-order (MTO) production environments. Each job is produced to customer order and involves very low production rates using very flexible equipment. Many products are one-of-a-kind. Examples include specialist tool making, furniture production, make-to-measure tailoring, and printing.
- *Batch*. This process choice is similar to the job shop process, but variety is lower and volume is higher. Products are normally built based on standard bills of material and routings. Small batch process production differs little from a job shop, but large batch production (batch flow) is similar to repetitive mass production processes. Batch processing is often used in machine tool manufacturing, components that go into mass-produced assemblies (automobiles), clothing lines, and some gourmet frozen foods.
- *Mass*. This process involves the production of standardized products or products subject to fixed features and options produced in high batch volumes in a narrow variety. These products are normally considered make-to-stock (MTS). This process is used in consumer durables (refrigerators) manufacturing, most food processing, and beverage bottling.
- *Continuous*. This process produces a very narrow range of highly standardized, commodity products in high volumes utilizing dedicated equipment. Price and low

cost are the key determining factors. Examples include chemicals, grains, petroleum products, fertilizers, steel, electricity, and glass.

The basic design matrix detailed in Figure 4.4 has been expanded in Figure 4.5 to include the five production process types and how the channel design attributes would be applied to each type. For example, for a producer of one-of-a-kind products, *supply chain complexity* is low because materials are usually purchased on a one-time basis from suppliers one echelon deep. On the other hand, common materials or components used in a mass or continuous production process normally require highly complex supply chains involving detailed planning and negotiations extending several supply echelons deep.

Standard/Intense Distribution
Custom/Single Source

Supply Channel				Distribution Channel		
Supply Channel Complexity	Supply Integrative Intensity	Supplier Intensity	Process Method	Market Penetration Intensity	Distribution Integrative Intensity	Distribution Intensity
Low	Very Low	Very Low	Project	Low	Very High	Low
Low/ Medium	Low	Low	Job Shop	Low	High	Low
Medium	Low/ Medium	Medium	Batch	Medium	Medium/ High	Low/ Medium
High	High	High	Mass	High	Medium/ High	Medium/ High
Very High	Very High	Very High	Continuous	Very High	Low	Very High

FIGURE 4.5 Channel design matrix – example.

Since materials are purchased for unique jobs, a producer of unique products would have low *supply integrative intensity*. For example, a job shop would not seek backward ownership or special supplier controls that extend beyond the supply requirements of specific projects. On the other hand, a company with make-to-stock products may actually purchase key suppliers to guarantee a constant supply of production inventories and keep critical components out of the hands of competitors. The extent of *supplier intensity* will depend on the depth of collaborative relationships. For example, a producer of mass produced products will seek close partnerships with essential suppliers to ensure a constant flow of high quality materials and components while a custom producer, that often buys inventories on a spot-purchase basis, will have low supplier intensity.

When it comes to the distribution side of the matrix, a producer must decide on the level of *market penetration intensity* necessary to reach the customer. For example, since custom producers create unique products to customer order, they normally have fairly shallow delivery channels. Commodity producers, on the other hand, are constantly searching to expand market penetration of product and service offerings and will pursue very high market penetration strategies. Likewise, a custom producer is more apt to deliver products to customers directly from the factory and has very high *distribution integrative intensity* versus a commodities producer that rarely delivers to the end-use customer. In fact, a commodities producer would depend on very high *distribution intensity*, seeking to establish extensive echelons of channel partners to execute last-mile delivery, while a custom manufacturer would have a low distribution intensity, delivering directly from the plant to the customer.

4.3.1.2 Deciding on Vertical Integration or Channel Intermediates

A critical decision that drives the *distribution integrative intensity* attribute of the channel design matrix is centered on ownership of the nodes in the distribution network. One option is for a company to vertically integrate (own some or all of the distribution channel); another option is to outsource to independent entities some or all of the channel's distribution functions. There are many arguments for vertical integration. Issues such as brand control, direct contact with the customer, control over pricing and promotions, and direct information feedback from the marketing channel are but a few.

Probably the most critical factor driving a company toward or away from vertical integration is *efficiency*. Efficiency is the ratio of operating performance (revenues) to the resources (direct costs and overhead) expended. For the most part, producers do not vertically integrate the distribution flow because it is typically inefficient to do so. The commitment to establishing remote facilities, personnel, inventories, local marketing, and logistics functions is expensive and it diverts corporate focus away from its prime role as a producer. However, a producer could own the distribution channel if it has the resources and the strategy increases efficiency in the long run.

Most producers and channel intermediates, however, choose to outsource their distribution channel flows simply because it is more efficient. According to Coughlan et al., independent distributors possess six advantages in performing channel functions [5].

1. *Motivation*. Independent channel intermediaries are highly motivated to provide superior service. The reason is that they are accepting the risk of stocking, storing, and delivering inventories plus conducting sales and marketing functions in return for the expectation of reward. Both positive motivation (profit) and negative motivation (fear of loss) drive these channel entities to perform. Often these businesses operate on narrow margins and focus on inventory turnover and cost management. The key to the motivation advantage is that these intermediaries are replaceable, and thusly subject to the market discipline of upstream channel players. Channel intermediaries are thus under constant pressure to improve operating results centered on both increasing sales and decreasing costs. In contrast, vertically integrated channels do not have such strong motivation and channel facilities cannot easily be decommissioned for low performance.
2. *Specialization*. Unlike a vertically integrated producer that must develop core competencies in both product and distribution management, an independent channel intermediary is focused solely on performing distribution functions. As upstream channel entities seek to narrow their organizations around core competencies, outsourcing distribution has become an essential strategic choice.
3. *Survival of the economically fittest*. The business of a distribution intermediary is relatively easy to enter and just as easy to fail. Because they are so specialized, intermediaries do not have alternate revenue sources that can make up for losses sustained by sub-par performance. In the end, the more successful channel distributors quickly weed out the poor performers, leaving the most efficient distributors in charge of the market.
4. *Economies of scale*. One of the important roles of a channel distributor is to aggregate the inventories of multiple producers or specialized distributors. Pooling of different product lines provides them with a significant advantage over vertically integrated

channels which only carry the products of the production plant. Pooling provides the distributor with economies of scale to offer broad product lines and accompanying services that enable them to amortize the fixed costs of distribution facilities, equipment, personnel, and so on. The intermediary's deep brand assortment enables them to capture a wide customer base which justifies its existence which otherwise would be uneconomical. Reference a W.W. Grainger or a McMaster-Carr that successfully trades-off the high fixed and variable cost involved in stocking extremely broad assortments with high customer sales.

5. *Heavier market coverage*. The ability of independent distributors to appeal to a wide marketplace stems from their ability to call on a large customer base, often local in origin, with an assortment of products and services that meet their individual needs. Instead of a single product line offered by a vertically integrated channel driven by a producer, distributors will marshal a diverse portfolio of products for the smallest of customers. By meeting the multiple needs of the customer base, the sales team can sell multiple brands and products on a single call or offer a broad catalog that customers can use to purchase online mixed product assortments in a single order. This ability to offer "one-stop shopping" enables distributors to win customers while providing them with a marketing base where future sales efforts are targeted around proven customer needs. In addition, distributors have the ability to choose just the high selling products from producers that enables them to establish a portfolio of high-revenue winners while bypassing weak sellers in the producer's product line. This ability to mix the product lines of many producers cannot be duplicated by vertically integrated channels that sell only the products of the production plant.
6. *Independence from any single manufacturer*. Channel intermediaries offer their customers what they consider the best products and services without the interference of the producers. Because they are normally located in a regional market, they also provide customers with a local presence that cements strong customer loyalties. Often producers struggle with surrendering control of their brands, pricing, and linkage to the local distributor.

4.3.2 Segment Marketplace

Using the channel design matrix model to broadly outline channel structures, planners must next determine the nature of customer demands. From a marketing standpoint, this step is usually perceived as segmenting customers by profitability, age, average purchase, or some other dimension. Selden and Colvin feel that effective customer segmentation consists of three dimensions [6]. The first dimension, determining *customer needs*, centers on documenting what customers value the most from the array of company offerings. This dimension reveals the most critical value proposition available to the customer. The second dimension, *customer behavior,* utilizes technology tools to reveal the experiential world of customers. The goal is to document how brand and service bundles impact experiences in both consumer and business-to-business contexts from the perspective of the customer. The final dimension, *customer profitability,* divides customers into segments by profitability. It is important that this step is concerned with how this information is used to further long-term customer loyalty and not purely as a way to devise strategies focused on just selling more products.

Once market segmentation is completed, the next step is to determine the channel structure needed to realize the segmentation strategy. For network designers, delivery channels are best defined by matching demand with channel *service outputs*. Grouping customers by the service outputs enables channel planners to associate market segments with specific channel network designs. In addition, understanding the market's environmental characteristics and constraints further assists designers to focus on how channel service outputs can best meet customer requirements.

The four channel service outputs (*bulk-breaking, spatial convenience, waiting and delivery time*, and *variety or assortment*) are discussed in detail in Chapter 2. When these service outputs are combined with the distribution attributes of the channel design matrix, they form a table where planners can position customers by their market segmentation characteristics. For example, W.W. Grainger, a leading distributor of maintenance, repair, and operating (MRO) supplies, has supplied products to a global market for over 75 years. Grainger's business strategy is to service buyers through catalogs, telephone sales, and direct selling with products either picked up at their 711 (400 plus in the U.S.) branches scattered throughout the world or shipped from six zone DCs, the national distribution center, or local country distribution sites. Local presence is critical for Granger's customers who need small quantities of MRO parts on an immediate, or very short delivery lead time. Grainger's e-commerce solution also gives customers access to more than one million products online which are shipped directly or picked up at one of the branch locations.

	Distribution Channel		
Service Output	Market Penetration Intensity	Distribution Integrative Intensity	Distribution Intensity
Bulk-Breaking	High	Medium	Low
Spatial Convenience	Very High	Very High	Medium
Waiting and Delivery Time	Very High	Very High	Low/ Medium
Variety (Assortment)	High	Very High	Low/ Medium

FIGURE 4.6 Grainger service output/channel design matrix.

When the service outputs and channel design matrix are applied to Grainer's market strategy, the results would resemble Figure 4.6. The matrix shows that the distribution channel needed to meet Grainger's service outputs fits the following characteristics:

- Grainger's distribution channel needs deep market penetration to reach the individual customer. Consisting of national, regional DCs, business partners, and an intense network of local branches, Grainger's network is designed to provide the customer with easy access to small quantities of MRO products, in a wide assortment, on an immediate or short delivery basis.

- To execute short delivery, Grainger has chosen to establish direct control of the marketplace by owning downstream customer-facing delivery echelons.
- In terms of *distribution intensity*, Grainer has decided to pursue a single source model where they perform all distribution activities to retain control over elements such as brand, price, promotion, service, and customer loyalty.

4.3.3 Channel Positioning [7]

Channel designers have access to a wide variety of available channel structures. Selecting which channel structure to use requires consideration of four groups of decision criteria. First, the channel structure must satisfy the *channel design attributes*. Second, as the channel configuration is designed, planners must be careful to identify which of the channel members is performing which of the essential *ten transaction flows* detailed Chapter 2. Third, planners must validate that the service outputs identified in the *segment channel* phase as essential to customer segments are being met and that there are no gaps. Finally, planners must validate that the channel structure represents the minimal cost that is to be expended by each network entity in executing the channel flows. Knowing the cost further assists planners in determining how channel profits are to be allocated equitably among channel members so that cooperation is furthered and reasons for channel conflicts are reduced.

4.3.3.1 Producer Storage with Direct Delivery

Probably the most basic structure is *producer storage with direct delivery*. As illustrated in Figure 4.7, the producer ships directly to the end-use customer without using any form of channel intermediary. A significant advantage of this channel model is very high interaction with the customer. Customers normally have direct contact with the producer through either company salespersons, a catalog, or some form of Internet-based communication. Order information flows directly from the customer to the producer. Products in this model tend to be make-to-order and flow from the producer's plant directly to the customer either by using an internal transportation fleet or a third-party carrier.

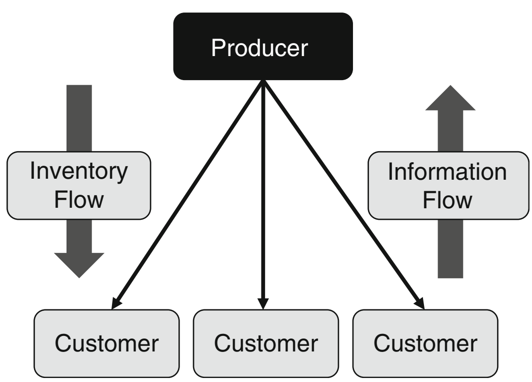


FIGURE 4.7 Producer storage with direct delivery.

Companies selecting this model assume full responsibility for managing the distribution channel. The ramifications of choosing this model are detailed in Table 4.1. The probability of most companies rigidly using this structure, however, is unlikely. Even if the producer possessed the capacity to perform all the necessary sales, inventory storage, transportation, and transaction flows, the producer would probably outsource some of the functions to channel partners who perform them better and at a lower cost.

TABLE 4.1. Channel Design Characteristics – Producer with Direct Delivery

Channel design attributes	Characteristics
Market penetration intensity	One echelon delivery channel means company totally controls the distribution channel. Producer has direct control over product quantities.
Distribution integrative intensity	One echelon delivery channel means total logistics control.
Distribution intensity	No channel intermediaries. Single source distribution.
10 transaction flows	High cost of performing all channel transaction flows. Normally one or more intermediaries involved to reduce costs. Producer incurs heavy inventory risk.
Service outputs	**Characteristics**
Bulk-breaking	Unique products or large lot quantities. Ability to minimize inventory costs by centralizing distribution warehouses. Presence of very low carrying costs.
Spatial convenience	Supply source often far from the customer. Possibly long-lead times for transportation to customer.
Waiting and delivery	Possible long-lead time wait for product delivery. Transportation costs normally low due to bulk shipments.
Variety (assortment)	Very low product variety available to the customer.

4.3.3.2 Producer Storage with Drop Ship

In this channel option, order information originates at a channel distributor or retailer. As illustrated in Figure 4.8, the customer order is sent to the producer and is shipped directly to the customer by the producer, bypassing the intermediary. In this option, downstream channel intermediaries carry no inventories (this would be especially true of online sellers). Interaction with the customer must first pass through the intermediary before it comes to the producer, thereby degrading the producer's level of direct customer contact. Products with high value and low, unpredictable demand benefit the most from this channel option.

Companies selecting this model use channel intermediaries for customer-facing functions while assuming responsibility for inventory, transportation, and final delivery to the customer. The biggest advantage to the producer is that the cost of customer-facing functions is shifted to downstream distributors and retailers. The biggest disadvantage is increased costs for small lot transportation. Some of this cost is offset by postponing finished goods carrying costs until the customer order arrives. The ramifications of choosing this model are detailed in Table 4.2.

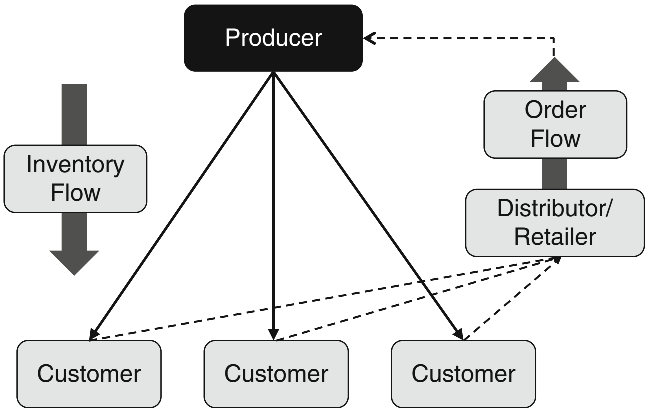


FIGURE 4.8 Producer storage with drop ship.

TABLE 4.2. Producer with Drop Ship

Channel Design Attributes	Characteristics
Market penetration intensity	Producer fully responsible for product delivery. Producer has reduced inventory costs due to centralization.
Distribution integrative intensity	Use of multiple customer-facing distributors and retailers. Producer retains control of all distribution flows.
Distribution intensity	Producer pursues an *intensive* or *exclusive* distribution model to reach as many customers as possible.
10 Transaction Flows	Producer surrenders costs of selling and promoting, pricing, negotiations, order management, customer financing to forward intermediaries.
Service Outputs	**Characteristics**
Bulk-breaking	Offers small lot quantities. Ability to minimize inventory costs by centralizing warehouses and postponement.
Spatial convenience	Loss of direct contact with the customer. Supply source can be far from the customer. Possibly long-lead times for transportation to customer.
Waiting and delivery	Possible long-lead time wait for product delivery. Delivery costs normally high due to many low quantity shipments. Strong information connection to forward distributors and retailers.
Variety (assortment)	Very low product variety available to the customer.

4.3.3.3 Producer with Extended Channel Networks

In this channel option, a single or multiple distribution centers (DCs) and local retail facilities are established geographically between the regional customer and the producer plant (Figure 4.9). Inventory is pushed down to the retail echelon through regional DCs where it is stored in anticipation of customer orders. Sales are made directly by the customer choosing products at the retail store. Overall, because inventories are stocked at the retail stores, which must respond to local demand uncertainty, total channel inventory costs greatly increase. This model is used to distribute inexpensive, mass-produced, commodity-type products into a mass market characterized by high competition. The most important benefits of the model are dramatically increased customer service and product availability.

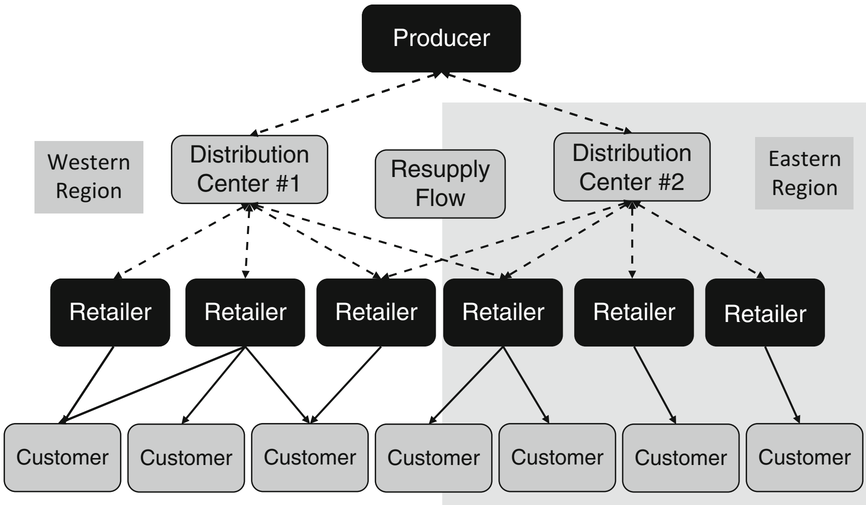


FIGURE 4.9 Producer with extended channel network.

Companies selecting this model make extensive use of channel intermediaries for inventory storage, channel forward functions, and delivery. If a producer decides to establish its own channel DCs, the producer will have to bear higher facility and inventory carrying costs. The biggest advantage to the producer is that the cost of customer-facing functions, outbound transportation, and small lot inventory storage is shifted to downstream distributors and retailers. Disadvantages include diminished control of brand, pricing, promotions, and direct contact with customer information. Table 4.3 describes the characteristics of this channel model.

4.3.3.4 Aggregator with Extended Channel Network

In this option, an independent distributor aggregates a wide assortment of products, often in various item categories, from a wide variety of producers to meet the demands of downstream channel distributors, retailers, and customers (Figure 4.10). This model enables upstream channel producers to gain access to a diverse marketplace, and it helps downstream channel intermediaries to access a wide assortment of products from a single supply source. Besides cutting supplier search costs, an aggregator often enables channel customers to gain economies of scale in pricing, as well as transportation costs. A drawback for producers is that they can lose control over branding, pricing, and promotion, as well as access to certain markets due to downstream exclusivity contracts.

Companies selecting this model are normally large distributors who sell to a mass market. These types of distributors must develop a detailed supply channel as well as a distribution network. Normally they will buy from other distributors or producers, thereby having minimal *supply channel complexity* and *supply integrative intensity*. Because they normally

TABLE 4.3. Producer Extended Network

Channel design attributes	Characteristics
Market penetration intensity	Deep marketplace penetration using multiple levels of distributors and retailers.
Distribution integrative intensity	Producer heavily dependent on channel intermediaries for all customer-facing (forward) order management and delivery functions. None to minimal supply/distribution channel ownership
Distribution intensity	Producer uses a wide multi-echelon network of channel partners to sell and deliver mass produced products.
10 transaction flows	Producer performs minimal channel transaction flows.
Service outputs	**Characteristics**
Bulk-breaking	Producer ships in bulk quantities to distributors who perform bulk-break activities. Low inventory costs due to centralized inventories
Spatial convenience	Total loss of direct contact with the customer. However, channel partners remove geographical distance and shrink customer wait and delivery lead times. High customer convenience.
Waiting and delivery	Low cost inbound and outbound transportation from producer to distribution partners. High information connection to forward distribution centers.
Variety (assortment)	Very low product variety available to the customer.

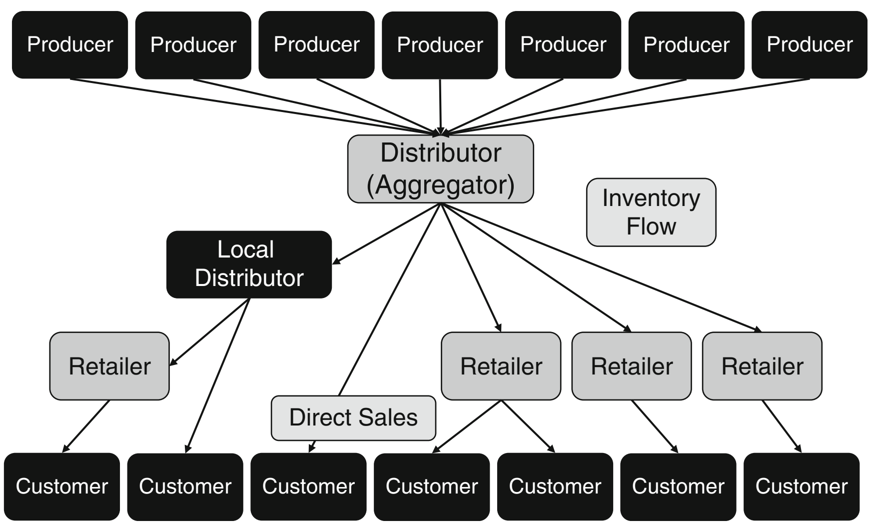


FIGURE 4.10 Aggregator with extended channel network.

buy from a multitude of sources, they often have high *supplier intensity,* characterized by extensive use of supplier contracts governing pricing, lead times, product availability, shared costs, and mutual responsibility for quality. A large distributor will also pursue strong relations with downstream channel intermediaries for the performance of aggregate inventory storage, channel transaction functions, and delivery. The biggest winner in this channel model is the customer who gains access to a wide range of products while minimizing the cost of supplier search. One-stop-shopping also enables the customer to significantly cut transportation costs by aggregating purchases into a single order. A serious disadvantage of this model is the high cost of holding inventories in multiple channel echelons, transportation, information system connectivity to guide in channel replenishment, and diminished control of brand, pricing, promotions, and direct contact with customer information. Table 4.4 describes the characteristics of this channel model.

TABLE 4.4. Distributor Extended Channel Network

Channel Design Attributes	Characteristics
Market penetration intensity	Deep marketplace penetration using multiple levels of distributors and retailers. Includes some direct sales.
Distribution integrative intensity	Distributor has no ownership of backward or forward supply or distribution echelons. Depends on channel partners.
Distribution intensity	Distributor uses a deep, multi-echelon network to penetrate deep into the marketplace to sell and deliver mass produced products.
10 Transaction Flows	Distributor performs channel replenishment transactions and initial inventory ownership. Minimizes risk by passing most transactions functions to downstream channel members.
Service Outputs	**Characteristics**
Bulk-breaking	Engages in significant bulk-break activities. High storage costs. Due to high cost of inventory, channel stock only high-volume items, with slow movers stored upstream in the distribution channel.
Spatial convenience	Fast-selling items have immediate delivery. Slow sellers must move at slower pace through the distribution channel.
Waiting and delivery	Low cost inbound but relatively higher cost outbound transportation due to more delivery points and smaller lot sizes to customers and delivery partners.
Variety (assortment)	High level of product variety by using multiple suppliers.

4.3.3.5 Aggregator with e-Business Network

e-Business has revolutionized the distribution channel. In the past, companies were forced to stock large quantities of product assortments close to the marketplace. Often distributors lost sales because they could not fulfill customer orders for items considered too slow moving to be inventoried. Online sales has dramatically helped channel intermediaries eliminate this problem. Internet websites enable distributors to leverage specialty channel partners to fulfill orders considered non-stock without the customer even knowing it. In addition, customers can order directly online without having to shop retail, further enhancing customer convenience and cementing brand loyalty. By leveraging multiple channels to satisfy the customer, distributors can drastically cut the number of stocked products and focus on the fast-selling items. The downside is that online sales places tremendous pressure on the logistics channel to execute flawlessly. This channel model is illustrated in Figure 4.11.

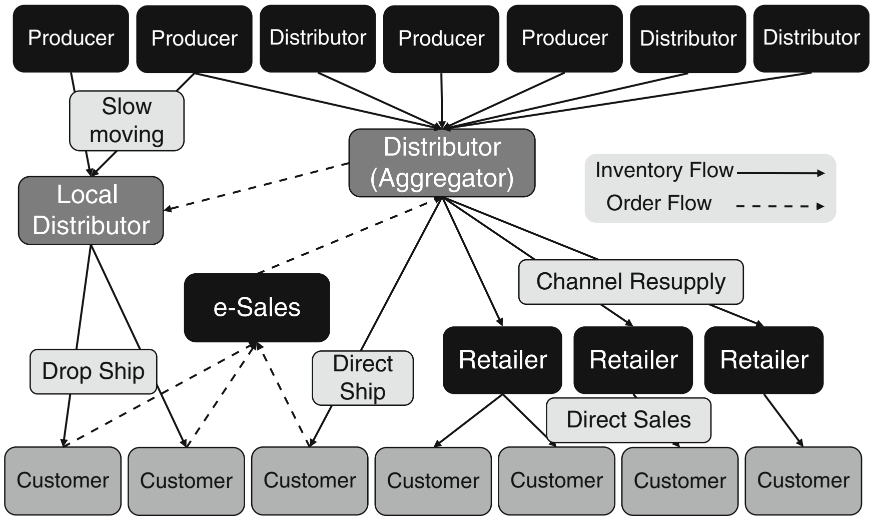


FIGURE 4.11 Aggregator with e-business network.

Companies selecting this model are normally large distributors who sell to a mass market direct and through local distributors, retailers, and e-business. The multi-channel approach enables the distributor/aggregator to reach a very large geographical market with a very large product assortment. The use of the Web for product search and ordering dramatically increases customer convenience. Customers can comparison shop, search for different product brands, assemble a purchase of diverse products, and pay online. The diversity of the delivery channel enables them to receive deliveries by mail, direct from the distributor, or pick up from local retail stores. Table 4.5 describes the characteristics of this channel model.

4.3.3.6 Comparing Distribution Network Option Performance

The five channel arrangements portrayed in Figures 4.7, 4.8, 4.9, 4.10, and 4.11 represent only a small number of the possible channel configurations. As designers propose possible channel structures, they must thoughtfully weigh the potential strengths and weaknesses of each possible configuration. While the five channels presented on the previous pages are fairly representative of most networks, the permutations can be endless and can change dramatically as the business strategy changes. For example, Dell's decision to sell PCs in a retail environment in addition to its traditional online sales business model required a thorough understanding of the effect it would have on its original distribution channel strategy.

Building a successful channel network requires planners to consider the opposing objectives of high customer service and low channel costs. If a network strives for very high customer service with high product assortment and short delivery times, the costs for channel inventories, transportation, facilities management, and overall channel complexity will increase. On the other hand, a focus on cost reduction will weaken customer service attributes. Although techniques such as channel postponement, the use of drop shipping, and online sales, blunt the sharpness of the dichotomies between customer service and cost, the service/cost trade-off restricts channel designers in their choice of network options.

A technique to assist channel planners to effectively map their channel networks is to compare the key channel characteristics against alternative channel structures. For example, in Table 4.6 planners have selected from the three distribution channel matrix attributes, the

TABLE 4.5. Aggregator with e-business Network

Channel design attributes	Characteristics
Market penetration intensity	Deep marketplace penetration using multiple levels of distributors and retailers. Includes direct and e-sales.
Distribution integrative intensity	Distributor has no ownership of backward or forward supply or distribution echelons. Depends on channel partners.
Distribution intensity	Requires a complex channel composed of distributors, brokers, jobbers, retailers, direct customer delivery, and e-business to sell and deliver a high level of product assortments.
10 transaction flows	Most transaction functions performed by channel partners. Manages e-business channel, replenishment to local distributors and retailers, performs direct shipment. Minimizes risk by passing most transactions functions to downstream channel members.
Service outputs	**Characteristics**
Bulk-breaking	High level of bulk-break and assortment assembly. Stocks only fast sellers, with slow seller dropped shipped using channel partners.
Spatial convenience	Customers can get immediate delivery at local stores for fast moving items. Slow sellers move at slower pace through the distribution channel.
Waiting and delivery	High customer service and product availability at retail level. E-business and slow moving sales has a short delivery wait. Distributor has low cost inbound but higher outbound transportation costs due to more delivery points and smaller lot sizes to customers and delivery partners.
Variety (assortment)	High level of product variety by using multiple suppliers.

TABLE 4.6. Comparing Channel Network Options

Performance attribute	Producer storage with direct delivery	Producer storage with drop ship	Producer with extended channel network	Aggregator with extended channel network	Aggregator with e-Business network
Distribution intensity	Low	Low	High	High	Very high
Customer service level	Low	Medium	High	High	Very high
Product assortment	Very low	Low	Low	High	Very high
Product availability	Low	Medium	Medium/high	High	Very high
Delivery time	Low	Low/ medium	High	High	High
Channel complexity	Very low	Low	Medium	High	Very high
Inventory cost	High	High	Medium	Medium	Low
Transportation	Very high	High	Medium	Low	Low/medium
Channel facilities	Very low	Medium	Medium/high	Medium	Low/medium

ten transaction flows, and the four service outputs eight key characteristics to be used to compare the five channel designs detailed in Figures 4.7, 4.8, 4.9, 4.10, and 4.11. By rating each channel design as High, Medium, and Low in relation to the channel characteristics, designers can get a clear picture as to how each of the channel structures meets company business objectives.

4.4 CHANNEL SELECTION

Once possible channel structures are identified in the *channel positioning phase,* channel designers are ready to move to the next step in the channel design process: *channel selection.* The overall goal of the channel selection process is to maximize customer responsiveness while optimizing company profits and lowering operations costs. Graphically, this goal is represented in Figure 4.12. The dotted line represents the customer response time and the solid line represents the total logistics cost (inventory, transportation, and facilities). As the customer response time shortens and the number of channel entities grows, total logistics costs at first decrease but then increase as they cross over response time. Planners must ensure the network has at least the number of channel facilities that optimize customer responsiveness.

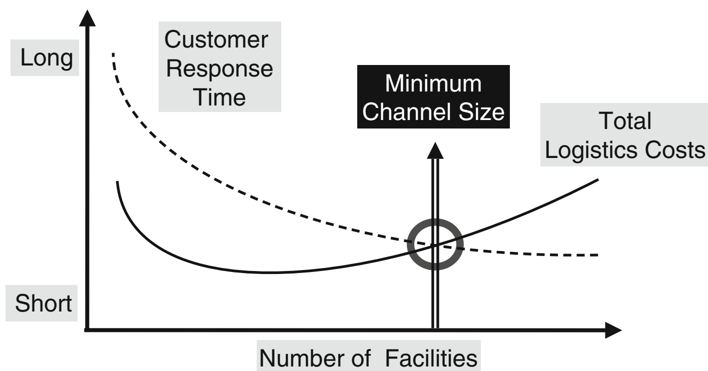


FIGURE 4.12 Customer responsiveness vs. channel costs.

Fundamental to determining the location and number of warehouses is clearly understanding the elements of channel network cost. Essentially, channel planners must balance total supply channel fixed and current costs (plant and inventory) with the cost of transportation and overall sales (response time). If these elements were portrayed graphically, they would resemble the curves found in Figure 4.13. As the number of warehouses expands to increase customer response times, inventory and facilities costs increase while relative outbound transportation and sales costs would decline due to increased closeness to the customer. However, as the number of channel supply points continues to increase, eventually inbound transportation and facilities costs would also begin to slope upward as the costs associated with interbranch transfer and customer delivery increase. Simply, as the number of warehouses grow, the ability of the channel to ship on a full truckload (TL) basis declines, requiring the firm to pay a higher transportation rate. Overall, the goal of the location strategy is to maximize the perceived benefits arising from the optimal positioning of each distribution point geographically in the channel.

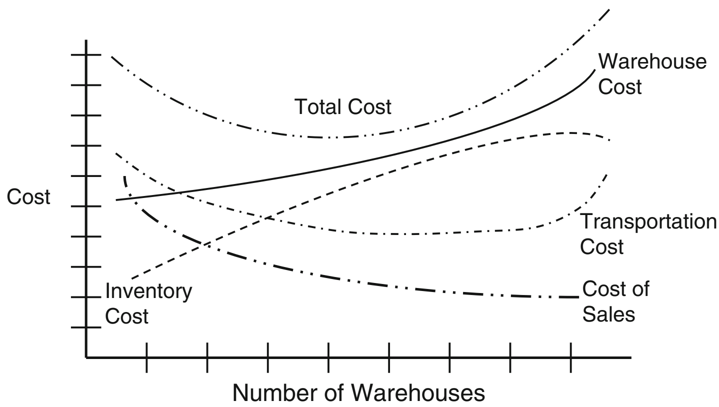


FIGURE 4.13 Cost elements of channel facilities.

In addition to calculating optimum transportation and assets cost trade-offs, determining the number of warehouses in the channel must also be guided by targeted customer service levels and, in particular, the speed with which product is delivered. In theory, the more centralized the pipeline inventories, the greater the average distance between supply points and the customer, and the longer the delivery lead time. This means that if customer service levels are related to the speed of delivery, it is likely that sales will decline as inventory is concentrated, and vice versa. When added to the curves in Figure 4.13, the sales revenue curve would appear to increase as the number of stocking points increase. In a very crude sense, the distance between sales revenue and total network costs is the measure of channel profitability. This analysis, however, is based on two assumptions: reducing delivery times generates additional sales and decentralizing channel inventories reduces delivery times. Because neither of these assumptions are necessarily true, planners must be careful to employ methods (such as cost analysis, grid and graphic techniques, and simulation and optimization modeling) that thoroughly explore long-term distribution patterns encompassing customer, plant, product and transportation costs, and opportunities, and to develop effective strategies for deploying goods to be held at various supply points in the channel.

Making the best channel network decisions requires channel design teams to follow the following four-step process.

- *Facility selection issues*. In the first step, planners identify and quantify all necessary macro and micro issues affecting possible channel facility choices. *Macro* selection issues are concerned with how well the proposed channel networks meet corporate objectives. *Micro* selection issues are divided into two categories: regional/community factors and site factors (discussed on the following pages).
- *Modeling choices*. There are essentially five types of channel modeling techniques. The first consists of statistical charting, mapping techniques, and spreadsheet comparisons that use a relatively low level of mathematical analysis. The other four models – simulation, heuristics, optimization, and expert system – are dependent on complex algorithms and, in today’s business environment, are run through computer software. Discussion of these four models is outside the scope of this chapter.

- *Assembling the network*. In this step, planners identify the geographical areas where proposed channel facilities are to be located. Planners can employ *gravity methods* to find locations that minimize the cost of transporting raw materials from suppliers to plants and finished goods from plants to channel distribution and retail facilities.
- *Confirming the network*. The final decision to be made in channel network selection is linking facilities to markets and determining the capacity resource allocation for each channel facility.

4.4.1 Facility Selection Issues

Identifying and quantifying the selection of possible channel network facilities is a critical first step. As mentioned above, these issues are broken down into three sets of factors. *Macro issues* affect the channels business strategy and include the following:

- corporate objectives translated into markets and competitive positioning
- customer service-level goals
- global economic conditions
- country-level political stability
- government regulations
- location of markets
- exchange rates and currency risks
- local cultural and economic issues and others.

On the *micro* level, *regional/community issues* are concerned with

- local taxes, culture, and climate
- labor availability, costs, wages, and union strength
- cost and availability of utilities
- local environmental regulations
- government incentives
- community resources (police, fire, schools, public transportation, and affordable housing)
- proximity to competitors (clustering) to take advantage of a major resource found in the region
- proximity to suppliers and customers

Finally, *site issues* are concerned with

- facility cost and size
- availability and accessibility of transportation modes
- proximity to highway systems
- communications infrastructure
- local taxes and fees
- environmental regulations

4.4.2 Methods for Locating Channel Network Facilities

There are several methods channel planners can use when locating channel facilities. These methods use both qualitative and quantitative methods to assist in the selection process.

4.4.2.1 Factor-Rating Method [8]

A simple method is the *factor-rating method.* This method utilizes the macro and micro factors detailed earlier. The advantage of this method is that it enables channel designers to incorporate quantitative factors, such as taxes, labor, and facility costs, as well as qualitative factors, such as community attitude and quality of life, into their channel network design criteria. Since some of these factors are more important than others for a particular network design, planners can assign weights to each factor that result in an objective, quantitative means of site selection.

The factor-rating method has seven steps:

1. Channel designers establish, quantify, and then select from a list of *facility selection issues* those relevant to the channel network design project.
2. The design team then assigns a weight to the selection criteria. The size of the weighting factor reflects the importance the team assigns to each design issue. The total weight must sum to 100 %.
3. A scale, such as 1–10 or 1–100, is established for the decision criteria.
4. The possible channel network locations are selected.
5. The design team, with top management assistance, rates the proposed channel locations for each decision criterion using the rating scale.
6. The scale is then multiplied by the weighting factor for each location and decision criterion.
7. The scores are summed and a recommendation based on the maximum point score is then made by the team.

Exercise 4.1: Factor Rating Method Calculation

The channel design team at ABC Electronics is responsible for performing a factor rating method calculation for two possible expansion locations: Chicago, IL and San Diego, CA. Using the seven step process described above, the following table was assembled. First eight facility selection criteria were identified and applied jointly to the two locations. Next, a weight and a score was assigned to each selection criterion for the two sites. Finally the weighted score was calculated by multiplying the weight by the site score for each location (Table 4.7).

Based on the results of the scoring, the San Diego location has a higher score and is therefore preferable. By changing the points or the weights slightly for the selection criteria for which there is some doubt, the decision can actually swing in the opposite direction.

The advantages of the factor rating method are that it provides an objective method of identifying hard to evaluate criteria related to each location and the ability to compute *quantitative* factors into the analysis. It is also very easy to compile and use as a basis for channel location selection. Disadvantages of the method are the use of qualitative factors that involve designer judgment concerning hard to quantify facility criteria.

TABLE 4.7. Factor Rating Method.

	Site scores (100 points)			Weighted scores	
Decision criteria	Weight (%)	Chicago	San Diego	Chicago	San Diego
Labor costs	20.0	18	25	3.60	5.00
Labor availability	14.0	95	75	13.30	10.50
Transportation costs	14.0	20	45	2.80	6.30
Transportation availability	14.0	95	70	13.30	9.80
Taxes	3.0	10	10	0.30	0.30
Quality of life	8.0	75	85	6.00	6.80
Infrastructure costs	7.0	15	20	1.05	1.40
Facilities cost	20.0	40	45	8.00	9.00
Total	100		*Totals*	48.35	49.10

4.4.2.2 Center of Gravity Method

Once facility selection criteria have been identified and quantified, channel planners can proceed to employ various design models to structure the proposed distribution channel. As previously mentioned, there are several models that are used ranging from simple mathematical to complex computerized models based on simulation, heuristics, optimization, and expert systems. A commonly used model is the *center-of-gravity* or the *centroid method*. Gravity models are used to find locations that minimize logistics costs to transport materials and components from suppliers and finished goods to the markets served. The method uses the location of markets, the volume of goods shipped to those markets, and shipping costs to find the best location for a new distribution center.

The first step in the process is to place the existing location of facilities on a mock coordinate grid. A common method is to use the longitude and latitude coordinates found on an ordinary map or by using a GPS system. The goal is to set up a grid (or map) where the relative distances between facilities are correctly represented. All distances are calculated as the geometric distance between two points on a plane. The inputs to calculate the distance between any two locations on the grid are as follows:

x_n, y_n = coordinate location of a supplier or demand source n

D_n = distance between coordinates

The formula to determine the distance is expressed as:

$$D_n = \sqrt{(x - x_n)^2 + (y - y_n)^2} \tag{4.1}$$

For example, a distributor currently has facilities located in Los Angeles, Denver, Philadelphia, New York, and Boston. The distributor wants to locate a distribution center (DC) that will supply these facilities. The DC is to be placed at the "center of gravity" somewhere between these locations. To begin the process, the channel design team first determines the geographical positions of each location. These locations are marked on a mock geographical grid as illustrated on Figure 4.14 using longitude and latitude coordinates.

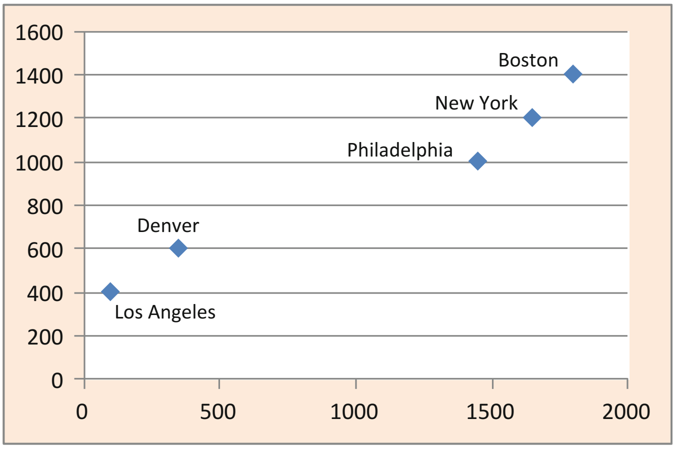


FIGURE 4.14 Geographical grid.

Now that the location coordinates have been defined, the next step is to determine the transportation cost per ton mile and the number of tons shipped from each warehouse. Since distance alone is not the sole criteria of where the new DC will be located, cost and the quantity/tons shipped needs to be entered into the calculation. This detail has been placed in Table 4.8. Note that the *x* and *y* coordinates for each location also appear on the table.

TABLE 4.8. Channel Grid Costs and Coordinates

Location	Transportation cost US$/Ton Mile		Quantity/tons	Coordinate *x*	Coordinate *y*
Los Angeles	$	1.25	2,000.0	100	400
Denver	$	1.25	1,000.0	350	600
Boston	$	1.20	1,000.0	1,800	1,400
New York	$	1.20	2,000.0	1,650	1,200
Philadelphia	$	1.20	1,500.0	1,450	1,000
		SUM	7,500.0		

Once these data elements have been detailed, it is possible to determine the location of the new DC.

Exercise 4.2: Center of Gravity Model Calculation

The channel design team at ABC Distribution wish to locate a new central DC for their channel network appearing in Table 4.8. An important first step is calculating the distance between their five existing warehouse locations. To do this, the planners use the *x* and *y* coordinates listed in Table 4.8 and then apply formula (4.1). For example, the distance between the Los Angeles warehouse and the Denver warehouse is calculated as follows:

$$D_n = \sqrt{(x - x_n)^2 + (y - y_n)^2} = \sqrt{(100 - 350)^2 + (400 - 600)^2} = 320.16$$

The results of the calculation have been entered into Table 4.9

TABLE 4.9. Channel Distances

Distance table					
Location	Los Angeles	Denver	Boston	New York	Philadephia
Los Angeles	0.00	320.16	1,972.31	1,744.28	1,477.33
Denver	320.16	0.00	1,656.05	1,431.78	1,170.47
Boston	1,972.31	1,656.05	0.00	250.00	531.51
New York	1,744.28	1,431.78	250.00	0.00	282.84
Philadelphia	1,477.33	1,170.47	531.51	282.84	0.00

Finally, the gravity method will provide the coordinates for the new warehouse. The new x coordinate is determined by multiplying the ton/quantity for each facility by the x coordinate for each facility, adding up the totals, and then dividing by the sum of the ton/quantity. The new y coordinate is calculated the same way, with the exception being that the y coordinate for each facility is used. For example, the x_n coordinate is calculated as follows:

$$\frac{100(2,000) + 350(1,000) + 1,800(1,000) + 1,650(2,000) + 1,450(1,500)}{2,000 + 1,000 + 1,000 + 2,000 + 1,500} = \frac{7,825,000}{7,500}$$
$$= 1,043.33$$

When the same calculation is applied to the y_n coordinates, the result is 893.33. The actual coordinates calculated by the gravity method may not correspond to a feasible location. Channel designers would then have to research the area to find a location close enough with the necessary infrastructure to support the DC's operations. In this case, planners have decided to locate the new DC in Cincinnati, Ohio (Figure 4.15).

The next step performed by the channel planners is calculating the distances from the

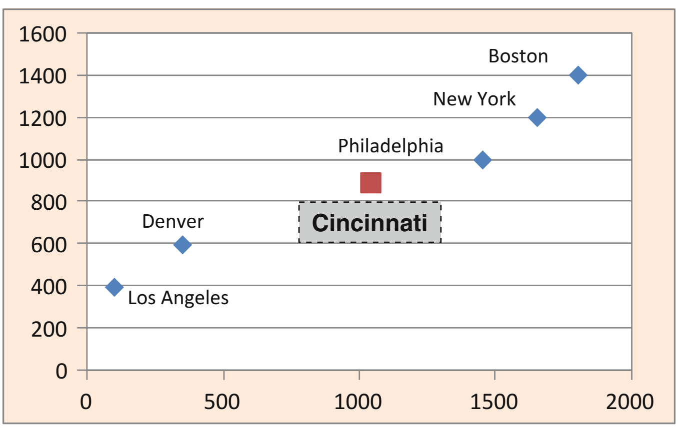


FIGURE 4.15 Geographic grid – solution.

Cincinnati DC to the other five warehouses. The distances are calculated using formula (4.1). The results are displayed in Table 4.10.

The final step is calculating the total cost of using the Cincinnati location to ship to the other five warehouses. The goal is to validate that the Cincinnati location provides the lowest total transportation cost versus other possible locations within the region. To determine the Cincinnati location cost, the design planners used the following equation:

TABLE 4.10. Distance Table – from Cincinnati

Distance table					
Location	Los Angeles	Denver	Boston	New York	Philadephia
Cincinnati	1,064.54	752.83	910.63	679.77	420.42

$$TC = \sum_{n=1}^{k} d_n Q_n C_n \tag{4.2}$$

Where
d = distance to locations
Q = quantity/tons
C = transportation cost US$/Ton Mile

The solution requires summing all of the distances from Cincinnati to the other five locations, the monthly quantity/tons, and the costs (ton/mile) for each location. Based on this information, the total cost of using the Cincinnati DC is US$7,083,375.57. Planners would then contrast this cost with alternative locations. The following Table 4.11 details the entire calculation.

TABLE 4.11. New DC Location – Summary

Channel network for ABC distribution					
Location	Transportation cost US$/ton mile	Quantity/tons	Coordinate *x*	Coordinate *y*	Distance to x_n, y_n
Los Angeles	$ 1.25	2,000.0	100	400	1,064.54
Denver	$ 1.25	1,000.0	350	600	752.83
Boston	$ 1.20	1,000.0	1,800	1,400	910.63
New York	$ 1.20	2,000.0	1,650	1,200	679.77
Philadelphia	$ 1.20	1,500.0	1,450	1,000	420.42
	SUM	7,500.0			

Distance table					
Location	Los Angeles	Denver	Boston	New York	Philadephia
Los Angeles	0.00	320.16	1,972.31	1,744.28	1,477.33
Denver	320.16	0.00	1,656.05	1,431.78	1,170.47
Boston	1,972.31	1,656.05	0.00	250.00	531.51
New York	1,744.28	1,431.78	250.00	0.00	282.84
Philadelphia	1,477.33	1,170.47	531.51	282.84	0.00

***x* Location**	**1043.33**
***y* Location**	**893.33**

Distance table					
Location	Los Angeles	Denver	Boston	New York	Philadephia
Cincinnati	1,064.54	752.83	910.63	679.77	420.42

Cost	**$ 7,083,375.57**

4.4.2.3 Location Break-Even Analysis

Often channel planners are charged with determining the optimal location to stock a product based on cost. The location break-even analysis model provides a quantitative way of selecting a location. Output can be examined either mathematically or graphically. There are three steps that must be performed in assembling the data and calculating the results.

1. The fixed and variable cost (per item) must be determined.
2. The costs for a specific projected item volume are then plotted for each channel location.
3. The location with the lowest cost is then chosen.

Exercise 4.3: Location Break-Even Analysis

The channel design team at ABC Distribution needs to determine the best location for a forecasted quantity of 2,000 units for the 1,400 sump pump (sold for US$120 each) for the coming year. There are three locations available: Los Angeles, Chicago, and New York. The costs are as follows Table 4.12:

TABLE 4.12. Channel Costs

Location	Los Angeles ($)	Chicago ($)	New York ($)
Fixed cost	30,000	60,000	110,000
Variable cost\unit	75	45	25

Based on these costs, the next step is to determine the quantity (break-even point) of the three locations. As an example, the break-even point for the Los Angeles location is calculated by adding the fixed and variable overheads times the forecast, or US $30,000 + US$75 × 2,000 units = US$180,000. Using this calculation, the break-even points for the Chicago and New York facilities are determined respectively as US $150,000 and US$160,000. Based on the results, the lowest cost location to inventory the expected volume of 2,000 units per year is Chicago. The expected total cost and profit is detailed in the following Table 4.13:

TABLE 4.13. Break-even Costs and Profits

Break-even points						
Location	Los Angeles		Chicago		New York	
Total cost	$	180,000	$	150,000	$	160,000
Expected profit	$	60,000	$	90,000	$	80,000
Expected profit %		33%		60%		50%

The next step is to determine the crossover points for different forecast quantities. This value, for example, is calculated by subtracting the fixed cost of the Los Angeles facility from that of the Chicago facility (60,000−30,000 = 30,000) and the two facilities variable (75−45 = 30). Finally the fixed cost total is divided by the variable cost to arrive at the (30,000/30 = 1,000) crossover point. The same calculation would be performed for the other two combinations, resulting in a quantity of 1,600 for Los Angeles and New York, and 2,500 units for Chicago and New York. The results are detailed in the following Table 4.14:

TABLE 4.14. Crossover Points

Crossover points	Volume
Los Angeles vs. Chicago	1,000
Los Angeles vs. New York	1,600
Chicago vs. New York	2,500

Figure 4.16 provides a graphic view of the break-even analysis for the three locations.

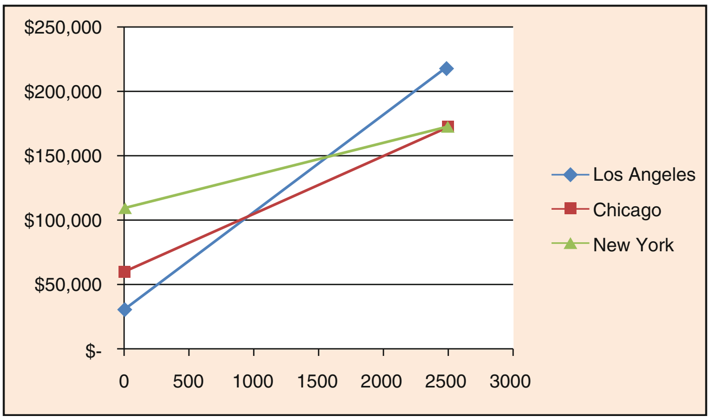


FIGURE 4.16 Break-even point – graph.

As indicated by the dotted line, all quantities of 999 units or less should be shipped from the Los Angeles facility; 1,000–2,499 units from the Chicago facility; and 2,500 units or greater from the New York facility.

4.4.2.4 Least-Cost-Per-Lane Problem

Often channel designers are faced with the problem of determining the least cost delivery from a supplying channel entity. Figure 4.17 illustrates a simple channel structure consisting of two DCs, two warehouses, and three customer zones. The costs associated with shipping product from the DCs and the warehouses is also shown. DC1 has an inventory limitation of 5,000 units and DC2 has an inventory limit of 20,000 units. Demand at each of the three stores is illustrated at the far right of the figure.

The object to find the shipping lane to satisfy store demand at the least cost.

Exercise 4.4: Least-Cost-Per-Lane Problem

After configuring the channel pictured in Figure 4.17, the channel design team at ABC Distribution needs to determine the least-cost-per-lane for ABC's prime product, the PC1600-01 personal computer. The first step is determining the item's monthly forecast and the breakdown per store. Next, the planners then calculate the delivery cost per store and per channel for each of the two ship-from warehouses. This step is illustrated in Table 4.15.

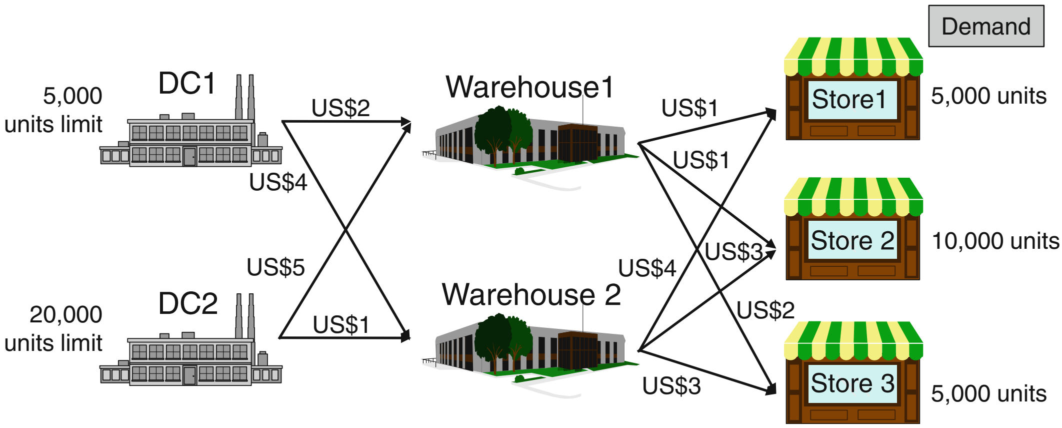


FIGURE 4.17 Channel structure.

TABLE 4.15. Store-Warehouse Costs

Store costs from warehouse 1				
Store	Store 1	Store 2	Store 3	
Delivery cost	$ 1	$ 1	$ 2	
Quantity	5,000	10,000	5,000	Total cost
Total cost	$ 5,000	$ 10,000	$ 10,000	$ 25,000

Store costs from warehouse 2				
Store	Store 1	Store 2	Store 3	
Delivery cost	$ 4	$ 3	$ 3	
Quantity	5,000	10,000	5,000	Total cost
Total cost	$ 20,000	$ 30,000	$ 15,000	$ 65,000

From this analysis, it is apparent that the least-cost delivery for the three stores is Warehouse 1 (US$5,000). Once this has been determined, the design team needs to investigate which of the DCs provides the least-cost delivery to Warehouse 1.

Deciding which of the two DCs would supply Warehouse 1 is dependent on two factors: the first is the total demand of 20,000 units; the second is the quantity availability limitation of 5,000 units at DC1. While it is true all units could be shipped from DC2, the cost of US$100,000 (20,000 units times US$5) is much more than if all 5,000 units were shipped from DC1 and the remaining 15,000 units were shipped from DC2. This solution is supported in Table 4.16.

TABLE 4.16. DC-Warehouse Costs

Warehouse Costs from DC1	
Warehouse	Warehouse 1
Delivery Cost	$ 2
Quantity	5,000
Total Cost	$ 10,000

Warehouse Costs from DC2	
Warehouse	Warehouse 1
Delivery Cost	$ 5
Quantity	15,000
Total Cost	$ 75,000

When the costs for the two DCs are combined, they equal US$85,000. With this value calculated, the full least-cost-per-lane is calculated by adding the US$25,000 shipping cost for product moving from Warehouse 1 to the three stores to the DC cost of US$85,000, or US $110,000.

The four channel design methods discussed above represent relatively simple models to structure a network channel. Most channel design work benefits from the application of more sophisticated simulation, optimization, and linear programming techniques. For example, while the least-cost-per-lane solution chooses the least-cost channel for item PC1600-01 as it moves from the plant to the warehouse to the market, it does not *optimize* the channel costs. By applying linear programming to the model, the optimal solution to the least cost is as follows (Figure 4.18):

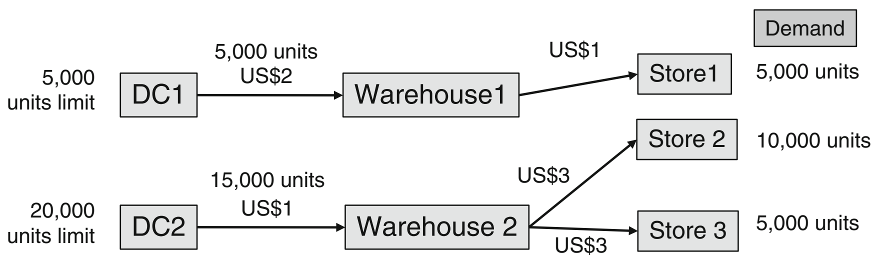


FIGURE 4.18 Optimized channel structure.

The total costs from the DCs to the warehouses equal US$25,000 and the total costs from the warehouses to the stores equals US$50,000 for a total network cost of US$75,000. In contrast, the least-cost-per-lane solution in Exercise 4.4 resulted in a total network cost of US$110,000.

4.5 CHANNEL IMPLEMENTATION

Once the channel selection process is completed, designers can turn to the final step in the channel network design process: *channel implementation*. This step is concerned with the management of four major functions: selection of channel partners, the nature and distribution of channel power, managing channel conflicts, and achieving strategic channel collaboration.

4.5.1 Selection of Channel Partners

Once the structure of the distribution channels needed to reach each targeted customer market segment has been identified, the channel design team proceeds to select the channel partners. The choice of partners is an important task. In many ways, channel partners are the face of the company. Many customers, often separated by global space and time, never deal with the producers of the products they purchase from their local distribution or retail source. Channel partners should be chosen that possess the attributes that best fit the requirements of the customer market segments. Critical criteria is the number of years in business, financial stability, depth of product assortment, relationships with possible competitors, growth and profit history, level of cooperativeness and collaboration, and service reputation.

Another critical element in today's computerized environment is the depth and status of channel partner information technologies. This element is particularly important if the product is sold through the Internet and a multi- or omni-channel strategy is being pursued. If the channel partners are retailers that want exclusive distribution, designers should evaluate locations, future growth potential, and type of customer. For intermediaries with sales forces, designers should evaluate the size and quality of the sales organization and the number and character of other lines carried by the company.

Once channel intermediaries are selected, the channel design team must be careful to determine their strengths and weaknesses and develop constructive relationships that ensure that the products and services to be sold through the channel provide them with strong incentives to provide customers with superior value. The goal is to incent intermediaries to be top performers. The channel master should provide training programs (to learn such things as product lines and sales and marketing techniques), market research programs, and other capability-building programs to drive higher channel member performance. The channel master should be committed to communicate that channel intermediaries are essential partners and that they are part of an integrated joint effort in the pursuit of marketplace leadership.

The final component in the selection of channel members is evaluating performance. Measurements include attainment of sales quotas, customer delivery time, average inventory levels, value of damaged and lost inventories, and cooperation in promotional and discounting programs. As time moves on, channel designers continue to determine the utility and effectiveness of the channel configuration and the intermediaries occupying key supply chain nodes. Channel modification becomes necessary when the distribution structure is not working as planned. Reasons are changes in marketplace buying habits, expanding or shrinking markets, inroads of a powerful competitor, innovations to distribution channel functions, or the product moves from one stage of its product life cycle to another. Metrics also indicate that a channel member is underperforming. Poorly performing intermediaries need to be counseled and their motivation increased, their staffs retrained, or in some cases they need to be terminated from the channel network.

4.5.2 Role of Channel Power

The issue of getting, using, and keeping power is of the utmost importance to channel leaders. The very basis of an effective channel network is the interdependence of members and how power is to be exercised to maintain viable, working relationships where each member creates strategies and performs actions that support the cooperation of all members in the pursuit of both individual company and aggregate supply channel value. It is important to note, however, that maximizing the supply channel's value is not the same thing as maximizing the value of each channel member. Without channel power, the tendency of individual members to maximize their own profit act as a powerful centripetal force splintering networked communities and institutionalizing local customer management decisions at the expense of overall channel performance. Preventing channel disintegration from occurring requires the exercise of power so that members can pursue their own objectives while engaging the entire channel to generate value.

Activating power requires a single channel entity (such as a channel master) or a tightly integrated alliance of a small group of channel players to act as the driving force to engineer a power structure that enforces network cohesiveness while enabling a sustainable level of individual channel member independence. Channels that have weak power relationships soon disintegrate. On the other hand, channels that are too strongly centralized and held hostage by a powerful channel master that routinely imposes its will on weaker members that have no escape become a kind of celestial black hole where members cannot escape the gravitational pull of the channel master and soon see their profitability and sustainability evaporate into insolvency.

Creating and exerting power in a channel network is a hotly debated subject that is approached from many angles. The commonly used concept comes from psychology and defines power as consisting of five forms [9].

- *Reward power*. In this form of channel power, a channel member is rewarded by conforming to a required or suggested behavior. The effective use of reward power is based on the assumption that a channel member possesses some value or resource that another member believes it can obtain by conforming to the policies or standards of the other member. An example would be a producer who offers intermediaries an extra benefit as a result of performing a certain behavior or function. This form of power normally works better than coercive forms. The drawback is that channel members come to expect a reward each time they conform to the producer's wishes.
- *Coercive power*. Coercive power is the reverse of reward power. In this form of channel power, a channel member is punished for nonconformance to a required or suggested behavior. An example would be a large wholesale distributor that threatens to withdraw or terminate certain resources or the entire relationship if downstream channel intermediaries do not follow a certain behavior. While this form of power can be effective, it normally provokes a sense of resentment and results in the development of countermeasures that simply provoke more channel tension.
- *Expert power*. In this form of power, a channel member possesses a certain expertise, specialization, or comparative advantage desired by other channel members. This expertise takes the form of special knowledge, technical expertise, marketing dominance, or customized resources. Often expert power is short-lived as channel members acquire it from the expert or develop it on their own. Expert power must be continuously generated if the member who possesses it expects that other channel members will want to continue cooperating.
- *Legitimate power*. In this form of power, a dependent channel member feels obligated, ethically, socially, or contractually, to comply with the requirements or policies of another channel member. The member with the legitimate power has power over other channel members it deals with that feel a sense of duty to carry out the wishes of the influencing member. An example is a producer that requires certain intermediaries to preserve product brand and pricing agreements based on contract.
- *Referent power*. In this form of power, a dependent channel member who values the marketplace recognition, technical expertise, or other attribute possessed by another channel member, seeks identification with the influencing member. For example, smaller downstream intermediaries seek to carry the brand names of a popular producer to increase their sales and improve local marketplace image. Companies such as Caterpillar, Sony, and Proctor & Gamble command high referent power from their channel distributors.

While the five sources of channel power are useful in defining relationships, the separation between sources of power is not always clear. Often one source will merge into another; often aspects of the five forms of power are combined.

It can be maintained that the discussion of channel power so far is conceived primarily as the power of an independent channel member over a dependent member. In reality, the best forms of power in a channel are expressed as a form of balance of power. Exploiting a dependent channel member may result in a short term gain, but the relationship cannot continue for long and the exploiter gains nothing other than a bad reputation and resistance on the part of other channel members to form partnerships. Sometimes, the dependent channel member possesses an important value the influencing member needs in order to succeed in the marketplace. This form of mutual dependence creates win-win situations for both parties by furthering strategic channel alliances.

Effective channel leaders see themselves in the role of what Rangan terms as *channel stewards* [10]. Rather than demanding compliance from channel members for insular programs focused on cost reduction and efficiencies, the goal of the channel steward is to merge individual company goals into a unified strategy that views the entire supply chain from the perspective of both the customer and each channel member. Practically speaking, it is the role of the channel steward to unearth the requirements and expectations of the customer, devise a comprehensive strategy, and then advocate change among all channel members. Stewardship involves carefully building supply chain synergies supportive of high levels of customer intimacy and deepening long-term relationships based on promoting those activities that enhance the customer experience, eliminate weak channel members, and reward channel partners providing discernable customer value.

Attaining such objectives is not an easy task and requires strong leadership to overcome very strong natural inertia and the pull of local channel member goals. Getting channel members to collaborate on product, price, and service strategies is difficult even for powerful channel leaders who can enforce compliance. Even if integrating products and plans is in everyone's best interests and drives profits for all, the risk involved in undertaking a channel transformation may exceed the alternative of simply leaving current working relationships as is. Still, the advantages of an integrated channel are enormous. Whether by coercing or convincing supply network members, the role of the channel steward is to provide the focus necessary to effectively shape a channel's evolution and ensure it is advancing simultaneously the interests of its customers, suppliers, and channel intermediaries. Success occurs when channel players perceive they are actually part of a single community capable of collectively addressing the needs and desires of all customers.

4.5.3 Managing Channel Conflict

Supply channel networks are often subject to conflict. Because they are really ecosystems of independent companies, each with their own set of performance metrics and competitive objectives, constantly finding common ground where everyone can realize their own goals in an atmosphere of mutual trust is a delicate and often complex management skill. Despite the fact that today's communications technologies enable companies to more closely integrate with their channel partners and customers, resistance to rather than the espousal of change is the norm for most channel networks. While individual players may want to embark on new initiatives designed to promote increased competitiveness or closer customer intimacy, getting other channel constituents to go along can be difficult. According to Rangan [11], there are three critical impediments to channel change.

1. Unless there is an overwhelming channel power player, like a Wal-Mart or a Home Depot, influencing the behavior and policies of a community of independent companies is complex. Besides constantly changing and recalibrating the strategic and performance targets of each channel member, there are also legal restrictions, contractual commitments, potential relationships with other delivery intermediaries, competitive practices, and marketplace conventions that make change difficult.
2. When channel changes are initiated, they are often undertaken by a single player. While a channel master like Wal-Mart possesses the power to mandate and orchestrate an initiative such as RFID, most channels do not have strong centralized leadership driving and coordinating improvements. Changes are normally seen as local, with no one overseeing the impact on overall channel capabilities, competitive positioning, and customer relations.
3. Because channels are opportunistic and voluntary, the operating conventions that do arise over time tend to get petrified. Even a strong leader like a Costco or Sysco often resorts to threats and admonishments targeted at altering often decades-old ingrained systems of behavior. As a result, the changes that are made are often realized on a local level and rarely impact channel design.

Because delivery networks by nature are difficult to change, conflict between channel players can easily erupt. Conflict could arise over a decision to drastically change the channel, such as Dell's decision in the mid-1990s to abandon altogether its retail stores in favor of a purely Internet-driven business format. Additionally, conflict can arise over channel goal compatibility, such as moving from a low-cost, high-volume commodity focus to a more upscale product focus, such as pursued by Target's apparel strategy. Since channels are often non-exclusive, a company could find its products being offered by a downstream player alongside those of a direct competitor's. Then again, conflict can arise over lack of specific demarcation in channel roles and rights, such as the conflict between major computer companies and their value-added resellers (VARs) who sometimes find themselves competing for the same customer. What is worse, a network partner could assume control over the end-customer relationship, even usurping brand identity and product pricing and promotions.

Conflict can arise between players at the same level in a channel, at different levels in a channel, and between two or more channels that sell within the same market. For example, when Apple opened its own retail store format, the strategy was in conflict with both large and small electronics retailers like Best Buy who sold Apple products along with other brands. In some mega-electronics stores, Apple has set up their own store within the retailer's store. Another example is the desire of companies to open e-commerce sites. Selling directly to the customer has the effect of disintermediating downstream delivery partners; sometimes this strategy violates long-held contracts, such as between automakers and car dealerships. For the most part, it is argued that as delivery networks elongate and become complex, the more difficult it is for producers to control brand and pricing issues. On the other hand, the more powerful a channel player, the less room network members have to create sources of channel conflict.

Progressive supply channel networks consider conflict not as a negative, but as a force for change. Since revenue growth and profitability is directly linked to a company's ability to manage their delivery network partners, identifying and quickly resolving conflict is essential to ongoing channel success. Still, while some channel conflict can be constructive and supportive of responses to a dynamically changing marketplace, much of it is dysfunctional. As illustrated in Figure 4.19, there are four general ways to respond to channel conflict [12]. At the bottom left quadrant is found channel members that *avoid* channel conflict. Such channel members normally occupy a weak position or have poor negotiation representatives. Often this strategy is followed by channel partners that do not have much invested in each other or the channel as a whole.

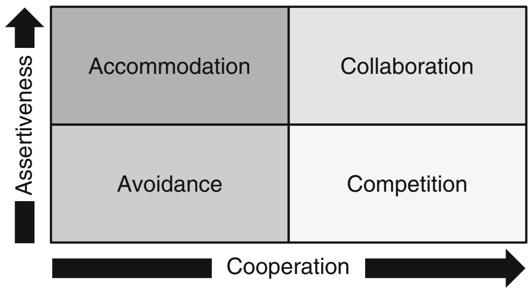


FIGURE 4.19 Conflict resolution styles.

On the top left quadrant is found channel members that manage conflict by being *accommodating* to other channel parties. In this strategy a channel member seeks to strengthen channel relationships by expressing a willingness to cooperate and build trust and cooperation over the long term. Channel members following this model must be careful not to be exploited by more powerful channel members. In contrast, channel members in the bottom right quadrant pursue a strategy of *competition* by taking an uncompromising stance when channel conflict arises. The problem with this strategy is that it aggravates the conflict, fosters distrust, and strains channel relations to the breaking point, particularly in regard to long-term relationships.

The best form of channel conflict management is illustrated in the top right quadrant and is defined as channel conflict *collaboration*. Achieving this level of channel conflict management is difficult to achieve and involves a high degree of compromise and willingness to engage in joint problem-solving. There are several methods for ensuring effective conflict management [13].

1. *Leadership*. In lieu of a powerful channel member who can enforce behavior and conformance to policies and established metrics, much conflict among network members is reduced by the emergence of a *channel steward*. The steward can be a producer, an intermediary, or any other participant in the supply channel network. The role of the steward is to design a "go-to-market" strategy that simultaneously addresses customers' best interests and generates profitability for all participants. The steward then acts as an advocate for change, transforming discordant partners into a unified channel for customer value and joint channel member profitability.
2. *Integration*. As customers demand more not fewer multi-channel sources for products and services, the need to develop integrated, collaborative channel processes is imperative. This method of alleviating channel conflict requires network partners to share sell-side data and analytics, construct metrics to more effectively chart channel

revenue contribution, search for ways to continuously reduce overall costs, construct new avenues to deepen customer intimacy at each level in the delivery network, and search for ways to rationalize new sources of channel conflict.

3. *Technologies*. An important source for the removal of channel conflict is the visibility of sell-side data from every source in the delivery network. Technologies, such as marketing portals, point-of-sales (POS), customer relationship management (CRM), and partner relationship management (PRM) computerized solutions, provide integrative tools for lead management, proposal and order management, global pricing and contract management, and service management that link each region together and provide the end customer with a single ordering and delivery entity.
4. *Performance intelligence*. Realizing the opportunities found in the marketplace requires looking at the performance of not just one company, but of all the firms comprising the entire end-to-end delivery channel. The optimal delivery channel has a keen understanding of customer demand and how it impacts producer capacities and schedules, logistics capabilities, and inventory. This knowledge reveals two critical sets of metrics necessary for the alignment of demand and supply: the cost to serve customer objectives and the performance management metrics used to measure best practices across the delivery channel. Such intelligence permits the establishment of a single version of the entire delivery network and enables modeling of the best combination of network partners, superbly integrated to provide the deepest forms of customer intimacy.

Removing delivery network conflict must be conceived as an *evolutionary* process. Whether driven by a mega-channel power or an emergent channel steward, highly collaborative channel networks need leadership focused on guiding and directing changes in channel design and management, while at the same time ensuring customer intimacy and profitability for all network participants.

4.5.4 Achieving Strategic Channel Collaboration [14]

Integrating the separate and often competing interests of the independent organizations constituting a supply channel network is a daunting task. Channel networks work best when they are able to cooperate and resolve power and conflict issues where each channel member benefits, and link goals and strategies so as to appear as a single, unified organization focused on total customer service. Because the interests of channel members are often pursued separately, at cross-purposes, or, at worse, competitively, collaboration is difficult to achieve. Strategic channel collaboration seeks to counter this challenge. While providing benefit to the customer is the prime objective, often linked channel members do not all profit the same way nor equally share in the cost.

To make strategic channel collaboration work, all channel members must be committed to a common objective. Each channel member must be willing to surrender some power and to sacrifice some short-term advantages to grow the necessary long-term channel relationships. This means that each party must develop a sense of trust: a feeling that each side is honest, will fulfill its obligations, is sincere, is generally interested in its partners' welfare, and will seek mutual gains rather than just manipulation to achieve selfish gain. Collaboration also means that channel members must risk becoming dependent on one another. Commitment to collaborative relationships occurs over a long-term horizon, requires the active participation of channel members to keep the relationship in place, and requires a willingness to solve conflict issues and accept power relationships that enable collaboration to grow.

As illustrated in Figure 4.20, there are four types of relationship that can be created between channel members. The first type, *channel awareness*, is barely representative of a relationship. Parties are aware of each other, possibly through minor channel competition, but there is little interaction. When members trade with one another, relations are based solely on ongoing transactions, each evaluated on its own merits. Members do not seek to explore their one-on-one business dealings by converting them into a more committed, continuous relationship. Conflicts that arise are primarily handled through avoidance. Parties could terminate for any reason their transactional relationship for a different party that provides more cost savings or competitive advantage.

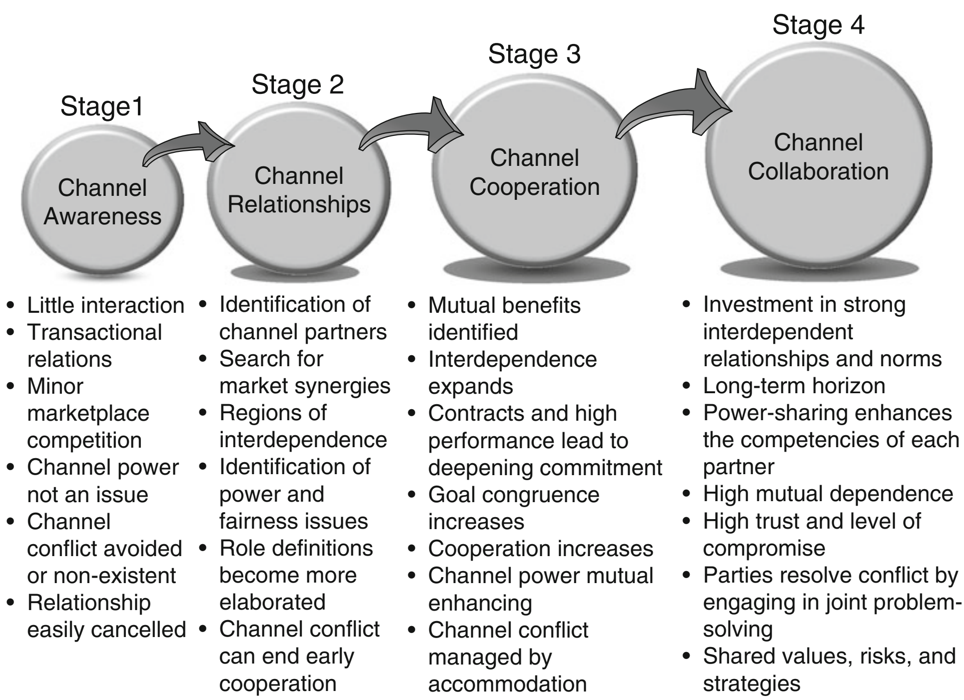


FIGURE 4.20 Stages of channel network collaboration.

In stage 2, *channel relationships,* channel members seek to move their dealings with each other beyond a transaction basis to one characterized by a more stable relationship. The goal is to seek a deeper interaction with other channel members in the hopes of securing additional sources of competitive advantage beyond just the buying and selling of inventories. Members begin to see synergies that can benefit both parties. Channel planners begin to determine the costs and benefits of creating a closer marketing channel together. Among the key discussion points are identifying regions of interdependence, power and fairness issues, motives and expectations, and channel roles. Relationship norms begin to emerge, information sharing becomes more open, trust begins to be established, and boundaries of risk begin to be defined. However, the budding relationship can be easily cancelled, especially if channel conflict grows.

In stage 3, *channel cooperation,* channel members begin to experience significant mutual benefit and high performance from their partner relationships. A deeper sense of trust and interdependence enables each partner to increase risks associated with exploring new markets and products. Cooperation relating to inventory flows, new product introduction, sharing of customer data, pricing and promotions, marketing information, and other elements grows. Contracts and agreements increase relationship stability and goal congruence, while establishing the boundaries for the exercise of channel power. Information technologies are increasingly used to convey every-day, as well as, critical events to planners on each side. Channel conflicts are managed by accommodation.

Stage 4, *channel collaboration,* represents the highest stage of channel network relationship. Each party feels that they have a substantial investment in the success of the channel network. They not only do not fear, but see their interdependence as providing extended resources and innovative ideas for marketplace growth. The robust cooperation ensures a high level of shared values and competitive strategies. Each party regards the relationship as long-term, views other partners as if they were an extension of the home business, and collaboratively engages in joint projects where new ideas are discussed, new products and processes tested, and costs shared. A growing history of collaborative success provides a strong desire for continuity maintained through robust communications and trust. Conflicts are resolved by compromise and joint-problem solving.

It is important to note that while a lot of time, understanding, and commitment is needed to build a collaborative relationship, unfortunately it could also experience quick dissolution or a long drawn out death due to disinterest or a failure to maintain consensus. Many events could spark a decline in cooperation: management changes, competitive pressures, arrival of breakthrough products, dissatisfaction that causes one party to hold back investment and resource sharing, faltering communications, and others. Many collaborative relationships decline simply because one party takes the other for granted or one party simply decides they want to free themselves to pursue other opportunities.

When they work, channel network relationships generate significant competitive advantage and outperform weaker channels. But not all channel members must engage in a collaborative relationship to be successful. In fact, because of the nature of the business environment, companies may find the risk is too great and they can generate better results with more traditional channels. According to Coughlan et al. [15], channel alliances are more likely to hold together when:

1. One partner has special needs that can be satisfied by another channel member.
2. The other channel member has the resources and capabilities to meet those needs.
3. Each side faces barriers to exiting the relationship.

The first two conditions create the basis for mutual value add, which is the foundation of collaborative channel relationships. One channel member feels that its interests are best served through a strategic alliance to the exclusion of other possible network parties. The third condition is necessary to prevent one partner from exploiting the other. Simply, the level of mutual dependence and past record of high marketplace performance is so great that the partners prefer to explore ways of keeping it together rather than dissolving the relationship. In the end, collaborative relationships must "mature, grow, and develop into a valuable asset." They cannot be built quickly. Effective relationship building "requires persistence, resources, and patience" [16].

4.6 SUMMARY

When confronted with the task of designing supply channels, design teams face a variety of decisions. Where should facilities be established, what roles do they perform in the channel, and what criteria should be used to determine how they meet customer needs. What physical factors, such as local infrastructure, attitudes of governments and the community, facility size and cost, and others, need to be taken into consideration? How many echelons should be in the supply and distribution channels? What is the role to be played by channel partners? What channel design models are to be used by channel designers that assist them to make the right decisions that increase long-term profitability for all involved in the supply network? Answering these and other questions begin with the development of a comprehensive channel network design process that is used not only to establish greenfield channel networks but to enable planners to effectively make changes to established channels as marketplace conditions and company objectives change.

The channel design model presented in this chapter suggests that design teams start by mapping the channel strategy. The overall goal is to establish a supply network that is integrated with and is supportive of the corporate business strategy. An effective tool that can be used is the *channel network matrix*. The matrix enables designers to determine how supply and demand channel structures should be constructed that will support the business strategy. The matrix is basically concerned with defining the content of three basic decisions.

1. *How many echelons deep in the supply and distribution channels should the company extend its reach?*
2. *How many echelons are required to source production inventories and deliver products to the customer?*
3. *How many channel partners are needed to effectively manage supply and delivery networks, and what is to be the nature of their relationships?*

Once channel mapping has broadly outlined the configuration of the channel structure, channel designers must then determine the nature of customer demands. In this step, customers are segmented by criteria such as profitability, average purchase, or some other dimension. Once the market segmentation is completed, the next step is to determine the channel structures that best services the needs of the market segments identified. An important strategy is using the four channel service outputs (bulk-breaking, spatial convenience, waiting and delivery time, and variety or assortment). When combined with the channel decisions identified in the channel network matrix, they form a table where planners can position customers by their market segmentation characteristics.

The third step in the channel network design process is constructing the various channel structures that will fit the findings arising from the channel network matrix and the customer segmentation design steps. As various design options are considered, channel design teams must keep in mind four groups of decision criteria. First, the channel structure must satisfy the *channel design attributes*. Second, as the channel configuration is constructed, planners must be careful to identify which of the channel members is performing which of the essential *ten transaction flows* detailed in Chapter 2. Third, planners must validate that the service outputs (response time, product variety and availability, customer experience, order visibility, and others) identified in the *segment channel* phase as essential to customers are being met and that there are no gaps. Finally, design teams must validate that the various channel structures identified represent the minimal cost that is to be expended by each network entity in executing the channel flows. Knowing the cost further assists in determining how channel profits are to be allocated equitably among channel members so that cooperation is furthered and reasons for channel conflicts are reduced.

Once the possible channel structures have been identified in the *channel positioning phase,* channel designers are ready to move to the next step in the channel network design process: *channel selection*. The overall goal of the channel selection process is to maximize customer responsiveness while optimizing company profits and lowering operations costs. Making the best channel network decisions requires planners to follow a simple four-step process.

- *Facility selection issues*. In the first step, planners must identify and quantify all necessary macro and micro issues affecting possible channel facility choices. *Macro* selection issues are concerned with how well the proposed channel networks meet corporate objectives. *Micro* selection issues are divided into two categories: regional/community factors and site factors.
- *Modeling choices*. There are essentially five types of channel modeling techniques. The first, consists of statistical charting, mapping techniques, and spreadsheet comparisons that use a relatively low level of mathematical analysis. The other four models – simulation, heuristics, optimization, and expert system – are dependent on complex mathematics and are run with the assistance of computer software.
- *Assembling the network*. In this step, planners identify the geographical areas where proposed channel facilities are to be located. Planners can employ *gravity methods* to find locations that minimize the cost of transporting raw materials from suppliers to plants, and finished goods from plants to channel distribution and retail facilities.
- *Confirming the network*. The final decision is linking facilities to markets and determining the capacity resource allocation for each channel facility.

With the channel selection process completed, channel designers turn to the final step in the channel network design process: *channel implementation*. This step is concerned with the management of four major functions. The first is selection of channel members. Channel partners should be chosen that possess the attributes that best fit the requirements of the customer market segments. The second function in the channel implementation step is determining the nature and distribution of channel power. Without channel power, the tendency of individual members to maximize their own profit and pursue their own strategies will act as a powerful centripetal force splintering channel networks.

The third function in the channel implementation step is managing channel conflict. Because channels are really coalitions of independent companies, finding common ground where all channel members can realize their own goals in an atmosphere of mutual trust is a delicate and often complex management skill. The final function in the channel implementation step is achieving strategic channel *collaboration*. Channel networks work best when they cooperate, resolve power and conflict issues where each channel member benefits, and link goals and objectives so as to appear as a single, unified organization focused on total customer service. In the end, collaborative channel networks must mature, grow, and develop into a valuable asset. They cannot be built quickly. Effective world-class channel network building requires persistence, resources, and patience.

DISCUSSION QUESTIONS

1. Why do businesses establish supply and distribution channel networks?
2. What are the four critical design considerations that guide channel design?
3. What are the three distribution channel attributes used in channel planning?
4. How do channel networks add value?
5. What are some of the detailed design factors that will influence channel design?
6. A key factor in channel design is the level of desired channel dependency. What are the four types of channel dependencies?
7. If a company decided on a distribution channel where it distributed directly to the customer, how would the decision impact the following channel service objectives: customer service level, product assortment, product availability, delivery time, channel complexity, inventory, transportation, and facilities?
8. Describe some of the micro-factors influencing channel design.

PROBLEMS

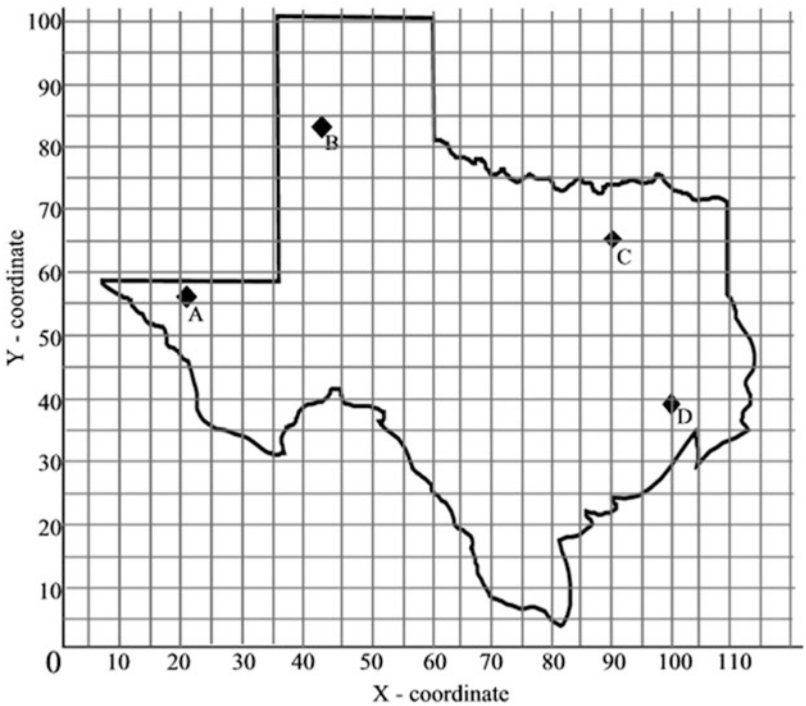
1. Using the *factor rating method*, select a new facility site.
   Scenario:
   The United States Postal Service is planning to establish a new regional postal facility in Washington State for the sorting of mail prior to shipment to individual urban distribution centers. The facility will be a state of the art center using a new high speed sorter. Three potential sites have been chosen for the facility. They are Seattle, Spokane, and Yakima. In order to facilitate the site selection process the following factors were chosen and weighted, and each of the potential sites has been scored. Using the factor rating method, determine which is the best site for the new postal facility?

Decision issue	Weight	Seattle	Spokane	Yakima
Access to air terminal	5	80	70	60
Skilled workforce	5	60	80	45
Construction costs	4	80	70	50
Labor costs	3	85	70	60
Room for expansion	2	70	60	65
MRO suppliers in the area	2	70	80	35

Decision issue	Weight	Seattle	Spokane	Yakima
Access to air terminal	5			
Skilled workforce	5			
Construction costs	4			
Labor costs	3			
Room for expansion	2			
MRO suppliers in the area	2			
	Totals			

According to the calculation the site selected is: _______________.

2. Use the *center of gravity* method to select a location.
Scenario:
A large retail chain is planning to build a new distribution center in Texas to supply its stores located in the state. They have chosen to use the *center of gravity* method to determine the best location for the facility. The map shown below indicates the locations of the four stores currently located in the state.

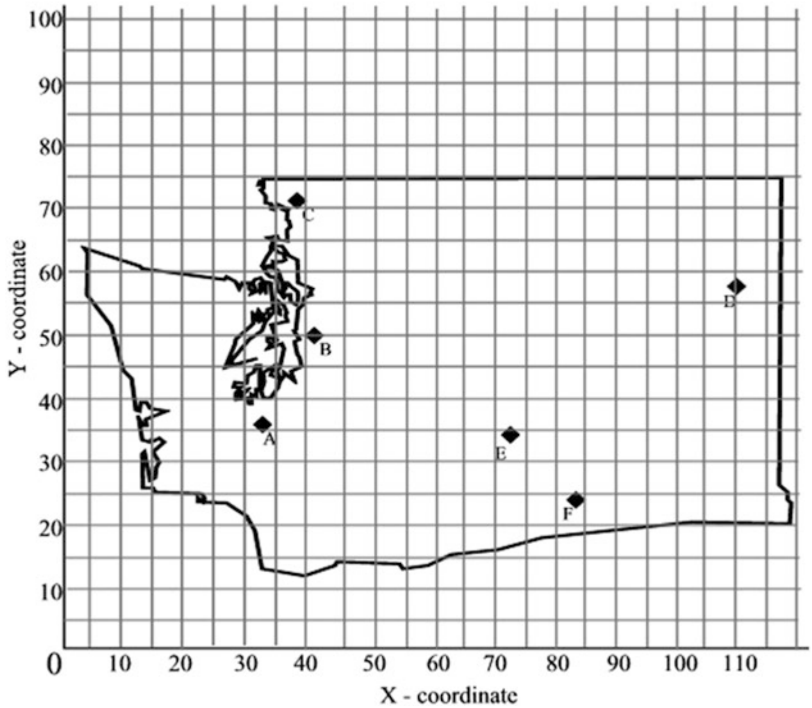


The following table of data has been compiled using both the map coordinates and shipment requirements for each store.

Channel network for texas distribution			
Location	Shipments per month	Coordinate *x*	Coordinate *y*
A-El Paso	8	22	57
B-Lubbock	6	43	84
C-Dallas	12	90	65
D-Houston	10	100	40

1. The location for the new x coordinate is: ___________.
2. The location for the new y coordinate is: ___________.
3. Plot them on the above map to see the physical location.

3. Use the *center of gravity method* to select a location.
   Scenario:
   The United States Postal Service is planning to build a new state-of-the-art mail sorting facility in Washington State. They have decided to use the *center of gravity* method to compare the results with a previously completed study. Based on the data below, determine where the new facility should be located using the *center of gravity* method.



Enter the data in the table below:

Channel network for texas distribution			
Location	Shipments per day	Coordinate *x*	Coordinate *y*
A-Olympia	3	33	36
B-Seattle	8	41	50
C-Bellingham	2	38	72
D-Spokane	6	110	57
E-Yakima	2	73	34
f-Kennewick	5	83	24

The location for the new *x* coordinate is: ___________.
The location for the new *y* coordinate is: ___________.
Plot them on the above map to see the physical location.

REFERENCES

1. All references to the *APICS Dictionary* in this chapter are from the 14th edition (2013).
2. This definition is from Christopher, Martin. 1992. *Logistics and supply chain management*, 11. London: Financial Times.
3. See the discussion in Donald, J. Bowersox, and David J. Closs. 1996. *Logistical management: The integrated supply chain process*, 94–100. New York: The McGraw-Hill Companies, Inc.; Kotler, Philip, and Kevin Lane. 2006. *Marketing management*, 12th ed, 476–486. Upper Saddle River: Prentice Hall; and Goldman, Steven L., Roger N. Nagel, and Kenneth Preiss. 1995. *Agile competitors and virtual organizations*, 201–234. New York: Van Nostrand Reinhold.
4. Some of the topics in this section were adapted from the marketing channel design framework in Coughlan, Anne T., Erin Anderson, Louis W. Stern, and Adel I. El-Ansary. 2001. *Marketing channels*, 6th ed. Upper Saddle River: Prentice Hall.
5. These six points are referenced in Coughlan, et al., 169–172.
6. Seldin, Larry, and Geoffrey Covin. 2003. *Angel customers and demon customers: Discover which is which and turbo-charge your stock*, 41–44. New York: Portfolio.
7. This section is based on the analysis found in Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operations*, 4th ed, 73–85. Upper Saddle River: Pearson/Prentice Hall and Kotler and Lane, *Marketing management*, 476–491.
8. Reference the analysis in Heizer, Jay, and Barry Render. 2004. *Principles of operations management*, 5th ed, 306–307. Upper Saddle River: Pearson/Prentice Hall.
9. The five forms of channel power can be found in French Jr., John R., and Bertram Raven. 1959. The bases of social power. In *Studies in social power*, ed. Dorwin Cartwright, 150–167. Ann Arbor: University of Michigan.
10. Rangan, V. Kasturi. 2006. *Transforming your go-to-market strategy: The three disciplines of channel management*, 9–28. Boston: Harvard Business School Press. The choice of *channel steward* is far more preferable than the more commonly used term *channel master*, which convey a tone of command and compliance.
11. Ibid., 9–12.
12. This figure has been adapted from Coughlan, et al., 268.
13. These points are adapted from Ross, David Frederick. 2008. *The intimate supply chain: Leveraging the supply chain to manage the customer experience*, 93–94. Boca Raton: CRC Press.
14. Parts of this section are borrowed from Coughlan, et al., 315–344.
15. Coughlan, et al., 343.
16. Ibid., 344.

5

Forecasting in the Supply Chain Environment

Much of the success of enterprise planning and decision-making processes depends on the formulation of accurate forecasts. Although it has often been said that nothing happens until a company receives a customer order, unless the enterprise has developed sound plans that enable it to purchase the proper inventory, establish the necessary supply channels, and deliver goods on a competitive basis, the business cannot possibly hope to achieve corporate objectives. In addition, forecasting permits firms to establish performance measurements for customer service, plan the level of total inventory investment, choose between alternative

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_5) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_5,

operating strategies, and develop assumptions about the ability of the business to respond to the future needs of the marketplace.

Effective forecasts can dramatically improve enterprise profitability, productivity, customer service, and ensure competitive advantage. Good forecasting also assists planners to eliminate excess inventory, reduce lost sales and expensive expediting, and control costs involved in maintaining plant size, labor, equipment, and transportation. Finally, the communication of accurate and timely forecasts enables entire supply chains to construct agile and scalable supply networks; architect unique channels of collaborative, value-creating relationships; and continuously align supply network capabilities with the requirements of the customer.

Developing and maintaining accurate forecasts is critical to effective decision making at all levels in the organization. All areas, from top management planning to daily transportation and warehousing, require some level of forecasting for sound departmental planning and control. As the Internet and global competition accelerate requirements for timely product introduction, supply chain management, and multi-channel delivery, forecasting has taken on added importance. In the past, many enterprises could be characterized as having not one but several forecasts, each reflecting the narrow operational objectives of each functional business area. Often the forecasts were out of alignment with each other, projecting different sets of critical performance indicators reflective of departmental goals. Today, supply chain strategists conceive of forecasting as an integrative and iterative process whereby strategic goals are formulated, integrated with the capabilities of supply chain partners, and then disaggregated down through the organization and into the supply channel network. As the forecast unfolds through time, data concerning actual activity is utilized for forecast revision and then communicated to channel partners. The objective of the whole process is to ensure that each supply chain node is utilizing the very latest data in the development of production, supply chain, and logistics plans.

In this chapter, forecasting in today's supply chain environment is explored. The chapter begins with an overview of forecasting as a tool for enterprise planning. Next, the steps necessary for effective forecast development and on-going management will be detail. From this vantage point, the discussion proceeds to a review of the three forecasting types: qualitative, quantitative, and associative (correlation). The major techniques of each of these three types will be detailed with examples and exercises offered to assists in the learning process. Following, the chapter provides an analysis of the various forecast performance models. These models provide forecasters with a window into forecast accuracy and how to use warning signals to adjust drifting forecasts in a timely fashion. Finally, the chapter concludes with a review of why forecast fail.

5.1 FORECASTING: AN OVERVIEW

The *APICS Dictionary* [1] defines *forecasting* as "the business function that attempts to predict sales and use of products so they can be purchased or manufactured in appropriate quantities in advance." Implicit in the definition are two critical concepts:

1. A *forecast* is an objective estimate of future demand attained by projecting the pattern of the events of the past into the future. Literally, the word forecast means to "throw ahead," to continue what has historically been happening. Forecasting is

fundamentally a calculative process whereby a sequence of historical raw data, reflective of demand as it has occurred, is first attained to which various statistical techniques are then applied in order to arrive at an estimate of what the next number or the next several numbers in the sequence are most likely going to be.

2. A *prediction*, on the other hand, is a subjective estimate of what events will be happening in the future. Prediction or "saying beforehand" is a matter of judgment that takes into account both the quantitative and the qualitative data derived from past events occurring in the business environment for the purpose of determining the course of future events. If, for example, a strike is anticipated in the plant of a competitor, a firm's management may very well predict that the demand on their products will rise despite what the current forecast has calculated based on past history.

Forecasting is necessary because the future *is* uncertain. In the physical world where physical patterns and relationships are measurable, mathematical models can be developed that calculate the outcome of any occurrence. In the business world, however, unless a company has a complete monopoly in an unsaturated market, a similar degree of predictability cannot be achieved. To begin with, instead of mathematically calculable factors, the world of human affairs is marked by randomness and endless variation. Patterns and relationships change, often dramatically. Instead of a process that produces exact calculations that are readily applied in management decision making, forecasters do well to begin with an understanding of the limitations and uncertainties that reside at the core of forecasting. Strategic planners must realize that forecasts will always be subject to error and that, although there are techniques available to improve forecast accuracy, the amount of effort expended soon reaches a point of diminishing returns. Beyond this point, forecasters should concentrate more on coping with forecast error than on architecting even more complex forecasting models.

Forecasting is an essential component of effective business management.

- Forecasts enable managers to deal with the underlying uncertainties that reside at the core of demand and supply.
- Forecasting permits firms to establish performance measurements for customer service, plan the level of total inventory investment, choose between alternative operating strategies, and develop assumptions about the ability of the business to respond to the future needs of the marketplace.
- Effective forecasts improve profitability, productivity, and customer service.
- Effective forecasts assist companies to eliminate excess inventory, reduce lost sales and expensive expediting, and control costs involved in maintaining plant size, labor, equipment, and transportation.
- A forecast is useful in creating, anticipating, and managing change within an organization.
- Finally, accurate and timely forecasts enable companies to construct agile and scalable capabilities aligned with the requirements of the customer.

5.1.1 Elements of Forecasting

In developing and deploying forecasting techniques, planners need to be aware of the following general characteristics of forecasting:

- Forecasts are usually wrong.
- Forecasts are most useful when accompanied by a method for measuring forecast error.

- Forecasts are more accurate the larger the statistical population used.
- Forecasts are more accurate for shorter periods of time.

In addition to the basic inability of forecasting to provide exact information for decision making, many supply chain planners have corporate cultures that militate against forecast success. Common complaints range from the fact that the forecasting effort has been so splintered that it is meaningless and that no one really understands the statistical calculations, to problems in the collection of accurate and forecastable data.

Although forecasting for supply chain management is often characterized more as an art and less as a science, there are, nevertheless, principles and statistical approaches that can be utilized to assist the forecaster. Like a physical scientist attempting to understand all the forces acting on an experiment, the forecaster uses known postulates and mathematical techniques to abstract general patterns and event relationships from the apparent randomness occurring in the detail. The solution to creating accurate forecasts is to develop a formal forecasting program that uses relevant techniques and consists of an effective system that detects, measures, and provides the mechanics to enable forecasters to react quickly to discovered errors. The goal is to determine predictable data that the business planning process can employ to assist in making good decisions about the best marketplace alternatives available for the enterprise.

There are seven characteristics or dimensions that play a critical role in determining effective forecasting [2].

1. *Time horizon*. The length of the time horizon influences the choice of forecasting model. Each forecast level possesses its own unique characteristics relative to the most appropriate forecasting method and data required. Long-range forecasts generally use qualitative models, whereas quantitative models are more appropriate for shorter-term forecasts. Planners must ensure that top management plans are easily disaggregated from high-level forecasts to detailed shorter-term detailed forecasts. In the end, there is a single set of forecasting numbers the only difference being different time windows, level of aggregation, and planning detail.
2. *Level of aggregate detail*. Forecasting in a multi-echelon environment occurs at many levels. Forecasts are used in the development of business, marketing, sales, logistics, and detailed inventory plans. Each forecastable area differs in two regards: the techniques employed and the level of detail required. As forecasters move from the general to the specific, the level of forecast detail correspondingly moves from a concern with aggregate data to gross detail. In selecting the appropriate forecast for a specific plan, forecasters must determine the level of detail required for that forecast if it is to be useful in decision making. Corporate planners, for example, are usually concerned with aggregate estimates of dollars and product groups and find a forecast of the weekly sales of a given item of little value. Generally, as forecasts become more specific, the size of forecastable data grows exponentially, necessitating the use of a computer system to assist in data collection, storage, and retrieval.
3. *Size of the forecastable database*. The number of elements in a forecast population has a direct impact on the forecasting methods employed. In general, as the number of historical data occurrences to be calculated in a forecast grow, the simpler the forecasting method. The reason is that the larger the number of occurrences, the more valid is the application of statistical forecasting techniques. Conversely,

the smaller the size of the data used in a forecast, the more complex the forecasting technique if variation is to be smoothed and accounted for. For example, a sales manager forecasting the sales by week of 1,000 finished goods items would not use the same techniques as another sales manager charged with forecasting 100 product groups in a business quarter.

4. *Forecasting control*. Planners need to utilize methods that render accurate and timely feedback to permit effective forecast control. Control methods must indicate when data occurrences have moved beyond predetermined acceptable forecast variance boundaries. Control methods provide forecasters with the capabilities to adjust for changes in historical demand patterns and relationships. The objective is to ensure that forecasting decisions are being made that are in alignment with actual events. An example is a forecast of sales established for a new product group. Because the new product group lacks the historical data needed for detailed forecast development, planners will have to closely monitor the forecast to ensure that actual sales supports the forecast, and if not, what patterns are emerging that permit the formulation of a more accurate forecast.
5. *Constancy*. The forecasting models used to project demand data exhibiting stability over time are quite different from the models needed to forecast historical data exhibiting stochastic demand. The principle underlying this dimension is simply that the more variation occurs in the forecast, the more forecasts will have to be adjusted. In a stable environment, a quantitative forecast based on historical data can be adopted and reviewed periodically to confirm its appropriateness. On the other hand, when there is great variation in forecastable data, forecasters should apply methods that are continuously adapted to reflect current events and the latest information.
6. *Forecast model selection*. Models should be selected that match the dimensions relevant to the forecast (such as geographical area, product groups, and customer groups). Forecasters must understand the differences in demand among the dimensions and select models that match the objectives with the demand patterns of the forecast target.
7. *Alignment with planning procedures*. Forecasting methods should be chosen that support the firm's planning and decision-making processes, as well as enhance and improve upon existing operational norms. Companies often confuse *forecasting* and *planning*. Often forecasters employ forecasting methods to simulate the outcomes of plans. After results are validated, they then revise plans, obtain new forecasts, and repeat the process until the forecasted outcomes are satisfactory. Once a forecast is decided upon and, as actual events unfold, they can revise plans until the next forecasting period. A common mistake of companies is that if events do not match the expected outcome, they revise their forecasts and not their plans. The supposition is that changing the forecast will change the outcome.

There are undoubtedly other dimensions that exist that characterize specific forecasting situations. Once these and other possible dimensions are understood, forecasters can advance to an investigation of the different levels of forecasting.

5.1.2 Forecasting Levels

Determining the forecasting time horizon was identified above as a critical dimension of forecast development. Planners forecast the probable course of events that might occur over varying lengths of time. As illustrated in Figure 5.1, forecasting occurs on four levels.

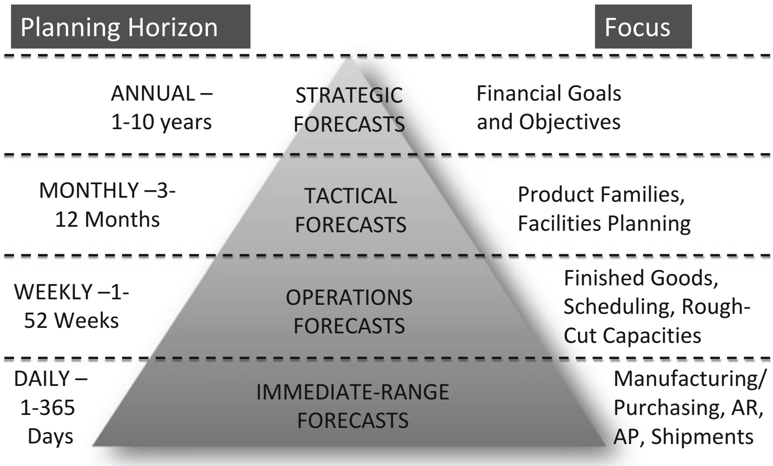


FIGURE 5.1 Forecasting levels.

- The highest level is described as *strategic forecasting*. This level has a time horizon of at least 1 year and is used in the development of top management planning. Forecasts on the strategic level are usually stated in very general terms such as total sales dollars, return on assets, or some other aggregate set of values. Normally forecasts in this area use judgmental and correlation models where aggregate data is related to economic or marketplace indicators such as the gross national product, housing starts, and unemployment. Among the decisions associated with this level of forecasting are developing corporate goals and objectives; performing corporate capital budgeting; planning for facilities, equipment and other fixed assets; and structuring channel networks.
- The next level, *tactical forecasting*, has a time horizon of 3 months to 1 year or longer and is normally applied to operations planning and control activities. Forecasts on the *tactical level* are usually stated in terms of aggregated values from sales revenues, output of product families, or some other measure. Classically, the forecast is built by aggregating the demand and forecasts for items into their respective product families. Forecasting decisions on this level impact sales, estimates of warehouse and transportation capacities, business area capital planning, production capacities, and contracting for public warehousing and transportation services. This level is concerned with forecasting product family level volumes.
- *Operations forecasting* comprises the third level of forecast planning. This level consists of item-level forecasts normally decomposed from the family forecasts developed at the tactical level. Forecasts are normally concerned with the actual mix of end-items comprising product family forecasts. Forecasts in this level usually extend for at least a year into the future and appear in weekly time frames. Forecasting decisions on this level impact such activities as manufacturing scheduling, supplier

scheduling, inventory procurement plans, transportation planning, materials handling equipment utilization, and detailed operating budgets.

- Finally, *immediate-range forecasting* is used for everyday performance of ongoing activities. Examples include transportation scheduling, receiving, stock put away, shop floor and postponement scheduling, order filling, and accounts receivables and payables flow through.

Each forecast level possesses its own unique characteristics relative to the most appropriate forecasting method and data required. It would be improper, for example, to employ a forecast method to calculate product demand on a weekly basis for the purpose of determining yearly aggregate sales income.

5.1.2.1 The Forecasting Process

In the forecast development process, the following steps are normally performed:

1. Define the purpose of the forecast
2. Select the appropriate forecasting model(s)
3. Prepare the statistical components
4. Ensure the interaction of the firm's functional area managers
5. Execute the forecast
6. Track and maintain the forecast through timely and accurate feedback

Before a forecasting technique is chosen, forecasters first determine the purpose of the proposed forecast. In accomplishing this task planners are faced with three critical tasks. To begin with, they must match the proper forecasting method with the stated objectives of the firm's business units, ranging from long-term to short-term goals. Second, forecasters must utilize forecasting methods that are easily integrated to provide the enterprise with a comprehensive game plan that is supportive of both departmental, as well as, corporate performance targets. Finally, the forecasts must be capable of being communicated to supply chain partners. Failure to integrate the various forecasts not only through each business unit throughout the firm, but also externally with each trading partner, results in dysfunctional management decisions where business entities pursue separate objectives and potentially opposing measures of performance.

Once the purpose of the forecast is defined, forecasters can then proceed to the selection of the techniques necessary to fulfill forecasting objectives. Choosing the proper technique(s) is perhaps the most critical stage in the forecasting process and consists of the following elements:

1. *System Dynamics*. The first stage in forecast technique selection is to determine the various business functions within the organization, such as sales, inventory management, production capacities, and others, that require forecasting. The forecasting system that is constructed should indicate where input is controlled by the company and where input is in the control of external forces. Such an analysis provides forecasters with the ability to match the technique with the source of input data. The more the firm has control over input, the more *quantitative* the forecast technique; correspondingly, the less control, the more *qualitative* the forecast technique.
2. *Technology Elements*. The requirements for computational power, sophistication of the system's forecasting functionality, integration with backbone data warehouses,

and electronic interoperability with supply chain partners make the selection and application of computerized forecasting systems a requirement before real forecasting strategies are developed. Today's ERP, "best-of-breed" applications, and Internet enablers provide a wide-range of software capabilities targeted at facilitating the gathering, analytical compilation, transmission, and release of forecasts in real-time from any node in the supply chain. The choice of technologies must closely support the purpose of the forecast as identified in the previous step.

3. *Time Horizon*. Selection of the proper time horizon is critical in the determination of the length of time to be considered by the forecast. Generally, qualitative and correlation methods are employed to calculate long-range forecasts, and quantitative methods are employed to calculate short- to medium-range forecasts. In addition, the data of the proposed forecast is also affected by the time horizon to be used. By using the requirements of the functional business area as one dimension and the time horizon for planning as the other, characteristics such as size of forecasted period (weekly, monthly, etc.), frequency of review, and unit of measure is determined. Purchasing, for example, has forecasting requirements that extend through short- to long-range horizons. In the short range, purchase order release, review, cash availability, and performance measurement are the key elements in forecast selection. Medium-range concerns focus on purchasing planning to support the materials plan. Finally, in the long range, purchasers are concerned with supplier partnership management, contracts, and delivery scheduling that requires aggregate business forecasts capable of being shared with upstream supply points.
4. *Data*. When selecting forecasting techniques, strategists must understand the nature of the data required and the availability and accuracy of that data within the organization and outside in the supply chain. Fundamental to the appropriateness of the data is understanding the kinds of patterns found in the data. Some data, for example, may exhibit a stable demand with limited random variation; on the other hand, other data may contain an historical trend or seasonal demand. Finally, other data may consist of combinations of these patterns. Furthermore, a desired forecasting technique may require data that the firm either does not possess or that has been poorly recorded. In such an instance, forecasters may be required to use qualitative rather than quantitative techniques in forecast creation. In the end, techniques that match the objectives of the forecast with the existence and observed patterns of the data to be employed in the calculations need to be carefully chosen.
5. *Cost*. As the utility of any forecast is reflected in the quality of the decisions that are made based on the results, ideally the selection of forecasting models are based on a simple correlation of forecast cost and the value of the forecasting decision. One simple criterion for forecast selection is to use a forecasting process that is low cost. As an example, the preparation of a forecast necessary to determine the future demand on thousands of items on a weekly basis requires a technique that is simple, effective, and low cost. In general, the shorter the range of the forecast, the more low-cost forecast techniques are used, with the more costly methods reserved for aggregate long-range forecasts.
6. *Accuracy*. Besides appropriateness, the data used must be accurate if forecast output is to be meaningful. Before a particular technique is selected, forecasters must

understand how the data have been obtained, verified, recorded, and transmitted. To ensure accuracy, forecasters employ tools that minimize errors and provide for appropriate adjustment of nonrecurring events. *Forecast alarms*, for example, assist by focusing attention on occurrences outside a predetermined range of acceptable high and low values. In summary, forecasters must examine the collection, calculation, completeness, source, and accuracy of the data before selecting a forecast technique.

7. *Ease of Use and Simplicity*. Many planners make the mistake of over-complicating their forecasts by trying to use complex mathematical formulas to solve relatively simple forecasting problems. The literature on forecasting is filled with obtuse mathematical approaches. The problem with these techniques is that they are potentially very costly solutions requiring computer storage, manual coding and file maintenance, and a trained expert to understand them. In reality, forecasters should select techniques that are simplistic, minimize file maintenance, and are easy for the user to understand.

The third step in forecast development is data preparation. It has already been stated that accurate data must be available *before* a forecasting technique is chosen. Data preparation, however, extends beyond the subject of the forecast (for example, historical sales figures) to consider other data that has impacted sales in the past. Looking purely at sales history without related information such as price increases, shortages, sales promotions, new products, actions of competitors, and other factors produces a biased and incomplete view of demand. In addition, the forecaster must determine just what is to be forecasted. For example, consider the forecaster who is attempting to derive item-level forecasts summarized from four distribution centers. One approach is to forecast demand individually at each distribution center. If this data set is used, forecasts are affected by the variations experienced at each distribution center. An alternative is to calculate a product-family national forecast and to disaggregate it to the SKU level on the basis of historical percentages. Finally, time needs to be allotted for actual data preparation. As a rule, the shorter the forecast time frame, the faster the data must be ready. For most forecasting methods, computer programs have been developed that greatly increase the speed and accuracy in calculation. Urgency and the length of time required for forecast preparation are key elements in forecast technique selection.

Before the forecast is executed, it must gain the consensus of the firm's management team. A firm that blindly executes the statistical portion of the forecast without soliciting the input of all affected functional managers, and sometimes channel partners, will get varied results. For example, marketing and sales has decided to run a promotion on a specific product group in an effort to increase market share. It is critical that expected sales be communicated to logistics management, who, in turn, forecasts the availability of purchasing, warehousing, and transportation capacities in anticipation of the impact increased demand will have on company and supporting channel partner resources. Without the proper communication and alignment of forecasts between these entities, it is doubtful whether the firm will be able to effectively respond to the promotion and achieve the targeted revenue and cost objectives.

Other forms of marketing and sales intelligence are critical to effective forecasting. Such factors as special pricing, loss of market share, attempts to gain market share, introduction of new products, changes to the supply chain structure, and others need to be communicated to ensure the organization and its trading partners are pursuing a common plan. When developing forecasts, inventory control and marketing should generate a "first-cut" forecast that is then reviewed by internal managers from sales, purchasing, warehousing, manufacturing, and finance, as well as outside channel partners who can assist in evaluating and approving the forecast data before the final forecast is calculated.

Execution of the forecast can potentially be a difficult task. Many companies have items exhibiting several different historical demand patterns that must be accounted for in the forecast calculation. For example, a distributor may have demand that is widely varied. Some items have demand that is horizontal: Sales are consistent over time with minimum variation. Older items may exhibit intermittent demand where sales are very irregular. Still other items might exhibit a trend. To ensure the proper forecasting technique is being applied to match demand patterns, forecasters need to employ systems that are flexible enough to satisfy the forecasting requirements of each type of event. Supply chain strategists should always keep referring back to the goals of the proposed forecast in guiding them in the selection and use of forecasting methods.

The final step in forecast development is monitoring forecast feedback. Forecasting should be conceived as a continuous process of measurement, like the use of statistical quality control in production. As such, monitoring feedback has two separate but connected activities. To begin with, feedback alerts the forecaster when the process is out of control. Second, feedback signals how far the process is out of control and what must be done to regain forecast control. There are several techniques revolving around the concept of a *tracking signal* that assist forecasters in monitoring feedback. A simple tool is the use of *forecast alarms* whereby significant errors that exceed a predetermined range are flagged for review.

5.2 FORECASTING TECHNIQUES

The variety of forecasting methods available can be organized into three basic types: *qualitative* or *judgmental*, *quantitative*, and *associative (correlation)*. Each major type is composed of several techniques. The first type uses basically non-statistical methods, such as expert judgment, intuition, and subjective evaluation, to determine forecasts. Quantitative methods employ statistical models, time-series analysis, and projection to search for historical patterns that can be extrapolated into the future. The final type, associative or correlation, attempts to express mathematically the relationships between the forecast object and other variables or factors, such as technological, political, economic, and socioeconomic events, to arrive at a forecast.

Figure 5.2 is a schematic flow of the forecasting function. Each of the three forecasting types is seen in their relationship to each other. Of critical importance is the closed-loop nature of the forecasting process. As actual events occur, the forecast system must be able to provide forecasters with sufficient data to compile the forecast, computer software that calculates the forecast efficiently and accurately, and computer applications that enable planners to quickly respond to forecast error, evaluate variances, and make informed changes to the current forecast.

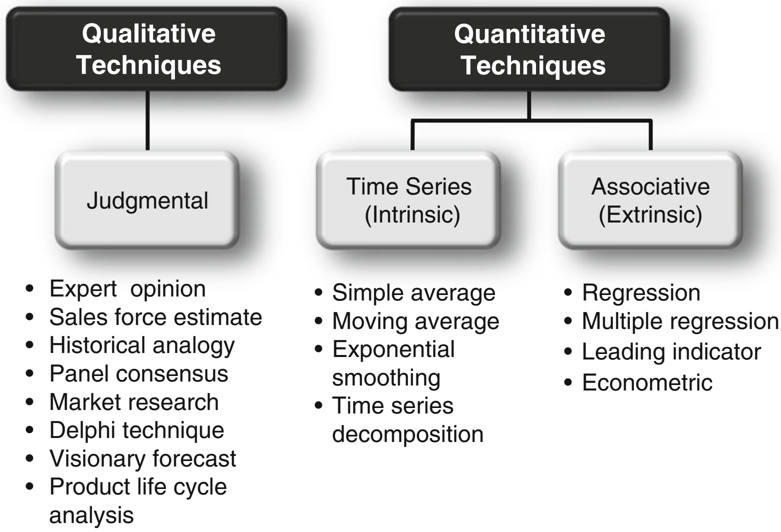


FIGURE 5.2 Forecasting types.

5.2.1 Qualitative Techniques

Qualitative or *judgmental techniques* are generally used when developing strategic-level forecasts. The objective is to use human judgment based on analysis to convert collected data, patterns of external relationships, or historical analogy into a forecast of probable events. For the most part, these qualitative forecasts are used by senior management to project trends and potential demand for large families of products over an extended time period or developing aggregate sales or inventory forecasts. These techniques are also ideal for developing forecasts for products in the design or introductory stages of their life cycles. These products generally do not have a large repository of historical demand data. In such a case, techniques employing market research and historical analogy might be used that combine personal judgment along with the statistical demand of similar products. A very simple example of qualitative forecasting is illustrated in Figure 5.3. The example demonstrates the development of a forecast of monthly sales based on the projections of a panel composed of three company executives.

$$\text{Monthly forecast} = \frac{\begin{matrix}\text{Executive 1}\\ \text{Forecast}\end{matrix} + \begin{matrix}\text{Executive 2}\\ \text{Forecast}\end{matrix} + \begin{matrix}\text{Executive 3}\\ \text{Forecast}\end{matrix}}{3} =$$

$$\text{Monthly forecast} = \frac{500 + 600 + 550}{3} = \mathbf{550}$$

FIGURE 5.3 Three-executive panel forecast.

The general flow of developing a qualitative forecast is outlined in Figure 5.4. The process begins by identifying the forecasting objective. This step enables forecasters to clearly identify what is to be forecasted and what results are anticipated. Once the object of the forecast is identified, planners move to the next step and seek to gather and determine what quantitative data is to be used in developing the qualitative forecast. Since non-statistical information is at the core of the qualitative forecast, forecasters will next seek to apply applicable techniques from social science (behavioral) research.

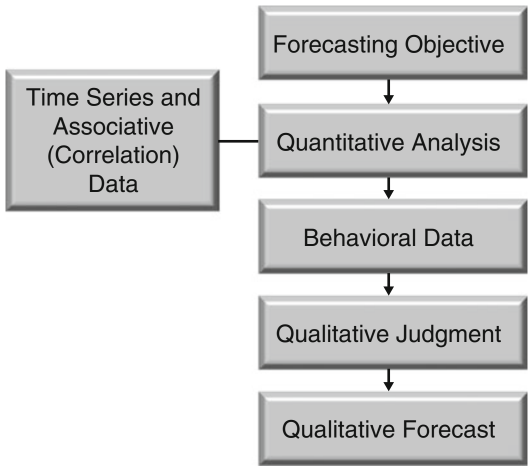


FIGURE 5.4 Qualitative forecast development.

Examples of such sources include:

- structured collections of market and customer data in surveys, focus groups, panels, and test marketing (such as market size, consumer income profiles and demographics, and spending habits)
- standard survey research methods
- statistical modeling of consumer behavior (relationship between demographics and purchasing)
- subjective yet experience-based assessments of customer behavior and product demand
- intuition based on practical experience

Once sufficient data are accumulated, forecasters then use the assembled data, combined with a personal, informed opinion or intuition, to draft a forecast. After the results of the process is reviewed, the forecast is ready to be used by the organization.

The standard qualitative forecasts techniques in use today are:

- *Personal Insight*. The most common qualitative technique is individual judgment based on intuition. In this method a single expert employs personal knowledge and past experience to produce a forecast based purely on subjective judgment. Advantages of this technique are its relative low cost and speed of formulation. Drawbacks are that although the method may render some good forecasts, results are extremely variable. Besides, it has been demonstrated that forecasters who follow a formal forecasting process will always out-perform forecasts based on subjective opinions.

- *Sales Force Estimates*. This technique use the projection of future sales compiled by the firm's sales force based on individual salesperson estimates, market/product expertise, or surveys of supply chain demand. The advantage of using this technique is that it employs the specialized knowledge of those closest to the marketplace.
- *Panel Consensus*. This approach brings together experts from across the supply chain to review and estimate the best forecast for a product, product group, or service. Advantages of this technique are that it is quick and easy to use, requires minimal preparation of statistical data, and pools the collective experience and judgment of experts from across the supply network. Disadvantages are that outcomes can be variable and exposed to biases and group think.
- *Market Research*. This technique attempts to forecast future demand trends and activity levels by surveying a market segment whose past behavior and actions indicate future buying patterns. The drawback with using this technique is that market surveys are expensive and time-consuming to execute and monitor. In addition, they rely on the accuracy of the randomness of the sample and the conclusions drawn from the analyses.
- *Visionary Forecasting*. This technique is the most radical and consists of a prophecy of the future based on personal insight, judgment, and, when available, historical analogies that can be extrapolated into possible future forecasts. It is characterized by subjective guesswork and imagination, and, in general, the methods used are nonscientific and non-quantitative.
- *Delphi Method*. In this popular approach, a panel of experts, who do not physically meet, is interrogated by a sequence of questionnaires concerning a new product, event, or process. Responses to the questionnaires are passed on to all the panel members for evaluation and rating as to the likelihood of occurrence and are then used to produce the next set of questionnaires. The object is to narrow down a field of opinions that can be used as forecastable data.

Qualitative methods of forecasting have advantages and disadvantages. In general, an important advantage lies in the ability of strategists to develop forecasts for products and services that lack initial quantifiable data or when the variations in recorded occurrences are so dramatic that it is impossible to determine stable historical patterns and relationships. In addition, forecasts using this method are easily and quickly assembled without complex statistical computation. Disadvantages are summarized as follows:

1. Lack of supporting evidence for forecasting decisions.
2. Overconfidence in the elements used and the results of the compiled forecast.
3. Possibility of over conformity of the individual to collective values and attitudes when group qualitative types are used.
4. High cost of development and maintenance when used in computerized forecasting systems.

Collectively, these limitations tend to create judgmental biases especially when the forecast is dependent on established patterns or relationships of data [3].

5.2.2 Quantitative Intrinsic Techniques [4]

Quantitative intrinsic techniques are best used for forecasting when there exists sizeable historical data and when the relationships and patterns of these data are both clear and relatively stable. The fundamental assumption of quantitative forecasting is that the future can be accurately extrapolated from the occurrences of the past. The operating principle is relatively simple: The forecaster uses the accumulated data of historical performance to attain an estimate on the current rate of activity (sales, for example) and how fast this rate is increasing or decreasing. Once this rate is ascertained, various statistical techniques are employed to calculate the forecast based on the assumption that historical demand patterns will continue into the future.

Unfortunately, it is very difficult to develop accurate forecasts using raw data because changes in the rates of activity are not directly observable. Cycles, trends, seasonality, and other factors create variations within the data. In addition, patterns are distorted by management decisions such as a promotion or special pricing that cause abnormal spikes of data to occur during select periods. To use historical data effectively, forecasters must massage the raw data by analyzing activity rates and uncovering patterns and applying the proper forecasting technique.

Much has been written concerning actual use of *qualitative* versus *quantitative* types of forecasting. Actually, both types of forecasting possess individual advantages and disadvantages. Quantitative forecasts are clearly more advantageous when it comes to objectivity, consistency, repetitively calculating a large-sized task (such as forecasting 10,000 items), and cost of execution. In contrast, qualitative forecasts are superior when historical data are lacking, inside information or knowledge is critical, and ease of evaluation and modification is paramount. In reality, even when established patterns or relationships are constant, forecasters cannot blindly accept statistical output without analyzing the applicability of the data to the current environment and reviewing the accuracy of the technique employed. In fact, both forecasting types are complementary and must be integrated to produce accurate and usable forecasts.

5.2.3 Basic Quantitative Forecasting Techniques

When selecting quantitative forecast techniques, forecasters must search for the most appropriate method that fits the nature of the data and the enterprise's forecasting objective. For example, quantitative forecasting occurs on the aggregate level (such as forecasts by product family or product-line sales on a monthly basis) or on the item level, such as a daily forecast by individual unit or sales value. Forecasters ask themselves several important questions:

- What is the cost and the amount of effort required to develop and execute the forecast?
- What is the level of data accuracy required by the forecast technique selected?
- Which forecasting technique will best match historical patterns such as trend, seasonality, and so on?
- Does the firm possess the necessary data processing tools for the desired forecast computation?

In this section, the major quantitative forecasting techniques are explored. The goal is to equip the reader with a working knowledge of basic quantitative methods.

5.2.3.1 Simple Forecasting

The simplest form of quantitative forecasting is referred to as a *naive forecast*. The elements necessary for the calculation are easy to understand and apply. The equation on which the technique is based is

$$Ft + i = Xt \tag{5.1}$$

where $Ft + i$ is the forecast for period $t + i$, t is the present period, i is the number of periods ahead to be forecasted, and Xt is the latest actual value (for period t).

This equation uses the most recent actual demand value, disregards the value of the past forecast for the same period, and extrapolates the result as the new forecast for the next period(s). For example, if the actual demand for period X is 125, that value then becomes the forecast for the next period(s), and so on. This technique could be used to forecast data where turning points indicating error cannot be predicted.

5.2.3.2 Averages

Forecasts can be calculated by the use of several forms of *average*.

Simple Average. In this technique, the actual demand found in the present period is added to the actual demand of the past period, and the average is then calculated. The resulting value is the new forecast. The equation on which the technique is based is

$$Ft + 1 = \frac{Xt\ +\ Xt - 1}{2} \tag{5.2}$$

where $Ft + i$ is the forecast for period $t + i$, t is the present period, and Xt is the actual values (for period t).

For example, if sales on an item totaled 400 units for the past period and 420 units in the current period, the new forecast would be calculated as (400 + 420)/2 = 410 units.

Year-To-Date Average. In this technique, actual demand is recorded as it occurs period by period and is added together. The calculated value is then divided by the number of periods used with the resulting value posted as the forecast for the next period. The equation on which the technique is based is

$$Ft + 1 = \frac{\Sigma Xt\ +\ Xt - 1 + \ldots Xt - n}{n} \tag{5.3}$$

where $Ft + i$ is the forecast for period $t + i$, t is the present period, Xt is the actual values (for period t), and n is the number of periods.

As an example, say that the sales over the first quarter of the year equaled 200, 210, and 190. The forecast is determined as (200 + 210 + 190)/3 = 200. If the sales for month 4 equaled 220, the forecast is calculated as (200 + 210 + 190 + 220)/4 = 205. The progression continues until a pre-determined number of periods is reached. Theoretically the number of periods could be infinite. The value of these two forms of forecasting is their simplicity and ease of use. Drawbacks are insensitivity to variation and unavailability of turning points for forecast adjustment.

Moving Average. One of the main problems associated with using a simple average is that the equation places equal weight on present and past data; year-to-date average places too much weight on past data, smoothing out variation especially as time moves forward. The result is that both techniques are insensitive to trends or outliers. One solution is to use a *moving average*. This technique calculates the sum of historical values for a set number of periods, finds their average, and then uses the result as the forecast for the next period. The average is moving because as time moves forward, the last period is dropped from the calculation and the current period value is added. The number of periods used can range from 2 to 12 or more with 3–5 being the most common. The formula for a three period moving average is

$$Ft+1=\frac{\Sigma Xt\ +\ Xt-1+Xt-2}{3}$$

$$Ft+2=\frac{\Sigma Xt-1\ +\ Xt-2+Xt-3}{3}, \tag{5.4}$$

For example, if the demand for periods one through three were 200, 220, and 240, then the calculation of the new forecast is as follows:

$$200+220+240=660/3=220$$

Although the moving average technique assists forecasters with solving the problem of period weighting, it does not work very well if the forecast exhibits trend or seasonality. In such cases the moving average consistently lags behind actual demand.

Weighted Average. While the moving average assists forecasters to smooth past demand to ensure a more accurate forecast, the ability to place a "weight" on instances of past demand enables planners to determine how much of an influence the relationship of past demand will have in the forecast calculation. Simply put, an "unweighted" time series of two instances of demand assigns a 50 % weight to each demand value. The *weighted moving average* technique enables forecasters to "weight" each instance of demand in an effort to determine a forecast that more closely resembles reality. The formula for this calculation utilizes the moving average technique plus the addition of a weighting factor that is multiplied by each instance of demand and then divided by the sum of all weighting factors.

$$Ft+1=\frac{\Sigma wXt\ +w\,Xt-1+wXt-2}{\Sigma w}$$

$$Ft+2=\frac{\Sigma wXt-1\ +\ wXt-2+wXt-3}{\Sigma w}, \tag{5.5}$$

where

$w1$ = Weight to be given to the actual occurrence for period $t1$
$w2$ = Weight to be given to the actual occurrence for period $t2$
$w3$ = Weight to be given to the actual occurrence for period tn
Σ = Sum of the total weighted factors

For example, if the demand for periods one through three were 200, 220, and 240 respectively and the weights correspondingly assigned at 2, 3, and 4, then the calculation of the new forecast is as follows:

$$2(200) + 3(220) + 4(240) = 2020/9 = 224.44$$

The weighted moving average can only be used when there are sufficient periods of demand data available. The weighting factors applied are determined by the forecaster in relation to the relative importance of instance of past demand. While the weighted moving average produces a forecast that is more receptive to changes in demand patterns, it still lags behind possible trends. In the example above, the new forecast of 224 is still considerably dampened in what appears to be an upward trend in sales.

Exponential Smoothing. The use of a moving average has at three important limitations. To begin with, to calculate a moving average necessitates the storage of a large amount of data, especially if the demand history is significant. Second, as the amount of historical data grows, it becomes more difficult to flag occurrences exhibiting trends or seasonality. Finally, the moving average method gives equal weight to old and new observed values. It can be argued that when preparing a forecast, the most recent events should be given relatively more or less weight in the calculation than older ones. *Exponential smoothing* is a technique that offers a solution to these problems. The advantages of this technique are that it permits forecasters to assign weights to past historical and present period data to reflect changes in demand patterns. In addition exponential smoothing requires only minimal computer space to store data and perform the forecast calculation.

The components of the exponential smoothing calculation consist of the value of the old forecast, the value of the current observed data, and a smoothing constant or alpha factor (α). The most commonly used formula to express exponential smoothing is

$$Ft = \alpha(Dt) + (1 - \alpha)(Ft - 1) \tag{5.6}$$

where Ft is the exponential smoothed new forecast, t is the current period in which the most recent actual demand is known, D is the current period actual demand, α is the constant, and F is the exponential smoothed forecast of one period past.

The alpha factor is expressed as a value between 0 and 1. The alpha factor assigned to the demand and past forecast cannot total more than 1. For example, if the current forecast is 500 units, the current period's demand is 450 units, and the alpha factor (α) is 0.2, then the exponential smoothing forecast for next period is

$$0.2 \times 450 + (1 - 0.8) \times 500 = 490 \text{ units}$$

Adaptive Exponential Smoothing. Choosing the correct *smoothing factor* is critical for exponential smoothing to provide the information necessary for effective forecasting. According to DeLurgio and Bhame [5], the following rules of thumb can be applied when selecting a *smoothing factor*:

$$\text{Use a low } alpha \text{ for a random demand series}$$
$$\text{Use a high } alpha \text{ for a random demand series}$$

In general, when determining a *smoothing factor* using heuristic methods, the primary issue is deciding upon the number of periods to be used in the computation. When calculating the *alpha* based on the number of desired periods the following formula is used:

$$\alpha = \frac{2}{(n+1)} \tag{5.7}$$

Using this formula, the following chart is produced:

$$\text{For } alpha \text{ of } 0.1: \; n = (2/0.1) - 1 = 19 \text{ period average}$$
$$\text{For } alpha \text{ of } 0.3: \; n = (2/0.3) - 1 = 5.67 \text{ period average}$$
$$\text{For } alpha \text{ of } 0.6: \; n = (2/0.6) - 1 = 2.33 \text{ period average}$$
$$\text{For } alpha \text{ of } 0.9: \; n = (2/0.9) - 1 = 1.22 \text{ period average}$$

When choosing an *alpha*, the goal is to select a value that yields the most accurate forecast and that value is best described as the one that achieves the lowest standard deviation of forecast error. To achieve this objective, simulation calculations are used to determine the alpha exhibiting the lowest error. This *alpha* is then used in the next forecast generation. The goal is to have the *alpha* be *adaptive* to the ratio of the absolute value of two averages: *average error* and *average absolute forecast error*. The formula for calculating an *alpha* from forecast deviation is as follows:

$$alpha = \left| \frac{Mean\ Error}{MAD} \right| \tag{5.8}$$

The *alpha* generated by the calculation is in reality a *tracking signal* that demonstrates forecast error over time. For example, when a series moves rapidly up or down, a high *alpha* is calculated and applied to the equation. In contrast, if the series is consistent and has low forecast error, then a low *alpha* is calculated. Also, if the model is systematically under or over the forecast then the *alpha* is impacted. The value of the calculated *alpha* can never be greater than 1 or less than 0. Because it *adapts* to the magnitude of forecast error, the *alpha* is referred to as an *adaptive alpha*.

A comparison of the base forecast techniques discussed above is detailed in Table 5.1.

TABLE 5.1. Forecast Technique Comparison

	A	B	C	D	E	F	G	H
1	Period	Demand	Average	Year-to-date average	3 Period average	3 Period weighted average	Exponential smoothing	Alpha (α)
2	1	110					110	0.30
3	2	85		110.00			110.00	
4	3	80	97.50	97.50			102.50	
5	4	115	82.50	91.67	91.67	88.33	95.75	
6	5	85	97.50	97.50	93.33	96.67	101.53	
7	6	125	100.00	95.00	93.33	93.89	96.57	
8	7	120	105.00	100.00	108.33	109.44	105.10	
9	8	85	122.50	102.86	110.00	113.89	109.57	
10	9	75	102.50	100.63	110.00	105.56	102.20	
11	10	120	80.00	97.78	93.33	88.33	94.04	
12	11		97.50	100.00	93.33	97.22	101.83	
13	Average	100	98.44	99.21	100.00	99.44	101.92	

	Cell	Cell formula	Equation	Copied to
15	Cell	Cell formula	Equation	Copied to
16	C4	AVERAGE(B1:B2)	5.2	C4:C12
17	D4	AVERAGE(B2:B3)	5.3	D4:D12
18	E5	AVERAGE(B2:B4)	5.4	E5:E12
19	F5	((B2*2)+(B3*3)+(B4*4))/9	5.5	F5:F12
20	G3	(H2*B2)+((1-H2)*G2)	5.6	G3:G12

5.3 TIME-SERIES ANALYSIS

The forecasting techniques detailed above use demand history as a basis to forecast what demand will be in the future. Since any estimate of future demand is uncertain, good forecasting becomes a key factor in company success. The ability of planners to use past demand history enables them to create forecasts that can be used to manage long-term corporate plans, as well as short-term estimates of sales, capacities, and product availability.

5.3.1 Basics of Time-Series Analysis

For the most part, forecasting techniques utilize time-series analysis. Collectively, these techniques use the time-sequenced history of demand activity as the source data to forecast future activity. Examples of time-series data are portrayed in Figure 5.5. As is seen, time-series analysis is composed of two elements: the data series and the time periods used. For example, in the base forecasting techniques explored in Table 5.1, a demand data series extending over ten past periods was used to calculate various forms of forecast. Time-series forecasting techniques always assume that patterns of activity recur over time. After establishing the span of the periods to be used as the benchmark for review, data are identified and calculated. The results are then extrapolated, employing observable patterns, into future time periods as the forecast.

I. Weekly Demand for Sump Pump #401-325-01

Date	Jan 7	Jan 14	Jan 21	Jan 28	Feb 4	Feb 11
Demand	21	28	30	26	24	33

II. Monthly Sales Forecast of Submersible Sump Pumps

Month	Jan	Feb	March	April	May	June
Demand	101	118	145	170	200	250

III. Quarterly Forecast of Shipped Dollars

Quarter	1st	2nd	3rd	4th	1st	2nd
Dollars	$235,000	$244,000	$310,000	$375,000	$421,000	$503,000

IV. Yearly Sales of ABC Company

Year	2010	2011	2012	2013	2014	2015
Sales (M)	$145	$148	$151	$156	$162	$165

FIGURE 5.5 Times series examples.

Time series analysis assists forecasters to isolate patterns that are occurring in the raw data. Some typical time-series patterns are illustrated in Figure 5.6 and described as:

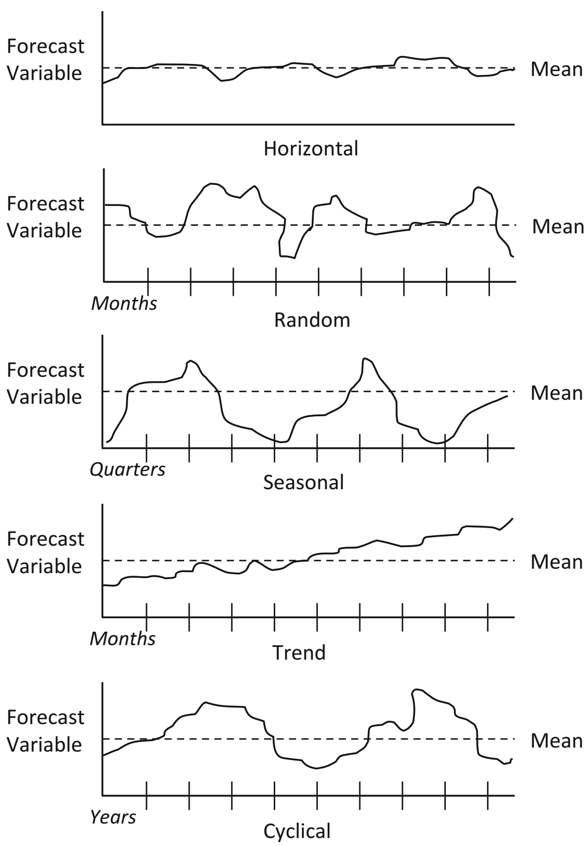


FIGURE 5.6 Types of time series.

- *Horizontal*. This type of time series exhibits patterns that are relatively stable and consistent with only minor upward or downward changes in demand over time. Such patterns are characteristic of items with stable sales patterns or aggregate product family-level forecasts. Items with horizontal patterns of demand are the easiest to forecast.
- *Random*. This type of time series exhibits patterns of demand that exhibit no historical pattern. Random demand often experiences wide and unpredictable swings and is said to exhibit *dynamic* demand. While it is possible to calculate an average demand, the possibility of large positive and negative demand around this mean makes random forecasting extremely difficult. The forecasting techniques in the previous section had mild random variability. As exhibited in Table 5.1, the demand average is 100 units. Instances of demand, however, ranged from as small as 75 units to as large as 125 units.
- *Seasonal*. This type of time series exhibits repeating periods of increasing and decreasing demand that occurs within a limited time frame year after year. This reoccurring pattern of demand may be the result of the weather, holiday seasons, or particular events that take place seasonally. Examples are demand for snow shovels during the winter months and beach equipment during the summer months. It is important to note that seasonal demand can occur over a long-term window of time such as a year or a short-term window such as a week or even daily. A restaurant's demand varies regularly with the hour of the day, and supermarket sales vary with the day of the week. Seasonal time series can also exhibit upwards or downwards trends over time.
- *Trend*. This type of time series exhibits consistent upward or downward patterns observable in the occurrence of a series of demand values. A trend exists when the demand pattern exhibits either an upward or downward slope for approximately seven or more periods.
- *Cyclical*. This type of time series is used by forecasters to track long-range trends in the overall economy that could have an effect on a firm's strategies. Cyclical influences often last for 1–5 years and then recur. Forecasting cycles is difficult because the demand does not recur at shorter intervals of time and its duration is not uniform.

5.3.2 Decomposition of a Time Series

Figure 5.6 illustrated five possible time series. While horizontal and random time series are adequately managed with base forecasting techniques, *trend* and *seasonality* require additional computation to arrive at the next period's forecast. Trend and seasonal forecasting has two basic forms. The first is described as *additive* and assumes that the trend and seasonal time series are constant regardless of the trend or average amount. The equation for additive trending is: *level (base model) + trend quantity + seasonal factor*. The second form is termed *multiplicative* whereby the trend is multiplied by seasonal factors. The equation for multiplicative trending is: *level* (*base model*) × *trend factor* × *seasonal factor*.

5.3.2.1 Trend Calculation

Item demand sometimes exhibit periods of upward or downward trends. When time series exhibit either a horizontal or random demand, temporary positive and negative trends occurring in the short-term tend cancel each other out. However, when a trend occurs, the use of level (base model) techniques will normally lag the trend, resulting in erroneous forecasts. For example, if demand for four periods is 100, 110, 120, and 130, a four period average results in a forecast of 115 for period 5. However, if the demand continues to increase in increments of ten units, the actual demand for period 5 is 140, or some 25 units greater than the forecast. Solving for trend requires forecasters to employ a further calculation that is then applied to the base model. Forecasters can use a variety of trend models.

Trend Calculation Using a Forecasted Average. In this method, the trend of a time series is determined by using some form of average and a *beta factor* (β). The beta factor determines the weight to which historical trends are considered when calculating a forecast. The higher the beta factor, the more weight is given to historical data. The beta factor value must be between 0 and 1.

The trend quantity forecast using an average involves three calculations as follows:

1. *Base forecast calculation*. The base forecast can, for example, use a moving average (5.4) or exponential smoothing (5.6). The key is that the number of historical periods must be large enough to detect the presence of an historical trend.
2. *Trend quantity calculation*. The trend calculation uses the current and prior period base forecast and the assigned beta factor (β). The equation is expressed as follows:

$$Tt = \beta(FBt - FBt - 1) + (1 - \beta)Tt - 1 \tag{5.9}$$

where

FB is the forecast base

T is the trend

3. *Forecast calculation*. Once the trend quantity is determined, it is added to the base forecast to determine the trended forecast. The forecast is extrapolated into the future by adding the trend quantity to each period's trended forecast.

Exercise 5.1: Trend Quantity Forecast

The planners at ABC Electronics are forecasting item #3925 that has been experiencing increased demand for several past periods. The planners have created a Table 5.2 detailing the last eight periods of demand.

TABLE 5.2. Table of Demand for Item #3925

Period	Demand
January year1	100
February	109
March	119
April	131
May	140
June	148
July	160
August	175

The planners have decided to use a three period moving average to calculate the base forecast starting with the month of September. The beta factor (β) to smooth the trend has been set to 0.3. The previous base forecast was 149.33 units and the trend was 15.39.

Step 1: Base forecast calculation. Using formula (5.4), the base forecast for item #3925 for the month of September is calculated as follows:

$$Fi = (148 + 160 + 175)/3 = 161$$

Step 2: Trend quantity calculation. Using formula (5.9), the trend quantity for item #3925 is calculated as follows:

$$TQ = ((161 - 149.33) \times 0.3) + (0.7 \times 15.39) = 14.27$$

Step 3: Trend forecast calculation. The base forecast and the trend quantity for September is added as follows:

$$TF = 161 + 14.27 = 175.27$$

Step 4: Trend forecast extrapolation. To extrapolate the forecast to *n* number of future periods the equation is as follows:

$$TF + n = TF + 1 + TQ + 1 \ldots TF + n + TQ + 1 \quad (5.10)$$

The trend quantity for September is added to the trended forecast for September to determine the trended forecast for October as follows:

$$TF + 1 = 175.27 + 14.27 = 189.54$$

Trend Calculation Using Exponential Smoothing. When calculating a trend with the use of exponential smoothing, forecasters refer to this model as *trend-corrected exponential smoothing (Holt's two-period trend model)*. The advantage of using exponential smoothing to determine the base forecast is that the calculation requires a much smaller historical database.

Exercise 5.2: Trend Forecast Using Exponential Smoothing

The planners at ABC Electronics have decided to run a trended forecast simulation for item #3925 using exponential smoothing. The planners have decided to assign the *alpha factor* (α) at 0.3 and the *beta factor* (β) for the trend at 0.3. August's base forecast is 150.58, the trend is 8.69, and the trended forecast is 159.27.

Similar to the three-period moving average used in Exercise 5.1, there are three steps that must be performed before the forecast is extrapolated into the future.

Step 1: base forecast calculation. Using formula (5.6), the base forecast for item #3925 for the month of September is calculated as follows:

$$Fi = (0.3 \times 175) + ((1 - 0.3) \times 159.27) = 163.99$$

Step 2: Trend quantity calculation. Using formula (5.9), the trend quantity for item #3925 is calculated as follows:

$$TQ = ((163.99\ 150.58) \times 0.3) + (0.7 \times 8.69) = 10.11$$

Step 3: Trended forecast calculation. The base forecast and the trend quantity for September is added as follows:

$$TF = 163.99 + 10.11 = 174.10$$

Step 4: Trend forecast extrapolation. The trend is added to the forecast for September to determine the trended forecast for October as follows:

$$TF + 1 = 174.10 + 10.11 = 184.21$$

Trend Projection. The final trend calculation method discussed is *trend projection*. This technique fits a demand trend into a line of historical demand quantities and then extrapolates the trend line into the future. Using the demand for item #3925 found in Table 5.2, the historical demand series exhibits a decidedly upward trend over the past eight periods. The demand begins at 100 units, but then rises each period. The line of the rise is portrayed graphically in Figure 5.7.

Period	Demand
January Year 1	100
February	109
March	119
April	131
May	140
June	148
July	160
August	175

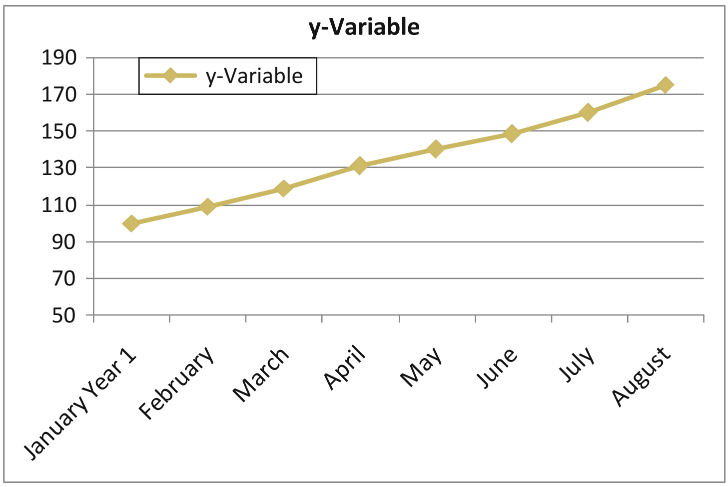


FIGURE 5.7 Forecast trend line.

Calculating a trend using trend projection uses a statistical tool called *linear least squares regression*. The formula for calculating a trend projection is expressed as follows:

$$Y = a + bx \tag{5.11}$$

Where

Y = dependent variable computed by the equation
y = the actual dependent variable data point (used below)
a = the Y-intercept
b = slope of the trend line
x = time period

The goal of the least squares formula is to fit the demand trend line to the data that *minimizes the sum of the squares of the vertical distance* between each demand data point and its corresponding point on the line. If a straight line is placed through the general area of the demand data points, the differences between the demand points and the line is y–Y. To find the values of a and b for any regression line two equations are needed. The first finds the slope b and is expressed as:

$$b = \frac{\Sigma xy - n\bar{x}\bar{y}}{\Sigma x^2 - n\bar{x}^2} \tag{5.12}$$

Where

b = slope of the regression line
x = known values of the independent variable
y = known values of the dependent variable (item demand)
$\bar{X}$ = average of the value of x
$\bar{Y}$ = average of the value of y
n = number of data points

The y-intercept a is calculated as follows:

$$a = \bar{y} - b\bar{x} \tag{5.13}$$

Exercise 5.3: Trend Projection Calculation

Using the demand data for item #3925 shown in Table 5.2, the planners at ABC wish to calculate the trend forecast using the trend projection method. The base trend data is retrieved item #3925 over the periods January to August. The first step the planners take is to minimize the data calculations in Eq. 5.12 by summarizing the x and y values as illustrated in Table 5.3.

TABLE 5.3. Trend Detail for Item #3925

Period	Time period (x)	Demand (y)	x^2	xy
January year 1	1	100	1	100
February	2	109	4	218
March	3	119	9	357
April	4	131	16	524
May	5	140	25	700
June	6	148	36	888
July	7	160	49	1,120
August	8	175	64	1,400
SUM	36.00	1,082.00	204	5,307
Σx/n	4.50	135.25	Σy/n	

Next, the planners calculate the b or *slope of the regression line* by using Eq. 5.12. The calculation is as follows:

$$b = \frac{5,307 - (8)(4.5)(135.25)}{204 - (8)(4.5^2)} = 10.43$$

Following, the planners calculate *a* or the *y-axis intercept* by using Eq. 5.13. The calculation is as follows:

$$135.25 - 10.43(4.5) = 88.32$$

Accordingly, the planners calculate the forecast for September as follows:

$$88.32 + (10.43 \times 9 \text{ or the next period}) = 182.18$$

Finally, the forecast is extrapolated through the next five periods by using the calculation: $88.32 + (10.43 \times n)$. For example, the trended forecast for October is

$$88.32 + (10.43 \times 10) = 192.62$$

The results of the trend projection extrapolation is illustrated in Table 5.4.

TABLE 5.4. Trend Project Results

Period	Forecast
September	182.18
October	192.62
November	203.05
December	213.48
January year 2	223.91
February	234.34

In order to verify the validity of the trend projection forecast, the planners calculated backwards to the first month, January, year 1. To do this, the planners simply reversed the direction of the extrapolation equation using the previous periods, the *y-axis intercept* and *slope of the regression line* values. So the forecast for August is $88.32 + (10.43 \times 8) = 171.76$. The historical forecast and trend line appears in Figure 5.8. In this case, the results of the trend projection forecast model looks to follow historical demand very closely.

While using the trend projection method involves several complex calculations, Microsoft Excel has a regression function designed to perform these calculations. The function is part of the Data Analysis ToolPack that is found in the Data ribbon at the top of the screen. Select the *Regression* Analysis Tool. When the regression panel appears, enter the Y-Range (demand) and the X-Range (periods) in the *Input* section of the spreadsheet (reference Figure 5.9). Next, enter where on the spreadsheet you want the results of the regression to be posted. In Figure 5.9, cell A13 has been chosen. When the <OK> button is selected, the regression will calculate. Note that the regression output produces a lot of data that is beyond the scope of this exercise. The *Intercept* and *X Variable* fields at the bottom left contain the forecasting data. Add them together and then perform the steps detailed in Exercise 5.3 to calculate the trended forecast.

History review
98.75
109.18
119.61
130.04
140.47
150.90
161.33
171.76

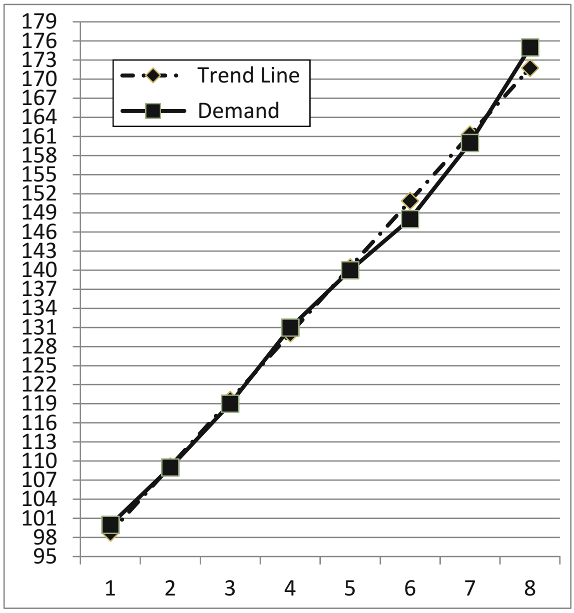
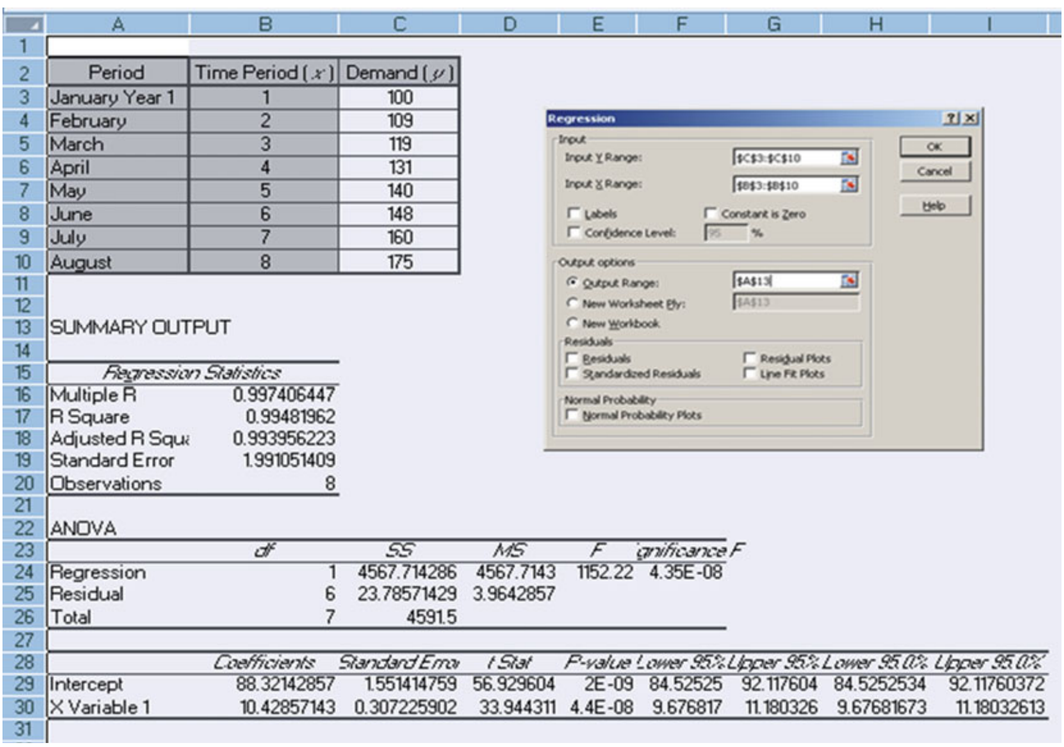


FIGURE 5.8 Historical trend line.



Period	Time Period (x)	Demand (y)
January Year 1	1	100
February	2	109
March	3	119
April	4	131
May	5	140
June	6	148
July	7	160
August	8	175

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997406447
R Square	0.99481962
Adjusted R Squa	0.993956223
Standard Error	1.991051409
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	1	4567.714286	4567.7143	1152.22	4.35E-08
Residual	6	23.78571429	3.9642857		
Total	7	4591.5			

	Coefficients	*Standard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	88.32142857	1.551414759	56.929604	2E-09	84.52525	92.117604	84.5252534	92.11760372
X Variable 1	10.42857143	0.307225902	33.944311	4.4E-08	9.676817	11.180326	9.67681673	11.18032613

FIGURE 5.9 Excel trend calculation.

5.3.2.2 Seasonal Forecast

Many supply chains stock products that are subject to seasonal demand. A snow shovel exhibits high sales in late autumn and early winter, peaks during the winter months, and declines dramatically in the spring and summer. The key to forecasting seasonal products is using the proper historical data. The most useful way to calculate a forecast exhibiting seasonal demand is to employ a *seasonal index*. For example, a firm may sell 125 snow shovels a month on average each year. In reality, during the fall and winter seasons, 200 are sold each month, and an average of 50 are sold during the warmer months of the year. Accordingly, during the peak season the index is 200/125 = 1.6 and 50/125 = 0.04 for the nonseasonal months. This index ratio then is used to adjust forecasts for seasonal patterns.

A relatively simple method to calculate seasonal influences, assuming no trend, is to use a *multiplicative seasonal model*. In the first step, the size of the historical time series to be used in the calculation is determined. Table 5.5 illustrates a demand series for three historical years broken down by quarter. As is seen by a quick review, there is significant seasonal sales that occurs each year in the fourth quarter. The first quarter of sales has historically is the lowest and the last quarter of sales is the highest.

TABLE 5.5. Seasonal Demand

Past demand	1				2				3			
Year	1-1 Qtr	1-2 Qtr	1-3 Qtr	1-4 Qtr	2-1 Qtr	2-2 Qtr	2-3 Qtr	2-4 Qtr	3-1 Qtr	3-2 Qtr	3-3 Qtr	3-4 Qtr
Demand	150	240	370	455	160	255	390	505	170	270	420	560

In the second step, the historical data is summarized by quarter. The goal is to add together and then calculate the average sales for each quarter over the historical period. Once the quarterly averages are compiled, it is then possible to calculate a total average for all quarters. This average serves as a benchmark when viewing the results of the seasonal demand. The third step is concerned with computing the *seasonal index* that is used to calculate the forecast. The seasonal index is determined by dividing each aggregate period average by the overall average. Once this step is completed, the seasonal index is used to calculate a forecast for the coming year.

Exercise 5.4: Seasonal Forecast Calculation

The inventory planners at ABC Electronics are calculating the demand on a product family that experiences seasonal sales. The first step is to determine the historical times series of past demand. Using the demand data detailed in Table 5.5, the planners have compiled 3 years of historical data broken down by quarter. A graph of the seasonal patterns and the average demand appears in Figure 5.10.

The next step is to summarize the historical data by quarter (Table 5.6). For example, the summarized data for the first period in each of the 3 years is computed as 150 + 160 + 170 = 480 units. Once calculated, the average of each year's quarterly summary data is determined by dividing each quarter's summary data by the number of quarters. For the summarized first quarter, this value is determined as 480/3 = 160 units. Each of the other quarters is calculated using the same method.

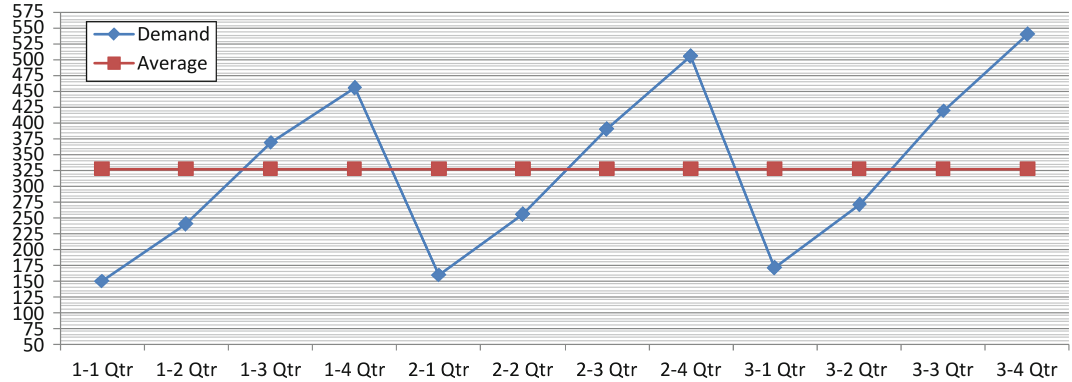


FIGURE 5.10 Seasonal data characteristics.

TABLE 5.6. Seasonal Demand Summary

Past demand	1				2				3			
Year	1-1 Qtr	1-2 Qtr	1-3 Qtr	1-4 Qtr	2-1 Qtr	2-2 Qtr	2-3 Qtr	2-4 Qtr	3-1 Qtr	3-2 Qtr	3-3 Qtr	3-4 Qtr
Demand	150	240	370	455	160	255	390	505	170	270	420	560

Summary	Total	Avg
Yrs 1,2,3 Ist Qtr	480	160
Yrs 1,2,3 2nd Qtr	765	255
Yrs 1,2,3 3rd Qtr	1180	393
Yrs 1,2,3 4th Qtr	1520	507
Totals	3,945	329

The next step in the process is calculating the seasonal index. The goal is to compare the demand activity for an item during the same periods spanning different years. Table 5.7 demonstrates the process of computing the seasonal index. The cumulative average for each discrete period is divided by the total average for all periods. As an example, the seasonal index for the first quarter is calculated by dividing 160 units by the 329 unit total period average to arrive at a first period index of 0.487.

TABLE 5.7. Seasonal Index

Past demand	1				2				3			
Year	1-1 Qtr	1-2 Qtr	1-3 Qtr	1-4 Qtr	2-1 Qtr	2-2 Qtr	2-3 Qtr	2-4 Qtr	3-1 Qtr	3-2 Qtr	3-3 Qtr	3-4 Qtr
Demand	150	240	370	455	160	255	390	505	170	270	420	560

Summary	Total	Avg	Season index
Yrs 1,2,3 Ist Qtr	480	160	0.487
Yrs 1,2,3 2nd Qtr	765	255	0.776
Yrs 1,2,3 3rd Qtr	1180	393	1.196
Yrs 1,2,3 4th Qtr	1520	507	1.541
Totals	3,945	329	4

The final activity is to use the seasonal index and the *estimated base forecast* for year 4 to calculate the seasonally adjusted quarterly forecast. As illustrated in Table 5.8, a base forecast of 1,500 units has been determined. When broken down quarterly (or deseasonalized), each quarterly forecast is computed as 375 units. Next, the seasonally adjusted quarterly forecast for year 4 is determined by multiplying the deseasonalized forecast per quarter by the seasonal index. For example, the forecast for the first quarter year 4 is computed as 375 units times 0.487 = 183 units. The remaining three quarters are determined using the same calculation.

TABLE 5.8. Seasonal Forecast

Past demand	1			
Year	1-1 Qtr	1-2 Qtr	1-3 Qtr	1-4 Qtr
Demand	150	240	370	455
	2			
Year	2-1 Qtr	2-2 Qtr	2-3 Qtr	2-4 Qtr
Demand	160	255	390	505
	3			
Year	3-1 Qtr	3-2 Qtr	3-3 Qtr	3-4 Qtr
Demand	170	270	420	560

New forecast	4			
Year	1 Qtr	2 Qtr	3 Qtr	4 Qtr
Demand	183	291	449	578

Summary	**Total**	**Avg**
Yrs 1,2,3 Ist Qtr	480	160
Yrs 1,2,3 2nd Qtr	765	255
Yrs 1,2,3 3rd Qtr	1180	393
Yrs 1,2,3 4th Qtr	1520	507
Totals	3,945	329

Season index
0.487
0.776
1.196
1.541
4

Forecast (Yr 4)
1,500

Avg forecast per quarter
375

5.3.2.3 Seasonal Forecast with Trend [6]

The forecast for year 4 in Exercise 5.4 indicates that the historical data not only exhibits a seasonal pattern but also a trend. If the trend continues in year 4, the forecast will lag the actual demand. Determining a more accurate forecast requires planners to calculate a seasonal factor and a trend. A method to calculate a seasonal forecast with trend is *time-series decomposition using least squares regression*. The process requires planners to first determine the seasonal index. This process was examined in Exercise 5.4. Next, planners need to determine and then *deseasonalize* the trend. The forecast is computed by multiplying the trend component by the seasonal index and extrapolating the forecast into the future.

Exercise 5.5: Seasonal Forecast with Trend

After calculating the seasonal forecast in Exercise 5.4, the inventory planners at ABC noticed that there was a distinct trend occurring in the 3-year pattern of the demand data. To account for the trend in the data the planners performed the following steps:

Step 1. Determine the seasonal index. Utilizing the results reported in Table 5.6, the planners were able to identify the seasonal index.

Step 2. Deseasonalize the original demand. Since the original demand occurring over the past 3 years contains a seasonal component, it is important to remove its affect by deseasonalizing the demand. To remove the seasonal effect on the demand data, each quarter's demand is multiplied by its seasonal factor. For example, in quarter 1 the demand of 150 units is multiplied by 0.487. The resulting value, 308.203 is the deseasoanlized demand for that quarter. The full deseasonalized demand calculation appears in Table 5.9.

Step 3. Combine the quarter (x) and the deseasoanlized demand (yd). Two steps are required. First, the sequence of each quarter is squared. This is demonstrated in column x^2. Next, the deseasoanlized demand (yd) is multiplied by the squared quarter. This step is performed for each of the quarters and appears in column xyd in Table 5.9.

TABLE 5.9. Deseasonalized Demand

Seasonal index				
Past demand	1			
Year	1-1 Qtr	1-2 Qtr	1-3 Qtr	1-4 Qtr
Demand	150	240	370	455
	2			
Year	2-1 Qtr	2-2 Qtr	2-3 Qtr	2-4 Qtr
Demand	160	255	390	505
	3			
Year	3-1 Qtr	3-2 Qtr	3-3 Qtr	3-4 Qtr
Demand	170	270	420	560

Summary	**Total**	**Avg**	**Season Index**
Yrs 1,2,3 Ist Qtr	480	160	0.487
Yrs 1,2,3 2nd Qtr	765	255	0.776
Yrs 1,2,3 3rd Qtr	1180	393	1.196
Yrs 1,2,3 4th Qtr	1520	507	1.541
Totals	3945	329	4.00

Trend Calculation

Quarters (x)	Quarter	Demand (y)	Seasonal index	Deseasonalized demand (yd)	x^2	xyd
1	1-1 Qtr	150	0.487	308.203	1	308.203
2	1-2 Qtr	240	0.776	309.412	4	618.824
3	1-3 Qtr	370	1.196	309.248	9	927.744
4	1-4 Qtr	455	1.541	295.226	16	1,180.905
5	2-1 Qtr	160	0.487	328.750	25	1,643.750
6	2-2 Qtr	255	0.776	328.750	36	1,972.500
7	2-3 Qtr	390	1.196	325.964	49	2,281.748
8	2-4 Qtr	505	1.541	327.669	64	2,621.349
9	3-1 Qtr	170	0.487	349.297	81	3,143.672
10	3-2 Qtr	270	0.776	348.088	100	3,480.882
11	3-3 Qtr	420	1.196	351.038	121	3,861.419
12	3-4 Qtr	560	1.541	363.355	144	4,360.263
78.00	Totals	3,945		3,945.000	650	26,401.258
$\sum x/n$	6.5	$\sum y/n$	328.75	$\sum yd/n$	328.75	

Step 4. Compute a least squares regression line for the deseasoanlized demand. Using formula (5.11), the planners calculate the least squares regression line. Because the calculation uses the deseasonalized versus the actual demand, the slope computation requires a variation to Eq. 5.12 as follows:

$$b = \frac{\Sigma xyd - n\bar{x}\,\overline{yd}}{\Sigma x^2 - n\bar{x}^2} \tag{5.14}$$

where yd is the deseasonalized demand.

Likewise, the y-intercept a Eq. 5.11 is calculated as:

$$a = \overline{y}d - b\overline{x} \tag{5.15}$$

The heart of the computation involves finding the *slope* (b) of the line and the *intercept* (a). Microsoft Excel provides a short cut to these lengthy calculations. If in Table 5.9 column *Quarters* spanned cells (A20:A31) and if column *Deseasonalized Demand* spanned cells (E20:E31), the slope is computed as: "=SLOPE(E20:E31, A20:A31)" and the intercept as "=INTERCEPT(E20:E31, A20:A31)." The slope is computed as 5.306 and the intercept is computed as 294.261.

Step 5. Calculate the forecast for year 4. The final step is computing the forecast for quarters one to four for year 4. The calculation for quarter 13 is as follows:

$$((5.306 \text{ slope} \times 13\text{th quarter}) + 294.261 \text{ intercept}) \times 0.487 \text{ seasonal index} = 176.79$$

Quarters 14–16 are calculated using the same formula. The forecast for year 4 by quarter (not rounded) is illustrated in Table 5.10.

TABLE 5.10. Seasonal/Trend Forecast

Quarter	Period	Slope	Intercept	Seasonal factor	Forecast
1	13	5.306	294.261	0.487	**176.79**
2	14	5.306	294.261	0.776	**285.87**
3	15	5.306	294.261	1.196	**447.29**
4	16	5.306	294.261	1.541	**584.35**

5.4 ASSOCIATIVE (CORREALTION) FORECASTING [7]

The last forecasting type is associative (correlation) forecasting. Also known as *explanatory* or *extrinsic forecasting*, this technique provides a forecast by using additional associated data beyond the time series data recorded for a specific occurrence (for example, weekly sales of an item). The idea behind the method is to leverage other patterns of events occurring in the marketplace beyond historical data to predict more precisely the course of future demand. Quantitative methods merely attempt to detail the mathematical relationships of events occurring in the past. In contrast, associative methods try to *explain* why these events occurred in the patterns in which they did. The information provided by associative forecasting methods assist companies to better utilize their quantitative forecasts by illuminating key insights into demand patterns.

Another critical difference between quantitative and associative forecasting relates to the size of the planning horizon and data sample. The quantitative methods discussed above are primarily short-range to medium-range forecasting techniques. Associative methods, on the other hand, focus on long-range forecasts that use qualitative and quantitative macro measurements such as political, demographical, new technology, and other events to predict the future. In addition, they are best used when making projections of aggregate demand such as the total sales of a company, sales of a product group, or sales in a specific geographical region. Possible associative forecasts are predicting when a new item or process will be available, what the impact of new inventions or discoveries will have on the marketplace, and what effects or changes might emerge as a result of developments in technology. An example is forecasting the year's sales of sump pumps based on the projected number of housing and commercial building starts. In this associative forecast, building starts are referred to as the *predictor* or *independent variables* and sump pump sales as the *predicted* or *dependent variable*.

The strength of explanatory methods lies in the use of a wide range of forecasts that are formulated using a field of related variables. Drawbacks to using this type are that it is useful only for aggregate forecasts, the data requirements are larger than what is required for time-series models, it usually takes longer to develop, and it is affected more by changes in the underlying relationships than is the case employing a time-series model. In addition, associative methods are more costly to develop than intrinsic (quantitative) methods due to the additional costs stemming from external data collection and the time engaged in analysis. For the most part, associative methods are rarely used in short-range forecasting.

5.4.1 Simple Associative Model

A common associative forecasting method is *linear regression analysis*. This mathematical technique relates a dependent variable to an independent variable in the form of a linear equation. Drawing on the discussion of linear regression used in trend and seasonal forecasting, the dependent variable (y) (for example, yearly sales) and the independent variable (x) (which no longer has to be time) are expressed through Eq. 5.11:

$$y = a + bx$$

Exercise 5.6: Simple Associative Model
The planners at Superior Pump Company have found that quarterly sales of pumps have a relationship to the number of housing starts in their geographical area. After much analysis, the planners noted the association of two variables (Table 5.11):

TABLE 5.11. Housing Starts and Pump Sales by Quarter

Quarter	Number of housing starts (0,000 units) (x)	Sales (US$000,000) ($y$)
1	1	2.0
2	3	3.0
3	2	2.4
4	3	3.1
5	4	3.7
6	6	4.5
7	5	4.0
8	4	3.5

Based on this data, the planners begin a least squares regression approach. The results are detailed as follows (Table 5.12):

TABLE 5.12. **Regression Model**

Quarter	Number of housing starts (0,000 units) (x)	Sales (US\$000,000) (y)	x^2	xy
1	1	2.0	1	2.000
2	3	3.0	9	9.000
3	2	2.4	4	4.800
4	3	3.1	9	9.300
5	4	3.7	16	14.800
6	6	4.5	36	27.000
7	5	4.0	25	20.000
8	4	3.5	16	14.000
$\sum x$	28.00	$\sum x^2$	116	
	$\sum y$	26.200	$\sum xy$	100.900
	b or slope	0.511		
	a or y-axis	1.486		

The slope and intercept values were calculated using formula (5.12). The associative forecast of sales for the next quarter is calculated as:

$$y = (b \times x) + a \tag{5.16}$$

where x is the estimated housing starts.

For example, if the forecast of housing starts for quarter 9 is 5.5 the sales forecast is computed as: $(0.511 \times 5.5) + 1.486 = 4.29$.

5.4.2 Correlation Coefficient for Regression

Associative (correlation) forecasting seems to imply that there is a cause-and-effect relation between the independent and dependent variables. Actually, the method simply shows the relation between the two variables reflected in the data. Another method to evaluate the degree or strength of the relationship is to compute the *coefficient of correlation*. Usually identified as r, the coefficient of correlation is any value between +1 and -1. An r of +1 indicates a strong positive relationship, an r of 0 indicates no correlation, and an r of -1 indicates a strong negative relationship. Using much of the same data needed to calculate a and b for regression analysis, the formula to calculate r is

$$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{\left[n\Sigma x^2 - (\Sigma x)^2\right]\left[n\Sigma y^2 - (\Sigma y)^2\right]}} \tag{5.17}$$

Exercise 5.7: Correlation Coefficient

Using the same data collected by the planners at Superior Pumps, the planners want to establish the relative strength of the correlation between the numbers of housing starts and pump sales. To compute the coefficient of correlation (r), another column (y^2) must be added to the data. Table 5.13 displays the full data to which Eq. 5.17 is applied to determine (r).

TABLE 5.13. Coefficient of Correlation

Quarter	Number of housing starts (0,000 units) (x)	Sales (US$000,000) ($y$)	x^2	xy	y^2
1	1	2.0	1	2.0000	4.0000
2	3	3.0	9	9.0000	9.0000
3	2	2.4	4	4.8000	5.7600
4	3	3.1	9	9.3000	9.6100
5	4	3.7	16	14.8000	13.6900
6	6	4.5	36	27.0000	20.2500
7	5	4.0	25	20.0000	16.0000
8	4	3.5	16	14.0000	12.2500
$\sum x$	28.00	$\sum x^2$	116	$\sum y^2$	90.5600
	$\sum y$	26.2000	$\sum xy$	100.9000	
	r (coefficient correlation)	0.9944			

$$r = \frac{(8)(100.9) - (28)\ (26.2)}{\sqrt{\left[(8)(116) - \ (28)^2\right]\left[(8)(90.56)\ -\ (26.2)^2\right]}}$$

$$= \frac{807.2 - 733.6}{\sqrt{(144)(38.04)}} = \frac{73.6}{\sqrt{5477.76}}$$

$$= \frac{73.6}{74.0118} = 0.9944$$

The coefficient of correlation of 0.9944 indicates a strong relationship between housing starts and pump sales and validates the positive results of the associative forecast calculated in Table 5.12. As a note, Excel provides a function that will perform the complex equation in (5.17). Assuming *Number of housing start (x)* begins at B6 and ends at B13 and the *Sales (y)* begins at C6 and ends C13, the equation is: “=CORREL(C6:C13,B6:B13)”.

5.4.3 Multiple Variable Associative Forecast

The real power of associative forecasting is evident when multiple independent variables are used in the calculation. For example, the planners at Superior Pumps have decided that they want to include interest rates as well as housing starts into the calculation. This will provide them with two independent variables when they make the forecast of sales. The equation for a multiple variable associative forecast is:

$$y = a + b1x1 + b2x2 + \cdots + bk \tag{5.18}$$

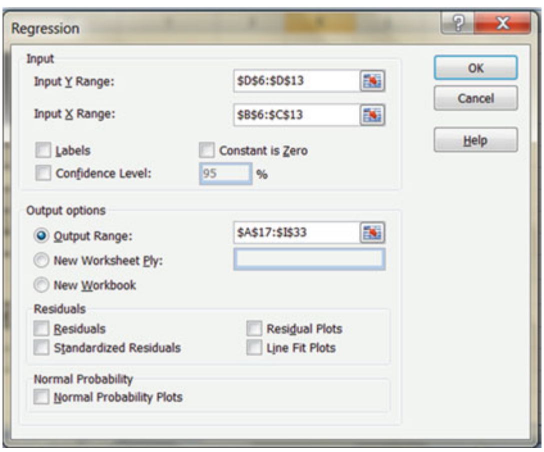
Exercise 5.8: Multiple Variable Associative Forecast
Using the same data collected at Superior Pumps, the planners want to add interest rates to housing starts to project the sales forecast. Table 5.14 illustrates the data.

TABLE 5.14. Multiple Variable Associative Forecast – Data

	A	B	C	D
5	Quarter	Interest rates (*x1*)	Number of housing starts (0,000 units) (*x2*)	Sales (US$000,000) (*y*)
6	1	4.50	1	2.0
7	2	3.60	3	3.0
8	3	4.00	2	2.4
9	4	3.40	3	3.1
10	5	2.90	4	3.7
11	6	2.00	6	4.5
12	7	2.60	5	4.0
13	8	2.80	4	3.5
14	Totals	25.8	28	26.2

Next, the planners used the Excel functions SLOPE and INTERCEPT to calculate the *sales*, *interest rate*, and *number of housing starts* coefficients as detailed in Table 5.15.

TABLE 5.15. Multiple Variable Slope and Intercept



	Coefficients
Sales	3.144444444
Interest rates	−0.333333333
Housing starts	0.344444444

Finally, the planners now use the two independent variables in the forecast for quarter 9. For example, if the forecast of interest rates is 2.3 and housing starts is 5.0, the sales forecast is computed as: $3.1444 + (-0.3333 * 2.3) + (0.3444 * 5.0) = 4.10$.

5.5 ALTERNATIVE FORECASTING METHODS

Forecasting has been criticized as being unable to adequately warn of forthcoming events and changes. Forecasts work well when demand patterns are stable and are easily manipulated by statistical techniques, there is a large repository of historical data available, and organizations possess significant continuity in regards to product, processes, and approaches to the marketplace. These forecasting tools work best with relatively long-lived products and stable demand environments where standardized products are "pushed" repetitively through the marketplace.

Problems arise, however, when the patterns of demand grow increasingly random, causing the best constructed forecast to be inaccurate. Even with sophisticated extrinsic, trend, and seasonal factors built in, it is obvious that the ability to say with a great deal of certainty what conditions will be 6 months from now is extremely limited. Ironically, it is just when the business environment grows increasingly turbulent that accurate forecasts are needed the most. If these changes to the demand patterns are not addresses quickly, the entire business can suffer.

Recently, companies have begun to deploy techniques and technologies beyond the bounds of traditional forecasting. The demand for highly flexible, agile product design and fulfillment structures capable of more frequent new product introduction, shorter lifecycles, and individualized configurability has rendered past "passive" approaches to forecasting of decreasing value and engendered a number of alternatives. Today's marketplace requires forecasting tools that provide for the development of a consensus forecast in which multiple supply chain partners share and reconcile forecasts to create a single supply chain plan. Demand-planning toolsets utilize algorithms to incorporate expected demand data, such as promotions, incentives, or even climate projections, to create a plan that is utilized by each channel constituent to respond to local demand by brand or sales territory. Such dynamic planning tools facilitate the activation of demand and supply balancing strategies by tracking the impact of pricing and promotions, providing visibility to supply in real time, enabling response to unexpected demand signals, and seamlessly integrating channel enterprise business systems.

Among the more "dynamic models" for forecasting demand is *supply chain demand engineering*. This radical method ignores the traditional statistical forecasting elements altogether and seeks to determine demand by removing channel barriers to the real-time flow of customer information. By focusing on making the supply chain more flexible and agile, channel partners have the ability to capture demand as it is actually occurring, thereby linking fulfillment functions directly with customer requirements as they occur. Instead of forecasting tools that calculate abstract patterns of expected demand, this model attempts to compress the time it takes to identify and fulfill demand by concentrating supply capabilities directly on the customer demand pull.

Another dynamic model is *supply chain demand smoothing*. This approach is founded on the assumption that smooth demand patterns are forecasted with greater accuracy than patterns subject to wide variation. The objective of forecasters employing this model is to actively pursue channel management techniques that smooth current demand, rather than depend on traditional passive forecasting tools that accept demand patterns as given. Under this approach, planners are constantly reviewing and making changes to existing standardized practices in sales, marketing, promotions, distribution, and transportation that cause forecast variation. Examples are requirements that product be produced and shipped in large lot sizes, or the use of specific pricing models that discourage the traditional end-of-month sales cycles.

A third alternative to traditional statistical forecasting is *customer collaboration*. This approach seeks to leverage the synergy and synchronization between buyer and seller achievable only through close demand and fulfillment collaboration. By utilizing interoperable technologies and integrative practices, this model seeks to establish an open, real-time sharing of demand-related information. To utilize this method forecasters must recognize that achieving results is difficult and expensive. Normally this method is used only when a single customer dominates demand and they provide a very stable forecast. Also, while very desirable, collaborative alliances are time consuming, and their value must be borne out by the value of the forecast control it provides.

There are a variety of technology tools that forecasters can use to support these dynamic models. These tools are

- *Electronic data interchange (EDI)*. Perhaps the oldest alternative technique to classical forecasting, EDI enables the company-to-company transmission of demand data. Although originally designed for the electronic transmission of transactions, such as customer orders, invoices, shipping notices, and payment, EDI is also used to transmit demand planning information from customer to supplier, thereby placing customer product and service requirements directly into the hands of the supplier.
- *Quick response (QR)*. Originating in the retail sphere, QR is a technology-driven cooperative effort between customers and suppliers to improve channel inventory management by closely matching consumer buying patterns to merchandise availability. By implementing continuous information exchange, QR reduces supply chain uncertainty, promotes flexibility, and reduces replenishment cycles from 15- to 30-days to a few days.
- *Point of sales (POS) and scanning tools*. Capturing sales data as it happens and transmitting it through electronic data interchange (EDI) or the Internet enables forecasters to better manage demand patterns. These tools provide supply chain planners with sales transaction data as it happens in real time so that replenishment plans are based on the actual demand-pull of the customer instead of a forecast.
- *Vendor-managed inventories (VMI)*. In this model, the full responsibility for the management of inventories is turned over to the supplier who directly manages the entire resupply process. In a VMI model, the supplier experiences and manages the demand-pull of the customer directly as it occurs. VMI also depends on a level of collaboration between customer and supplier that negates the timing and distance gap imposed by conventional forecasting.
- *ERP-to-ERP integration*. The ability of today's integrative technologies to link the planning systems of supply channel partners enables planners to gain immediate access to the actual demand patterns and marketing plans through ERP-to-ERP networking. By linking ERP systems together, customers can directly load their demand requirements into the ERP systems of their suppliers.
- *Supply chain event management (SCEM)*. SCEM is described as a computer application layer that standardizes and transmits demand information as it flows between channel trading partners. Basically, the system is engaged when an event impacting demand, whether planned or unplanned, occurs requiring planner intervention. Depending on the impact of the event, the planner is alerted to the violation of a predetermined event boundary by way of a performance scorecard or dashboard indicating presence of out-of-bounds conditions.

A popular technology offering an alternative to traditional forecasting is *collaborative planning, forecasting, and replenishment* (CPFR). CPFR is defined in the *APICS Dictionary* as

> A collaboration process whereby supply chain trading partners can jointly plan key supply chain activities from production and delivery of raw materials to production and delivery of final products to end customers. Collaboration encompasses business planning, sales forecasting, and all operations required to replenish raw materials and finished goods.

The objective of CPFR is to provide all types of companies occupying the supply channel with the capability to synchronize total supply with total network demand from one end of the channel to the other. CPFR simplifies and connects overall channel demand planning by providing a single, real-time plan of forecast and supply. Initially created for the consumer goods industry, CPFR concepts and application tools can be used as the foundation for the communication of demand and channel inventory statuses for all industry sectors.

How does CPFR work? The objective of CPFR is to directly link the consumer with the entire supply chain. While other techniques, such as continuous replenishment planning (CRP), VMI, and QR, focus on removing excess inventory from the supply channel and smooth out demand variances, they are incapable of solving the twin problems residing at the core of channel demand management: the timely communication of forecast inaccuracies and the capability to utilize exception messaging that alerts channel partners of impeding bumps in network supply and demand. A CPFR implementation consists of three major phases: planning, forecasting, and replenishment. In the first phase, two or more members of a supply chain (retailers, transport planners, distributors, and producers) establish a collaborative partnership with the intent of creating the technical and operations management architectures necessary to address the existing gaps impeding the synchronization of critical supply chain information. In phase 2, the CPFR partners agree to share critical demand information detailing what products are going to be marketed, how they are going to be promoted and merchandized, and when sales cycles are to begin. The output of CPFR is a unified channel forecast by *stock keeping unit* (SKU) by time period and quantity that is communicated to the supply network.

In phase 3, each partner agrees to implement techniques that provide for the real-time sharing of channel inventory levels, *point of sales* (POS) transactions, and internal supply chain constraints. In addition, each trading partner is responsible for ensuring continuous forecast and inventory accuracy as well as system database update. When these requirements are fulfilled, the illumination of unnecessary inventory buffers and hidden bottlenecks in the network flow are revealed and initiatives put in place to eliminate them. Furthermore, by establishing interoperable technology toolsets that promote the timely communication of total channel supply and demand, CPFR makes visible all plans and ongoing planning variances, thereby assisting companies to improve forecasting and replenishment decisions that yield optimal results. The culmination of the process is the generation of a consensus forecast, created and shared by all participating supply chain trading partners, detailing what is to be sold, how it will be merchandized and promoted, in which marketplaces, and during what time period.

The ability to leverage supply chain collaborative relationships holds significant promise in assisting companies to create more accurate estimates of future demand than the use of just conventional forecasting methods. Collaborative relationships enable forecasters to receive information immediately about events that are occurring in the supply chain to drive short-term forecasts and through the use of technologies, such as CPFR, to receive the medium to long-term forecasts of demand formulated by channel business partners. Finally, collaboration enables supply chains to build consensus forecasts that can be used to plan for production, replenishment, and shipments.

5.6 MANAGING FORECAST PERFORMANCE

It can be said that every forecast is always correct – it is just that reality is perverse and it is variation rather than constancy that is the nature of every forecast. In a universe where patterns of occurrences are uniform and predictable, forecasts would not be necessary. Unfortunately, in our universe it is the randomness, sometimes even the chaos of events that the planner must contend with when constructing a forecast. Ensuring the correctness of any forecast can, therefore, be said to be more of an exercise in limiting forecast error than in searching for the optimum forecast. Forecasting can be compared to searching for the philosopher's stone: the solution always seems to be just in reach with the promise of turning dismal computations concerning seemingly disparate atoms of data into gold.

To a surprising extent, the effectiveness of forecasting systems is dependent on how well they handle stochastic demand. Consistent patterns in demand are effectively handled by forecasting methods that deploy techniques that model trend, seasonality, and relatively deterministic instances of demand. As the data becomes more random causing the model to consistently over- or under-forecast or, when abnormal demands or outliers occur, the forecast becomes increasingly unstable. Detecting when a forecast model is no longer representative of demand is an important component of a good forecasting system. In fact, developing methods to track, measure, and update forecasts are as important as the effort spent in designing and selecting the forecast models. Failure to perform effective forecast monitoring and corrective action poses a serious risk to the organization in the form of faulty strategies, dysfunctional aggregate plans, lost sales, and excess inventories.

Effectively monitoring forecasts requires planners to manage the following dynamics:

- *Shifting customer demand*. The value of a forecast is realized when it enables the organization to effectively align its resources with customer demand. Forecasters should have in place monitoring and change management techniques that enable them to respond quickly to shifting marketplace priorities.
- *Impact of demand assumptions, choice of forecasting models, and quality of forecast management*. The level of forecast accuracy is shaped by the quality and objectiveness of demand assumptions, the selection of the most appropriate forecasting models, and the overall management of the forecasting process.
- *Forecasts are naturally in error*. Forecasts, by their very nature, are inaccurate. Forecasters must have a detailed review and change management process in place to ensure that forecasting results are continuously monitored and a mechanism is in place to replace suboptimal forecasting models.
- *Impact of forecast bias*. It is important to measure forecast bias (the magnitude of the variance between cumulative actual demand and cumulative forecast demand). Bias results when the average actual demand and the forecast average show continuous incremental divergence. This is different than random variation, where, while the variance between actual demand and the forecast will exhibit large plus and minus variations through time, in the end there is negligible cumulative or unbiased variation.
- *Pursuit of continuous improvement*. The process of monitoring and managing forecasts should identify opportunities for continuous improvements in forecasting techniques, as well as in business processes for reducing bias and demand variation.

5.6.1 Measures of Forecast Error

The results of every forecast calculation results in two elements: the forecast and a random component or error. An effective forecasting program enables forecasters to select an optimal model that considers the random forecast error that is the natural outcome of the calculation. The size of the variance between forecast and actual demand provides forecasters with the means of measuring the extent to which the forecasting model is providing an optimal solution. As long as the degree of forecast error is within acceptable boundaries, the forecast model can continue to be used. If, on the other hand, a forecast model consistently overestimates or underestimates demand, it should be changed. Determining the extent of forecast error requires the use of the following monitoring tools.

- *Forecast error*: the deviation of the actual demand from the proposed forecast.
- *Absolute percent of error (APE)*: the deviation of the actual demand from the proposed forecast expressed as a percent.
- *Bias*: illustrates whether a forecast model consistently overestimates or underestimates demand.
- *Mean absolute deviation (MAD)*: the average of the absolute values of the deviation of the variance between actual and forecast demand. All other factors being equal, the forecaster would select the forecast model with the smallest MAD.
- *Mean absolute percent error (MAPE)*: the sum of the APE over *n* periods, divided by the same *n* periods.
- *Tracking signal*: used to alert the forecaster to a signal (a ratio) that a variation between forecast and demand has occurred for several periods in a row in the same direction indicating a bias in the forecast.

5.6.1.1 Calculating Forecast Error

Forecast error is defined in the *APICS Dictionary* as “The difference between actual demand and forecast demand, stated as an absolute value or as a percentage.” Determining forecast error provides a basic way of understanding how well a forecast is tracking to actual demand through time. The equation is expressed as

$$Et = Dt - Ft \tag{5.19}$$

Where

$E =$ the forecast error
$F =$ the forecast
$D =$ the demand
$t =$ time

For example, if the forecast for a period is 110 units and the actual demand for the period is 125 units:

$$Forecast\ error = 125 \text{ units} - 110 \text{ units} = 15 \text{ units}$$

5.6.1.2 Calculating the Absolute Percent of Error (APE)

This forecast error model calculates how much the forecast deviates from the actual demand for a given period by expressing the period forecast error as a percent. Note that the percentage value is expressed in absolute terms. The equation is expressed as

$$APE = \frac{|Dt - Ft|}{Dt} \tag{5.20}$$

For example, if the forecast for a period is 300 units and the actual demand for the period is 325 units, then the error percent is:

$$APE = \frac{|325 - 300|}{325} = 7.7\%$$

5.6.1.3 Calculating Forecast Bias (Mean Error)

Bias indicates a consistent deviation of demand from the mean in one direction (high or low). If the bias of the forecast is positive, the demand is greater than the forecast; if the bias is negative, the demand is less than the forecast. If the forecast consistently exhibits a positive bias, the forecast should be adjusted upward to match the actual demand. If the forecast consistently exhibits a negative bias, then the forecast should be lowered to match a lower actual demand. Thus, bias is a measure of general tendency or direction of error.

A bias of 0 (zero) is highly desirable. A negative bias indicates that the firm may be carrying too much inventory, while a positive bias means that the company is risking stock out and lost sales. The equation to calculate forecast bias is as follows:

$$Bias = \frac{\sum (Dn - Fn)}{n} \tag{5.21}$$

The steps necessary to calculate the forecast bias are as follows:

1. Sum the total forecast and the total demand for n periods.
2. Subtract the demand from the forecast to arrive at the total forecast error.
3. To find the forecast bias, divide the sum of the forecast error by n periods.

For example, for the past 12 periods of history, the total demand on an item is 3,666 units and the total forecast is 3,600 units. The bias would be calculated as

$$\frac{3,666 - 3,600}{12} = \frac{66}{12} = 5.5$$

This means that, on average, each of the 12 periods indicates a positive bias of 5.5 units.

5.6.1.4 Mean Absolute Deviation (MAD) of Forecast Error

This model is used to determine the dispersion of the forecast error around the average demand. MAD calculates the deviation between the forecast and actual demand by ignoring whether the demand was above or below the forecast, and arriving at the average. The elements of the MAD are described as follows:

- *mean* implies an average of the demand series
- *absolute* means that the calculation considers forecast variance demand without regard to its sign (plus or minus).
- *deviation* refers to the size of the forecast and demand variance or error.

The equation for the MAD of forecast error is as follows:

$$MAD = \frac{\sum_i^n = 1|Di - Fi|}{n} \tag{5.22}$$

For example, for the past 12 periods of history, the total demand and forecast on an item is 3,600 units (no bias). However, period by period (forecast minus the demand), the data exhibited a total absolute error of 118. The MAD is then calculated as

$$MAD = \frac{118}{12} = 9.83$$

This means that, on average, each of the 12 periods has an absolute error of 9.83 units. The value of the MAD is that it provides the forecaster with a quick display of the extent of forecast and demand variation. All other factors being equal, the forecaster would select the forecast model with the smallest MAD.

5.6.1.5 Mean Absolute Percentage Error (MAPE)

MAPE enables forecasters to monitor the accuracy of the forecast by calculating how much the average percentage of forecast values deviates from the actual demand values. MAPE is the sum of the absolute percent error (as a percentage) for a given number of periods divided by the number of demand occurrences. In other words, the sum of all demand minus forecast divided by the demand for each period divided by the number of periods will provide the MAPE. The formula to calculate MAPE is as follows:

$$MAPE = \frac{\sum \left|\frac{Dt - Ft}{Dt}\right| 100}{n} \tag{5.23}$$

The steps necessary to calculate MAPE are as follows:

1. Subtract the demand from the forecast to arrive at the forecast error for each period.
2. Convert the forecast error to an absolute value.
3. In each period, divide the absolute forecast error by the period's demand.
4. Multiply this value by 100 to arrive at the period APE.
5. Sum all of the period-level APEs.
6. Divide the sum APE by *n* periods to arrive at the MAPE percent.

For example, assume planners are calculating the APE for a set of demand and forecast data extending over 12 periods. When the APE for each period is determined, the 12 periods of APE percentages are summed. Finally, the cumulative APE is divided by 12 periods to arrive at the MAPE (Table 5.16).

TABLE 5.16. MAPE Calculation

Period	Forecast	Demand	Forecast error (FE)	Absolute error	Absolute percent error (APE)(%)
1	300	299	–1	1	0.33
2	300	305	5	5	1.64
3	300	312	12	12	3.85
4	300	310	10	10	3.23
5	300	294	–6	6	2.04
6	300	315	15	15	4.76
7	300	306	6	6	1.96
8	300	286	–14	14	4.90
9	300	292	–8	8	2.74
10	300	285	–15	15	5.26
11	300	311	11	11	3.54
12	300	285	–15	15	5.26
Totals	3,600	3,600	0	118	39.51
				MAPE	**3.29**

5.6.1.6 Tracking Signals [8]

Tracking signals are used to measure forecast bias and are calculated by dividing the cumulative sum of the forecast errors (also referred to as the running sum of forecast errors, RSFE) by the MAD. Bias is shown if the results are consistently negative or positive. Tracking signals should stay close to 0 (zero) and should vary between negative and positive so as to cancel each other out.

The tracking signal trip value is a predetermined threshold beyond which an action message is generated, indicating that the bias has exceeded the assigned (acceptable) value. If the tracking signal, for example, is set to 3, a value less than negative 3 indicates a serious negative forecast bias, while a value greater than 3 indicates a positive forecast bias. The equation to calculate the tracking signal is as follows:

$$Tracking\ \ Signal = \frac{\sum (Di - Fi)}{MAD} \tag{5.24}$$

The selection of a trip value is not a set standard and often depends on company policy. An often-used criteria is item usage. For example, the tracking signal may be set using maximums of ±3.75 for high-volume items and ±7.5 for lower volume items. The 3.75 number comes from the relationship the data exhibits between the standard deviation (σ) and the mean absolute deviation (MAD). Since 1.25 MAD equals approximately 1 σ, a total of 3.75 MADs equals 3 σ. 4 MADs equals 3.20 σ. When applied to the standard table of safety factors for normal distribution, a tracking signal of 3.75 would cover 99.86 % of occurrences and a tracking signal of 4 would cover 99.99 % of occurrences. When using the tracking signal, planners compare bias to the threshold value to see if the forecast process is out of control either on the positive or negative side. A tracking signal is a measure used to evaluate if the actual demand does not reflect the assumptions in the forecast about the level and perhaps trend in the demand profile. Corrective action should result in evaluation of the validity of the current forecasting model and a change made, if warranted, to amend the tracking value.

Exercise 5.9: Tracking Signal

The planning team has assembled six periods of forecasting data on a critical item. For the six periods, the forecast is a uniform 300 units with varying demand quantities. The planners also established the target tracking signal as ± 3.0. Based on the tracking signal Eq. 5.24, the first period's tracking signal is calculated as follows:

$$\text{Forecast} = 300 \text{ units}$$
$$\text{Demand} = 302 \text{ units}$$
$$\text{Forecast error} = 2 \text{ units}$$
$$\text{Cum forecast error} = 2$$
$$\text{Absolute error} = 2$$
$$\text{MAD} = \text{cumulative forecast error divided by the period}(1) = 2$$
$$\text{Tracking signal} = \text{cum forecast error divided by the MAD} = 2/2 = 1$$

For the second period, the planners used the same calculation to develop the following spreadsheet (Table 5.17):

TABLE 5.17. Tracking Signal

Period	Forecast	Demand	Forecast Error (FE)	Cum FE Error	Absolute Error	MAD	Tracking Signal
1	300	302	2	2	2	2	**1.00**
2	300	310	10	12	10	6	**2.00**
3	300	290	-10	2	10	7	**0.27**
4	300	325	25	27	25	12	**2.30**
5	300	328	28	55	28	15	**3.67**
6	300	310	10	65	10	14	**4.59**

Since the tracking signal was set to 3.0, the signal would have been tripped in periods 5 and 6. These conditions would have alerted forecasters that a possible unacceptable bias was forming in the forecast caused by variances in the demand patterns.

5.6.1.7 Summary of Measures of Forecast Error

Each of the forecast performance measurements provides a different window into the accuracy of the forecast. The interesting thing about these measurements is that their importance changes based on the interplay of forecast and demand. For example, in one period a bias might be developing but disappears several periods later as new demand values cancel out the apparent bias. As a result, planners must view each measurement in their search for the best forecast.

Exercise 5.10: Forecast Error Method Review

The planning team at Superior Pump has decided to use a three-period moving average as their first simulation of a new forecast for a high-demand item. As illustrated in Table 5.18, the forecast is based on the demand and forecast covering ten periods of history. Next, the planners used several forecast performance methods: forecast error, absolute error, bias, MAD, APE, MAPE, and tracking signal.

TABLE 5.18. Forecast Performance Summary

Period	Demand	Forecast	Forecast Error	Absolute Error	Bias	MAD	APE	MAPE	TS
1	1,000								
2	1,100								
3	1,200								
4	1,050	1,100.00	–50.00	50.00	–50.00	50.00	4.76%	4.76%	–1.00
5	900	1,116.67	–216.67	216.67	–133.33	133.33	24.07%	14.42%	–2.00
6	1,200	1,050.00	150.00	150.00	33.33	138.89	12.50%	13.78%	–0.84
7	900	1,050.00	–150.00	150.00	–50.00	141.67	16.67%	14.50%	–1.88
8	800	1,000.00	–200.00	200.00	–50.00	153.33	25.00%	16.60%	–3.04
9	1,250	966.67	283.33	283.33	38.89	175.00	22.67%	17.61%	–1.05
10	1,100	983.33	116.67	116.67	9.52	166.67	10.61%	16.61%	–0.40
Avg.	1,029	1,038.10		Total Bias	–201.59		Total MAPE	98.28%	

When reviewing the results, the planners were able to make the following judgments about the three-period moving average model. The ten periods of demand show that while significant variation occurs over the forecast history, the average demand is fairly aligned to the average forecast. Once the demand for the first 3 periods is removed, the 7 period average variance is only 9 units. The forecast *bias*, on the other hand, displays considerable variance. While period 10s ending bias of 9.52 is small, the historical variances are very large indicating that the demand series is perhaps too erratic for a three-period model. The MAD of 166.67 with a MAPE of 16.61 % is on the small side relative to the forecast for period 10. The estimate of the standard deviation of forecast error for the forecast model is 1.25×166.67 (MAD) $= 208.33$. In this case, the standard deviation of forecast error is relatively low to the forecast of 983. Finally, if the tracking signal was set to 3, with the exception of period 8, the forecast over the seven periods of data remained within acceptable bounds.

5.6.2 Why Forecasts Fail

Developing, maintaining, and using forecasting techniques are a critical function in the successful execution of the various planning processes of the enterprise. The following points attempt to illustrate the reasons why forecasts fail.

- *Management Involvement*. Effective forecasting is needed at the top management, operations management, and operations execution levels of the firm. What is more, these forecasts must be in alignment with one another. Perhaps the foremost reason why forecasts fail is because of a lack of participation of all management levels both in the development and in the execution of the forecast while in process. To be successful, forecasting should be viewed as a team effort and not be entrusted solely to an expert or "black box" approach.

- *Over-sophistication and Cost*. Forecasting systems that are too difficult to understand are doomed to failure. Most organizations rely on simple, yet effective, "rules of thumb" in developing a forecast. Complex statistical techniques that require sophisticated calculations turn forecasting into a "black box" activity that divorces users from the process. In addition, the more complex the forecasting model, the more forecasters will have to code and maintain system elements. Finally, the more complex the system, the more costly it is to run and maintain.
- *Compatibility*. Forecasts fail when there is a lack of compatibility between the forecasting system and the capabilities of the using organizations. When internal managers and channel partners do not understand the techniques employed nor trust the output produced, there is a strong likelihood that they will not follow the forecast. The result is that managers bypass the formal system in favor of their own informal techniques. The unnecessary proliferation of separate forecasts produces a dysfunctional approach, where values promoting alignment and team work are replaced by departmentalism and the uncoupling of the business planning process.
- *Data Accuracy*. Although it is obvious that the data used by a forecasting technique must be accurate, errors do arise in the data collection process. Data collection errors arise in seven areas:
    1. *Sampling methods*. Although an important tool in quantitative forecasting, sampling can contain errors due to the size of the sample and incorrect application in statistical calculations. In addition, the patterns and relationships of the data on which the sample is based can change over time, also creating error.
    2. *Measurement errors*. These errors occur in the collection, data entry, and forecast calculation. The more these activities are automated, the less the chance for error.
    3. *Hidden information*. Sometimes information may be unintentionally left out, deliberately falsified, or withheld.
    4. *Poorly designed questionnaires*. Questionnaires can suffer from a number of errors ranging from respondent misunderstanding to lack of questionnaire comprehensiveness.
    5. *Data aggregates*. Errors in aggregate data collection can occur as a result of omitting or double-counting data elements.
    6. *Classification and definition*. Data elements need to be as sharply defined as possible. Lack of definition causes data either to be left out or double counted.
    7. *Time factors*. It is critical that the time periods and the data collected are in alignment. An example would be inventory transaction data that is not reported in the same time period as accounting information.
- *Unnecessary Items*. Often forecasts are developed for items that should not be forecasted. One example is *dependent demand* item usage. In this category can be found components within a Bill of Material. Forecasters, however, must be careful to create forecasts for dependent demand items that may also be subject to independent demand, such as service parts. Also, forecasts should not be established for final assembled products that are the result of features and options. An example is several models of bicycle that can be assembled from a combination of modular subassembly, common parts, and individual items. Forecasting such products should be done at the feature and option and not at the end product level.

- *Lack of Management Control*. Review and maintenance are critical to forecast effectiveness. By its very nature, every forecast developed is likely to be wrong. Forecasters must be diligent in monitoring the forecast to ascertain the degree of error, when the forecast should be altered, and what parameters should be used to guide forecast adjustment.

Ensuring forecast effectiveness is an ongoing process that requires the participation not only of internal managers but also of the entire supply chain. To guard against incorrect and misleading forecasts, planners must be careful to select the proper forecasting techniques that fit the needs of the organization and the supply channel. In addition, forecasters must be careful to audit and maintain forecast data accuracy, track demand closely against forecasted results, and promptly adjust forecasts that have exceeded acceptable boundaries.

5.7 SUMMARY

Forecasting is a necessary part of the business planning process. Perhaps no other activity has as much immediate and long-range effect on the operations of the supply chain as forecasting. An effective forecast can dramatically improve channel-wide profitability, productivity, and customer service and ensure competitive advantage. Effective forecasting is also fundamental to the well-being of individual enterprises and supply networks. Good forecasting assists companies to eliminate waste in the form of excess inventory; reduce shortages, missed due dates, lost sales, lost customers, and expensive expediting; and provide visibility to control capacity requirements such as plant size, labor, equipment, and transportation.

The various forecasting models available can be broken down into three types. The first type employs qualitative models that combine human judgment along with collected data. These techniques are best used when historical data are scarce or when developing aggregate forecasts. The second forecasting type utilizes quantitative models in forecast development. Quantitative techniques are best used when there exists historical data and when the relationships and historical patterns of these data are both clear and relatively stable. The forecasting models in this type depend on statistical tools to extrapolate the probable future from the occurrences of the past. The final forecasting type utilizes associative (correlation) models focusing on long-range forecasts that use qualitative and quantitative macro measurements such as political, demographical, new technology, and other events to predict the future. Associative forecasts are employed to predict the impact of a disruptive technology, product, or processes discoveries would have on the marketplace.

The forecast development process is a critical function that is guided by a sequence of steps. To begin with, forecasters must be careful to define the overall purpose and goal of the forecast. Next, forecasters will proceed to the selection of the proper types, techniques, and computerized models necessary to fulfill forecast objectives. The third step in forecast development is data preparation. Critical activities in this step are auditing data accuracy, the speed and accuracy of forecast calculation, and the urgency and length of time required for forecast preparation. The fourth step consists in gaining the consensus of the firm's management team. After these preparation steps are completed, the forecast is executed. Forecasters can choose from a variety of forecasting methods such as simple averages, moving averages, exponential smoothing and regression. The final step in forecast development is monitoring the feedback and performing appropriate action to maintain forecast control.

DISCUSSION QUESTIONS

1. Why is forecasting important?
2. Describe the general characteristics of forecasting.
3. What are the three basic forecasting categories?
4. What are the four levels of forecasting?
5. What are the five characteristics of demand important for forecasting?
6. Explain the differences between qualitative and quantitative forecasting models.
7. Describe some qualitative forecasting models.
8. Explain the function of the alpha factor (α) used in exponential smoothing.
9. Explain quantitative causal techniques.
10. Explain why forecasts fail?

PROBLEMS

1. Given the following historical demand time series, calculate a 3-month moving average forecasts for months 4, 5, 6, and 7 (round answers).

Month	Actual demand	Forecast
1	210	
2	245	
3	220	
4	215	
5	190	
6	235	
7	245	

2. Given the following historical demand time series, use exponential smoothing to calculate forecasts for months 4, 5, 6, and 7. The alpha factor (α) is 0.2 (round answers).

Month	Actual demand	Forecast	Alpha factor
1	325	330	0.20
2	305		
3	300		
4	320		
5	335		
6	305		
7	345		

3. A company's demand data from the last two quarters is displayed in the table. Based on the demand data, what is the forecast for July if a simple average forecasting model is applied?

Month	Actual demand	Forecast
January	154	
February	148	
March	214	
April	180	
May	225	
June	245	
July		

4. Based on the table below, calculate the forecast for July using exponential smoothing. Use an alpha factor (α) of 0.2 in the calculation.

Month	Actual demand	Forecast	Alpha factor
January	154	158	0.20
February	148	157	
March	214	155	
April	180	167	
May	225	170	
June	245	181	
July			

5. If the forecast for July is 241 and the actual demand for July is 251 units, what would be the forecast error?
   a. 4
   b. 5
   c. 7
   d. 10

6. Based on the calculated forecast for July in problem 5, if demand for July was 251 units and the forecast was 241 units, what would be the forecast for August if using exponential smoothing with an alpha factor of 0.3?

Month	Actual demand	Forecast	Alpha factor
January	154	158	0.30
February	148	157	
March	214	154	
April	180	172	
May	225	174	
June	245	190	
July	251	241	
August			

   a. 225
   b. 230
   c. 239
   d. 244

7. The planner has decided to use a year-to-date average forecasting model to calculate the new forecast for August using the period demand data found on the grid in the problem 6. What is the new forecast using this model (round values)?
   a. 185
   b. 191
   c. 202
   d. 210

8. If a planner wanted to use an alpha factor (α) for exponential smoothing equivalent to 4 past periods of demand, what would be the alpha factor (α) chosen?
   a. 0.4
   b. 0.5
   c. 0.6
   d. 0.8

9. Calculate the absolute percentage of error (APE) for the month of June based on the data on the table below:

Period	Demand	Forecast
April	180	185
May	225	220
June	245	240

   a. 1.06
   b. 2.04
   c. 2.08
   d. 2.10

10. What is the MAD for period 5 given the below data if the forecast was 1,000?

Month	Actual sales
1	600
2	1,200
3	200
4	1,600
5	1,500

   a. 450
   b. 500
   c. 525
   d. 550

11. Based on the forecast and demand data displayed in the below table, calculate the mean absolute percent error (MAPE). Round to 1 decimal place.

Month	Demand	Forecast	Error	MAPE
April	180	190		
May	225	221		
June	245	254		
July	250	255		
			Total	
			MAPE	

a. 2.4 %
b. 2.0 %
c. 3.3 %
d. 4.2 %

12. Based on the forecast and demand data displayed in the below table, calculate the tracking signal for each period. If the tracking signal is set at 3 for review, which period will need attention?

Period	Forecast	Demand	Forecast error	CUM forecast error	Absolute error	MAD	Tracking signal
1	300	315					
2	300	310					
3	300	320					
4	300	290					

a. Period 1
b. Period 2
c. Period 3
d. Period 4

CASE STUDY

Managing seasonal demand at Magic Water Sports, Inc.

As the senior forecaster at Magic Water Sports, Inc., you have been charged with the task of creating a forecast for a new product that was introduced to the marketplace 1 year ago. After examining the demand pattern on the item for the past year, you have been able to compile the below historical time series. A review of the data reveals a definite seasonal pattern.

According to sales, the product has performed above expectations. Since it was a new product, sales elected to combine the past year's sales with a qualitative forecast using a

Delphi group exercise with the top marketing and sales managers as participants. The outcome provided a forecast for the new year's sales of 2,000 units.

At this point, the forecast has been handed over to you to calculate the detailed expected forecasted sales for the forthcoming year. Your job is to generate a seasonally smoothed forecast using the spreadsheet data below.

Exercise:

1. Calculate the seasonal index. Enter the values into the *seasonal index* column.
2. Calculate the expected monthly forecast using the data and the new forecast of 2,000 units.

Month	Average demand	Seasonal index	Forecast
1	45		
2	50		
3	75		
4	105		
5	125		
6	185		
7	235		
8	200		
9	165		
10	120		
11	75		
12	60		
Total			
Average			

REFERENCES

1. All references to the *APICS Dictionary* in this chapter are from the 14th edition (2013).
2. Some of these characteristics are identified in Makridakis, Spyros, and Steven Wheelwright. 1989. *Forecasting methods for management*, 26–28. New York: John Wiley & Sons.
3. The descriptions of qualitative methods are summarized from Makridakis and Wheelwright, 240–275 and DeLurgio, Stephen A., and Carl D. Bhame. 1991. *Forecasting systems for inventory management*, 201–204. Homewood: Business One Irwin.
4. Key references used in the writing of this section are Makridakis and Wheelwright, 170–191; DeLurgio and Bhame, 261–286; Jacobs, F. Robert, William L. Berry, D. Clay Whybark, and Thomas E. Vollmann. 2011. *Manufacturing planning and control for supply chain management: APICS/CPIM certification edition*, 79–91. New York: McGraw-Hill; Heizer, Jay, and Barry Render. 2004. *Principles of operations management*, 5th ed, 25–136. Upper Saddle River: Pearson-Prentice Hall; and Lind, Douglas A., William G. Marchal, and Samuel A. Wathen. 2010. *Statistical techniques in business and economics*, 14th ed, 454–563. Boston: McGraw-Hill Irwin.
5. DeLurgio and Bhame, 244–245.
6. Reference Jacobs, et al., 86–90 and Lind, et al., 612–622.
7. Reference DeLurgio and Bhame, 198–201; Makridakis and Wheelwright, 52–53; and Lind, et al., 455–491.
8. See the discussion in Plossl, George W. 1967. *Production and inventory control*, 2nd ed, 106–108. Upper Saddle River: Prentice Hall and Heizer and Render, 130–131.

6

DEMAND MANAGEMENT

Demand management constitutes the prime engine driving the supply chain. Classically, the role of demand management is to plan, execute, and control the design, pricing, promotion, sale, and distribution of the business's products and services to meet the goals of the

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_6) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_6, © Springer Science+Business Media New York 2015

corporate strategy and fulfill the needs of the marketplace. In this effort, the firm's demand management team is responsible for the development of the inventory and branding strategies, the marketing plan, the sales plan, and the demand forecast that defines the nature of the marketplace and the objectives of each customer-support department within the organization. Collectively, these plans constitute the business's *demand strategy*.

Today, this conventional view of demand management has been dramatically expanded. Demand management is now not only responsible for customer management, demand-shaping, and demand prioritization, but also for integrating and facilitating the planning and deployment of the business's supporting supply resources. Instead of being solely the reserve of marketing and sales, demand management requires the participation of multiple disciplines and departments, including production, procurement, logistics, supply chain management, inventory planning, and finance. Outside the organization, demand management requires channel network partners to co-evolve closely synchronized, collaborative strategies and processes that collectively enhance customer value by increasing the velocity of inventory, services, information, order management, and fulfillment at the critical "moment of truth" when the customer encounters a supply node in the value delivery network.

This chapter will explore how the demand and supply management plans are developed and eventually merged into the sales and operations (S&OP) process. The chapter begins with a definition of demand management. Constructing the demand plan is described as consisting of four processes: planning, communicating, influencing, and prioritizing demand. At the core of these processes is determining the product and brand strategy, the marketing plan, the sales plan, and the demand forecast. Next, the chapter explores assembling the contents of the supply plan. This plan provides a statement of the firm's product and productive resource capabilities needed to meet the demand plan. Particular attention is paid to the development of the production, resource requirements, inventory, and distribution supply plans. The chapter concludes with a comprehensive discussion of the merger of the demand and supply plans in the sales and operations planning (S&OP) management process. The foundational components of S&OP are detailed and the five steps needed to conduct a successful S&OP process are examined in detail.

6.1 DEFINING DEMAND MANAGEMENT

Demand management is the culmination of the corporate planning process. In the past, marketing and sales management received their portion of the corporate plan and then proceeded to formulate tactical strategies in pursuit of marketplace and sales performance objectives. By creating the demand plan in isolation from other parts of the business, however, disconnects between demand objectives and the firm's supply capabilities often arose to the detriment of the corporate business strategy. Today, this practice has largely been discredited and replaced with *collaborative demand management* where functional managers work closely together to produce an integrated approach to marketplace requirements, resource capacities, and supply channel delivery capabilities. The goal of the exercise is to craft a single, joint demand management plan that is feasible, supportive of overall enterprise goals, and in alignment with the objectives of all business functions. The output of this process then drives the operations-level plans defining the firm's medium-to short-range inventory, production, supply chain, and logistics support strategies.

6.1.1 Demand Management Definitions

Demand management is often perceived narrowly as a set of business functions concerned with customer management, forecasting, product/brand management, marketing, sales, and order management. While these activities are core components, they by no means comprise the totality of today's concept of demand management. In today's expanded view of demand management, the enterprise's customer-facing functions must also collaborate with the supply-side of the business to ensure that the capabilities required to satisfy demand in terms of product volumes and mixes, quality, flexibility, delivery, cost, and administrative support are available. A comprehensive definition of demand management is offered by the *APICS Dictionary* [1] and consists of two interrelated meanings.

1. The function of recognizing all demands for goods and services to support the marketplace. It involves prioritizing demand when supply is lacking. Proper demand management facilitates the planning and use of resources for profitable business results.
2. In marketing, the process of planning, executing, controlling, and monitoring the design, pricing, promotion, and distribution of products and services to bring about transactions that meet organizational and individual needs.

In a similar vein, the Council of Supply Chain Management Professionals (CSCMP) perceives demand management as a synergy that occurs when demand and supply are closely integrated. Demand management is

> The proactive compilation of requirements information regarding demand (i.e., customers, sales, marketing, finance) and the firm's capabilities from the supply side (i.e., supply, operations and logistics management); the development of a consensus regarding the ability to match the requirements and capabilities; and the agreement upon a synthesized plan that can most effectively meet the customer requirements within the constraints imposed by supply chain capabilities. [2]

Perhaps the central principle arising out of these definitions is that demand management denotes a much broader set of activities than just the management of marketing and sales. At the heart of successful demand management is the development of "a consensus" among demand and supply teams that business objectives are more effectively achieved when demand requirements and supply capabilities are mutually supportive; that a truly effective demand plan provides for the development of closely synchronized, collaborative strategies that dramatically increase the velocity of inventory, services, and information as they pass through the supply chain and out to the customer.

6.1.2 Components of Demand Management

As discussed in the Chapter 3, the corporate business strategy provides a comprehensive definition of enterprise vision, mission, objectives, and strategies shaping the direction and determining the performance measurements of the business. Once overall enterprise goals have been established and driven down through the firm's business units, it is then possible to begin the demand management process.

As illustrated in Figure 6.1, demand management consists of six drivers. The *marketing strategy* identifies the structure of the target marketplace, the products and services to be sold, issues relating to price and promotions, and the structure of the distribution channel.

Integral to the marketing strategy is the *demand forecast*. Forecasting enables planners to estimate the demand on the company's products and services. At this level, forecasting is performed on the product family level. Forecasting techniques, such as pyramid forecasting, enable planners to "roll-up" actual sales occurring at the finished goods level into an aggregate forecast of product family demand. As will be demonstrated, the product family-level forecast serves as the central input into the demand planning process.

FIGURE 6.1 Components of demand management.

As the dimensions of the marketplace emerge, it is the function of *customer relationship management (CRM)*, *customer service management (CSM)*, and the *sales plan* to identify the requirements of the customer, develop the demand satisfying resources to service market demand, draft the sales campaign, ensure sales capacities, and define sales performance metrics. The output of this process constitutes the *demand plan* that will be used in the sales and operations planning (S&OP) process. The counter-companion of the demand plan is the *supply plan*. This plan determines the production rates and aggregate resources required to satisfy the shipment, inventory, and cost of sales objectives stated in the corporate business and marketing plans. An integral part of this plan is the supply chain strategy that determines how the network is designed and operated and the nature of the level of integration and collaboration existing between supplier, producer, wholesaler, and retailer constituents. The culmination of this process is the formulation of the final component of demand management: the *demand strategy*.

6.1.3 Formulating Demand Strategies

Drafting a comprehensive demand strategy usually begins with a value proposition surrounded by strategic decisions associated with such factors as the type of market to be pursued, its geographic scope, the mix of products and services offered, and the capabilities of resources to be deployed. Once goals have been identified, the resultant demand strategy encompasses one or more of the following approaches [3].

- *Growth strategies* are focused on determining how companies gain market share by developing internal competencies or leveraging synergies acquired through merger or acquisition. Growth strategies expand demand management objectives by building value proposition models that enable the business to activate new resources to drive competitive advantage through enhanced product/service mixes, customer segmentation, pricing and promotions, delivery chain structures, and technology enablers.
- *Portfolio strategies* are concerned with the type, scope, nature, and life cycles of the range of products and services offerings constituting the firm's value proposition. Based on demand feedback, portfolio management is concerned with four critical criteria. The first, *design*, focuses on the capability of product offerings to meet existing standards for quality, usability, life cycle positioning, and opportunities to include services and activate logistics functions to speed supply chain fulfillment. *Cost* requires planners not only to pursue opportunities for process improvement and cost reduction, but also to continuously reduce the time it takes from product conception to sales. *Services* provides tools to deliver product-enhancing values such as self-service, real-time pricing, credit management, documentation, training, and e-learning opportunities. Finally, *quality* enables supply chains to be more responsive not just to base expectations of performance, reliability, conformance, and so on, but also to the ability to assist customers in selecting the right combination of products and services, and then configuring the solution to meet *individual* customer requirements. Effectively managing these dimensions will ensure strategic diversification of the product portfolio to match demand expectations.
- *Positioning strategies* seek to continuously renew supply chain structures that effectively place the right combination of products and services within the supply channel network based on demand and supply economics. Among the most important activities is determining the optimal placement of the highest value-products in the most strategic channels, determination of postponement strategies, utilization of geographical deployment, and the agility of logistics resources.
- *Investment strategies* are concerned with the creation of a flexible portfolio of assets that provide strategic planners with the capability to expand and channel capital, physical resources, and research investment to realize the best marketplace opportunities. Based on demand feedback, this area is critical in determining which products, services, channel structures, network partnerships, and human and physical assets should be invested in to support overall competitive advantage.

From a strategic level, demand management is more than just a tactical tool used by marketing and sales to forecast demand. Instead, it is a dynamic, strategic function capable of continuously growing the relationships between a company's value proposition, its product and service portfolio, and its ability to quickly adapt supply chain functions to continuously respond to the nature and intensity of the marketplace's demand for increased value. At the center of this broader view of demand management is the integration of the demand plan and the supply plan in the sales and operations planning (S&OP) process that will be described later in this chapter.

6.2 CREATING THE DEMAND PLAN

The content of the strategies associated with demand management are found in the *demand plan*. The demand plan provides a roadmap and a comprehensive statement of how the business will use its products, services, competencies, and resources to succeed in the marketplace. The demand plan is constructed from three sub-plans: the product and brand management plan, the marketing plan, and the sales plan. The output of the demand plan enables planners to validate the marketing, sales, and revenue assumptions by matching them to the firm's productive capacities and resource availabilities.

6.2.1 Demand Planning

Designing the demand plan requires a comprehensive process. According to the *APICS Dictionary*, demand planning is defined as "a process that weighs both customer demand and a firm's output capabilities, and tries to balance the two. Demand management is made up of planning demand, communicating demand, influencing demand, and prioritizing demand." The four main processes described in the *APICS* definition are illustrated in Figure 6.2 [4]. Reflecting the broader view of demand management expressed in the previous section, the demand management process is significantly more than just crafting an effective forecast: It is also a model whereby the organization shapes its product, marketing, and sales activities to create and influence demand.

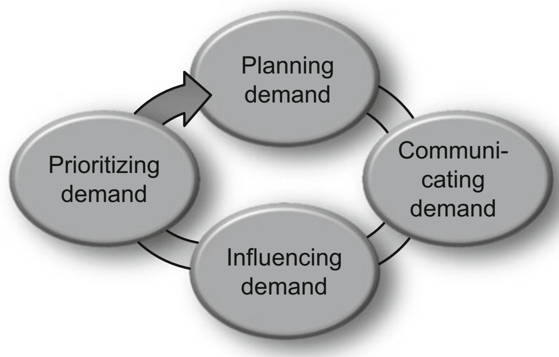


FIGURE 6.2 Four processes of demand management.

- *Planning demand* consists of activities associated with the development of the product, marketing, and selling plans and strategies that will deliver the anticipated marketing positioning and performance objectives identified in the corporate business strategy.
- *Communicating demand* consists of three critical activities: (1) communicating the approved demand plan to the other functional business areas so that they can begin their planning processes, (2) providing detailed information as to the effectiveness and performance to date toward realization of demand plan objectives, and (3) alerting the sales, marketing, and supply organizations of gaps in their planned to actual performance. Communication assists the organization to understand the actual state of the demand plan. It serves as the key building block of sales and operations planning

(S&OP) that enables the organization's functional teams to determine the actions necessary to accomplish company objectives. Finally, communications enables the demand planning team to minimize the impact of unplanned surprises caused by such events as the entrance of a new competitor or product, a natural disaster, or an economic downturn so that demand, supply, and financial plans stay synchronized and focused on company business objectives.

- *Influencing demand* refers to the activities performed by product and brand management, marketing, sales, and operations to persuade or germinate a need that convinces customers to purchase the organization's products and services. Besides this outward-facing objective, influencing demand has inward-facing objectives. Influencing customer demand cannot effectively happen unless the demand-side can influence the product development and supply-side of the organization to support projected customer expectations and requirements. Demand influencing activities include developing products and services demanded by the marketplace, determining the most profitable product mix, setting pricing and promotions, configuring the supply chain to have in-demand products available in the quantities demanded by local customers, and promoting products through advertising, special offers, and other formats. Influencing internal demand requires the demand-side to focus on marketing and sales programs that will increase net income (profit) rather than simply increasing sales volume or revenue.
- *Prioritizing demand* refers to the ability of flexible demand and supply functions to quickly resequence demand priorities when constraints arise and then to align the supply chain to meet the new prioritization schedule. According to Crum [5], prioritizing demand is driven by several best practices.
  1. Prioritizing demand occurs whenever it is recognized that the volume, timing, and mix of demand is out of synchronization with the supply organization's capability to deliver the anticipated demand.
  2. The responsibility for managing and prioritizing demand requires the collaboration of managers from the demand and supply planning teams. Effectively managing and prioritizing demand also requires a broad view of the business's strategic objectives, market and sales goals, and cost and profit objectives.
  3. The speed at which demand is effectively managed and prioritized is directly proportional to the availability of options and control over sales revenues, production and transportation costs, profits, and customer service.

  Situations requiring managing and prioritizing demand would be when supply functions cannot meet the demand plan without changes; the demand plan overstates actual demand and plan changes will impact sales revenue and product costs; the demand plan understates actual demand and plan changes impacting sales revenues and product costs; and a large, opportunity order arises that would adversely affect regular orders, production costs, and profits.

6.2.2 Planning Demand

Planning demand is the process of translating the company's corporate level demand goals and expectations into a detailed demand plan. Figure 6.3 displays the main business functions needed to establish the demand plan [6].

FIGURE 6.3 Processes used in planning demand.

6.2.2.1 Product and Brand Management

The opening step in demand planning is assessing the competitiveness of the company's products and services. A company's products and services are at the very heart of the demand plan. They provide the business with marketplace identity (brand), often have a long history, shape the way the enterprise is configured, and signify the values it offers to its customers. The process to manage products and services is detailed in Figure 6.4.

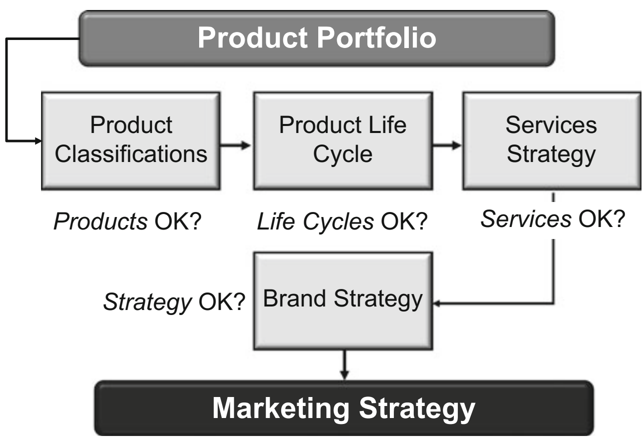


FIGURE 6.4 Product/services planning process.

Product Classifications. A product is a matrix of physical characteristics and customer perceptions. As physical entities, products possess weight, volume, shape, functionality, cost, and other attributes. As a customer perception, products possess intangible features such as convenience, status, quality, usability, accessibility, and distinctiveness. In terms of a formal definition, a *product* is *a physical good offered to the market for acquisition, use, or consumption that satisfies a want or need*. Products are broadly grouped into *durable* goods (products that are designed to last for an extended period of time without rapid deterioration or obsolescence), *non-durable* goods, (products that are consumed or must be consumed quickly or that deteriorate rapidly), and *services* (products that are intangible, produced and consumed simultaneously, often are delivered with varying content, and cannot be stored). Products range from low-cost, high-volume produced convenience goods such as Coca-Cola or Bic Pens, to high-cost, low-volume produced goods such as industrial machinery, automobiles, and accompanying services.

One way to view products is to position them in a product hierarchy. At the highest level is a *product family* (a general grouping of individual items that satisfy a general need) followed by a *product class* (individual items grouped together within a product family that possess common functional characteristics); a *product line* (individual items grouped together within a product class because of functional, cost, delivery, or customer requirements similarities); a *product type* (individual items within a product line sharing attributes common to a generic product); and finally, an *item* or *stockkeeping unit*. As an example, a bicycle distributor would consider men's trail bicycles as a product type; all adult-sized trail bikes as a product line; and all trail bikes as a product class which belongs to a product family called adult recreational bicycles. In addition, products are often described as belonging to a *product system*, defined as a diverse set of products that are sold together as a set. As an example, hardware stores stock fastener sets that consist of many kinds of bolts, nuts, washers, and nails packed in a variety of containers that can easily be stored on a workbench. Finally, products can be described as a *product mix* or *assortment* of all possible goods a distributor makes available to the marketplace [7].

Products are further classified into two major categories based on product characteristics. The first category is defined as *industrial goods*. Products in this category belong to three subcategories.

- *Raw materials and component parts*. In this category is found farm and natural products, such as foodstuffs, lumber, petroleum, and iron ore, and fabricated or manufactured components. For the most part, these products are distributed through supplier channels and are used by manufacturers who convert them into finished products. Marketing considerations focus on price and service.
- *Capital goods*. In this category is found equipment such as generators, computers, automobiles, material handling equipment, and office furniture. Products in this category are considered finished goods. Marketing considerations focus on quality, price, product features, and service.
- *Maintenance, repair, and operating goods (MRO)*. In this category is found consumer-type goods such as paint, nails, office supplies, small tools, lubricants, and fuels. Marketing considerations focus on price, service, availability, and delivery.

The second major product category is defined as *consumer goods*. Products in this category also belong to three subcategories.

- *Convenience goods*. In this category is found products usually purchased frequently, immediately, and with the minimum of effort in comparison shopping or buying. Examples include staples, such as bread, milk, and toothpaste; impulse goods, such as chewing gum, candy, and magazines; and emergency goods, such as medical supplies, snow shovels, and cold weather clothing. Marketing considerations focus on availability and price.

- *Shopping goods*. In this category are products customers normally will shop for in many locations and compare such elements as price, quality, performance, and suitability before a decision to purchase is made. Examples include fashion apparel, appliances, books, and home furnishings. Marketing considerations focus on quality, brand name, availability, price, and service warranty.
- *Specialty goods*. In this category is found products possessing unique characteristics and/or brand recognition for which customers are willing to expend a significant effort to acquire them. Examples include art work and furs, and such brands as Mercedes in automobiles and Armani in women's fashions. Marketing considerations are focused on high quality and prestige.

Because the above characteristics are subject to interpretation, the following additional characteristics of products should be observed [8]:

- *Form*. This characteristics refers to the size, shape, color, or physical structure of a product.
- *Replacement rate*. This characteristic refers to the frequency a product is purchased or produced. This factor has an impact on channel size and distribution costs.
- *Level of service*. Some products require specific levels of service during the distribution process necessary to meet customer expectations. Such services take the form of training, warranty and repair.
- *Conformance to quality*. This characteristic describes the degree to which products meet the promised specifications.
- *Durability*. This characteristic refers to the length of a product's functional life under normal operating conditions.
- *Reliability*. This characteristic refers to the probability that a product will not fail within a specified time span.
- *Degree of customization*. Nonstandardized products often require special assistance for installation, training, or other forms of servicing that are performed by the producer or seller. The level of contact between producer or seller and customers associated with standardized products is much lower.

Product Life Cycle. The second step in the product management process is *product life cycle analysis*. The theory behind the product life cycle is that the average product can be divided into distinct life stages, each characterized by differing marketing, investment, and distribution requirements. Although the universality of the model can be debated, the concept has a great deal of authority based on the following four assumptions:

1. Products have a limited life. Changes in taste and technology dictate that no product will remain in demand by customers indefinitely.
2. Products pass through distinct life stages. These stages can be described as introductory, growth, maturity, and decline (Figure 6.5).
3. Profits and competitive advantage rise and fall at different stages in the product life cycle.
4. A firm's marketing effort, sales volume, distribution channel size, and financial investment is impacted by a product's life-cycle stage.

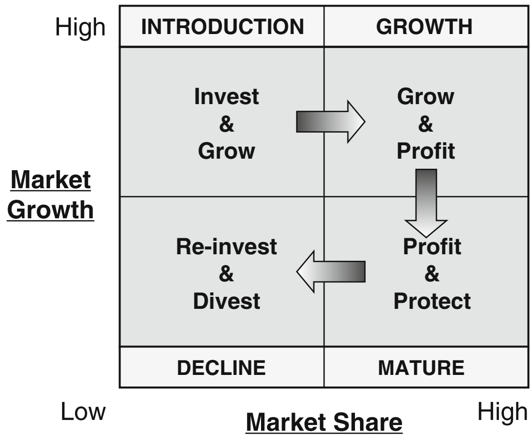


FIGURE 6.5 Product life cycle dynamics.

Table 6.1 suggests how the position a product occupies in its life cycle will impact six criteria: availability, product volume, sales volume, supply chain structure complexity, inventory and marketing investment, and the competition. In the *introduction stage*, companies are reluctant to stock large volumes of inventory. Because the new product has not yet received market acceptance, sales volume is low. In contrast, research and development costs are high as product deficiencies are fixed and features solidified. Channel product availability is restricted to a few targeted market areas capable of generating margins high enough to support heavy promotional spending. In addition, logistics management must be integrated early in the process to guarantee effective product rollout. At this stage, the competitive strategy is to offer customers products and features not generally available in the marketplace.

TABLE 6.1. Product Life Cycle Characteristics

Characteristic	Introduction	Growth	Mature	Decline
Product availability	Low	Increase	Level	Low
Product volume	Low	Increase	Level	Low
Sales volume	Low	Increase	Level	Low
Complexity of supply channel structure	Minimum	Increased complexity	Complex	Minimum
Investment	Very high	High	Level	Low
Competitive attribute	Product features	Quality and availability	Price and dependability	Availability

If the product begins to acquire marketplace traction, the growth in sales volumes will require increased inventory investment and product availability. In addition, expanded transportation and storage, promotional expenses, discounting, and competitive pricing will increase costs. Decisions regarding the structure of the distribution channel are particularly difficult in this *growth stage*. Although product demand is much greater, it is still too irregular, rendering sales and marketing information often unreliable as a source for channel planning. Judgmental methods in forecasting are mostly employed in this stage to determine the depth and volume of inventory stocked at supply network nodes. Competitive strategies are designed to capitalize on growing market demand by focusing on attributes relating to product quality and availability. The growth stage can be long or short depending on the extent of the competitive turbulence arising from the marketplace. Success will generate aggressive emulators who will contest for established market niches and customer loyalty through new features, price, and distribution counter-strategies.

During the *maturity stage* that follows, product and sales volume is no longer experiencing the same dramatic percentage increases. Sales are forecasted using accumulated historical usage. At this point, product demand has reached its highest point, normally requiring companies to maintain high inventory and promotional investment to remain competitive. The distribution structure is characterized as intensive and extensive, with a strong emphasis on keeping delivery points as fully stocked as possible while trying to minimize inventory investment. Competitive strategies focus on competitor activities, cost and price decisions, maintaining brand and customer loyalty, and product and value-added service dependability.

In the *decline stage*, sales volumes decrease as a result of changes in technology, competition, and customer interest. As profitability declines, so does investment in inventory and promotional activities. At this point, inventory planners usually begin to scale back general inventory availability throughout the channel, restricting product to centralized warehouses or to targeted locations with enough residual customer demand. Finally, planners must develop effective strategies to discontinue "dead stock" clogging the distribution pipeline, plan for market exit, and redirect resources to more profitable products. Competitive strategies at this point focus on phase out of the product price and increasing prices to cover remaining inventory storage and services costs. Advertising and promotions are discontinued, production ends, and sales and support may be outsourced.

Besides providing a window into product and marketplace dynamics, the product life cycle presents marketers with a structure to assist in making marketing decisions. Knowing what particular life cycle stages the firm's products are in assists marketers to design focused strategies that enables their proper positioning in the marketplace. Without effective product planning, estimated and actual long-term profitability, and return on investment on new products may be inaccurately assumed. Similarly, product life cycle analysis permits marketers to review the profitability of older products. What appears to be a "star" may, after closer analysis, be, in reality, a liability draining away critical resources. The effective management of old products has as great a financial impact on the enterprise as the introduction of new products with high profits.

Services Strategy. Most companies not only market products but they also offer services that add value to goods purchased. Service can be defined as any product-oriented activity or performance provided by a firm that does not involve the transfer of ownership of tangible goods. For the most part, companies offer tangible goods accompanied by one or more services targeted at enhancing product appeal. These product services can take the form of pre-sales supplier contracts, technical advice, discounting, quality and delivery reliability, sales representative availability, and credit. In addition, businesses often offer after-sales services such as transportation, warranty, repair, technical support, trade-in allowances, product guaranties, and user training.

Services differ from products in several different ways. To begin with, a service is usually an *intangible* exchange of value, in contrast to the tangible value found in a physical product. Second, services are often produced and consumed simultaneously. The service value found in product delivery, for instance, is value received with the activity of the delivery process. Third, the services received by a customer are often unique to that customer. For example, the education services provided by a software firm for their customer base are customized to accommodate the particular needs of each business environment. The factor that makes each service unique is found in the fourth characteristic: high customer-service interaction. Service uniqueness arises out of the particular needs communicated by each customer and how the product and standard service offerings are shaped to respond to those needs. The last characteristic of services are found in their lack of precise definition. While products are rigorously defined as to form, fit, and function, services normally consist of a core value around which a variety of different outcomes can occur. A discount, for example, may not only differ between customers, but also be different with each sale, even for the same customer.

The services companies offer to their customers have two dimensions. Many of the traditional services are described as being almost "commodity" in nature because they directly accompany the product. Such services as warranties, packaging, rebates, and training allow customers to receive additional value with the receipt of the tangible product. Such *intrinsic* services have become so commonplace that most customers assume that suppliers will automatically provide them. There are, however, other services that are *extrinsic* to the product. Such services as discounting, improved supply channel efficiency, credit, and product assortment add value to products by reducing customer internal costs, facilitating the flow of business information, and improving productivity. In a marketplace in which competitors provide a large proportion of the same products, extrinsic value-added services have become a competitive advantage, differentiating one company from another.

Like products, services also possess a life cycle. In the *development stage*, marketers will experiment with new forms of services they anticipate will provide a point of differentiation separating their products from the competition. Costs for development and delivery are high, although the customer perceives the value to be low. During the *growth stage*, planners are still investing in services development, but customers are beginning to see that the new service is providing sufficient value to persuade them to purchase the product. During the *maturity stage*, investment declines as the service becomes standardized, while increasing customer market demand for the product and accompanying services allow cost recovery and profit. As competitors begin to copy the new service in an effort to decrease competitive differentiation, the service enters the *saturation stage*. Customers feel the service is part of the product offering, often requiring that it be offered with little or no charge attached. At this point, the service migrates from a value-add to a requirement if the product is to remain competitive, but in itself offers little or no competitive advantage. In developing product value-added services strategies, marketers need to plot the life cycles of both product and service offerings and determine the trade-off between cost and potential sales.

Brand Strategy. The final component of the product/services planning process is creating, maintaining, and enhancing product brand recognition. Today's most sought-after products (Lexus, Sony, Gucci, Coca-Cola, and others) command huge market appeal and loyalty because of the name their products and services carry in the eyes of the customer.

The American Marketing Association defines brand as "a name, term, sign, symbol, or design, or a combination of them, intended to identify the goods or services of one seller or group of sellers and to differentiate them from those of competitors" [9]. Brand is thus described as a form of product or service attribute that helps a company differentiate their products and services from the competition. Brand takes on many appearances. It can be tangible and functional when related to the performance of a physical product; it can also be intangible and emotional when the brand acts as a symbol.

Almost all products and services are linked in some degree to a brand name. Even common commodities have messaging in the form of packaging, slogans, and logos that help the customer to distinguish between different company products and services that may appear to possess the same form, fit, and function. According to Kotler and Keller [10]

> To brand a product, it is necessary to teach consumers "who" the product is—by giving it a name and using other brand elements to help identify it—as well as "what" the product does and "why" consumers should care. Branding involves creating mental structures and helping consumers organize their knowledge about products and services in a way that clarifies their decision making and, in the process, provides value to the firm.

Building successful brands requires a strategy that begins by identifying and establishing brand positioning; developing strategies for growing brand recognition; establishing and measuring brand performance; and managing brands to maximize their value. Brand strategy involves deciding on the brand attributes to be applied to new and existing products.

Brand management, as integrated into the marketing and sales plan, is an important component of an effective demand plan for several reasons. To begin with, brand enables the marketplace to easily identify the product or service producer or distributor. Customers learn about brands through past experiences and through the firm's marketing programs. Second, brands provide important information for the firm such as organizing their products and quality records. Third, branding enables companies to legally protect unique attributes and designs through registered trademarks and copyrights. And finally, brands leave an indelible impression on customers regarding anticipated levels of quality, functional predictability, and purchase peace-of-mind possessed above the physical product or service (often termed *brand equity*) that cannot be duplicated by even the best replicas created by competitors. An effective brand strategy seeks to expand the content of each of the above four points to define a distinctive place in the expectations of the target market. Brand strategies succeed when they strongly influence the mind of the customer thereby maximizing the profitability of the portfolio of products and services.

6.2.3 Marketing Plan

The science and practice of marketing management constitutes an enormous field of study and cannot be covered in the short space allotted to it in this section. The discussion to follow is designed to provide a concise outline of the marketing planning process and how it fits into the larger function of planning demand. The American Marketing Association defines marketing as "the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large" [9]. As a whole, the main purpose of marketing is to determine what customers want, products and services the firm is to offer its customers, the sales and revenue potential of the marketplace, and the mechanics of how the delivery chain should operate.

The marketing plan is the central instrument for directing and coordinating the marketing effort. Without effective and closely integrated marketing, sales, supply chain, and operations strategies, the enterprise cannot hope to achieve the performance targets set forth in the corporate business forecast.

6.2.3.1 Marketing Planning Process

Marketing planning is the collective responsibility of the marketing management team. As illustrated in Figure 6.6, the *marketing planning process* begins with an analysis of the firm's marketplace. In this step, marketers determine whether they are pursuing a "niche market" or a "mass market" strategy, the size of the customer base, what market segments are to be targeted, customer buying criteria (quality, price, service), customer industry (producer, retailers, other distributors, or a mix), and potential sales and profits. Also, in this step marketers gain an understanding of customer needs and expectations and how they can build and grow collaborative, intimate partnerships. Finally, marketing planning evaluates the firm's competitive strengths and weaknesses (SWOT analysis). Competitive advantage is weighed by benchmarking the market strategies of competitors. Criteria includes pricing, discounting, delivery, and stages of product life cycles, and how they compare to the firm's own sales strategies and product and services offerings. Ultimately, it is marketing's responsibility to develop the strategies that provide customers with superior value that simply cannot be attained when dealing with the competition.

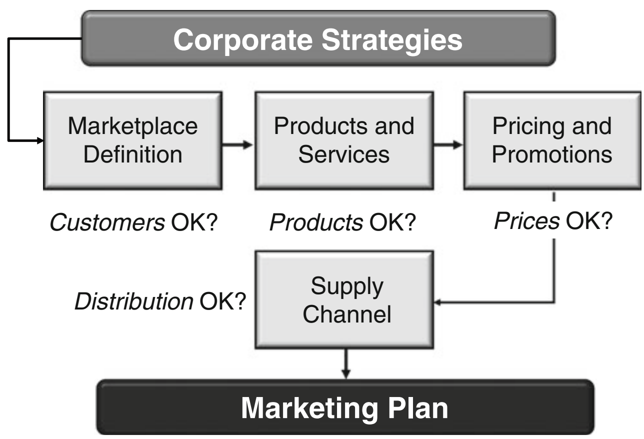


FIGURE 6.6 Marketing planning process.

The second step in the marketing planning process is assessing the competitiveness of the company's products and services. As discussed in the section on product and brand management, a company's products and services are at the heart of the demand plan. Marketing planning can use various tools, such as product family segregation, product life cycle analysis, the services strategy, and the strength of brand recognition, to ensure the firm is not only offering competitive products but is also investing in the right product and service mix. The goal is to determine the relative position of the business's products and how well they meet the emerging wants and needs of the marketplace. Products characterized by high profit growth and market share should be protected from competitors and promoted with continued investment. Conversely, products demonstrating low growth and declining market share should be divested and the capital reinvested in new or existing growth-oriented products. In addition, marketers must weigh the role and profitability of value-added services. The scope of services is a significant competitive advantage, especially when businesses find their inventories stocked with a large proportion of the same or similar products that their competitors are offering to the same marketplace. Value-added services provide a basis for differentiation by offering customers new avenues to meet expectations, reduce costs, increase productivity, and increase sales.

An important component of marketing planning is inventory *placement* or *distribution*. This component seeks to answer the question: Where is the best place or places to sell products and accompanying services to the marketplace? Market planners have a variety of options: products may be shipped directly from the plant without the use of intermediaries; a company-owned distribution channel could be used; third party intermediaries and retail outlets might be the appropriate strategy; a product catalog accompanied by Internet online sales might be the best market penetration strategy; or a combination of these strategies might provide the desired level of marketplace leadership. Whatever the product placement strategy chosen, from the customer's perspective, it must possess attributes such as accessibility, delivery reliability, ordering convenience, and delivery flexibility. From the business's perspective, product placement should enhance control and consistency of brand message and intended values and profitability at the lowest cost.

The third step in the marketing planning process is concerned with price and promotion decisions. Although companies hope that the range of product and service combinations they offer will be sufficient to maintain marketplace leadership or to gain entry into a new market, often special pricing and periodic sales promotions are necessary to stave off competitors, penetrate new markets, and introduce new products. Pricing decisions will have a direct impact on the volume of the profits the company has identified in the business plan. Pricing decisions can lower the cost of sales by reducing inventories, plant size, and processing costs while increasing responsiveness, productivity, service, and product quality. Finally, firms increase profits by increasing prices, a distinctly unfavorable strategy.

Promotion decisions also will affect profitability. Promotion includes such marketing activities as market research and analysis; segmentation of the customer base; crafting strategies for target market segments; the planning, development, and placement of advertising; and creating and enhancing brand image. It also involves determining and communicating the timing of marketing and promotional activities and collecting feedback on the effect of the promotion on customers. Trade advertising, sales promotions and deals, and publicity can all be used to open markets and increase sales of products and accompanying services.

The final step in the marketing planning process is structuring channels of distribution that enable the business to deliver the right mix of goods and services to the right target market. Options include building additional warehouses close to customers, renting space in public warehouses, outsourcing logistics functions, and acquiring a competitor or trading partner strategically positioned in the distribution pipeline. In mapping the channel network, marketing planners must be careful to measure both the estimated costs as well as the benefits. A distribution network must be designed that will provide the firm with sufficient return on investment by offsetting investment in plant, equipment, staff, and inventory with increases in sales and profitability. A more detailed analysis of channel design is found in Chapter 4.

6.2.3.2 Developing Markets

To be successful, market strategists constantly search for ways to best position their products and services while recognizing the unique requirements of their customers. The value of effectively structured supply channels and focused products and services are accentuated by marketing strategies that competitively meet the specific needs of customers while avoiding the trap of trying to offer all things to all people. A fundamental goal of marketing is the effective management of a firm's portfolio of organizational, product, and service investments to achieve optimal profit return from the customer base. In pursuing such objectives, marketers must have strategies in place that identify the most attractive markets available and measure individual customer profitability.

An important decision for marketing is choosing between a *mass marketing* or a *segmented* (*niche marketing*) strategy. Mass marketing is described as a strategy whereby the seller engages in the mass production, promotion, and distribution of a single product or narrow product line targeted at a wide marketplace. The strategy is appropriate for products and services that have broad appeal across several market segments, either because they are commonly used staples or they service a general want or need. Bottled water is an example of such a product.

The mass marketing strategy has several advantages. It enables marketing to create a simple and direct message that can be repeated using mass media until the message enters the consciousness of consumers. It also enables marketing to create a very large potential market, which leads to the lowest costs, which in turn can lead to lower prices or higher margins. The mass market strategy has become increasingly more difficult to pursue with the proliferation of advertising media and distribution channels. As an alternative, marketers are applying *micromarketing* models at one of four levels: segments, niches, local areas, and individuals.

The pursuit of micromarketing strategies centers on the performance of three essential activities:

1. *Segment* the customer base into groups sharing common wants and needs, resources, geographical locations, buying attitudes, and practices. Seldin and Covin feel that effective customer segmentation consists of three dimensions [11]. The first, determining *customer needs*, centers on documenting what customers value the most from the array of company offerings. This dimension reveals the most desirable value proposition available to the customer. The second dimension, *customer behavior*, utilizes technology to reveal the experiential world of customers. The goal is to document how brand and service bundles impact direct as well as usage experiences in both consumer and business-to-business contexts from the perspective of the customer. The final dimension, *customer profitability*, seeks to divide customers into segments by profitability. It is important that this step be concerned with how this information is used to further long-term customer loyalty and not purely as a way to devise strategies focused on just selling more products.
2. *Target* those market segments that manifest the proper size and growth, are attractive in regard to a lack of competitors, match existing products and services, and leverage the business's internal and external strengths and resources. Marketers do not create the customer segments; their task rather is to identify the segments that do arise from market research and then decide which ones to target.
3. *Position* the company's image, products, services, and brands so that customers within selected market segments understand the firm's competitive value.

The benefits of pursuing a micromarketing strategy are found in the ability of marketing teams to develop a focused message and product/service portfolio that corresponds exactly to customer segment requirements. The company has the ability to better design, price, position, and deliver the goods or services directly to the segmented market. Finally, this strategy enables marketers to more clearly perceive and counter the marketing efforts of competitors.

Once the market segment is defined, the marketing team can develop a strategy to optimize the segment or the more detailed *market niche*. A market niche is defined as a narrow, homogeneous sub-segment of a larger customer segment demonstrating specialized requirements different from the broader market. The goal is to achieve a strong niche presence and a low-cost and/or a unique capability for servicing the market niche that competitors could not justify entry due to the meager returns expected. Rolls Royce, for example, enjoys a global automotive market niche. Timex uses low-priced, quality watches available through mass-merchandizing channels to maintain its market niche.

Local marketing or an *individual* strategies are further subdivisions of the market segmentation approach where the marketing effort is targeted at customers in a narrow geographical region or focused on the individual buyer. The elements of an effective segmentation strategy center on customer growth potential, lack of interest by competitors, possession of special skills and resources required by niche customers, and brand recognition or customer loyalty. Market segmentation provides the firm with a lasting opportunity and is structured around stable demographic, cultural, and technological wants and needs.

Just as the changing markets of the late-twentieth century had forced companies to abandon the mass-marketing approach in favor of market segmentation, so in the twenty-first century the explosion in Internet online buying, marketing, and social media are forcing marketing teams to focus their efforts on working closely with each customer on an individual basis, matching their concerns with a specific set of products and services that resonate directly with their wants and needs. As online vendors, such as Amazon.com and "bricks-and-clicks" omni-channel distributors and retailers, continue to capture more of the consumers' buying dollar, marketers are rapidly moving beyond the mass and segmented marketing models to a *market segment of one* approach. This strategy requires the marketing team to have a firm grasp of the product, service, brand, and delivery strengths that give them a competitive advantage. Once this is done, they must advance to a position that views each customer as if they were a separate market. A key element is using technology to enable the customer to determine exactly how, what, and at what price they want to buy. This involves a process of continually evaluating supplier and customer performance, quantifying value-added services against cost, and communicating this information back to the customer. A *marketing strategy of one* approach requires that the entire business understands the investment and market potential of each individual customer and how to develop strategies to build them into a critical mass.

6.2.4 Sales Plan

The third major component of planning demand is the sales plan. The objective of the sales planning process is to drive the marketing strategy down through the field sales organization and to reconcile the demands identified by marketing with the company's sales resources. In formulating effective plans, sales management must ensure that sales objectives match the goals of the marketing plan, production has the capacities to make the necessary volume of products, and logistics has the capacities necessary to execute delivery expectations. In addition, the effective utilization of the sales force is important to organizational efficiency. After transportation and inventory, the cost of performing sales functions is the second largest source of expenditure, averaging 25–30 % of gross margin and can range as high as 40 % for some commodity lines such as paper. Sales planning must find answers to such questions as:

- What are the objectives of the firm's sales function?
- What strategies should be formulated to ensure sales is meeting the objectives of the marketing plan?
- How should sales quotas be set to support the business plan?
- How should sales be organized to optimize the market segmentation strategy?
- What kinds of sales, pricing, and promotion techniques should be used to find new customers and how can existing accounts be better penetrated?
- What kinds of compensation should be offered to motivate the sales force?
- What kinds of relationships should the sales force develop with the customer base?
- How should customer profitability, account penetration, and sales force productivity be measured?

In answering these and other questions, sales management must develop a comprehensive plan that details sales objectives and goals. As illustrated in Figure 6.7, the sales planning process begins with the translation of the corporate business and marketing plans into a detailed set of sales objectives. For the most part, sales objectives are concerned with the actual sale of products and services that meet the sales revenue and profitability performance targets specified in the corporate and demand plans. Several alternatives are possible. For example, the demand plan may call for sales to focus the majority of their efforts on current customers and established products. Another set of objectives might be for sales representatives to break into a new marketplace, penetrate deeper into a very profitable customer segment, center their efforts on a new product line, or increase online sales. Sales objectives should detail the effort to be expended in *prospecting* (search for new sales), *targeting* (how sales force time is to be split between prospects and customers), *communicating* and *selling* (presenting information and closing sales), *servicing* (providing consulting, technical assistance, financing, and delivery services), and *information gathering* (conducting market research and intelligence).

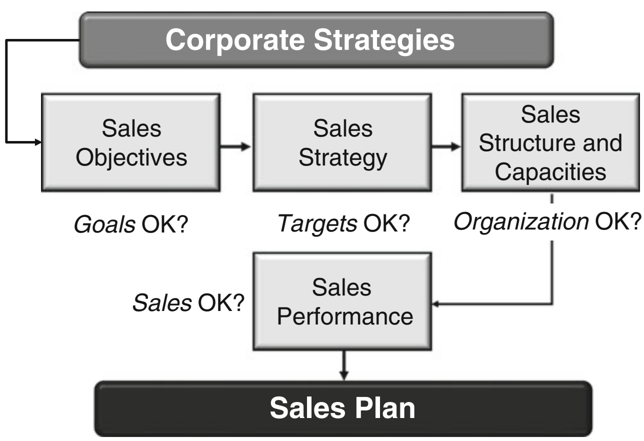


FIGURE 6.7 Sales planning process.

The second step in the sales planning process is determining the sales strategy [12]. Companies can pursue several alternative strategies. A common strategy is to establish a *direct sales force* consisting of employees who work exclusively for the company. This group in turn could be divided into a *leveraged sales force*, where direct salespeople call on large account customers to sell complex and customized products and *inside sales* which is responsible for low-end selling based on a catalog, direct mail, telemarketing, advertising, or social media. Or, the sales strategy could center on a team approach where account managers are responsible for assembling a team of technical, customer service, and office staffs. Another strategy is to use a *contractual sales force* consisting of manufacturers' reps, sales agents, and brokers who are paid a commission based on sales. Finally, the sales strategy may not be to use sales people at all but to sell through electronic marketing. Examples include direct-response infomercials, at-home shopping channels (Home Shopping Network and QVC), interactive TV, and Web-selling (Amazon.com and Eddie Bauer).

Aligning available sales force resources with the sales and revenue campaign takes place in the third step of the sales planning process. Once sales market segmentation and product group strategies are developed, sales management has several alternative organizational structures they could use. For example, for a company with major account-driven products and services (such as enterprise computer systems or capital equipment) a team structure would be the best alternative. Another example would be a geographical sales force used for the sale of inexpensive products and services to thousands of customers in different territories. Again, the decision might be made to use a distributor sales force that works with regional distributors (such as Motorola or Whirlpool). An important part of the sales planning process is ensuring that the size of the sales force is large enough to realize the anticipated sales demand. The sales force size is calculated by assembling information on the size of the customer base and the number of sales calls to be made by salespeople each year. Simply, if there are 12,000 customers each requiring 12 visits each year and each salesperson is expected to make 1,200 calls a year, the company would require a sales force of 120 people. Where direct sales capacities are insufficient to meet expected demand, the corporate revenue plans must be revised downward, the sales force expanded, or contracting of outside agents and representatives explored.

The final step in the sales planning process is charting sales performance. Sales performance is measured through the use of a number of reporting techniques. Whereas actual sales compared to forecast is the most obvious, enhanced performance systems are available that measure customer potential, customer profitability contribution, account penetration, and sales force productivity. Recently, sales force automation (SFA) software has been deployed to manage sales force performance. SFA was originally conceived as an electronic method to collect and analyze customer information that in turn could be used to advance opportunities for customer retention and acquisition as well as enhance marketplace relationships and revenues. Today, SFA provides automation tools that assist salespeople to more effectively manage their existing accounts; prospect for new customers; track the effect of pricing, promotions, campaigns, forecasts, and other sales efforts on their pipelines; generate meaningful analysis and statistics from their sales database; become more mobile; organize their contact lists; and have access to real-time customer information.

A central module of an SFA is *Sales Process/Activity Management*. This application provides imbedded, customizable sales process methodologies designed to serve as a road map guiding sales activity management. Each of the steps comprises an aspect of the sales cycle and details a defined set of activities to be followed by each sales rep. In addition, SFA tools ensure that major sales events, such as product demos or proposal deadlines, trigger alarms as they become due and remind sales reps of closing dates. These software tools promote sales process standardization and, ultimately, greater productivity.

6.2.5 Developing the Demand Forecast

The centerpiece of the demand plan is the *demand forecast*. The demand forecast enables the business to make *assumptions* (what demand will happen in the future) and view *occurrences* (what demand has actually happened in the past and how it impacted performance and forecast accuracy). Forecast assumptions are concerned with internal actions (such as new product introductions, sales promotions, pricing, and so on) that shape future customer demand. Assumptions are also concerned with how the anticipated effect of events occurring in the external environment, such as the economy or actions of competitors, affect marketplace demand. Occurrences, on the other hand, are comprised of a record of what demand actually was in the past that can be used to guide construction of the future forecast.

Figure 6.8 portrays forecasting as occurring on many levels in the enterprise. Which is the best one to use for demand planning? Forecasts created on the company and business unit level are too high level and too focused on financial numbers to be useful. On the other hand item-level forecasts are too detailed and fail to leverage the *law of large numbers* (aggregation of items are easier to forecast and provide a higher level of accuracy). The optimal level is the product family level which enables forecasting teams to aggregate demand based on actual sales of the items belonging to each product family. The product family is optimal for the use of statistical models using bottom-up (pyramid) forecasting where the detailed end-product demand data is rolled-up into product families. Or planners could use a top-down method where statistical forecasting is done at the product family level and then decomposed to the detailed item level. Other forecast methods use detailed customer forecasts that are added up by region, territory, or market segment coming from the field sales force.

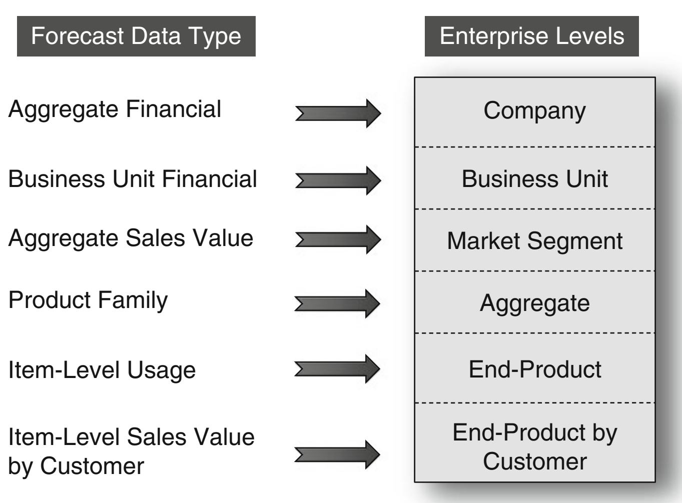


FIGURE 6.8 Forecast hierarchy.

Product families are optimal for the demand forecast for other reasons. To begin with, product families are normally organized to match the actual SKUs the supply channel sells to the marketplace as well as how they are processed or purchased. Secondly, since product families rarely exceed more than perhaps a dozen or so, they are easily identifiable. Third, product families permit sales to use detailed financial and demand history data. This data is "rolled-up" from actual SKUs and summarized into the product families to which they belong. Finally, as actual sales occurs through time and the data is rolled-up into the appropriate product families, sales is provided with a more accurate view of the viability of their forecasts. For example, while the actual mix of SKUs constituting a product family may deviate from the forecast, aggregate sales may show that the product family is on target to meet forecasted sales revenues. Developing an effective demand forecast requires demand planners to effectively use the forecast assumptions and the actual historical forecast to reach consensus. It is the role of the demand planners to analyze these various sources of demand and arrive at a forecast that can be fed into the demand side of the sales and operations planning (S&OP) process.

6.2.5.1 Pyramid Forecasting

Creation of the demand forecast begins with the compilation and review of historical data. Since the demand forecast occurs on the product family level, forecasters must translate detailed data compiled on the individual item level into aggregate product family data. Once compiled, qualitative, quantitative, and associative forecasting techniques are then applied to the aggregate forecastable data to produce a statement of product-level forecast. This aggregate forecast is then used in the sales and operations planning (S&OP) process and decomposed down to the individual item level for use in master scheduling product mix planning. This process is broadly termed *pyramid forecasting* and is illustrated in Figure 6.9.

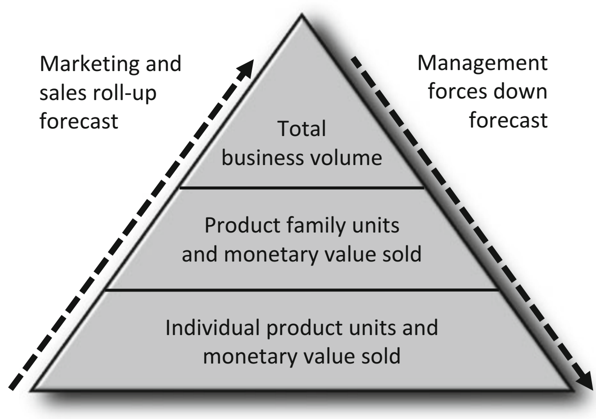


FIGURE 6.9 Pyramid forecasting overview.

The components of the pyramid forecasting process include the following:

- database containing all of the sales by individual product by quantity and monetary value over a determined period of time, usually 1 year
- assignment of all sold items to defined product families

- aggregation (roll-up) of all individual item sales into the assigned product families
- selection of one or multiple forecasting methods used to calculate the product family forecast
- roll-up of all product-family forecasts into a cumulative forecast for the company
- method to reconcile the output of the pyramid forecast with the corporate business forecast
- download of the product-family level forecast into the demand plan.

Figure 6.10 provides an example of a pyramid forecast. The illustration shows historical demand, expressed in terms of monetary value and units, are first assembled for every item sold by the company. In the example, there are four items (A1, A2, B1, and B2) that belong to two product families. The detailed revenues and units sold for each of the items shown at the base of Figure 6.10 reside in the firm's transaction history database. Since the overall company forecast is determined by revenue and not units, the next step is determining the percent of sales represented by each item relative to its product family. For example, the sales of items A1 and A2 are each US\$400MM. When added together, the total sales for Product Family A is US\$800MM. To determine the percent of sales, each of the item-level sales is divided by the product family total. In this case, items A1 and A2, by monetary value, each equal 50 %.

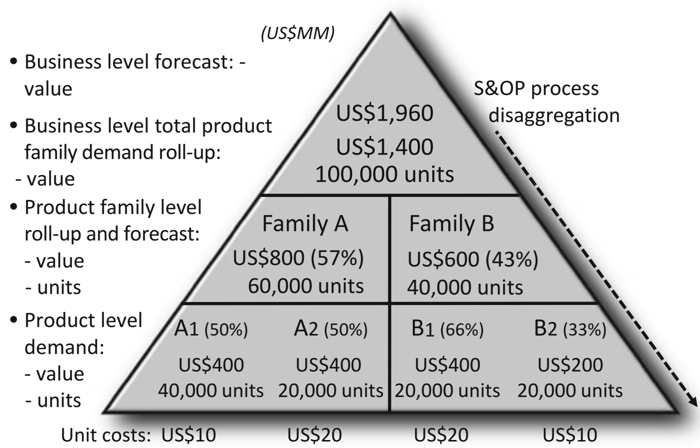


FIGURE 6.10 Pyramid forecasting example.

At this point, the family level sales and units are combined to arrive at the total company-level sales and units sold. In Figure 6.10, the total sales are 100,000M units and the total revenue is US\$1,400MM. After reviewing the aggregate total, forecasters then apply forecasting techniques to arrive at the company-level forecast. In the example, the new forecast is determined as US\$1,960MM. Note the difference between the historical product-family demand and the forecast. It is now the responsibility of management to reconcile the discrepancy. At this point, planners could try several possible forecasting models to determine what they feel is the optimal business forecast for the company based on past demand.

Once agreed upon, the forecast is decomposed, first to the product family level, and then to the end item level. This calculation is first performed by using the historical percentage of sales for Product Family A and Product Family B and then multiplying the percent by the company level forecast. For example, if the new company level forecast is US$1,960MM, the forecast demand on Family A is calculated as US$1,960MM times 57 % or US $1,117MM and Family B as US$843MM. The family forecast values are then extrapolated out through time and form the content of the demand forecast.

With the family-level forecast created, it is then possible to calculate the new item-level forecasts. This step uses the same logic as described in calculating the family-level forecast. For example, items A1 and A2 each constitute 50 % of family sales. The new family-level forecast is multiplied by 50 % for both items A1 and A2 to arrive at their new forecasts. This process structure is classically termed a *planning bill of material*. The importance of this process is that the output quantities are passed to master scheduling as the finished goods forecast, which in turn, will act as a key driver of demand in determining production and purchasing levels.

Exercise 6.1: Pyramid Forecasting

The demand team must create a business level sales forecast for the month of July for its two product families. After reviewing the historical demand data for the month of June, the team has identified the sales of the items constituting the two product family as follows

- Item A1 = 1,300 units
- Item A2 = 1,050 units
- Item A3 = 975 units
- Item B1 = 2,100 units
- Item B2 = 1,850 units
- Item B3 = 1,450 units

The team has also decided to use a four period moving average to calculate the new forecast for both product families. The total company-level demand for the two product families over the past 3 months is as follows:

- March = 8,100 units
- April = 8,450 units
- May = 8,500 units

The first step in the pyramid forecasting technique is to total the June demand of the six items. This value will constitute the total sales of Product Family A and Product Family B. Next, the planners must establish the percent of sales represented by each item in the product family. The results of the computation are illustrated in Table 6.2 (Note: some percent are rounded).

TABLE 6.2. Demand for June

Detail demand for June/SKUs	Actual demand	Percent%
Item A1	1,300	39.1
Item A2	1,050	31.6
Item A3	975	29.3
Family A total	3,325	100.0
Item B1	2,100	38.9
Item B2	1,850	34.3
Item B3	1,450	26.9
Family B total	5,400	100.0
Combined total	8,725	

The next step is to combine the total item sales for June for Product Family A and Product Family B. The total of 8,725 units represents the sales for the month of June. Once compiled, the planners use a four period moving average to determine the company forecast for July which is calculated as:

$$8100 + 8450 + 8500 + 8725/4 = 8443.75 \text{ units}$$

Planners can now decompose Product Family A's and B's forecasts down to the item level by multiplying the percent of item usage times the new aggregate forecast. The results are illustrated in Table 6.3.

TABLE 6.3. Pyramid Forecast – Item Disaggregation

July forecast		
Base family forecast	8443.75	
Family level	Percent	Forecast
Product family A	38.11%	3,217.82
Product family B	61.89%	5,225.93
Total		8,443.75
SKU forecasts	Percent%	Forecast
Item A1	39.10	1,258.09
Item A2	31.58	1,016.15
Item A3	29.32	943.57
Item B1	38.89	2,032.31
Item B2	34.26	1,790.37
Item B3	26.85	1,403.26

The development of the demand forecast marks the conclusion of the demand planning process and the finalization of the contents of the demand plan. In summary, the demand plan consists of:

- *Product and brand management*. This component determines the way the firm's products are classified, product positioning in the product life cycle, the nature of the firm's services, and the competitiveness of the firm's brands.
- *Marketing plan*. The marketing plan translates the business strategy into a statement of how the firm's product, service, promotion, pricing, advertising, and distribution strategies are to shape marketplace demand. A critical part of the marketing plan is the development (with the assistance of sales) of the business forecast.
- *Sales plan*. The sales plan links the expected demand numbers in the forecast with the capability and capacity of the firm's sales force. The sales numbers that occur in a demand campaign period are an essential input into the demand plan and indicate how closely actual sales are matching total expected demand.
- *Historical data and demand forecast*. The database of historical transaction data is an essential input into marketing and sales planning. The record of sales quantities and values provide the fundamental building blocks for the calculation of the forecasts that will drive the demand side of the business.

6.3 CREATING THE SUPPLY PLAN

At the beginning of this chapter it was emphasized that the overall demand plan must be accompanied by a supply plan. The goal of the supply plan is to provide a comprehensive statement of the firm's resource capabilities to meet the demand plan. This statement contains operation's estimate of available capacity, quality, cost, flexibility, and responsiveness. The output from the supply plan represents its commitment to the demand plan that covers production and purchasing costs, inventory, and customer service. The definition of the supply plan is the responsibility of the supply planning team.

The supply plan consists of the following sub-plans as shown in Figure 6.11.

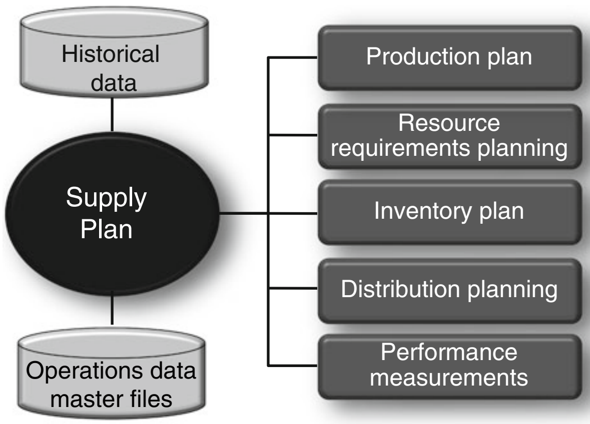


FIGURE 6.11 Supply plan components.

- *Production Plan*. This component defines the overall level of production output planned to be produced, usually stated as a monthly rate for each product family. Various units of measurement can be used to express the plan: each, tonnage, standard hours, number of workers, and so on.
- *Resource requirements planning (RRP)*. The goal of the RRP is to validate that operations has sufficient people, equipment, facilities, land, inventories, supplier capacities, and capital on an aggregate level to meet the requirements of the supply plan. RRP enables the operations team to identify resource gaps, what resources need to be acquired, and which acquisitions require top management approval.
- *Inventory plan*. The goal of the inventory plan is to establish an ending inventory target at the end of a future period or group of periods. Once the inventory targets are determined, the supply planning team needs to compare the end-of-period balances with the target inventory min/max values. The planning team looks over the planning horizon for any instances in which the inventory plan violates the targets.
- *Distribution planning*. Distribution planning is used to determine the logistics resources required to execute the aggregate channel inventory and shipment plans. The output of the distribution planning process consists of the aggregate channel inventories, shipments, warehousing, and transportation capacities necessary to support the supply plans.

- *Performance measurements*. Performance metrics enable the supply team to measure the ongoing performance of operations resources. Measurements, such as planned to actual production, enable the operations team to pinpoint where processes are in control and where deficiencies have caused production output to vary from the plan.

6.3.1 Elements of Production Planning

The development of the production plan is a critical step in the supply planning process. The production plan should be viewed as a living document that must be managed on an ongoing basis. The production plan is used in various ways to measure the effect of the proposed plan on the organization's capacities, assets, inventories, and costs. Production planning must find answers to such questions as:

- What strategies should production use in managing production?
- What production rates are required to support the supply plan?
- How much inventory should there be at the end of each planning period?
- Is there sufficient aggregate capacity to realize the production plan?
- How much will it cost to build the production plan?
- How is the production plan to be integrated into the sales, logistics, and inventory plans?

Once finalized, the production plan serves three basic functions. First, it is the authorized statement of the volume of product family inventory that will be produced. Second, the production plan provides a medium for the calculation of the cost to produce the inventories required by the supply plan. Finally, it provides detailed production load information used to determine the capacity requirements expected of the firm's productive resources.

6.3.1.1 Production Planning Process

The production plan provides important analysis and performance tools that enable the enterprise to pursue detailed, measureable objectives and goals. The production planning process is illustrated on Figure 6.12.

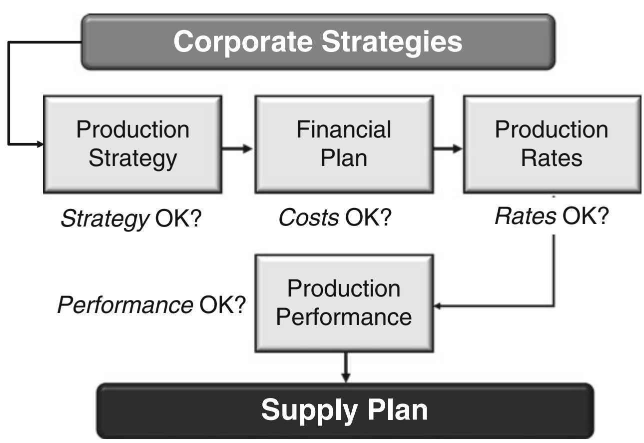


FIGURE 6.12 Production planning process.

The production planning process begins with the selection of the production strategy. Planners have essentially three strategies from which to choose: *chase, level*, and *hybrid*. As an option, planners could also choose to outsource production. The selection of one or multiples of these strategies is based on factors such as cost, availability of productive resources, storage space, product obsolescence, seasonality, marketplace trends, materials availability, and others.

The second step is assessing the financial implications of the selected production plan strategy. An important area is the calculation of workforce and equipment costs. A particular strategy may require the hiring or layoff of the workforce or acquisition of equipment. The effect on inventory costs of a particular strategy must also be considered. Selection of a production strategy requires operations planners to compare the costs arising from alternative plans before actual selection.

Once the production strategy is selected, planners can proceed to the third step in the production planning process: the establishment of the production rates. Since most production environments must produce a minimum quantity of products to remain cost positive, while also recognizing maximum output levels, a viable production plan establishes production levels that never exceed these boundaries while ensuring product is available to meet demand. In addition, since dramatic changes to the shop floor even within defined low/high boundaries is expensive, a level production rate enables planners to optimize productive resources while minimizing ramp-up and ramp-down costs.

The final step in the production planning process is mapping production performance. Production performance is measured through the use of a number of reporting techniques. Probably the most obvious is the variance between planned and actual production. Besides providing a metric of how well the plan is progressing on an aggregate family level, the variances are also used to monitor the effect on the sales and inventory plans.

6.3.1.2 Creating the Production Plan

Before planners begin production plan development, several of the following critical prerequisites need to be in place.

- A detailed demand plan existing at the product family level
- A statement of aggregate product family inventory on-hand balance
- A planning horizon that extends at least 1 year into the future
- Agreed upon common planning unit of measure
- Detailed load profiles for each product family
- Detailed capacity profiles for each aggregate work center, including efficiencies and utilizations
- Defined aggregate production planning objectives
- Compatibility with the master production schedule (MPS)

Once these prerequisites are completed, calculating the production plan begins. The first task is to define the production strategy by choosing from one of the following models:

- *Level production rate*. The goal of this strategy is to produce inventory, regardless of changes in actual demand, according to as level a production rate as possible to meet average demand. Excess inventories built during slow demand periods are assumed to cover periods of excess demand.

- *Demand matching* (Chase strategy). This strategy seeks to produce inventory in exact quantities to meet demand through time. The objective of this strategy is to avoid high inventory costs by varying production rates and employee levels. This strategy requires highly flexible production resources that are capable of being easily idled and restarted.
- *Combination*. Often production management will seek to use a level production rate with the option of switching to a chase strategy based on certain sales volume or production or inventory-cost breakpoints. For example, during periods where demand remains fairly consistent a level rate strategy is used. As variability grows in demand, planners might switch over to a chase strategy to avoid inventory excesses or shortages.
- *Outsourcing*. A fourth possibility is subcontracting production. The most common use of this strategy is to purchase low-cost commodities the company does not make. Operations may also pursue this strategy to manage a temporary and unplanned spike in demand it is incapable of responding to without significant increases in labor and plant costs. This strategy might also be used to acquire product from a supplier that has special expertise in design and production. The advantage of this strategy is that it guarantees the firm a level flow of inventory that is easily adjusted at minimal cost. The main disadvantage is that the cost of purchasing, shipping, and inspecting may be greater than if the product was made in the plant.

A graphic example of these strategies can be seen in Figure 6.13.

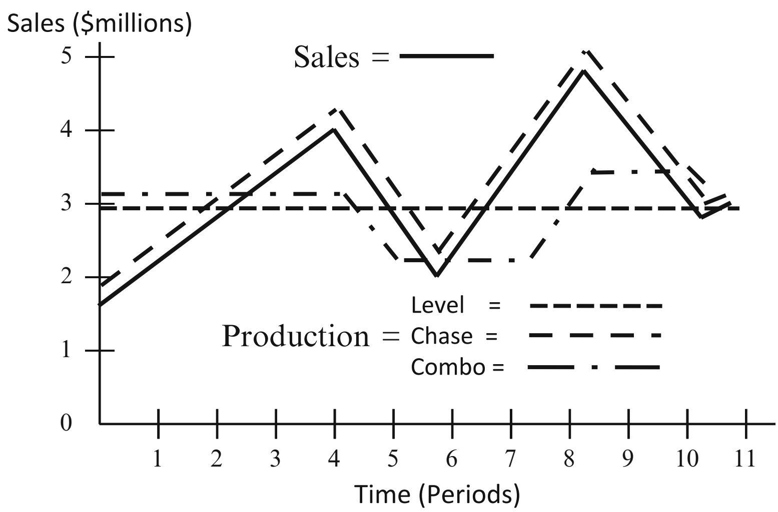


FIGURE 6.13 Production strategies.

Level Production Strategy Graphic and Example. The level production strategy is characterized by a level production rate for a set number of periods. This concept is illustrated graphically in Figure 6.14. The advantage of a level production strategy is that it avoids the cost of changing production levels. Variability in workforce levels, equipment usage, and possible subcontracting costs are eliminated. Disadvantages are the possibility of inventory build-up when supply exceeds the level of demand. Another possible cost is the use of safety stock to meet unexpected or seasonal demand requirements in excess of actual production rates.

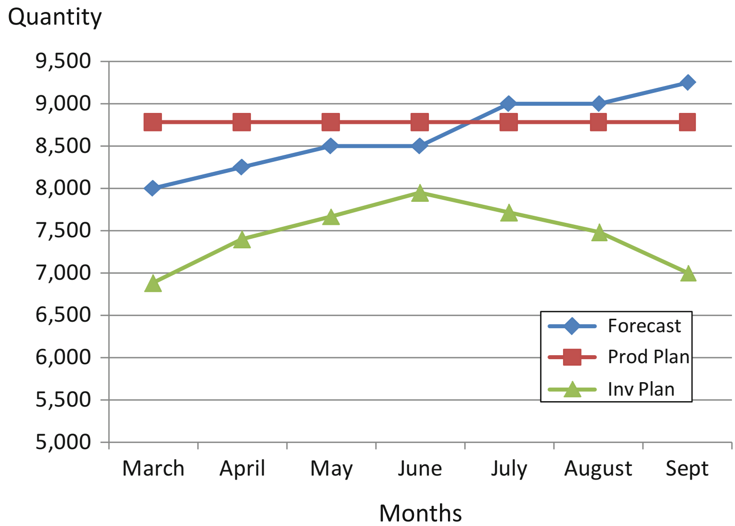


FIGURE 6.14 Level production strategy graphic.

The production rate is created by performing the following steps:

1. Review the detailed product group forecast.
2. Load the product group forecast into a time-phased format by period.
3. The planning horizon should extend out into the future.
4. Determine the aggregate beginning on-hand balance for the product family.
5. Determine the target ending inventory.
6. Calculate the production plan for each product group by period.

The following formula would be used to determine the production rate:

$$Production\,rate = \frac{(Ending\,inventory - beginning\,inventory) + forecast}{Number\,of\,periods} \tag{6.1}$$

An example of the production rate calculation is demonstrated in Figure 6.15.

Product Family	Flat Screen TVs
Ending Inventory Target/units	7,000
Unit of Measure	100 units

	Past Periods		Forecasted Periods						
	January	February	March	April	May	June	July	August	Sept
SALES FORECAST	8,000	8,000	8,000	8,250	8,500	8,500	9,000	9,000	9,250
ACTUAL SALES	7,500	7,800							
PRODUCTION RATE	8,000	8,000	**8,771**	**8,771**	**8,771**	**8,771**	**8,771**	**8,771**	**8,771**
ACTUAL RATE	7,800	7,750							
INVENTORY PLAN	6,000	6,000	**6,871**	**7,393**	**7,664**	**7,936**	**7,707**	**7,479**	**7,000**
ACTUAL INVENTORY	5,500	6,100							

FIGURE 6.15 Level production plan example.

Based on the data in Figure 6.15, the production rate for periods March through September would be expressed as follows:

$$Production\,rate = \frac{(7,000 - 6,100) + 60,500}{7\,months} = 8,771\,units\,(rounded)$$

Chase Production Strategy Graphic and Example. The chase production strategy is a method that maintains a stable inventory level while varying production to meet demand. This concept is illustrated graphically in Figure 6.16. Note that the *production* line and the *forecast* (demand) line are identical.

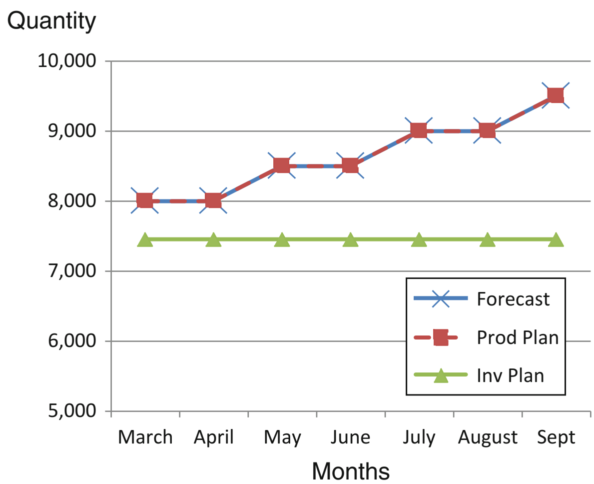


FIGURE 6.16 Chase production strategy graphic.

The chase method requires sufficient production capacity and flexibility to allow the demand forecast to determine the production levels. Production rates will often vary greatly using the chase strategy because they are adjusted to variability in demand. This strategy enables the firm to avoid high inventory costs by varying production and workforce levels, using overtime and subcontractors, and reassigning workers during low demand periods. Note in the grid in Figure 6.17, the production rate matches exactly the demand forecast. Note also that the method projects a constant inventory ending value of 7,500 units.

Product Family	Flat Screen TVs
Unit of Measure	100 units

	Past Periods		Forecasted Periods						
	January	February	March	April	May	June	July	August	Sept
SALES FORECAST	7,000	8,000	8,000	8,250	8,500	8,500	9,000	9,000	9,250
ACTUAL SALES	6,910	7,600							
PRODUCTION RATE	7,000	8,000	**8,000**	**8,250**	**8,500**	**8,500**	**9,000**	**9,000**	**9,250**
ACTUAL RATE	7,800	7,750							
INVENTORY PLAN	7,000	7,400	**7,050**	**7,050**	**7,050**	**7,050**	**7,050**	**7,050**	**7,050**
ACTUAL INVENTORY	6,900	7,050							

FIGURE 6.17 Chase production plan example.

6.3.2 Resource Planning

While the production plan sets the aggregate levels of production and inventories over the product family planning horizon, planners must also match the plan against the aggregate capacity needed to produce the products. Resources are defined as any productive capability that adds value to a product or service through production, storage, or delivery. By their very nature, resources are limited and must be closely managed and synchronized with demand requirements. This process of management is termed *resource planning* (or *resource requirements planning*) and is defined in the *APICS Dictionary*, as:

> Capacity planning conducted at the business plan level. The process of establishing, measuring, and adjusting limits or levels of long-range capacity. Resource planning is normally based on the production plan but may be driven by higher level plans beyond the time horizon for the production plan (e.g., the business plan). It addresses those resources that take long periods of time to acquire. Resource planning decisions always require top management approval.

Resource planning is the capacity management activity by which the production plan is evaluated for feasibility. It is also a way to address the issue of resource acquisition. Productive resources often have long acquisition or installation lead times and it is important to make sure they are available when needed. To work effectively, resource planning must consist of the following components:

- a detailed production plan
- an agreed upon unit of measure
- detailed statement of resource capacities
- a bill of resources
- procedure to attain top management authorization

Resource planning uses the production plan for a product family and calculates its capacity requirements (load) by time period using the product family's *bill of resources*. The capacity of the needed productive resources is determined and compared to the load originating from the product family. Planners can compare load to available capacities to determine overloaded and under-loaded resources and perform adjustments as necessary. The family level production plan developed during the S&OP process is used as a dynamic tool for planning the firm's production resources.

6.3.2.1 Resource Planning Process

The resource planning consists of the steps detailed on Figure 6.18.

The resource planning process begins with the identification of the *aggregate capacity resource profiles* of the productive resources possessed by the firm. Normally, this process groups individual work centers into larger production entities that match the aggregate resources and time frames needed for product family planning. Another approach is to define aggregate bottleneck resources in the factory matched to product families. Examples include entire departments, such as the weld shop, linked assembly lines, the machine shop, or a large multipurpose machine. The resource profile should also be capable of being easily converted into aggregate capacity units of measure over monthly or larger time frames.

The second step is defining product family *bills of resources*. The bill of resources is a list of the resources and process units of measure (such as hours or cubic feet) that is required to make one unit of a typical or average product (within a product family) made at the resource.

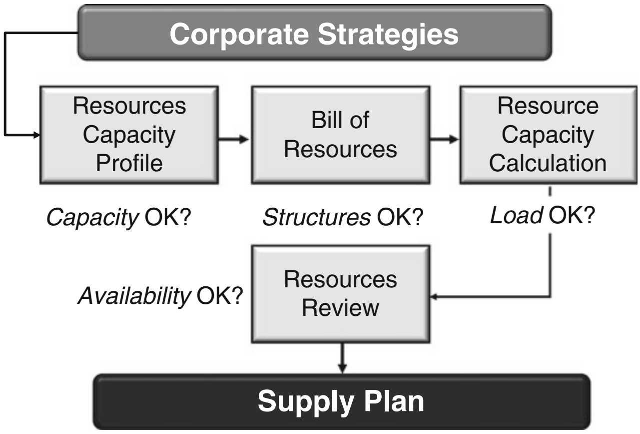


FIGURE 6.18 Resource planning process.

A "typical unit" may not be an actual unit at all, but a composite unit developed from the average need of a family item for resources. An example would be a company that makes shoes, boots, and other footwear products. While the boot family may consist of two dozen different models and sizes, the bill of resources would consist of the resources and process times to make the "typical" boot.

Once the resource profiles and bills of resources for each product family have been completed, the *resource capacity calculation* is performed. This process begins by referencing the statement of product family unit demand by time period found in the production plan. This number is multiplied by the resource usage factor in the product family bill of resources to determine the load created by that product family in that time period. After the load for each product family is totaled, it is then compared to the planned capacity for each productive resource. As illustrated in Figure 6.19, the light colored bars represent the load on an aggregate work center, the dark bars the future planned load, and the dashed line the work center capacity. Note that the released decreases through time. By using this display, production planners can pinpoint when the production plan has become unfeasible.

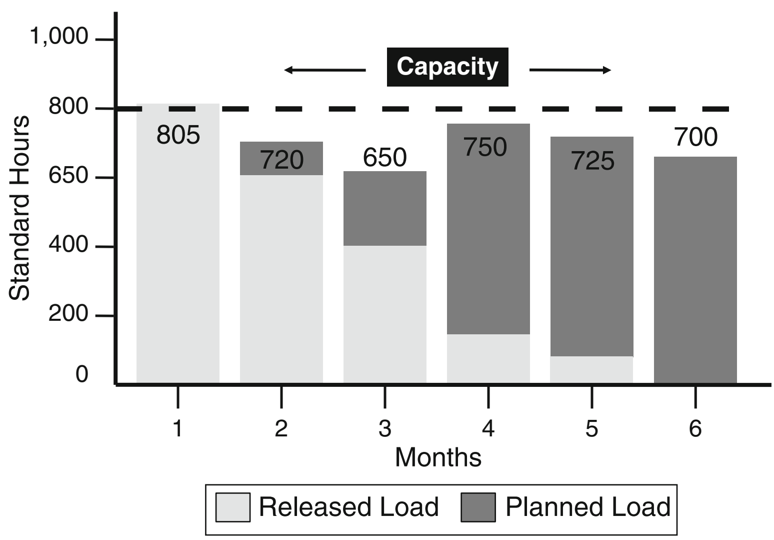


FIGURE 6.19 Resource capacity bar chart.

The final step in the resource planning process is to *identify situations of significant overload or underload* and refer them for additional management review. Management decisions may involve changing the production plan, rescheduling demand, outsourcing, or adding or removing capacity to ensure the production plan is feasible. It is extremely important that these decisions be made and verified with the objectives stated in the supply plan before the production plan is passed down to the master schedule level. If the resource plan cannot be verified, the closed-loop management process requires changes be made in the demand or even the corporate business plan.

Resource Profile and Bill of Resources. The top portion of Figure 6.20 provides an illustration of the *resource profiles* for several work centers found in an electronics manufacturing plant. The field *aggregate capacity* contains the total monthly capacity for each of the five resources. Note that each of the five resources represents an aggregate of the actual work centers found in that resource. For example, the plant's grinders, computer numeric control (CNC) machines, lathes, sanders, and drill presses are all located in the machine shop resource profile.

Resource Profile:

RESOURCE PROFILE	UNIT OF MEASURE	Monthly Capacity
MACHINE SHOP	HOURS	19,000
WELDING LINE	HOURS	27,500
ASSEMBLY A	HOURS	30,000
ASSEMBLY B	HOURS	9,250
FINISHING LINE	Cu Ft	3,600.0

Bill of Resources:

BILL OF RESOURCES	UNIT OF MEASURE	Product Family A	Product Family B	Product Family C	Product Family D
MACHINE SHOP	HOURS	5	5	4	3
WELDING LINE	HOURS	3	7	8	5
ASSEMBLY A	HOURS	6	8	5	6
ASSEMBLY B	HOURS	2	2	2	2
FINISHING LINE	Cu Ft	0.5	0.5	1.0	1.5

FIGURE 6.20 Resource profile and bill of resources.

A critical task in the creation of the resource profile is determining the resource unit of measure. For some resources, such as the machine shop, individual work centers could establish their capacity in units, hours, lengths, cases, or others. Failure to arrive at a consensus is one of prime reasons for the failure of a resource capacity plan. In the example found in Figure 6.20, all of the resources with the exception of the finishing line, which uses cubic feet, use *hours* as the unit of measure.

Once units of measure are determined, the next step is to compile the *bill of resources*. Similar to a product routing, a bill of resources is created for each product family. In the example on the bottom of Figure 6.20, manufacturing Product Families A through D requires their processes to pass through all five resources. The next step is for product engineers to determine a product family-level production (run) time it takes for each resource to produce a unit of each product family. For example, it takes 5 h in the machine shop to produce one standard unit of Product Family A. Constructing the bill of resources requires planners to determine, on an aggregate basis,

1. what resources are required to build a typical product?
2. what is the unit of measure that describes the processing of a typical product at each resource?
3. how much capacity of each resource is needed to produce a typical product?

Once the resource profiles and the bills of resources are completed, planners then turn their attention to generating the resource plan.

Figure 6.21 provides an illustration of a resource requirements plan calculation. The bottom grid contains several key fields:

- The resource profile
- Resource unit of measure
- Product families A through D
- Total load
- Capacity available
- Load %

RESOURCE PLAN	UNIT OF MEASURE	Product Family A	Product Family B	Product Family C	Product Family D	Total Load	Capacity Available	Load %
PRODUCTION PLAN/MARCH	UNITS	950	1,110	1,200	1,100	4,360		
MACHINE SHOP	HOURS	4,750	5,550	4,800	3,300	18,400	19,000	96.8%
WELDING LINE	HOURS	2,850	7,770	9,600	5,500	25,720	27,500	93.5%
ASSEMBLY A	HOURS	5,700	8,880	6,000	6,600	27,180	30,000	90.6%
ASSEMBLY B	HOURS	1,900	2,220	2,400	2,200	8,720	9,250	94.3%
FINISHING LINE	Cu Ft	475	555	1,200	1,650	3,880	3,600.0	107.8%

FIGURE 6.21 Resources planning calculation.

The production plans for the four product families for the month of March have been loaded in the first row. Next, the production plan for each family is multiplied by the work center bill of resources (Figure 6.20). For example, for Product Family A, the requirement for 950 units to be made in the machine shop is multiplied by the bill of resources run time of 5 h to arrive at a total of 4,750 h. Next, the total loads for the five work centers across the four product families are totaled and then compared to the monthly capacity available. Finally, the *load %* indicates work center underloads or overloads. Using the RRP capacity grid enables the supply team to identify capacity problem areas. All conflicts, such as the overload at the finishing line, would have to be resolved before the demand and supply plans are authorized.

6.3.3 Inventory and Distribution Planning

An important component of the supply plan is establishing a comprehensive inventory and distribution channel plan. Plan output consists of the aggregate channel inventories, shipments, warehousing, and transportation capacities necessary to support the marketing and sales plans. The components of the inventory and distribution plan are detailed in Figure 6.22.

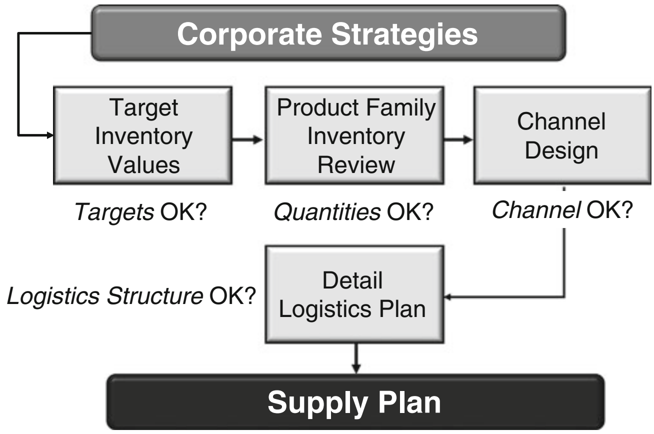


FIGURE 6.22 Inventory and distribution planning process.

The first step in the inventory and distribution planning process is to determine a target aggregate inventory for each product family. The target value is expressed as a quantity remaining at the end of a time period after demand and supply plans have been executed. The period could be a month, a quarter, a season, or longer depending on the business and marketplace. Actually, there are three inventory targets to be determined: the planned inventory target, the minimum inventory target, and the maximum inventory target. Once these target and min/max values have been established, the production/replenishment plan is calculated by using formula (6.1).

The second step in the inventory and distribution planning process is a review of the aggregate inventory end-of-period balances with the target inventory min/max values. The object of this step is for the supply management team to identify the projected end of period balances for each product family over the planning horizon for any instances in which the ending inventory plan violates the targets. The final activity is revising the proposed plan to meet the inventory min/max targets. For example, if a product family inventory balance drops below the minimum quantity, planners will need to increase production. Such an action requires that the new production/replenishment plan be validated against resource and financial capacities. An outsourcing option may be selected, but this choice must be reviewed against available capital assets to fund the proposal. Extra stocked inventory may require additional warehousing and handling costs. If there are no viable options, the demand forecast may have to be reduced or additional resources acquired.

Figure 6.23 illustrates a grid that enables planners to quickly determine if product family ending balances are within acceptable target ranges. Decision criteria on the grid are as follows:

- *Grid time periods*. The grid is expressed in monthly time periods.
- *Planning start date*. The grid calculation begins in January.
- *Inventory target interval*. The inventory target is reviewed on a quarterly basis.
- *Target inventory quantity*. The target inventory quantity balance is 500 units.
- *Minimum target inventory quantity*. The minimum allowable target inventory is 250 units.
- *Maximum target inventory quantity*. The maximum allowable target inventory is 1,100 units.

As illustrated on Figure 6.23, the supply planning team has calculated a quarterly target inventory (500 units) using formula (6.1).

Product Family		Flat Screen TVs							
Opening Balance		700							
Target inventory:	March	500	June	500	Sept	500	Dec	500	
Maximum Inventory		1,100							
Minimum Inventory		250							

	Original Inventory Plan									
	January	February	March	April	May	June	July	August	Sept	4th 3 MOS
SALES FORECAST	13,400	13,200	12,900	12,500	12,100	11,800	11,400	11,100	12,300	38,200
PRODUCTION PLAN	13,100	13,100	13,100	12,133	12,133	12,133	11,600	11,600	11,600	38,200
INVENTORY PLAN	400	300	500	133	167	500	700	1200	500	500
TARGET INVENTORY			500			500			500	500
MIN VIOLATION	OK	OK	OK	MIN	MIN	OK	OK	OK	OK	OK
MAX VIOLATION	OK	OK	OK	OK	OK	OK	OK	MAX	OK	OK

FIGURE 6.23 Inventory planning grid review.

For example, the target production plan for January through March is calculated as ((500–700) + (39,500))/3 periods = 13,100 units. The bottom two rows on the grid indicate whether the min/max target values for each month are "OK" (within the acceptable min/max values) or have been violated. For example, in April it is projected that the ending inventory balance will be 133 units. This value is below the minimum of 250 units. As the supply team plans the aggregate inventory plan for the product family in January, they will need to resolve the impeding inventory shortages occurring in months April and May and overstock in August.

The third step in the inventory and distribution planning process is determining the logistics resources required to execute the aggregate channel inventory and shipment plans. The focus of this step is structuring and validating the distribution channel design. When deciding on the structure of the channel network, planners must align products with the time, place, and delivery needs of the marketplace. This objective is accomplished by first examining how well the distribution channel optimizes the micromarketing model decisions (customer segment, niches, local areas, and individuals) established in the marketing plan. Next, the supply team must validate that the supply channel has the necessary depth and breadth of product variety and services, fast delivery time, and availability of desired lot sizes and assortments. The channel can be characterized as *echelon* (an arrangement of geographically dispersed facilities guiding the flow of product from source to delivery), *direct* (direct shipment to the customer from the producer), and *combined* (echelon and direct channel structures combined). Channel design issues are more fully discussed in Chapter 4.

The final step in the inventory and distribution planning process involves determining the warehouse, labor and equipment, and transportation capacities necessary to execute the demand plan.

- *Warehouse capacity requirements*. Once inventory and channel plans have been completed, planners can calculate the total warehouse space necessary to house the aggregate inventory plan. Inventory storage requirements are matched by time period to the available capacities of different storage types located in each channel facility, such as racks, pallets, bins, space volume, and weight.

  The following elements are used to compile the report:

  1. *Product group storage profiles*. For each product group, an aggregate weight, number of pallets, and volume space requirements are determined. These figures represent the basic storage characteristics of the product family to house the stocking unit of measure. Products can be stored in bins, racks, barrels, pallets, and so on.
  2. *Total warehouse space*. The total space in the warehouse must be determined by the storage area unit of measure. Logistics calculates how many cubic feet of shelf space, pallet racking, floor space, barrels, and so on, are available per warehouse.
  3. *Warehouse space calculation*. The aggregate warehouse space requirements are calculated by extending the inventory plan for each product family by the product family's storage profiles. These aggregate space requirements are then netted against total available warehouse space by storage area to reveal both filled and open space.

  An example of a *warehouse capacity analysis* appears in Figure 6.24.

Product Family	Flat Screen TVs
Unit of Measure/units	1,000
Opening Balance	1.6
Weight/Unit (lbs.)	8.0
Quantity per Pallet	5
Cube Space per Pallet (feet)	48

	Current Year's Warehouse Plan										
	January	February	March	April	May	June	July	August	Sept	Next 3 Months	12 MO TOTAL
INVENTORY PLAN	2.4	2.4	2.6	2.6	3.0	3.7	3.8	3.5	2.8	7.5	
WEIGHT (lbs.)	19.2	19.2	20.8	20.8	24.0	29.6	30.4	28.0	22.4	60.0	274
CUBE SPACE (feet)	23.0	23.0	25.0	25.0	28.8	35.5	36.5	33.6	26.9	72.0	329.3
PALLETS	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.7	0.6	1.5	7
CAPACITY/Cube (feet)	200	200	200	200	200	200	200	200	200	600	2,400
PERCENT USAGE	11.5%	11.5%	12.5%	12.5%	14.4%	17.8%	18.2%	16.8%	13.4%	12.0%	13.7%

FIGURE 6.24 Warehouse capacity analysis.

  Warehouse planners would need to calculate the space requirements for each product group for each warehouse in the distribution network. Although actual space requirements for products will vary due to sales and product changes, aggregate space estimates should be accurate enough in general to support the supply plan.

- *Labor and equipment*. Effective logistics planning requires that planners be able to determine the aggregate manpower and equipment needs of each warehouse in the distribution channel. Too much or too little manpower can be expensive, as is the cost of underutilized equipment or lost productivity due to equipment shortages. Much in the fashion of a production routing, logistics planners develop aggregate labor and equipment processing work standards per product group. Routings in a production environment specify the operations to be performed, the equipment to be used, and the number of hours required to build a specific lot size of a product. Using the same principles, logistics planners can develop product family labor and equipment work standards. These standards are then used for two main activities: product receiving and material put-away and order picking and shipping. The first standard encompasses determining the work requirements needed to load and unload trucks, railcars, or other vehicles, and material put-away. The second is calculated by developing standards for order picking and shipping. Capacity requirements are then calculated by extending processing times by the aggregate totals found in the inventory and shipping plans. The results of the calculation should yield an aggregate statement of manpower and capacity required to actualize supply plan objectives.

- *Transportation volume*. This plan provides traffic planners with a window into the transportation requirements necessary to manage inbound and outbound transportation in the supply channel. Calculating transportation needs is critical. In many companies, the cost for transportation is the largest single logistics cost, accounting in some instances for more than half of the total cost. Although the most obvious benefit of transportation planning is to measure actual costs to budgets, it also provides planners with the ability to negotiate freight rates, make intelligent decisions as to the use of company-owned transportation versus contractors, and view areas for transportation cost savings. Effective performance measurements require dividing transportation into two separate areas: transportation services that are purchased and transportation that is provided by company-owned equipment. When transportation is purchased, performance is determined by tracking purchase cost (price) and carrier delivery performance. Companies that possess their own transportation fleets measure performance by analyzing fixed costs (vehicles, maintenance facilities, terminals, and information systems) and variable costs (labor, repair and service, fuel, and administrative staff) to budgeted standards.

6.4 BALANCING THE DEMAND AND SUPPLY PLANS

If the enterprise was unaffected by changes in the marketplace or shifts in corporate goals and objectives, the resource capacities of the company and its supply channels would be sufficient to satisfy the requirements detailed in the demand plan. Unfortunately, things change and often in a dramatic way, negating even the best demand and supply plans. As plans diverge, the synchronization of sales, production, and inventories engineered during the annual corporate planning process begins to rapidly decay. The result is production output does not match the requirements of actual demand; inventory balances in the supply chain exceed their budgeted costs; and marketplace demands are out of balance with what is actually in channel inventories.

The solution to keeping the demand and supply plans in synchronization is *sales and operations planning* (S&OP). As defined in the *APICS Dictionary*, S&OP is

> A process to develop tactical plans that provide management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focused marketing plans for new and existing products with the management of the supply chain. The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans. It is performed at least once a month and is reviewed by management at an aggregate (product family) level.

The goal of S&OP is to provide a collaborative management process in which department managers mandatorily meet regularly to synchronize the content and revisions they are making to their departmental objectives, strategies, and performance metrics. The S&OP meeting is a forum where teams from the demand and supply areas of the business discuss their ongoing plans, review progress to plan, note differences and the impact on each other's goals, make decisions and resolve conflicts, and come to consensus on how the plans should be integrated and the direction the business is to take until the next review period.

S&OP is characterized by the following points:

- It is a formal business process used by the firm's leadership team to connect corporate business planning with tactical planning, driving master scheduling and distribution planning.
- It provides managers with an opportunity to review and update the strategic business plan to meet organizational and marketplace changes as they occur through time.
- It ensures that the demand and supply plans are realistic, synchronized, and support the business plan.
- It provides sales and marketing with an opportunity to periodically review and revise demand plans so that they are closely synchronized with actual sales occurring in the marketplace.
- It enables operations managers to review and revise production and inventory plans that support the supply plan while optimizing productive and financial assets.
- It uses the aggregate data of sales, production, and inventory along with aggregate planning time buckets and product families to ensure greater planning accuracy. S&OP rarely uses individual products.

6.4.1 S&OP: A Balancing Act

The main goal of the S&OP process is to coordinate the plans and activities of the firm's operational departments with the objective of balancing *marketplace demand* and *resource supply*. When demand exceeds supply, the organization cannot provide products in sufficient volumes to meet forecasted customer requirements. Costs increase due to overtime and premium freight rates. Quality suffers as production hurries to produce and ship products. If supply exceeds demand, productive assets are not optimized, inventories increase, layoffs occur decreasing plant efficiency, and profit margins are squeezed due to price cuts and discounting. Balancing the needs of customer demand with the capabilities of operations supply is the central planning challenge faced by company management.

As illustrated in Figure 6.25, the demand side of the S&OP process consists of two elements: *demand forecasts* and *actual customer orders*. Forecasts are estimates of the

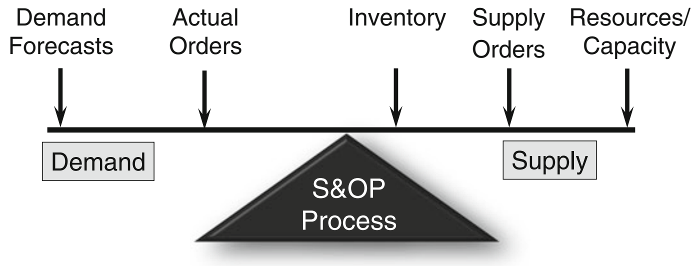


FIGURE 6.25 S&OP – a balancing act.

level of future demand activity. Actual orders are real demand placed on the organization. As actual orders are received, they are matched against the forecast to evaluate forecast performance. The supply side of the balance consists of *inventory, supply orders*, and the firm's *resources* and *capacities*. Inventory consists of products for sale or for use in production. Inventory represents an enormous cost accepted by the firm to meet customer delivery strategies. Supply orders consist of production and purchase orders. Production orders are created to authorize the production of items in the varieties and volumes necessary to meet anticipated demand sales. Purchase orders are issued to suppliers authorizing the delivery of goods and services to meet the inventory requirements detailed in the supply plan. Finally, the firm's resources and capacities constitute the productive assets (labor, equipment, and physical plant) that produce and manage the inventory plans.

The planning challenge is to keep the demand side and the supply side synchronized at all times. Meeting this challenge is not easy. As variability in demand and the capabilities of resources occurs, managers must adjust plans to ensure they support the demand and supply realities surrounding them. S&OP is the centerpiece in this change management process. The key activity is to quickly identify demand and supply gaps occurring on the aggregate level before detailed departmental plans are revised and coordinated. Balancing demand and supply is essential to the effective and efficient running of the business, and this balancing must occur at both the aggregate, volume level and at the detailed product mix level.

S&OP is focused not only on balancing demand and supply, but also product *volume* and *mix*. These elements are portrayed in Figure 6.26. Volume is concerned with the aggregate planning associated with production rates for product families. Mix is concerned with detailed decisions about which individual end-products constituting a product family are to be made, in what quantities, in what sequence, and for which customer orders. Issues relating to product volume are normally resolved before product mix requirements are considered. S&OP is concerned with ensuring that aggregate product volumes (production rates, inventories, and order backlog) are in balance with product family forecasts.

As illustrated in Figure 6.26, once the S&OP aggregate product family plan is validated, it is then passed down to the master schedule where it is decomposed into a statement of end-product mix and fed into the MRP and plant and supplier scheduling systems. Supply planners normally find that when they keep their product aggregate volume supply levels in balance with the demand forecast the job of managing the product mix (individual product and orders) becomes easier.

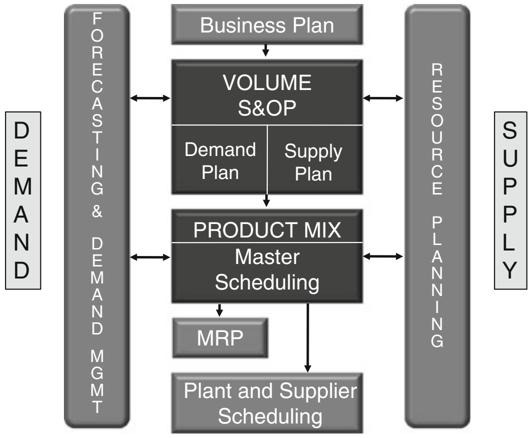


FIGURE 6.26 Demand and supply and volume and mix.

6.4.2 S&OP Foundations

S&OP consists of several foundational components as illustrated on Figure 6.27.

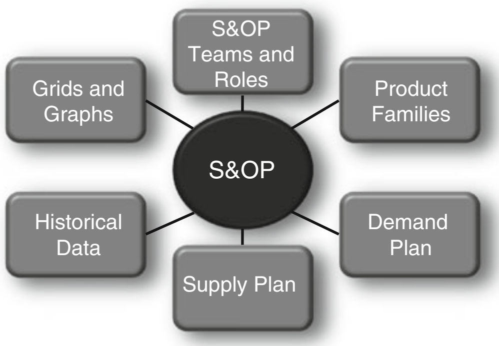


FIGURE 6.27 S&OP foundation components.

The effective management of these components is essential for an effective S&OP effort. These components can be broken down into six basic areas:

- *S&OP teams and roles*. This component is focused on the establishment of effective S&OP teams and the definition of their roles in the S&OP process. S&OP teams cut across business functions. It is the responsibility of the S&OP teams to assemble the necessary planning data, conduct the S&OP meetings, reach consensus on the decisions confronting the business, and decide on courses of action that enable the business to realize competitive opportunities.

  The main players in the S&OP process are:

  – *Executive S&OP team*. This team is composed of the senior executives of the firm. It includes the president, chief operating officer, or general manager; vice presidents of sales, marketing, operations, product development, finance, logistics, and human resources; and the S&OP process owner. The primary role of this team is to provide strong leadership and commitment and make final demand and supply decisions.

– *Executive sponsor*. This individual is usually a member of the top management team assigned to champion the S&OP process. The president (or CEO) is the first choice to fill this role, but it could alternatively be assumed by of one the vice presidents reporting directly to the president. The primary role of the *executive sponsor* is to set clear performance expectations for top management, authorize necessary resources, and clear obstacles hindering an effective S&OP process.
– *S&OP process owner*. The primary role of this individual is to chair the S&OP team meetings. Responsibilities include maintaining the S&OP implementation project schedule, managing the list of issues and concerns arising from the team meetings, assisting in issue resolution, and reporting problems to the *executive sponsor* and the *executive S&OP team*.
– *Demand planning team*. This team is composed of managers responsible for demand management, product analysis, customer service, sales administration, marketing, and account managers, as well as forecast analysts, new product coordinators, field sales, and the S&OP process owner. The primary role of this team is to generate the new demand forecast for the next 15–18 months into the future.
– *Supply planning team*. This team is composed of managers responsible for plant management, purchasing, materials, production control, logistics, quality, accounting and distribution as well as the master scheduler, new products coordinator, and the S&OP process owner. The primary role of this team is to generate the production and inventory plans.

• *Product families*. The foundational data for the S&OP process is based on the product families for all demand and supply planning activities. There are several reasons for using product family aggregates. Planning at an aggregate level enables managers to focus their attention at the right level for tactical decision making. A focus on individual finished goods (mix) provides too much detail and is better handled by master production scheduling (MPS). Additionally, forecasts are easier to work with and are more accurate at the aggregate level. It also assists the S&OP team to stay focused on the big picture of the aggregate demand being placed on the collective resources of the business. As a rule, S&OP works best when there are no more than 12–16 product families.
• *Demand plan*. The demand plan enables the S&OP process to assemble, review, and authorize the anticipated customer demand that will drive the planning process. Creating and managing this database is the responsibility of the S&OP demand planning team.
• *Supply plan*. This component is concerned with defining and validating the production and distribution capacities and capabilities needed to execute the supply plan. Assembling and managing this database is the responsibility of the S&OP supply planning team.

- *Historical data*. This component is concerned with the collection and management of the firm's historical forecast, sales, production, and transaction database histories. Assembling and ensuring the accuracy of these databases is the responsibility of all individuals in the company.
- *S&OP grids and graphs*. Managing the S&OP process requires the application of several types of reporting that normally takes the form of management *grids* and *graphs*. These tools enable the S&OP teams to assemble data to conduct planning simulations, make visible patterns in the data, prepare alternative courses of action, and perform informed decision making.

6.4.3 Working with S&OP Planning Grids [13]

The use of planning grids for forecasting and supply planning was introduced earlier in this chapter. The purpose of the S&OP grids is to enable planners to assemble the sales, production, and inventory plans and to review them against actual performance. Review of the S&OP output is the foundation for the decisions made by the S&OP team in its effort to ensure the business is performing to plan.

6.4.3.1 Make-to-Stock (MTS) Planning Grid

A crucial decision made by S&OP planners is determining whether the product families are make-to-stock (MTS), make-to-order (MTO), or a combination. The planning grids will use different data and will work differently depending on the choice.

Figure 6.28 provides an example of a standard S&OP grid for a product family made in a MTS environment. The components of the grid are described as follows:

	Past Periods				Current Period	Forecasted Periods				
SALES	January	February	March	April	May	June	July	August	Sept	Oct
FORECAST	2,000	2,000	2,000	2,050	2,100	2,100	2,100	2,150	2,150	2,150
ACT SALES	2,150	1,950	2,200	2,150						
DIFF. MO	150	-50	200	100						
CUM	150	100	300	400						
DIFF. %	7.50%	2.50%	5.00%	4.97%						
PRODUCTION										
PLAN	2,000	2,000	2,050	2,100	2,200	2,300	2,300	2,300	2,300	2,300
ACTUAL	1,950	2,000	2,000	2,150						
DIFF. MO	-50	0	-50	50						
CUM	-50	-50	-100	-50						
DIFF. %	-2.50%	-1.25%	-1.65%	-0.61%						
FINISHED GOODS INVENTORY										
PLAN	1000	1000	1050	1100	900	1100	1300	1450	1600	1750
ACTUAL	950	1000	800	800						
DIFF. MO	-50	0	-250	-300						
CUM	-50	-50	-300	-600						
DIFF. %	-5.0%	-2.5%	-9.8%	-14.5%						
DAYS ON HAND	9.7	9.1	7.4	7.6	8.6	10.5	12.1	13.5	14.9	

FIGURE 6.28 S&OP grid – MTS.

- *Planning time frame and horizon*. For most businesses, a monthly time frame is used that extends out for a rolling 12-month or longer planning horizon.
- *Sales planning area*. The rows on the grid are described as follows:
  - *Forecast*. The first row of the sales planning area contains the sales forecast from the demand plan. This is a projection of product family anticipated sales volume by month.
  - *Actual sales*. The second row displays the actual sales for the product family within a particular month.
  - *Difference*. This row is used to compare the forecast row to the actual sales row. A positive number indicates actual sales exceeded the forecast plan, and a negative number indicates actual sales were less than the forecast plan.
  - *Cumulative*. This row contains the cumulative totals of the difference of actual sales to forecast beginning with the opening period of historical comparison.
  - *Percent difference*. This row shows the cumulative percent difference between the sales forecast and the actual sales.
- *Production planning area*. The rows on the grid are described as follows:
  - *Plan*. The first row contains the projection of anticipated production volume by month for the product family. It is developed using a level, chase, or combination (hybrid) strategy.
  - *Actual*. The second row contains the actual quantities that are received from production for the product family within a particular month.
  - *Difference*. This row is used to compare the production plan row and the actual production row. A positive number indicates production exceeded the production plan, and a negative number indicates production was less than the production plan.
  - *Cumulative*. This row contains the cumulative running totals of the difference of actual production to planned production beginning with the opening period of historical comparison.
  - *Percent difference*. This row shows the cumulative percent difference between the production plan and actual production.
- *Finished goods inventory planning area*. This area contains the results of how well the sales and production plans are synchronized. Organizations establish an aggregate product family inventory plan for each period, and then track how closely the actual inventory matches the end-of-period inventory target. The components of the inventory plan are described as follows:
  - *Plan*. The first row contains the projected inventory level by period for the product family over the planning horizon. It is a calculated field based on adding the planned ending inventory for a given period to the planned production in the next period and then subtracting the next period's sales plan. For example, the planned inventory balance for February is calculated as the planned ending inventory for January (1,000 units) plus the planned production for February (2,000) minus the forecasted sales for February (2,000 units) equals 1,000 units as the ending inventory for February.
  - *Actual*. The second row contains the actual ending inventory for each period. It is a calculated field based on adding the actual ending inventory for a given period to

the actual production in the next period and then subtracting the next period's sales plan. For example, the actual inventory balance for February is calculated as the actual ending inventory for January (950 units) plus the actual production for February (2,000) minus the actual sales for February (1,950 units) equals 1,000 units as the ending inventory for February. Note that it is always better to use an actual value as the basis for a future projection.

– *Difference*. This row compares the plan and actual period-ending inventory. A positive number indicates inventory exceeded the inventory plan, and a negative number indicates actual inventory was less than the inventory plan.
– *Cumulative*. This row contains the cumulative running totals of the difference of actual to planned inventory.
– *Days on hand*. This row shows the number of days of inventory on hand at the end of each period. It is calculated by first dividing the next periods sales forecast (actual sales for historical periods) by the number of work days in the period. This value is then divided into the actual current period inventory (planned in future periods) to attain the inventory days on hand. For example, the forecast for May (2,100 units) is divided by 20 working days in the period to arrive at the daily sales rate of 105 units a day. The actual finished goods inventory for April (800 units) is then divided by 105 to arrive at 7.6 days of inventory on hand for the month of April.

6.4.3.2 Make-to-Order (MTO) Planning Grid

In a MTS environment the focus is on the inventory plan and days of inventory on hand to satisfy future customer orders. For a MTO environment, there is no stocked inventory. Products are built based on the receipt of customer orders. As such, in an MTO environment, the focus shifts from inventory to managing the actual and planned customer order backlog. The goal of the process is to determine a certain level of customer order backlog through time.

With the exception of a few elements, the S&OP grid for a MTS and a MTO company are basically the same. The differences are detailed as follows:

- *Bookings planning area*. In place of the demand forecast, the MTO grid considers only the forecast of planned and actual booked orders for each product family.
- *Produce/ship planning area*. This area of the grid represents the actual and planned production and is calculated the same as the MTS grid.
- *Order backlog planning area*.

– *Plan backlog*. This row contains the order backlog. It is a calculated field determined by adding the planned ending backlog for a given period to the forecasted bookings in the next period and then subtracting the next period's production/shipment plan. For example, the planned backlog for May is calculated as the actual backlog for April (56 units) plus the forecasted bookings for May (58) minus the planned production/ shipments for May (50 units) equals 64 units as the planned ending backlog for May.
– *Actual*. The second row contains the actual customer order backlog in product family units. It is calculated by adding the actual ending backlog for a period to the actual sales bookings in the next period, and then subtracting the next period's production plan. For example, as illustrated in Figure 6.29, the actual backlog for April is

	Past Periods				Current Period	Forecasted Periods				
BOOKINGS	January	February	March	April	**May**	June	July	August	Sept	Oct
FORECAST	50	55	52	60	58	60	65	65	70	70
ACT BOOKINGS	45	49	55	50						
DIFF. MO	-5	-6	3	-10						
CUM	-5	-11	-8	-18						
DIFF. %	-10.0%	-10.5%	-5.1%	-8.3%						
PRODUCE/SHIP										
PLAN	45	45	50	50	50	55	55	60	65	65
ACTUAL SHIPMENTS	43	42	51	53						
DIFF. MO	-2	-3	1	3						
CUM	-2	-5	-4	-1						
DIFF. %	-4.4%	-5.6%	-2.9%	-0.5%						
ORDER BACKLOG										
PLAN BACKLOG	45	55	57	67	64	69	79	84	89	94
ACTUAL BACKLOG	48	55	59	56						
DIFF. MO	3	0	2	-11						
CUM	3	3	5	-6						
DIFF. %	6.7%	3.0%	3.2%	-2.7%						
BACKLOG (Wks)	4.6	4.3	4.5	4.5	4.7	5.0	5.3	5.2	5.5	

FIGURE 6.29 S&OP grid – MTO.

calculated as the actual backlog for March (59 units) plus the actual bookings for April (50) minus the actual production/shipments for April (53 units) equals 56 units as the ending actual backlog for April.

– *Backlog (weeks)*. This row shows the *number of weeks* of backlog orders. It is calculated by first dividing the *production/shipments* plan by four (average weeks in the period). This value is then divided into the backlog to attain the backlog in weeks. For example, as illustrated in Figure 6.29, the production/shipments plan for June (55 units) is divided by four to arrive at the daily backlog of 13.75 units a week. The planned backlog for May (64 units) is divided by 13.75 units to arrive at a total backlog of 4.7 (rounded) weeks for May.

6.5 MONTHLY S&OP PROCESS

The monthly S&OP process consists of a series of meetings, finishing with an "executive" meeting where the plans of the S&OP process are reviewed and authorized (Figure 6.30). The demand portion of the S&OP states what marketing and sales expect to sell in terms of product families and aggregate volumes in the coming periods. The supply portion of the S&OP states the volume of production manufacturing must accomplish if the demand plan is to be realized. The end goal of the S&OP process is an agreement between the various departments on the best course of action to achieve balance between demand and supply. The output of the S&OP process will, in turn, drive the detailed marketing, sales, and production plans onto the next level of the planning process. Typically, the S&OP process begins at the beginning of the month and lasts for about 10–12 working days.

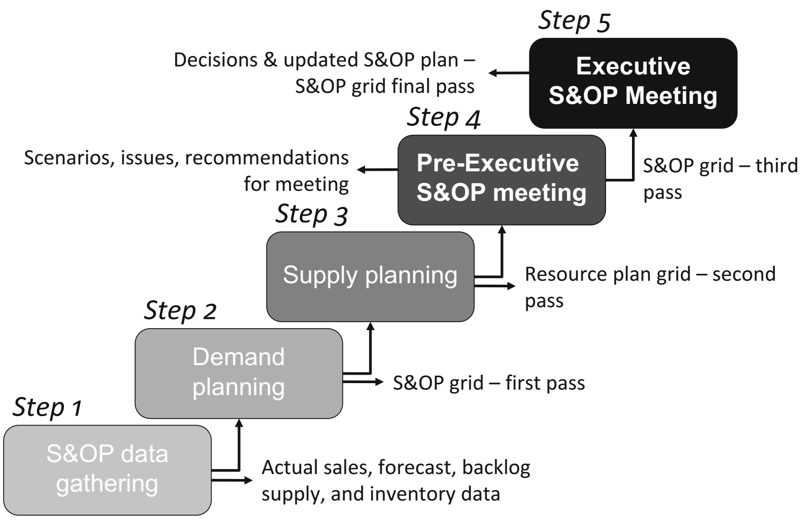


FIGURE 6.30 Monthly S&OP process [14].

6.5.1 *Step 1*: Data Gathering

Before the S&OP process begins, the organization must be fully committed to the process. This means the following components are in place:

- An executive champion has been identified. This is classically a chief operations officer who will act as the S&OP chairperson.
- The organization has a common understanding and vision of S&OP. It has agreed on terminology, understands how the process will work, has the tools to support it, and accepts its responsibilities.
- Issues such as product family definition and organization of the S&OP grid format are determined.
- S&OP performance measurements are defined. These include actual sales, production, inventory and backlog metrics, and how they are to be compared to the plan. Acceptable tolerances are also established.

Once these components are in place, the S&OP process begins. The first step commences shortly after the end of a period. While companies can use any variety of time frames, a monthly S&OP period is the norm. In this step, the organization, with the assistance of the information system department, completes, validates, and updates all the data files necessary to generate new S&OP grids and graphs, as well as identify any marketplace or internal resource changes that might have an effect on the S&OP decisions. These files consist of the total sales and backlog, a statement of aggregate production for the past period, and an end-of-period inventory or order backlog by product family.

A second activity is generating new data for the demand team members to use in the development of the new demand forecast. The data outputs used include sales analysis data, statistical forecast reports, and revised worksheets from the field sales force. The next activity is disseminating the information to the demand and supply S&OP teams. To make the S&OP a timely process, it is important that this step be completed within a week after period end. Because of the complexity and size of the databases, it is preferable to have the data needed for S&OP grids and graphics automatically uploaded from the enterprise business system.

6.5.2 *Step 2*: Demand Planning

The second step begins with the receipt of the demand and sales data collected in step 1. The main objective of this opening step is for the S&OP demand planning team to analyze past period sales results against the existing forecast. This step will involve using tools, such as pyramid forecasting, that enables the team to aggregate transaction history on individual products into the pre-determined product families. The results are then compared to past and future estimates of demand assembled in the last period's S&OP demand plan.

Once this opening review has been completed, the demand team begins the process of developing a new demand forecast for the next period by integrating changes brought about by new inventory/brand, marketing, and sales strategies. Consideration is given to any new intrinsic and extrinsic events, such as new products, product life cycle changes, new customers, promotions, pricing, and competitor activity. Forecast development uses applicable forecasting techniques, input from the field, and simulation models. The revised family-level demand forecast, finally, is reviewed by a senior sales and marketing executive before it is entered into the new S&OP grid. The authorized demand forecast is considered as the "first pass" S&OP plan that will next be used by the S&OP supply team.

6.5.3 *Step 3*: Supply Planning

In this step, the S&OP supply planning team begins by reviewing the production and inventory data collected in step 1. This step involves using reporting that discusses resource capacities, production performance to plan, and other metrics. The goal is to see how well the supply-side of the business responded to the previous period's supply plan. In this step, the supply planning team reviews the first-pass MTS and MTO demand grids against current family-level resource and capacity plans. The goal is to identify any new gaps appearing in the S&OP plan. Next, the supply planning team adjusts the current supply plan to meet new inventory (MTS) and backlog (MTO) targets. To ensure availability of resources and capacities to meet the new supply priority plan, supply planners will run resource requirements planning (RRP) and readjust the supply plan where needed. Planners use aggregate statements of resource capacities and family level bills of resources in the determination. Other constraints to be considered are materials, warehouse space, refrigerated storage, and others.

After review, the proposed supply plan is adjusted as needed. If the resource plan contains overload or underload conditions, alternative scenarios for solving resource problems will have to be developed. Underload conditions could be resolved by cutting overtime, eliminating temporaries, or layoffs. Overload solutions range from minor alternatives, such as increasing overtime, outsourcing, or hiring more staff, to major alternatives such as adding a new shift or expanding the physical plant. These alternative scenarios will be considered at the Pre-Executive S&OP meeting and perhaps at the Executive S&OP meeting. These plans should be clear, concise, facilitate decision making, and contain the necessary financial information. All unresolved issues need to be recorded for presentation at the Pre-S&OP Meeting. Finally, the new supply plan is then integrated with the demand plan and final S&OP grids and graphs produced for review in step four: the Pre-Executive S&OP Meeting. This set of documents represents the second pass S&OP plan.

Exercise 6.2: Resource Requirements Calculation

The S&OP supply planning team has just received the demand forecast from the demand team. The forecast for three essential product families has been increased to meet expected demand and the supply team needs to review the impact on aggregate capacities. The first step in the process is to develop a grid detailing past production for the current and past months and the new demand forecast for the next 4 months. The results of the exercise appear in the grid below.

Next, the planners created a *load profile* specifying a generic production time for each of the PC-product families. The results appear in the grid below.

	Product family load profile		
Product family	Work center K200-1		Assembly
PC-1500	1.5	hrs/unit	
PC-1600	1.8	hrs/unit	
PC-1700	2	hrs/unit	

With this information, the planners are then able to calculate the *resource profile*. For example, in month -1, it takes 1.5 h to build one unit of product family PC-1500, or a total of 225 h (1.5 h × 150 units of demand). The results of the resource profile calculation are as follows:

	Resource profile (in standard hours)						
Product family	Month -1	Month 1	Month 2	Month 3	Month 4	Month 5	Total/hrs
PC-1500	**225**	**225**	**247.5**	**262.5**	**262.5**	**262.5**	**1,485**
PC-1600	**198**	**189**	**189**	**189**	**198**	**198**	**1,161**
PC-1700	**200**	**210**	**210**	**210**	**210**	**210**	**1,250**
Total	**623**	**624**	**646.5**	**661.5**	**670.5**	**670.5**	**3,896**

Based on the total load on Work Center K200-1, the planners were able to generate a resource requirements planning (RRP) load report that compared the load with the available work center capacity. Note that for each of the months there is a total of 625 h of capacity available. When the load and the capacity are netted out over the planning horizon, supply planners can easily identify overload and underload hours as illustrated in the below grid.

	Production and forecast						
Product family	Month -1	Month 1	Month 2	Month 3	Month 4	Month 5	Total
PC-1500	150	150	165	175	175	175	990
PC-1600	110	105	105	105	110	110	645
PC-1700	100	105	105	105	105	105	625
Total	360	360	375	385	390	390	2,260

	RRP report						
Work center K200-1	Month -1	Month 1	Month 2	Month 3	Month 4	Month 5	Total/hrs
Std hrs required	**623**	**624**	**646.5**	**661.5**	**670.5**	**670.5**	**3,896**
Capacity avail.	**625**	**625**	**625**	**625**	**625**	**625**	**3,750**
Over/under load	**2**	**1**	**−21.5**	**−36.5**	**−45.5**	**−45.5**	**−146**
Cum over/under	**2**	**3**	**−18.5**	**−55**	**−100.5**	**−146**	

By converting the data to a graph (as seen below), a visual of the demand and supply dynamics occurring at Work Center K200-1 is available (Figure 6.31).

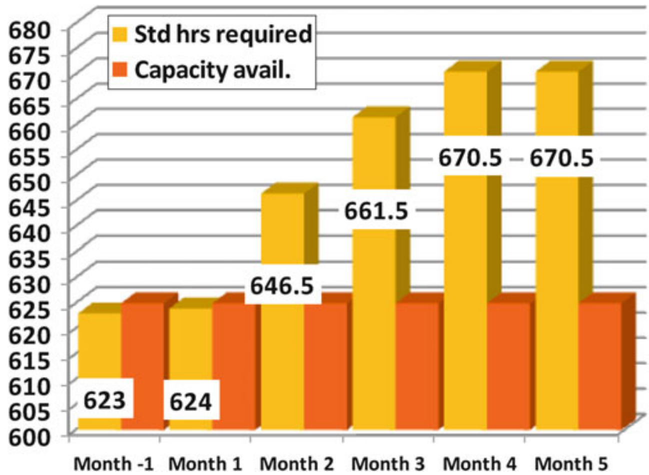


FIGURE 6.31 Work center load and capacity.

This output provides essential information indicating impending problems for review by the supply planning team. For example, for the current month, there is a slight overcapacity at the work center. However, beginning in month 2 and continuing out through the planning horizon, the demand plan is requiring increasingly more capacity than is available. The supply planning team would then review possible alternatives to solve this impending overload condition. If the problem can be resolved in the supply planning meeting, the new demand and supply plan would be validated. If not, the problem would then be elevated to the next step in the S&OP process.

6.5.4 *Step 4*: Pre-Executive S&OP Meeting

The Pre-Executive S&OP meeting is where the planning teams assemble to review the planning results from the previous stages and to prepare for the Executive S&OP Meeting. A key objective of the meeting is to resolve as much as possible all outstanding issues. In this sense, the meeting should perform the necessary "heavy lifting" associated with providing the data for detailed plans, arriving at consensus on thorny issues, crafting alternative scenarios indicating possible choices, backup data used to justify decisions taken, recommendations for problem areas, and a concise log of unresolved problems. The key activities performed in this step are:

- In the opening activity, the two planning teams review the assumptions constituting the initial set of performance goals and metrics used in the previous steps. The teams look at actual performance to plan for sales, production, inventories, and backlogs. The objective is to validate these goals and metrics before the third-pass S&OP plan is submitted to the executive team.
- The next step for the planning teams is to review the data gathering process used in assembling the S&OP spreadsheets and graphs. The goal is to ensure that they are accurate and complete.

- With the assistance of accounting, the planning teams need to craft a number of financial views of the S&OP plan. These financial views are extremely important for the executive team meeting to follow.
- Next, the demand team presents their decisions and recommendations regarding the demand forecast and backlog for each product family. Related issues, such as new product introductions, growth in new markets, pricing and promotions changes, and others, will also be reviewed. The goal is to reach consensus regarding the viability of the demand plan.
- Following, the supply team presents their decisions and recommendations regarding changes to plant resources (plant, labor, and equipment) and outsourcing. In addition, the supply team presents their analysis of the ending inventory plan. Possible courses of action are to leave plans unchanged, increase or decrease the demand plan, and/or increase or decrease the supply plan. The goal is to reach consensus regarding the viability of the supply plan.
- Where consensus among the planning teams cannot be reached, such unresolvable issues must be fully documented and prepared for presentation to the executive meeting for final resolution.
- The key output of the Pre-Executive S&OP meeting is the "third pass" S&OP grids and graphs and the agenda for the Executive S&OP Meeting.

6.5.5 *Step 5*: Executive S&OP Meeting

The final step in the S&OP planning process is the executive S&OP meeting. Lasting about 2 h, the meeting is composed of the executive S&OP team (the CEO and the functional vice-presidents) and representatives from the demand and supply team. Several key agenda items are discussed. An important action item is the need for senior managers to make decisions regarding conflicts that the pre-meeting team could not reach a consensus solution or was outside the scope of their authority. Included in the discussion is a review of how well the S&OP plan to date is performing to key performance indicators. Decisions and adjustments are made to the S&OP plan where performance was less than planned. Outputs from the meeting include a record of all decisions; modification to the corporate business plan, if any; the "fourth-pass" S&OP grids and graphs reflecting all changes; and authorization from the executive team to execute the S&OP plan.

Exercise 6.3: Solving Impasses: Workforce Costs

The demand planning team has generated a new MTS forecast that increases production rates since the last S&OP meeting. The supply planning team must decide how to approach the new production plan that was generated. The options are to follow either a chase or a level production strategy. Making the choice requires the supply team to investigate the cost of both plans. Since the new plan will require changes in workforce costs, the decision is an important one. To assist in the decision making, the supply team has created the below grids. Since the criteria is the cost of the new production plan, the grids are expressed in millions of US dollars (Figure 6.32).

Product Family B	Sound Systems
Employee Production Rate	100 units/month/employee
Labor Cost/$50 per hr*20 days	$ 8,000 per employee/month
Cost of Layoff of Employee	$ 5,500
Cost of Hiring Employee	$ 2,000

	Past Periods		Forecasted Periods								
CHASE PRODUCTION	January	February	March	April	May	June	July	August	Sept	Next 3 Months	12 MO TOTAL
PLAN	8,000	8,000	7,500	8,000	9,000	11,000	12,000	10,000	9,000	24,000	90,500
# EMPLOYEES	80	80	75	80	90	110	120	100	90	240	90.5
EMPLOYEE COST	$ 640,000	$ 640,000	$ 600,000	$ 640,000	$ 720,000	$ 880,000	$ 960,000	$ 800,000	$ 720,000	$ 1,920,000	$ 7,240,000
EMPLOYEE CHANGE			-5.0	5.0	10.0	20.0	10.0	-20.0	-10.0	-10.0	
LAYOFF COST	0.0	0.0	$ 27,500	$ -	$ -	$ -	$ -	$ 110,000	$ 55,000	$ 55,000	
HIRE COST	0.0	0.0	$ -	$ 10,000	$ 20,000	$ 40,000	$ 20,000	$ -	$ -	$ -	
CHANGE COSTS	$ -	$ -	$ 27,500	$ 10,000	$ 20,000	$ 40,000	$ 20,000	$ 110,000	$ 55,000	$ 55,000	$ 337,500
TOTAL COSTS	$ 640,000	$ 640,000	$ 627,500	$ 650,000	$ 740,000	$ 920,000	$ 980,000	$ 910,000	$ 775,000	$ 1,975,000	$ 7,577,000

	Past Periods		Forecasted Periods								
LEVEL PRODUCTION	January	February	March	April	May	June	July	August	Sept	Next 3 Months	12 MO TOTAL
PLAN	8,000	8,000	7,500	8,000	9,000	11,000	12,000	10,000	9,000	24,000	
# EMPLOYEES	80	80	96	96	96	96	96	96	96	288	
UNITS PRODUCED/CUM	8,000	16,000	9,600	19,200	28,000	38,400	48,000	57,600	67,200	96,000	
PLAN/CUM	8,000	16,000	7,500	15,500	24,500	35,000	47,500	57,500	66,500	90,500	
EMPLOYEE COST	$ 640,000	$ 640,000	$ 768,000	$ 768,000	$ 768,000	$ 768,000	$ 568,000	$ 768,000	$ 768,000	$ 2,304,000	$ 7,680,000
EMPLOYEE CHANGE			16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
LAYOFF COST	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
HIRE COST	0.0	0.0	$ 32,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
CHANGE COSTS	$ -	$ -	$ 32,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 32,000
TOTAL COSTS	$ 640,000	$ 640,000	$ 800,000	$ 768,000	$ 768,000	$ 768,000	$ 768,000	$ 768,000	$ 768,000	$ 2,304,000	$ 7,712,000

FIGURE 6.32 Workforce costs.

The grid consists of three parts:

1. Data relating to product rates per employee, labor costs, hiring costs, and layoff costs.
2. The production and workforce costs to pursue a *chase production strategy*.
3. The production and workforce costs to pursue a *level production strategy*.

The key rows on the chase and level grids are as follows:

- *Plan*. This row contains the required planned production abstracted from the full S&OP grid needed to meet sales and inventory requirements.
- *# Employees*. Based on the employee production rates in section 1, this row indicates how many people are needed to execute the production strategy.
- *Employee costs, changes, and hire and layoff costs*. These rows represent the workforce costs to execute the production strategy.

When compiled, the workforce costs to pursue a *chase strategy* for the remainder of the year (March through December) is detailed for each month and then totaled for the March through December planning horizon.

The *level product strategy* requires more calculation. Supply planners must determine a steady workforce that enables production to meet the plan for each period. This determination is visible in the two rows (black highlight) entitled:

- *Units produced/cum*: this is the number of units produced cumulatively by the workforce.
- *Plan/cum*: this is the number of units required by the production plan.

As can be seen, the required number of workers for a level strategy is 96. This means that production must hire an additional 16 new employees over the February total. Since the supply team has been restricted from adding employees, the supply team has decided to refer the decision to the Executive S&OP team for resolution. Based on workforce costs for labor and changes to workforce levels, the *chase strategy* appears to offer the lowest total cost. From this information, the executive team must make a decision regarding their restriction on increasing workforce costs as well as weigh the impact of layoffs if a *chase strategy* is chosen.

6.5.6 Benefits of the S&OP Process

S&OP provides the central linkage drawing the various levels of strategic, tactical, and operations plans together into a single company game plan. The power of S&OP resides in assisting planners to focus on the two essential attributes of S&OP: *change management* and *continuous improvement*. It can be argued that the real enabler of S&OP is providing visibility to the changes new marketplace realities have had on past plans and the mechanism to effect consensus replanning of demand and supply. According to Iyengar and Gupta [15], “An S&OP project is 60 percent change management, 30 percent process development, and 10 percent technology.” An effective S&OP drives process ownership and restructuring of roles and responsibilities; the tools to develop necessary adjustments to company culture and capabilities to handle change; and winning employee acceptance about the appropriateness of the changes.

In a similar vein, S&OP drives continuous improvement. By its very nature, S&OP provides companies with a never-ending opportunity to expose and eliminate root causes of demand and supply mismatches by enabling continuous monitoring, feedback, and sharing of improvement ideas on all levels of the organization. S&OP encourages employees to take ownership and reinforces teamwork, thereby improving organizational motivation and collaborative skills. The following points summarize the main benefits of S&OP:

- Establishes operational plans consistent with the business plan
- Continually updates the production, financial, and sales plan
- Provides for cross-functional planning
- Establishes regular meetings with senior executives to resolve demand versus supply trade-offs
- Checks availability of resources to validate the production plan
- Increases teamwork and collaborative skills

6.6 SUMMARY

Demand management is a process that weighs both marketplace demand and a firm’s output capabilities and tries to balance the two. Demand management consists of six activities:

- *Planning demand*. This activity seeks to determine the products and services desired by the marketplace. It is concerned with estimating how many products and services customers will buy, at what price, and on what timetable.
- *Demand communicating*. This activity consists of three critical activities: (1) communicating the approved demand plan to the other functional business areas so that they can begin their planning processes; (2) providing detailed information as to the effectiveness and performance to date toward realization of demand plan objectives; (3) alerting the sales, marketing, and supply organizations to gaps in their planned to actual performance.
- *Demand sensing*. This activity seeks to uncover and prioritize demand as close as possible to the moment that it occurs in the supply chain. By deflating the time it takes

to receive market data information, supply chain members can respond quicker to shifts in marketplace demand.

- *Demand Shaping*: This activity consists of the steps performed by product and brand management, marketing, sales, and operations to persuade or germinate a need that convinces customers to purchase the organization's products and services.
- *Demand translation*. This activity consists in translating actual and forecasted demand into information that can be used in supply planning. Effective demand translating means that sales components, such as product family identities, units of measure, revenues, and volume and mix quantities, can be easily passed to supply side production and distribution planning databases in a meaningful way.
- *Demand orchestration*. This activity focuses on the development of demand plans that ensure that the expected trade-offs between demand opportunity and demand risk are optimized. Success is revealed in the level of performance of actual to expected demand and actual to expected operations costs.

The second component of demand management is *supply planning*. The goal of the supply plan is to provide a comprehensive statement of how the firm's resource capabilities meet the requirements of the demand plan. This statement contains operation's estimates of available capacity, quality, cost, flexibility, and responsiveness. The output from the supply plan represents its commitment to the demand plan that covers costs, inventory, and customer service.

The supply plan consists of the following sub-plans.

- *Production Plan*. The production plan defines the overall level of manufacturing output planned to be produced, usually stated as a monthly rate for each product family. The production plan serves three basic functions: (1) it is the authorized statement of product family inventory volumes that will be produced; (2) it provides a medium for the calculation of the cost to produce the inventories required by the supply plan; and (3) it provides detailed production load information that can be used to determine the capacity requirements expected of the firm's productive resources.
- *Resource requirements planning (RRP)*. The RRP validates that operations has sufficient productive resources on an aggregate level to meet the requirements of the supply plan. RRP enables the operations team to identify resource gaps, what resources need to be acquired, and which acquisitions require top management approval.
- *Inventory plan*. The inventory plan establishes an ending inventory target at the end of a future period or group of periods. Once the inventory targets are determined, the supply planning team needs to compare the end-of-period balances with the target inventory min/max values. The planning team looks over the planning horizon for any instances in which the inventory plan violates the targets.
- *Distribution planning*. The distribution plan determines the logistics resources required to execute the aggregate channel inventory and shipment plans. The output of the distribution planning process consists of the aggregate channel inventories, shipments, warehousing, and transportation capacities necessary to support the supply plans.
- *Performance measurements*. Performance metrics enable the supply team to measure the ongoing performance of operations resources. Measurements enable the operations team to pinpoint where processes are in control and where deficiencies have caused production output to vary from the plan.

A critical requirement of the planning process is keeping marketplace demands and supply resources in constant balance. To the extent that the demand and supply plans are not synchronized, production output will not match the requirements of the demand forecast; inventory balances in the supply chain will exceed their budgeted costs; and marketplace demands will be out of balance with what is actually in channel inventories. The solution to this negative dynamic is *sales and operations planning* (S&OP). S&OP is a collaborative management process in which department managers mandatorily meet regularly to discuss their ongoing plans, review progress to plan, note differences and the effect on each other's goals, make decisions and resolve conflicts, and come to consensus on how the plans should be integrated and the direction the business is to take until the next review period.

The culmination of the S&OP process is the monthly S&OP meeting. Before the meeting begins, however, several factors must be in place: (1) the S&OP executive, demand, and supply teams must be formed with critical roles defined; (2) S&OP aggregate product family and resources defined; (3) the demand and supply plans created; (4) the necessary historical demand and supply data made available; and (5) report grids and graphs finalized. Once these components are in place, the S&OP meetings can begin.

The monthly S&OP planning process consists of the following steps:

- *Step 1: Data gathering*. At month end, the organization completes, validates, and updates all the data files necessary to generate a new S&OP. These files consist of the total sales or backlog, a statement of aggregate production for the past period, and end-of-period inventory or backlog by product family.
- *Step 2: Demand planning*. The S&OP demand planning team reviews the past period results and the existing forecast. Based on the results, the team may decide to generate a new forecast and make further alterations to the new forecast as necessary. The output of the process is the authorized demand plan.
- *Step 3*: *Supply planning*. Based on the past period production results and the new demand plan, the S&OP supply planning team may alter the existing production plan and review the impact on the inventory and backlog plan. The output of the process is the authorized supply plan.
- *Step 4*: *Pre-Executive S&OP meeting*. The S&OP demand and supply teams assemble to review the preliminary S&OP product family grids, make adjustments to the S&OP plan as necessary, make decisions regarding conflicts, and set the agenda for the final step, the executive S&OP meeting.
- *Step 5*: *Executive S&OP meeting*. Lasting about two hours and composed of the firm's senior executives and assisted by select members of the demand and supply teams, the executive team may accept the decisions forwarded from the pre-S&OP meeting, or they may ask for plan revision. The output of this meeting is then driven into the tactical plans of each business functional department.

The entire process takes between 2 and 3 weeks to complete and is used to determine next period's operational plans. The benefits of S&OP are the establishment of operational plans consistent with the business plan; ability to continually update the production, financial, and sales plan; providing for cross-functional planning; establishment of regular meetings with senior executives to resolve demand versus supply trade-offs; ability to check availability of resources to validate the production plan; and increased teamwork and collaborative skills for the entire organization.

DISCUSSION QUESTIONS

1. Describe product life cycle management and why it is so important to demand planning.
2. Describe the three manufacturing strategies described in the chapter.
3. Describe the pyramid forecasting concept.
4. What are the components of demand management?
5. What are the four major components involved in the marketing planning process?
6. What are the components of a firm's supply plan?
7. Define sales and operations planning (S&OP) and describe its goal.
8. Describe the input data needed to construct a sales and operations planning (S&OP) grid.
9. Sales and operations planning (S&OP) has been described as performing a balancing act. What does this mean?
10. Describe the five step S&OP process.

PROBLEMS

1. Complete the S&OP grid illustrated below for make-to-stock product family A. Calculate the ending inventory plan values and enter them into the grid. The current period is the month of May. The unit of measure is 1 unit. Place your answers directly into the grid.

	Past periods				Current period	Forecasted periods				
Product family A	January	February	March	April	May	June	July	August	Sept	Oct
SALES FORECAST	325	325	340	340	350	370	350	325	360	390
ACT SALES	310	320	335	345						
DIFF. MO	-15	-5	-5	5						
PRODUCTION PLAN	325	330	335	340	360	360	360	350	350	350
ACTUAL	328	335	335	345						
DIFF. MO	3	5	0	5						
INVENTORY PLAN	100	105	100	100						
ACTUAL	105	120	120	120						
DIFF. MO	5	15	20	20						

2. Complete the S&OP grid illustrated below for make-to-order product family B. Calculate the ending backlog plan values and enter them into the grid. Also, calculate the number of weeks of backlog available. The current period is the month of May. The unit of measure is 1 unit. Place your answers directly into the grid.

	Past periods				Current period	Forecasted periods				
Product family B	January	February	March	April	**May**	June	July	August	Sept	Oct
PLAN BOOKINGS	100	100	105	105	105	110	110	115	115	120
ACT BOOKINGS	102	106	103	108						
DIFF. MO	2	6	-2	3						
PRODUCTION PLAN	95	95	95	100	100	100	105	110	110	115
ACTUAL	96	94	94	103						
DIFF. MO	1	-1	-1	3						
CUM	1	0	-1	2						
BACKLOG PLAN	55	60	70	75						
ACTUAL ORDERS	55	67	76	81						
DIFF. MO	0	7	6	6						
BACKLOG (Wks)										

3. Review the following production plan. If the company decides to pursue a *level production strategy*, what would be the production rate for the months March through August?

	Past periods		Forecasted periods					
	January	February	March	April	May	June	July	August
SALES FORECAST	125	150	150	200	225	200	225	230
ACT SALES	125	145						
PRODUCTION RATE	175	175						
ACTUAL	150	170						

a. 150
b. 205
c. 225
d. 230

4. Based on your answer to question 4, calculate the inventory plan row. Enter your answer in the below spreadsheet.

	Past periods		Forecasted periods					
	January	February	March	April	May	June	July	August
SALES FORECAST	125	150	150	200	225	200	225	230
ACT SALES	125	145						
PRODUCTION RATE	175	175						
ACTUAL	150	170						
INVENTORY PLAN	125	150						
ACTUAL	115	140						

5. Review the following production plan. If the company decides to pursue a chase production strategy, what would be the production rate for the months March through August? Enter your answer in the below spreadsheet.

	Past periods		Forecasted periods					
	January	February	March	April	May	June	July	August
SALES FORECAST	125	150	150	200	225	200	225	230
ACT SALES	125	145						
PRODUCTION RATE	175	175						
ACTUAL	150	170						

6. Based on your answer to question 6, calculate the *inventory plan* row. Enter your answer in the below spreadsheet.

	Past periods		Forecasted periods					
	January	February	March	April	May	June	July	August
SALES FORECAST	125	150	150	200	225	200	225	230
ACT SALES	125	145						
PRODUCTION RATE	175	175						
ACTUAL	150	170						
INVENTORY PLAN	125	150						
ACTUAL	115	140						

7. Review the following production plan. If the company decided to mandate that the ending inventory balance at the end of August was to be 150 units following a *level production strategy*, what should be the build plan to arrive at 150 units as the ending inventory plan for August? Enter your answer in the below spreadsheet.

	Past periods		Forecasted periods					
	January	February	March	April	May	June	July	August
SALES FORECAST	125	150	150	200	225	200	225	230
ACT SALES	125	145						
PRODUCTION RATE	175	175						
ACTUAL	150	170						
INVENTORY PLAN	125	150						
ACTUAL	115	140						

CASE STUDY

Performing a S&OP Review at ABC Electronics

The S&OP team is currently reviewing the preliminary S&OP grid for a mature product family as part of the pre-S&OP meeting. The average cost for a unit in the family is US$100. The marketing team had forecasted significant sales on the product family for the balance of the year. In the May pre-S&OP meeting, however, the team noticed that actual sales were actually decreasing due to a much cheaper version of the product family offered by a foreign competitor. The marketing team had wanted to keep 10 days of inventory as the target at the end of each month.

Because of anticipated sales, the supply team had created an aggressive build plan and during the first 4 months had produced close to the plan. The result of the lack of sales was a ballooning inventory. At the end of April, the inventory was 24 % above the original goal and the ending number of days of on hand inventory had increased to almost 19 days. The estimate for the end of May was almost 20 days of on hand inventory. The full grid appears below:

	Past periods				Current period	Forecasted periods				
SALES	January	February	March	April	**May**	June	July	August	Sept	4th 3 MOS
FORECAST	200	200	200	205	210	210	210	215	215	645
ACT SALES	185	182	175	170						
DIFF. MO	–15	–18	–25	–35						
CUM	–15	–33	–58	–93						
DIFF. %	–7.50%	–8.25%	–9.67%	–11.55%						
OPERATIONS										
PLAN	210	210	210	215	220	220	220	220	230	690
ACTUAL	205	210	205	215						
DIF. MO	–5	0	–5	0						
CUM	–5	–5	–10	–10						
DIFF. %	–2.38%	–1.19%	–1.59%	–1.18%						
FINISHED GOODS INVENTORY										
PLAN	100	110	120	130	208	218	228	233	248	293
ACTUAL	95	123	153	198						
DIFF. MO	–5	13	33	68						
CUM	–5	8	41	109						
DIFF. %	–5.00%	3.81%	12.42%	23.70%						
DAYS ON HAND	9.5	12.3	14.9	18.9	19.8	0.0	0.0	0.0	0.0	0.0
PROJ. COST	$ 9,500	$ 12,300	$ 15,300	$ 19,800	$ 20,800	$ 21,800	$ 22,800	$ 23,300	$ 24,800	$ 29,300

After further analysis, the marketing team decided that the forecast for May through December should be reduced. The marketing team then proposed the following new forecast plan to be added to the S&OP grid in place of the old plan.

	Past periods				Current period	Forecasted periods				
SALES	January	February	March	April	**May**	June	July	August	Sept	4th 3 MOS
FORECAST	200	200	200	205	175	175	175	175	175	525
ACT SALES	185	182	175	170						
DIFF. MO	–15	–18	–25	–35						
CUM	–15	–33	–58	–93						
DIFF. %	–7.50%	–8.25%	–9.67%	–11.55%						

Based on the forecast reduction, the operations team has likewise decided to cut production of the product family. Already inventories at the end of April are too high. The plant has been using a level production schedule strategy which will not be changing. The monthly production rate for the periods June through December is to be cut 25 %.

Based on this information, create the new grid in the form below.

	Past periods				Current period	Forecasted periods				
SALES	January	February	March	April	**May**	June	July	August	Sept	4th 3 MOS
FORECAST	200	200	200	205	175	175	175	175	175	525
ACT SALES	185	182	175	170						
DIFF. MO	–15	–18	–25	–35						
CUM	–15	–33	–58	–93						
DIFF. %	–7.50%	–8.25%	–9.67%	–11.55%						
OPERATIONS										
PLAN	210	210	210	215						
ACTUAL	205	210	205	215						
DIF. MO	–5	0	–5	0						
CUM	–5	–5	–10	–10						
DIFF. %	–2.38%	–1.19%	–1.59%	–1.18%						
FINISHED GOODS INVENTORY										
PLAN	100	110	120	130						
ACTUAL	95	123	153	198						
DIFF. MO	–5	13	33	68						
CUM	–5	8	41	109						
DIFF. %	–5.00%	3.81%	12.42%	23.70%						
DAYS ON HAND	9.5	12.3	14.9	22.6						
PROJ. COST	$ 9,500	$ 12,300	$ 15,300	$ 19,800						

Once the S&OP grid has been recalculated to reflect the changes to the sales and production plans, the S&OP teams need to further evaluate the outcome. Answer the following questions regarding the newly proposed S&OP plan:

1. What is the demand pattern shown in the old and new sales plans?

2. What is the impact of the new sales and operations plan on inventory levels?

3. Is the new inventory level acceptable?

4. What could be done further and what is the possible impact?

5. What would you recommend at the pre-S&OP meeting?

REFERENCES

1. All definitions from the *APICS Dictionary* used in this chapter are from the 14th edition, 2013.
2. This definition can be found at www.cscmp.org/resources-research/glossary-terms.
3. These points can be found in Langabeer, James R. 2000. Aligning demand management with business strategy. *Supply Chain Management Review* 4(2): 68.
4. These four processes also constitute the core of analysis of Crum, Colleen. 2003. *Demand management best practices: Process, principles, and collaboration*, 25–96. Boca Raton: J. Ross Publishing.
5. Ibid., 76.
6. This figure has been adapted from Sheldon, Donald H. 2006. *World class sales & operations planning*, 68. Ft. Lauderdale: J. Ross Publishing.
7. For additional discussion reference Ballou, Ronald H. 1999. *Business logistics management: Planning and control*, 4th ed, 54–56. Englewood Cliffs: Prentice-Hall; and Kotler, Philip, and Kevin Lane Keller. 2006. *Marketing management*, 12th ed, 372–381. Englewood Cliffs: Prentice-Hall.
8. Reference Kotler and Keller, 376–377.
9. This definition is found on the American Marketing Association website (www.marketingpower.com/resourcelibrary).
10. Kotler and Keller, 275–276.
11. Seldin, Larry, and Geoffrey Covin in their book. 2003. *Angel customers and demon customers: Discover which is which and turbo-charge your stock*, 118–138. New York: Portfolio.
12. This paragraph is based on Kotler and Keller, 617.
13. The basic structure of S&OP grids have been long established and appear in Wallace, Thomas F., and Robert A. Stahl. 2008. *Sales and operations planning*, 3rd ed. T. F. Wallace & Co.
14. This figure is adapted from Ibid., 54.
15. Iyengar, Charanyan, and Sandeep Gupta. 2013. Building blocks for successful S&OP. *Supply Chain Management Review* 17(6): 17.

PART 3

INVENTORY MANAGEMENT IN THE SUPPLY CHAIN ENVIRONMENT

CHAPTERS

Part 3 is concerned with a review of the nature and function of inventory in a supply chain environment. Chapter 7 examines the central role that inventory plays in assisting supply chain managers ensure that sufficient products are available in the right place and in the right quantities at each point in the supply channel. Inventory management is no longer considered a narrow discipline centered on calculating lot sizes and economic order quantities. Today's enterprise perceives the effective management of inventory as the centerpiece of supply chain leadership and understands that total supply chain inventory performance is a strategic channel resource that spans and connects all node in the supply network. Such a view requires that not just individual companies, but the entire supply chain network optimize inventories to respond to the changes in today's shorter product life cycles, product proliferation, ever-increasing customer service levels, globalization of the marketplace, increased competition, and increased pressure on margins.

Chapter 8 contains a detailed review of statistical inventory planning techniques in an independent demand environment. Determining the most effective inventory replenishment techniques is one of a company's most important tasks, requiring a detailed understanding of general inventory concepts and the ability to apply mathematical models and statistical formulas. A firsthand knowledge of such elements as demand usage, lead time, and safety stock are critical for the effective use of such ordering techniques as statistical order point, min/max, joint replenishment, and period review. Of equal importance is knowledge of the components of various order quantity techniques. Computing the economic order quantity (EOQ), order lot sizes when there are quantity discounts, and replenishing by ABC classification are examples. The chapter concluded with an analysis of lean inventory management in the supply chain environment.

Chapter 9 explores inventory management in a multi-echelon distribution environment. The salient characteristic of this environment is that items are stocked at more than one geographical facility and that downstream channel locations are *dependent* on one or more upstream supplying facilities for replenishment. Inventory planners have two choices when applying replenishment techniques: *statistical replenishment techniques* and *distribution requirements planning (DRP)*. Central to the decision is an understanding of channel "push" and "pull" methods. Push methods drive inventory replenishment down to the end-channel level. Pull methods literally pull requirements from upstream supplying locations to downstream locations using either reorder point or DRP. DRP is the recommended method for channels supplied from an originating production plant. Because of its ability to provide a time-phased, extended schedule of channel requirements, DRP generates resupply orders at each channel stocking point and then "pulls" the inventory through upstream supplying facilities including the plant. The chapter concludes with the formulation of the financial estimating, transportation, warehouse space, and labor and equipment plans arising out the channel resupply plan.

7

MANAGING SUPPLY CHAIN INVENTORIES

One of the most important challenges facing supply chain managers is the effective control of inventory. Supply chain inventories consist of the raw materials, components, assemblies, and finished goods necessary to support demand throughout the supply channel pipeline. At the core of inventory management resides a fundamental dilemma. When it comes to the

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_7) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_7,

timely fulfillment of demand requirements, inventory is necessary and useful; however, too much or the wrong inventory at the wrong place becomes a significant liability, a huge financial millstone around the neck of the enterprise, reducing profitability and draining the vitality of strategic supply chain initiatives targeted at increasing competitive advantage or exploring new markets. Inventory ties up capital; incurs carrying costs; needs to be transported; requires receiving, material handling, and storage; and can become damaged and obsolete over time. On the other hand, the value of a properly managed inventory exceeds its cost. Product availability at the time, location, quantity, quality, and price desired by the customer not only provides immediate profits but also secures long-term customer loyalty and brand leadership. When it is effectively controlled, inventory management enables the realization of channel marketing, sales, and logistics strategies and provides the lubricant for the smooth flow of product and service value from supplier to the customer.

This chapter describes the role of inventory in the supply chain environment. The chapter begins by defining the nature and function of supply chain inventories. Following these introductory comments, the chapter proceeds to a discussion of the characteristics of inventory in the supply chain. Topics include understanding inventory dynamics, measuring throughput, describing inventory channel flows, and making inventory trade-off decisions. The chapter then continues with a review of the inventory decisions associated with cycle, safety, and seasonal inventories. Following, inventory cost will be reviewed. Among the topics detailed are the components of inventory cost, costs relating to inventory operations and decisions, and the various methods of valuing inventory. The chapter concludes with a review of inventory performance, including financial statements, inventory turns and ratios, ABC analysis, the annual physical audit, and cycle counting.

7.1 INVENTORY MANAGEMENT BASICS

To begin the discussion of inventory management, it is useful to look at two definitions that will act as the foundation for this chapter. The first definition is from the *APICS Dictionary* [1].

> Those stocks or items used to support production (raw materials and work-in-process items), supporting activities (maintenance, repair, and operating supplies), and customer service (finished goods and spare parts).

The second definition describes the nature and tasks of *inventory management*.

> Inventory management is responsible for the timely replenishment of inventories and the accurate and timely status of on-hand balances, on-order quantities, and the financial value of finished goods, components and raw materials physically present at stocking locations.

These definitions describe inventory as being acquired through the receipt of materials, components, or finished goods into the business either through purchasing or production. Inventory management is the name for the business function charged with the task of ordering, controlling, and disbursing inventory to production, the supply channel, and to the customer. It is important to note that inventories, regardless of whether they are for production, distribution, or service, do not exist in a vacuum. Inventories are acquired to perform several functions and it is the role of inventory management to ensure that they are accurately ordered and maintained to match their intended purposes.

Unfortunately, whereas everyone can agree on the *purpose* of inventory, there is considerable disagreement in regard to how best it should be managed. The sales department, for example, considers inventory availability as fundamental to customer service and views the ratio between customer orders filled and lost as the prime measurement of enterprise success. Finance, on the other hand, while accounting for inventory on the asset side of the balance sheet, nevertheless considers inventory as a necessary evil that ties up capital and should be eliminated whenever possible. Finally, the operations department is caught somewhere in between. Operations must walk a thin line between two contradictory measurements: They must continually search for ways to reduce inventory costs while at the same time stock just the right products in the right quantities at the right location to satisfy customer service levels.

In responding to these apparent dichotomies residing at the heart of inventory management, inventory planners must strike an effective balance between inventory, cost, and demand. This balancing requires finding answers to six major questions:

1. *What is the optimal balance between inventory and customer service?* This question is perhaps the most fundamental of all. Simply put, the larger the variety and volume of stocked quantities, the higher the customer service level. It is equally true, however, that the higher the inventory, the higher the inventory cost. Companies must determine what costs they are willing to bear to achieve a desired customer service level. Strategies such as lean and make-to-order production help reduce costs while increasing service levels.
2. *What is the level of control an enterprise should establish over its channel inventories?* Companies must choose between exercising a centralized control over inventory in order to reduce costs, remove channel redundancies, and leverage economies of scale and a decentralized strategy which, while increasing inventory costs, enables local facilities to reduce customer lead times and increase profitability. On the other end of the spectrum, companies seeking to decentralize control could use outsourcing to unload tasks involving noncore competencies to supply channel partners.
3. *Under what circumstances should control over inventories be changed?* Changes in markets, technologies, channel direction, government regulation, and the status of supply network alliances often alter channel equilibrium and cause once profitable channel inventory strategies to lose their value. Changes also are brought about by trading partners searching for new opportunities to reduce total inventory cost by either assuming more centralized control of channel inventory management or off-loading them to channel partners who can perform these functions more efficiently and at a lower cost.
4. *What is the optimum balance between inventory investment and associated carrying costs?* Changes in markets, products, technologies, channel direction, government regulation, and the status of supply partners require continuous review to determine if the present equilibrium between channel demand and inventory supply remains viable.
5. *What is the optimum balance between inventory investment and replenishment costs?* The size of the replenishment order quantity will have a direct impact on both inventory carrying and acquisition costs. Generally, as the replenishment lot size

decreases, the inventory carrying cost decreases. As the lot size decreases, planners order more frequently thereby driving up ordering, receiving, stock put away, and payables costs. The reverse would be true if replenishment lot sizes are increased. The appropriate lot size is the one that minimizes the risk of stock out while maintaining the equilibrium between the cost of carrying and the cost of ordering inventories.

6. *What is the optimum balance between inventory investment and transportation costs?* As a rule, as customer responsiveness increases so does transportation costs. In general, for products with high value-to-weight ratios, a faster transportation mode is favorable. Correspondingly, for products with low value-to-weight ratios, a cheaper mode of transportation is preferable. By aggregating inventories in a central warehouse, companies reduce inventory and inbound logistics costs, but incur increased outbound costs as the size of shipping lot sizes decline and faster delivery transportation modes are used.

Determining the optimal balance between the value of holding inventory and the costs incurred to order it requires that inventory planners possess a complete understanding of the deployment, function, and expected value of inventories as they appear across the supply channel network.

7.1.1 The Magnitude of Inventory

The importance of inventory in today's supply chain is illustrated by examining inventory statistics. Inventories can represent anywhere from 40 to 80 % of a typical company's sales dollar. Effectively managing this huge investment is critical to the financial well-being of the organization and to the supply chain as a whole. The following figures provide a quick reference to the size of the financial investment companies in the U.S. have in inventory and related logistics costs (reference Table 7.1). In 2013, the inventory investment by all U.S. businesses, including agriculture, mining, construction, utilities, services, manufacturing, wholesale, and retail trade, was US$2.4 trillion. This figure alone was equivalent to 2.8 % of the entire U.S. GDP. In addition, U.S. firms spent US$1.3 billion for transportation and administration associated with moving this inventory through the distribution pipeline [2].

TABLE 7.1. Magnitude of Inventory

Year	Nominal GDP US$ trillion	Values of all business inventory (billion)	Inventory carrying costs (billion)	Total logistics costs (billion)	Inventory as a % of GDP (%)
2005	13.1	1,842	410	1,195	3.1
2007	14.48	2,119	510	1,419	3.5
2010	14.96	2,233	429	1,245	2.9
2011	15.53	2,296	439	1,310	2.8
2013	16.8	2,459	469	1,385	2.8

7.1.2 Inventory Management Objectives

While inventory managers can pursue several detailed objectives, each are subsets of a single overriding principle: The presence of inventory is the result of an informed trade-off decision between the cost of acquiring and stocking inventories and the ability to meet or exceed a targeted level of customer responsiveness. The objective of inventory managers is to find methods to continuously reduce the cost of the inventory-side of the trade-off decision. Just because customer responsiveness is projected to increase does not necessarily mean that inventories must also rise. Exploring alternatives to decrease inventory investment is a fundamental objective of the inventory control function.

Among the subsets of this basic trade-off decision are:

- *Serviceability*. Good inventory management prevents stock outs. Inventory managers investigate and resolve issues causing high demand and supply variability stemming from such events as inaccurate forecasts, materials and component shortages, inadequate shop floor scheduling, high scrap, poor communications, inaccurate information, and faulty processes. The negative effect of uncertainties caused by these and other factors is higher inventory levels.
- *Cost reduction*. Since inventories are a major capital cost, a critical objective of inventory managers is continuous cost reduction *without* accompanying reductions in customer service levels. This is a difficult objective to achieve, involving decisions such as weighing make-or-buy alternatives, determining inventory levels for different stocked products, establishing the number of channel locations, defining the role of supply chain partners, defining lead times and process cycles, establishing consignment stocking policies, reducing scrap, and others.
- *Process efficiency*. Effective inventory management enhances the efficient use of the production workforce and equipment to meet customer responsiveness targets. Proper inventory planning enables resource optimization, ability to make quick changeovers, and scalability of resources based on demand. At the same time, effective inventory management reduces overtime costs, cycles of employee lay-offs and rehires, and premium purchase order and transportation costs.
- *Capital budgets*. Effective inventory control enables companies to realize inventory as well as a range of linked departmental budget objectives. Inventory expenditures are matched periodically to the capital expense plan to obtain return on investment (ROI) measurements, analyze variances, and provide a basis for corrective action. In addition, as inventory stock outs decline, sales is able to make its revenue numbers, finance is able to more effectively plan for cash flow, and operations is able to reduce the costs associated with overtime, expediting, and uncertainty.

7.1.3 How Does Inventory Provide Value?

In the past, inventory management provided value by acting as a conduit for the flow of mass-produced goods from the producer to a mass market. The supply system's role was to push highly standardized products, utilizing mass-production era advertising, media, and distribution channels, out to the marketplace. Buyers, in turn, searched available suppliers to locate product and service offerings that came closest to matching their needs or desires. In such a supply system, customers had little interaction with producers whose channel systems focused on moving large, unsynchronized batches of narrowly defined product families from supply channel node to supply channel node. Customized products, driven by customer participation in the ordering, design, and production process, were considered to be very costly and the reserve of specialized supply channels.

Today, this model of supply channel management has all but become obsolete. In the place of the mass production-era "push" systems of the past, today's supply chains are being restructured to accommodate increasing product diversity, shortening life cycles, increasing customer response and fulfillment velocities, universal commitment to quality, and the ability to configure and customize products at the last stages in the fulfillment cycle to meet the demand "pull" of a global customer. Unlike the passive customer/supplier relationship of the past, developments, such as the Internet and social networking, are driving the creation of dynamic supply channels capable of delivering both high levels of interaction and partnership between producer and buyer and the exact goods and services based on the unique requirements of the customer.

This shift in the role of the supply chain has altered traditional views of the value of inventory. In the past, companies perceived inventory as generating profit by selling to a captive consumer who had minimal opportunities to search for alternatives in a closed marketplace. In contrast, it is today's customers who define what value means to them. While revolutions in communications and computerized tools have provided the mechanism, the real driver of this transformation has been the ability of each customer to assert their *uniqueness*. Rather than being placed within an aggregate market segment serviced by standardized products and supporting services that the company wants to sell, today's customer is demanding that their suppliers instead understand and provide solutions that they want to buy. That they be, in short, *intimate* with what product/service solutions each of their customers want and how they are to be serviced. Rather than marketing a product/service to as wide a group of customers as possible, companies are being required to continuously devise value propositions that offer unique solutions that are capable of evolving with the competitive needs of each individual customer.

Managing this customer-centered value principle is even more important in the increasingly complex supply chains of today. Formerly, planners focused on managing and controlling inventory costs and serviceability solely within their own companies. Now, planners are often involved in managing channel inventories that span both their customers' inventory as well as the inventories of their suppliers and suppliers' suppliers. Supply chain inventories provide value through the following five service elements:

1. *Lowest cost for value received*. The effective management of inventory costs enables supply chains to maintain market leadership by keeping prices low, ensuring depth of product assortment and quality, and expanding on capabilities to mass produce customized products. Some of the techniques used to achieve these service attributes are creating channel and cross-channel partnerships that shrink buffers and accelerate inventory flows; utilizing alternate channel formats like warehouse/wholesale clubs; participating in e-marketplace exchanges; selling producer direct; and pursuing lean contracts that guarantee fixed prices and service levels.
2. *Improved channel efficiency*. By removing excess channel inventory buffers, reengineering distribution processes, implementing lean, deploying planning tools that provide for real-time cross-channel information management, and streamlining inventory flows to prevent the bull-whip effect, supply channels can significantly diminish total pipeline costs while ensuring the right product is in the right place to capitalize on marketplace opportunities. Above all, improved channel efficiencies increase product *access*. Access refers to the degree of ease by which customers can

purchase products or contact sales and service functions. Access also means making available goods and services within parameters generally accepted by the marketplace. Finally, access means the speed by which after-sales replacement parts and services are delivered. Customer convenience and access to goods and services are fundamental to competitive advantage.

3. *Improved quality*. Reducing the occurrence of stock outs, product defects, order fill inaccuracies, and other related inventory management errors significantly decrease operating costs while increasing customer service. The focal point is service reliability. Supply chain leaders continually deliver the promised product dependably and accurately each and every time. Reliability of service permits channel suppliers to "lock in" their customers who will gladly pay premium prices for superior delivered quality and service.
4. *Supply network simplification*. Removing inventory flow bottlenecks and redundant channel functions simplifies and makes all supply channel activities transparent. Increased visibility expands the capability of channel suppliers to be more responsive to the demands of the marketplace. Simplification takes the form of intense process reengineering at the enterprise level, the discontinuance of channel functions whose costs exceed their value-enhancing capacities, or the use of third party services for inventory and transportation management and accompanying transaction processing.
5. *Improved channel inventory information*. Accurate and accessible information about products, stocking levels, location, and order status constitutes the foundation for inventory service value. Internally, information enables network suppliers to control inventory levels, ensure timely and accurate stock replenishment, and leverage price and delivery economies from upstream sources of supply. Externally, information reduces the occurrence of missed customer activities that have a rippling effect back through the entire supply channel.

7.1.4 The Purpose of Inventory

The management of inventory is an important task. While the central purpose of maintaining inventories is to enable firms to respond to customer requirements, inventories enable businesses to accomplish several other key objectives.

- *Demand buffer*. In an ideal world, companies would not have to stock any inventory at all. Supply processes would be agile and flexible enough to materialize just the right product in the right quantities to fill every order exactly when the customer wanted it, on time, without stock out. Since this ideal is not possible, companies must stock inventories. In this sense, inventory acts as a buffer enabling planners to fill the gap separating the time, place, and quantity of product demanded by the customer and the lead time it takes to purchase or produce it. Today's computer systems and lean techniques are often used to assist planners in reducing the number and quantities of items stocked, while at the same time closely matching demand and supply.
- *Demand uncertainty*. If customer demand was fixed and could be forecasted precisely, companies could arrange their production and purchasing processes to have the right inventory available exactly when the customer wanted it. In reality, demand is not

completely known and safety or buffer stocks of finished goods, raw materials, and components must be maintained to absorb the variation.

- *Supply uncertainty*. When inventory is purchased from a supplier, delivery delays occurs for a variety of reasons. Often there are unpreventable, random variations in shipping time. A shortage of production inventories at the supplier's plant or finished goods at a distribution center, a strike at the supplier's plant, a lost order, or a shipment of incorrect or defective material all are causes of supply uncertainty. Covering such potential variations requires companies to stock additional safety inventories to guard against the possibility of late shipments and possible stock out.
- *Lot-size economies*. Buyers often decide to inventory more product than expected demand to capitalize on short-term opportunities. One example is to stock excess finished goods in anticipation of sales occurring during a promotional period. Another example would be the opportunity to take advantage of a purchasing quantity price discount whereby an item could be attained at a low price if bought in bulk.
- *Process flexibility*. Inventories enable companies to be more agile to respond to unforeseen demand. Extra finished goods enables customer service to capture opportunity and up-sell orders. The availability of production materials and components also enables shop floor planners to quickly change production schedules, build more economical lot sizes, and enable work centers to quickly recover from unforeseen equipment, labor, and raw materials problems.

7.1.5 The Role of Inventory Management

The scope of inventory management activities in a typical organization encompasses a wide variety of tasks and critical decisions. A critical role of inventory managers is the planning of inventories on various organizational levels. Strategically, inventory managers are responsible for integrating supply chain inventory objectives with the corporate goals of the organization. These objectives should be meaningful and achievable and establish the processes and standards guiding the creation of the tactical inventory plans arising out of sales and operations planning (S&OP) activities. Finally, on the daily execution level, inventory planners are responsible for establishing the policies and procedures for the management of all inventory functions to facilitate uniform, efficient operations. Among the tasks on this level are selection of inventory replenishment parameters and techniques, running the inventory planning system, forecast review, developing the inventory replenishment schedule, and performing analysis of inventory planning performance.

Another important role played by inventory management is replenishing the business's inventories. The goal is to continuously monitor inventory statuses and generate purchase and production orders as determined by planning systems to guard against possible stock out. Tasks associated with acquisition are expediting orders, calculating order costs, and performing replenishment order audits to ensure on-time delivery. Other activities are concerned with measuring the performance of order timeliness and completeness and validating order receipt and closeout. Effective inventory replenishment requires close cooperation between inventory, purchasing, and production management.

The management of inventory in the firm's channel system is a traditional function of inventory management. The central goals of effective stockkeeping are ensuring inventory balance accuracies and the timely disposition of inventory quantities to their demand sources. Strategic goals are positioning of warehouses in the supply channel, configuring the warehouse to facilitate the movement of materials, pursuing lean methods for waste reduction, and establishing effective general operating procedures. Among the stockkeeping tasks performed are replenishment order receipt and put away; performing cycle counting and annual physical inventory; assessing inventory value; and determining inventory performance measurements, such as inventory turns; levels of excess, damaged, and obsolete inventories; and operating cost.

The final function of inventory management is disposition of inventory stocks. Disposition occurs when inventories are issued from stores and consumed by production orders. Disposition also occurs when finished goods are picked from stock and sold to the customer. Finally, disposition occurs when inventory balances are adjusted to reflect the actual physical count or when scrap, damaged, and obsolete inventories are purged from active inventories.

7.1.6 Classes of Inventory

Inventory is a physical asset that a firm holds in stock with the intent of selling it or transforming it into products that, in turn, are used for further processing or sale to the customer. Inventory comes in a variety of forms. A business that distributes home appliances purchases, stores, and sells inventory in a different way than a petroleum distributor. In addition, not all companies sell inventory in exactly the same form as they build or acquire it. Products can be manufactured into other items, broken down into smaller lots, relabeled, repackaged, or combined to form new assemblies. Also, the class of an item is often dependent on its position in the supply chain. For example, for a fastener manufacturer, bolts, washers, screws, and the like are considered finished goods, while the manufacturers they are sold to consider them as purchased components consumed in the production process.

Inventory is classified as belong to the following possible forms.

- *Raw materials/commodities*. This class consists of products extracted from nature. Examples include wood, grains, cloth, steel, chemicals, and other unfinished commodities. While these products can be sold as received, normally they are not useful until they have been transformed into semi-finished items or finished goods ready for sale.
- *Work in process*. Inventory in this category is classified as raw materials, components, and subassemblies that are being or are waiting to be transformed through production processes into assemblies or finished goods. Although distributors historically stock little or no work-in-process inventories, marketing and cost requirements for economies and value-added services have forced many distributors into performing light assembly, repackaging, kitting, labeling, and other postponement techniques to remain competitive.
- *Finished goods*. Products classified as finished goods are defined as purchased items, assemblies, or service parts that are ready for shipment to a customer without further processing.
- *Distribution channel inventories*. This class of inventory consists of finished goods located in various warehouses in a distribution channel system. This inventory

includes items in transit and in storage at a channel warehouse that are awaiting delivery to a customer.

- *Maintenance, repair, and operating supplies (MRO).* This class of inventory consists of purchased or produced products used to support general facility operations and maintenance, such as spare parts and goods expended in production or supporting operations. In terms of financial value and quantity, this inventory can be considerable, sometimes constituting 40 % of each purchasing dollar.
- *Service parts.* This class of inventory consists of modules, assemblies, kits, and components used to replace prior purchased originals without modification. Service parts are frequently part of distribution inventory. Many producers of mechanical finished goods keep spare parts inventories for customers who experience product breakdowns and to service warranty claims.
- *Damaged and obsolete.* This final class of inventory consists of products that are no longer sold or cannot be sold because of damage. While constituting a relatively small proportion of inventory value and quantity, this class of inventory must be closely managed. Continuous review will enable managers to determine whether products in this class can be repaired and returned to stock, salvaged, or disposed of.

The value of inventory classification is that it enables the organization to designate which products are available for customer order, assists in decision making in production planning and inventory management, and facilitates record keeping and costing.

7.1.7 Function of Inventory

The central function of inventory is to act as a *buffer* shielding the organization from the discontinuousness of customer demand on the one hand and variations in supplier delivery on the other. Inventory also enables the *decoupling* of production processes from each other so that each process can operate at maximum efficiency without being constrained by slower preceding processes. Optimally, businesses would like to carry as little inventory as possible, preferring to move new product receipt directly to the shipping dock to be met just in time with customer orders. In reality, many firms need to stock inventory to overcome limitations imposed by time, processing, and space.

Inventory control literature has traditionally identified five general functions of inventory: cycle stock, safety stock, anticipation, transportation, and hedge (or speculative) inventories. A review of these functions is as follows:

- *Cycle stock.* This function is the result of replenishment lot-size rules that require planners to purchase, produce, and transport inventories in batches that exceed the demand quantity. Cycle stock inventory exists because of economies realized by trading off the cost of ordering or producing and the cost of carrying inventory. For example, the frequency of order cycles may require the purchase of inventory in large lots to reduce ordering costs. As a rule, as the rate of customer order demand increases for a given product, planners normally will increase the acquisition lot size versus decreasing the replenishment order cycle. In another example, businesses performing production produce large lot sizes of a product to reduce unit costs due to the cost of setting up a production line or gains in productivity attained by producing larger inventory quantities than required.

- *Safety stocks*. This function of inventory seeks to have a calculated amount of excess inventory on hand to cover unplanned fluctuations in customer demand and uncertainties in supply. If demand was constant, inventory planners could rely on cycle stock to guarantee that there would always be sufficient stock on hand to meet demand. However, because products are subject to random periods of above average demand, cycle stocks function best when there is a safety stock buffer (Figure 7.1). The amount of safety stock depends on the degree of random variation in demand, the lead time required to replenish stock, and the service reliability policy established at the stocking point. The larger the safety stock, relative to demand variation, the higher the percentage of customer serviceability. Cycle stock plus safety stock equals the average inventory of a stocked product. This average inventory should be sufficient to service demand in normal circumstances.

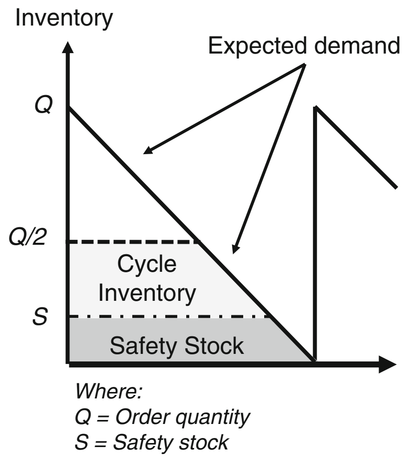


FIGURE 7.1 Safety stock.

- *Anticipation inventory*. Often inventory is purchased or built in advance of demand to enable efficient response to seasonal sales, a marketing promotional campaign, or expected changes in demand or supply. A sporting goods distributor, for example, may begin to warehouse winter sports equipment during the summer months to take advantage of sales discounts from producers and to avoid higher prices and potential stock outs as the winter season approaches.
- *Transportation inventory*. Inventory in this category is defined as products in transit (for example, in ships, railcars, or truck transport) from one node in the channel network to another. Transportation inventory exists because *time* is required to physically move stock through the supply channel. Supply chain nodes must plan to have additional inventories on hand to cover demand while inventories are in transit. As an example, if delivery of a product takes 3 weeks, and sales average 1,000 units a week, a total of 3,000 units would reside in the channel pipeline. Transportation costs must be carefully examined when structuring a supply channel. The following formula is used to calculate the yearly *transportation inventory cost* (TIC):

$$TIC = C \times D \times UC \times T$$

where C is the transportation carrying cost, D is the demand requirements per period, UC is the item unit cost, and T is the transportation time. For example, in calculating the yearly transportation inventory cost for the 3,000 units in transit described above, the unit cost is \$20 each, and the carrying cost is 15 %. Then

$$TIC = 15\% \times 1{,}000 \,\text{per week} \times \$20 \times 3 \,\text{weeks} = \$9{,}000 \,\text{per year}.$$

Management could reduce the transportation inventory cost by changing the mode of transportation or switching to a supplier closer to the plant. If 1 week of transit time is eliminated, the cost savings would amount to \$3,000 per year. On the other hand, another approach might be to gain economies by reducing the lot size of inventory received. Although this might mean more frequent deliveries and higher transportation costs, the overall decline in inventory carrying costs might justify the approach.

- *Hedge inventory*. The final function of inventory provides planners with the opportunity to purchase or build large quantities of raw materials, components, or finished goods to take advantage of temporarily low replenishment prices, the threat of a supplier strike, or other unanticipated events. Effectively managing hedge or speculative inventories requires planners to have a firm knowledge of price trends, assess the risk of potential spoilage or obsolescence, and be conversant with handling commodity futures. The utility of hedge stocks is measured by the resulting percent of profit or return on investment.

The existence of pools of inventory located at strategic points in the channel pipeline provide essential buffers protecting supply chain nodes from the occurrence of unplanned variances in demand and supply. On the other hand, inventory buffers inherently contain several serious drawbacks. They divert capital badly needed for improvement elsewhere; create costs necessary to maintain inventory record accuracy; must be moved and stored; often need to be sorted, packaged, and containerized; and staff must be available to expedite, search for, and inspect them. Buffers risk creating the bullwhip effect whereby a small change in demand downstream in a supply chain causes major changes in the inventory positions of supplying nodes as the demand moves serially upstream in the supply chain system. Finally, buffer inventories mask the true nature of channel demand and supply, conceal channel inventory management inefficiencies, and gloss over costly channel inventory and capacity imbalances.

The challenge to inventory planners at all levels in the supply chain is to develop programs that cut inventories by eliminating "dead stock"; improving quality, inventory planning, and ordering practices; and increasing organizational and supply channel flexibility while maintaining customer serviceability levels that exceed the competition. Channel imbalances and the bullwhip effect are also eliminated by synchronizing the demand and supply needs of all supply chain participants.

7.1.8 Types of Supply Chain Inventory

Inventories exist in many forms in the supply channel and at each channel echelon position possess several dynamics. Figure 7.2 provides a visual of the different states in which inventories can reside at any time in the supply channel.

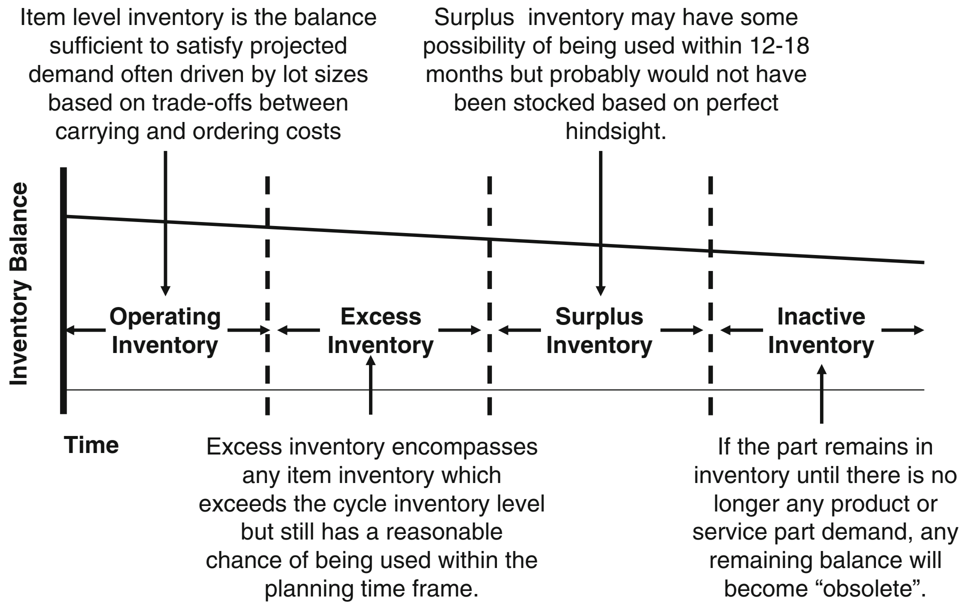


FIGURE 7.2 Inventory dynamics.

Operating inventory is the optimal state of inventory. Inventory in this status is stocked to satisfy projected demand requirements. The expectation is that inventory quantities will cycle through the business quickly in response to the demand pull. Products in this dynamic provide the highest level of profit for the supply chain and managers must be careful to ensure sufficient inventory balances are always available to meet customer, distribution channel, and other sources of demand while keeping inventory carrying and ordering costs to a minimum.

A less favorable state is *excess inventory*. Inventory in this state contains products whose stocked balances exceed the projected demand. Typically, companies have excess inventories because of replenishment lot-size quantities. Inventory planners must determine the trade-offs between the cost of stocking larger than demanded quantities versus the cost of more frequent ordering. Sometimes it is cheaper to order one large lot size than to place many smaller orders that align more closely to projected demand. In other instances, suppliers will not ship in less than a specified lot size, also contributing to excess inventory. Another cause is using safety stocks to cover potential stock outs due to variability in demand or supply. Inventory in this status is stocked in the assumption that the inventory overstocks will be sold in the short term to cover unplanned demand, thereby reducing the risk of excess carrying costs. Finally, the presence of excess inventories may be a signal that demand has decreased. Inventory planners must be vigilant in ensuring stocks remain at operating inventory levels.

Stocked inventory balances that continually exceed their demand will normally fall into the class of *surplus inventory*. Items in this state exist because the anticipated demand never materialized and replenishment quantities have not sold in the expected volume. Regrettably, as much as 50 % of the active item master in the typical organization falls within this status. These items are traditionally slow sellers with the bare minimum of annual demand.

Inventory managers should review these items periodically for possible quantity reduction or even phasing them out of stock altogether.

The final condition of inventories in a supply chain is *inactive*. This state is the least desirable inventory dynamic. Inactive items are either obsolete or damaged. These items are no longer sold either because they have been phased out or because they have been replaced by new products. Sometimes companies are required to stock obsolete components and subassemblies to cover service parts warranties or field repairs. Damaged items are products that have defects incurred during production, purchase order receipt, or customer return. These items should be reworked and returned to an operating state or they should be salvaged as soon as possible. Since demand on items in this state no longer exists, they constitute a drain on company profitability and should be reviewed periodically for removal.

7.2 COMPONENTS OF INVENTORY DECISIONS

Once an organization decides that inventory needs to be stocked, inventory planners must consider four key inventory-related decisions that will influence how the inventory is to be managed. These decisions relate to cycle inventory, safety stock, seasonal inventory, and surplus and obsolete inventory.

7.2.1 Cycle Inventory

Cycle inventory is defined as the average amount of inventory on hand for a product sufficient to satisfy demand during the replenishment lead time. The size (amount) of the cycle inventory of an item is the result of ordering in a lot size. A *lot size* is defined as the replenishment order quantity of a particular item that is ordered from the plant or a supplier. The use of inventory lot sizes enables managers to leverage economies of scale in production, transportation, and purchasing.

As an example, a distributor orders a specific video recorder in lot sizes of 250 (Q) units. Assuming stable demand, if the distributor sells 25 (D) units a day, it takes an average of 10 days for the inventory to be depleted before a replenishment order is created. The distributor would, therefore, statistically have sufficient inventory for 10 days of sales. Once the inventory balance reaches 0, another lot of 250 video recorders is received and the cycle begins again. This cycle of inventory receipt and depletion is illustrated in Figure 7.3.

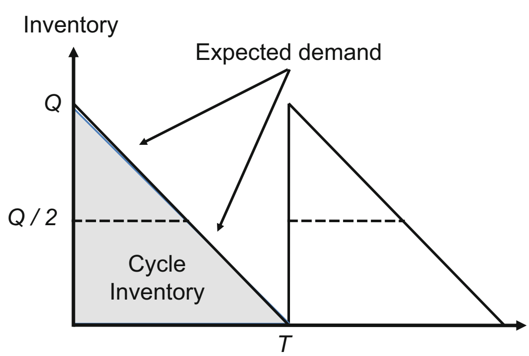


FIGURE 7.3 Inventory profile of video recorders.

Assuming steady demand, the relationship between cycle inventory and lot size is indicated as follows:

$$\text{Cycle inventory} = \text{lot size}(Q)/2$$

The exact stocked quantity of the video recorder at any one given time can be anywhere from 250 to 0 units. Since the on-hand balance is actually a variable, the best way to express it is to view the quantity as an average of the lot size. To calculate the *cycle inventory*, the lot size (Q) is divided by 2 to arrive at the average inventory for the 10 day period. The answer is calculated by dividing the 250 units by 2 to arrive at a cycle inventory of 125 video recorders.

Cycle inventory provides important information for a number of inventory calculations. For example, by applying Little's Law to cycle inventory, the average flow time of the video recorders can be determined as follows:

$$\text{Average flow time} = Q/2D = 250/50 = 5\,\text{days}$$

The cycle inventory of 125 units results in the distributor adding 5 days to the average amount of time that video recorders spends in the channel. The larger the cycle inventory, the longer the time the channel holds inventory [3].

7.2.2 Safety Inventory

The *APICS Dictionary* defines safety inventory as "a quantity of stock planned to be in inventory to protect against fluctuations in demand or supply." If the exact demand for products was always known and rarely varied, cycle inventories would be sufficient to supply demand. In real life, demand is *uncertain*. It is uncertain because planners cannot know exactly what items in what quantities customers will want. The purpose of safety inventory is to guard against the possibility of higher than expected demand that will exceed cycle inventories and cause a stock out.

How safety inventory works with cycle inventory is illustrated in Figure 7.4. Using the data for the video recorder, the cycle inventory ($Q/2$) is calculated by dividing the order quantity of 250 units (Q) by 2 or 125 units. For the purposes of this exercise, it has been determined that the *safety inventory* should be half of the cycle inventory. Therefore, the safety inventory would be determined by dividing the cycle inventory of 125 units by 2 to arrive at a safety inventory of 63 units (rounded).

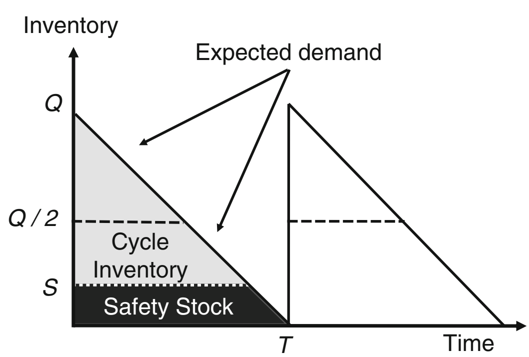


FIGURE 7.4 Safety stock and cycle inventory.

The diagram in Figure 7.4 also explains how cycle and safety inventories work with each other. If the safety inventory was 63 units, when the order was initially received the inventory balance of the video recorder would total 313 units. As time went on and 100 units were sold, the total on hand balance would consist of 150 units of cycle stock and 63 units of safety stock. The safety stock is used only if all of the originally ordered 250 units were sold and a replenishment order had not yet been received. When combined, inventory planners could expect to have an average on-hand balance for the video recorder of 188 units. A negative aspect of safety inventory is that it is inventory that is held in reserve to guard against unplanned demand. This perpetual “unsold inventory” cumulatively constitutes a significant amount of a company’s total inventory investment. Calculating safety inventories is covered in further detail in Chapter 8.

7.2.3 Seasonal Inventory

The *APICS Dictionary* defines seasonal inventory as “Inventory built up to smooth production in anticipation of a peak seasonal demand.” Seasonal inventory is composed of products that experience high demand for only a few periods during the year, and then dramatically decline in demand during periods opposite the buying season. Normally, seasonal inventory is built in periods of low demand and consumed during periods of high demand. Seasonal inventory is built ahead of time for a variety of reasons, such as the plant does not have the capacity available to build and warehouse the demand requirement when it is in season.

Figure 7.5 illustrates the use of seasonal inventories. The vertical axis of the diagram represents inventory and the horizontal axis represents time. The selling seasons are basically quarters two and three and the off-seasons are quarters one and four. Note how the demand line increases over time and peaks at the center of the demand season. Also note how the inventory volume declines over time and reaches its lowest levels at the end of the demand season.

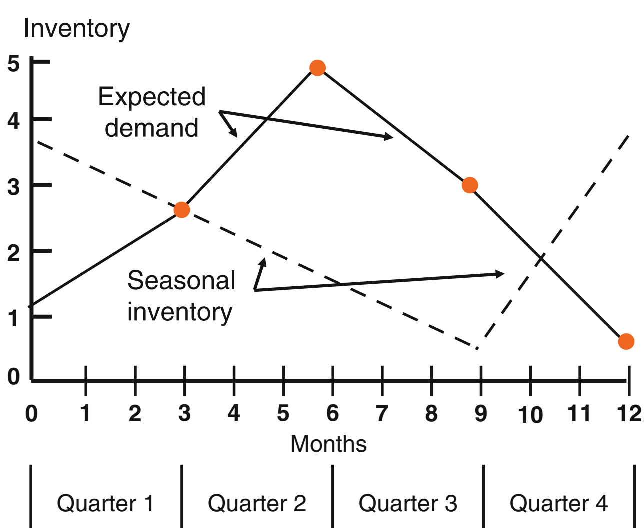


FIGURE 7.5 Seasonal inventories.

Building seasonal inventories is a decision that is based on the cost of production, available capacities, and storage of inventory. If the cost of changing the rate of production is minimal and capacities are easily added or subtracted, companies may not choose to build seasonal inventories. On the other hand, if changing the rate of production is expensive and there is insufficient capacity to build the anticipated load, companies may choose to build to a level schedule throughout the year. In addition, the cost of carrying the excess inventories must be less than the cost of utilizing a more flexible production rate.

7.2.4 Surplus and Obsolete Inventory

A critical but neglected area for inventory management is surplus and obsolete inventory. *Surplus inventory* occurs when the balance quantity of an item exceeds the demand over a period of time. Managing excess inventory is difficult as demand ebbs and flows over time with the result that many companies actually stock about 40 % more inventory than they really need. Inventory builds up for many reasons: poor forecasting of demand, safety stocks, new product introduction, market pressures for higher response rates, and so on. Although the anticipated demand volume forecasted by sales and marketing seems to validate stocking higher quantities of inventory, in reality inventory managers must be vigilant to ensure that the cost of housing current stocking levels supports a corresponding level of revenue large enough to justify the inventory investment. Such excess stock is a major contributor to low aggregate inventory turnover. There is also a danger that sales will be discontinued permanently, rendering the remaining balance of the stock obsolete.

Obsolete inventory is composed of raw materials, components, and finished goods that no longer have active demand. An example is an item with remaindered stock that has been superseded by a new model. Obsolete inventory normally will never be used or sold at full value. Eliminating this class of inventory is critical if inventory managers are to improve on inventory investment and turnover rates. Reducing surplus and obsolete inventories involves a cost-benefit trade-off. While removing these inventories reduces operating costs, it is important to note that they are also on the asset side of the balance sheet and reducing inventories means reducing the company's financial value.

It is recommended that managers establish a program of continuous surplus inventory reduction and the elimination of obsolete stocks. An effective excess and dead-stock program consists of the following steps:

1. *Prevention*. In this phase, planners deploy effective inventory planning tools to eliminate the ordering of excess stock and properly phasing-out dead-stock inventories.
2. *Identification*. In this phase, the creation of effective inventory transaction (usage) reporting is critical. Reporting assists planners to quickly focus on products with low to null usage value that are targeted for quantity reduction or possible removal from stock.
3. *Coordination*. In this step, an excess or "dead stock" project team are defined to tackle the problem.
4. *Disposal*. Once excess and obsolete inventory are identified, the project team must develop a program to consume or dispose of the inventory, and maximize the monetary value generated from the disposition.

7.3 INVENTORY COSTS

The cost of inventory has a direct impact on the competitiveness of the supply chain. To begin with, inventory often constitutes the largest portion of a typical company's assets. The objective of this investment is to provide sufficient inventory to meet or exceed customer service levels. The capability to calculate the cost trade-off between inventory investment and service levels is critical. By preserving cost history, planners can use the financial consequences of past inventory decisions to assist them in determining the *expected cost* of future actions. Poor control over inventories affects company profitability in two ways. First, net profit is reduced not only through direct purchase but also for ongoing expenditures associated with a range of inventory carrying costs. Second, the value of the inventory investment must be added to the firm's total assets. As inventory grows, total company asset turnover decreases, resulting in a reduction in return on assets and net worth.

Understanding inventory cost assists supply chain planners to answer such questions as:

- What is the appropriate level of inventory to be carried by each supply channel node?
- What are the inventory costs necessary to support customer service, and how can service levels be improved while reducing inventory investment?
- Is the selling price of goods too high or too low?
- What will it cost to transport inventory through the supply chain?
- How many supply channel points should there be and what should be their inventory levels?
- What will be the cost of channel postponement strategies?

Finding solutions to these and other questions requires supply chain planners to have a detailed knowledge of inventory cost elements. Accurate cost information is paramount if companies are to exploit new markets, optimize information and communications systems, explore new forms of product delivery, and realize targeted levels of customer service.

7.3.1 Elements of Inventory Cost

The decision to stock inventories requires planners to understand and manage the following dimensions of inventory cost.

7.3.1.1 Unit Cost

Perhaps the most fundamental cost associated with inventory is acquisition cost. This cost is defined as the value charged by the supplier in exchange for ownership of the product, or the material, labor, and overhead costs incurred in producing the product as well as inbound transportation, packaging, unitization, and other costs. The unit cost is determined by reviewing supplier quotations and invoices and by collecting production cost data. In developing the unit cost, several factors are necessary. To begin with, the costing unit of measure must be known. Establishing the unit of measure sometimes appears to be a variable, especially if the product is purchased, stocked, and sold in different units of measure. In determining the unit of measure, planners should use the unit of measure in which a product is stocked. When a product is produced, the unit cost is the sum of the material and processing costs. Take the following cost calculation as an example:

If:

$$\text{Total quantity of an item assembled} \quad = 500\,\text{units}$$

$$\text{Total production cost incurred} \quad = \$3500$$

then

$$\text{Unit cost} = \$3,500/500\,\text{units} \quad = \$7.00\,\text{per unit.}$$

The unit cost is affected by the acquisition or production lot size. Normally, as the order quantity of an item increases, the unit cost decreases. This phenomenon is known as *economies of scale*. Increasing order quantities reduces unit costs because the asset costs to produce the item are spread over a larger quantity of the item. For example, using the same total production cost detailed above, if the production lot size increased to 1,000 units, the unit cost would drop to $5.00 per unit. Increasing the lot size, however, negatively increases carrying cost. When determining the proper order lot size, planners must make effective inventory cost trade-off decisions.

7.3.1.2 Cost of Ordering

Once it is determined that a product needs to be replenished, there are several costs associated with order generation. These costs are best understood by assigning them to one of three possible classes. The first is described as *fixed costs*. These costs are considered "fixed" because they are incurred regardless of the number of orders created. Capital expenditure for land, plant, equipment, private transportation fleets, and personnel are examples of sunk costs. The second class of order cost is *variable costs*. These costs are considered "variable" because they are only incurred when a replenishment order is created. Whereas the asset cost of a fork lift is fixed, the costs associated with its use are dependent on its level of activity. Finally, ordering may incur costs that are difficult to quantify or are expressed in values not readily applied to cost categories. Examples of these *intangible costs* are the cost of incomplete information or inefficient operations. One of the most common intangible costs is customer satisfaction. Quantifying the effect of inventory shortages or poor product quality on customer satisfaction is a difficult to determine, yet important cost measurement.

Businesses incur most of the following costs associated with replenishment order management.

- *Production planner and buyer costs*. These costs consists of the salaries and benefits the company must pay the production planners and buyers. This cost is a fixed cost and is not impacted by the number of orders released.
- *Supplies and operating expenses*. These costs consist of the supplies and equipment needed for production and purchasing order management. Since this is a fixed cost it is not affected by the number of orders released.
- *Order generation costs*. Costs in this area consist of expenses incurred during order generation. Costs include order preparation costs, use of computer systems to identify

items for order release, and order transmission costs, such as electronic data interchange (EDI), Fax, Web-based ordering tools, and order documentation. If suppliers are not predefined, additional costs are incurred for sourcing, supplier negotiations, value analysis, quality assessment, and quotation review. Since these costs are generated by the number of orders created, they are considered a variable cost.

- *Production costs*. When products are produced by the company, the replenishment cost is composed of elements such as order research, scheduling, and release; shop order documentation; process setup, labor and overhead; WIP maintenance; scrap; and order completion. Since these costs are generated by the number of orders created, they are considered a variable cost.
- *Lost capacity costs*. Every time a production order is created, the time expended in equipment setup is lost as productive time. Since these costs are generated by the number of orders created, they are considered a variable cost.
- *Receiving and put-away costs*. These costs consist in the salaries of the employees and the equipment involved in order receipt and inventory put away. Since this cost is not dependent on the volume of orders, it is considered a fixed cost.
- *Miscellaneous overheads*. This group of costs consists of expenses incurred for the use of non-manufacturing and non-purchasing personnel in order management. Since this set of costs depends on the volume of orders, it is considered a variable cost.

7.3.1.3 Carrying Cost

The inventory decision cost associated with holding inventory is *inventory carrying cost*. This cost is directly related to the size and value of the inventory and the length of time it is carried in stock. The value of inventory ranges anywhere from 30 to 70 % of a typical company's current assets and up to 50 % or more of total assets. In 2013 carrying costs were estimated at US$469 billion [4]. For comparison, in 2000 the carrying cost was US$385 billion. If the average annual value of a single product was $1,000, a carrying cost of 25 % means that the firm spent $250 annually just to hold this product in stock. In analyzing the carrying cost of inventory, it is useful to divide the cost into four components: capital costs, service costs, risk costs, and storage costs.

Capital Costs. The most significant element in inventory carrying cost is the value of capital tied up in inventory. By converting capital to inventory, the firm forfeits the use of this capital for further investment in the hope of earning a profit when the inventory is sold. Consequently, when planning inventories, executives need to determine return on inventory investment hurdles as they would any other investment venture. For example, a firm might group inventories into high-, medium-, and low-risk categories. High-risk inventories may include new products or goods subject to fashion or seasonality that management targets to receive a 25 % after-tax return. Products in the medium range normally consist of the company's "bread-and-butter" items that need a 15 % return. On the lowest level are the firm's slow-moving items that require only a 5 % return.

Although the cost of capital accounts for as much as 80 % of the total inventory carrying cost, it is perhaps the most intangible and subjective of all the carrying cost elements. When balancing the cost of capital and the size of the inventory investment, planners must find answers to such questions as "What would be the rate of return if capital was invested in other projects instead of inventory?" "If money needs to be borrowed to attain targeted inventory levels, how much will it cost the firm?" Usually most companies will calculate the cost of capital by referencing the prime rate, the interest rate on short-term securities, or the expected ROI from projects the company is unable to execute because the money has been spent on inventory.

Service Costs. Service costs represent direct cash expenditures necessary to support inventories. An example would be insurance coverage required as a protection against fire, theft, or natural disaster. As inventory is considered an asset, taxes are levied on the physical inventory quantities on hand on the day of assessment. Although insurance and taxes represent only a small fraction of total carrying costs, nevertheless, they represent direct cash flow out of the firm. Unlike the cost of capital, exact information concerning service costs are easily obtained for inventory decision making. Service costs are calculated as a percentage of the year's inventory value and added to the cost of money component of the total carrying cost. Like the cost of capital, service costs are directly proportional to the level of stocked inventory. Unless a company undergoes dramatic expansion or downsizing, service costs remain fairly consistent over time.

Risk Costs. Companies always assume some form of risk when stocking inventories. All products risk *obsolescence.* Changes in the tastes of the public and in technology are two of the most common reasons why inventory becomes obsolete and can no longer be sold at its original price. Often such inventory is salvaged or sold at discount, the variance showing up in the profit and loss statement as a separate item. The faster inventory turns over, the less is the risk of obsolescence.

Damage and *shrinkage* are also elements of inventory risk. Spoilage happens as a result of natural processes characteristic of products such as foodstuffs and chemicals. Companies also risk inventory loss due to damage. Damage during production, lack of quality and effective training of the company's staff, incorrect use of material handling equipment, poor packaging, and inadequate storage practices are instances of where inventory loss occurs. Incoming inspection is a key element in reducing hidden damage and spoilage. Furthermore, theft is an unfortunate, yet real cost. Pilferage is reduced through tighter internal company security measures.

A potentially large area of risk is balancing inventory levels among several channel stocking locations. Relocation costs occur because of poor planning and lack of management visibility into the inventories of the warehouses constituting the distribution network. For the most part, the inventory is relocated in the channel to avoid the possibility of stock out, reduce channel stocking level imbalances, and reduce field-level replacement purchase orders. Such movement risks further damage and pilferage and causes additional cost in the form of interbranch transportation.

Storage Costs. Costs for holding inventory are most visibly found in warehouse space, storage, and materials handling. Inventory is stored in four possible types of facilities: company warehouses, public warehouses, rented warehouses, and inventory in transit. The costs associated with company-owned warehouses and the accompanying material handling equipment are primarily fixed in nature and are not part of inventory carrying costs. Any variable costs, however, that change with the level of inventory, such as receiving, put away, and recordkeeping, should be considered part of carrying costs. As an example, the annual carrying costs for a given warehouse are the following:

	US$
Utilities	65,000
Personnel	1,400,000
Equipment maintenance	415,000
Plant maintenance	323,000
Security	225,000
Total	U$2,428,000

If the average value of the inventory is $12 million, the percentage of carrying cost for the warehouse is 20.3 % (2,428,000/12,000,000).

The carrying costs incurred for the use of public or rented warehouses are attained using the same calculation. Only those charges for recurring inventory storage that are explicitly included in the warehouse rates or those costs that are variable with the quantity of inventory held should be considered as carrying cost. As an example, the rate charged by a public warehouse to handle a pallet is US$5.00 per month or US$60 per year. If 100 pallets are handled during a single month, the carrying cost would be US$500. The last type of warehouse, inventory in transit, consists of goods that have been shipped from the supplier but have not as yet arrived at the purchasing facility. If the buyer has accepted ownership at the time of shipment, the carrying costs consist of all charges associated with material handling, insurance, storage, and other transportation charges.

Exercise 7.1: Carrying Cost Calculation
Determining the cost of carrying inventory is achieved by combining the expenses specified above for each of the relevant cost types. The costs for each type are expressed as a percentage of inventory value. Assume the following values:

	%
Cost of capital	13
Insurance costs	0.07
Taxes	3
Damage and theft	1.3
Obsolescence	2
Storage and handling	6
Carrying cost	26

The calculation of the inventory carrying cost with even the most accurate information is at best an estimate. In reality, the actual costs accumulated are subject to interpretation and management policy. The carrying cost is calculated by multiplying the carrying cost percentage by the average value of the items being stored. For example, if the average inventory value of a company is US$2 million, the carrying cost is 2,000,000 $\times$ 26 % or US $520,000.

7.3.1.4 Stock Out Costs

An important cost associated with inventory is the cost of a stock out. Although the exact cost of a stock out is difficult to determine, the cumulative effects of stock outs on the business are significant. A stock out occurs when demand for a product exceeds the available inventory. When an item stocks out, two possible conditions may ensue. In the first, the demand order is taken and the stocked out item is placed on backorder. This means that when the inventory becomes available it will be shipped against the demand backorder. The backorder condition remains until the original items and quantities on the demand order are shipped. If the demand order is not placed in a backorder status, the order is lost.

A stock out will generate a variety of different costs. Among the most important are:

- *Lost sales*. The most serious effect of a backorder is that a sales order and its revenue are cancelled. In the long run, however, the cost involved in lost orders is even more damaging to the enterprise. Poor customer service can cost a company dearly in lost future opportunities, customer goodwill, and marketplace reputation.
- *Backorder costs*. When it has been decided to place the demand order into a backorder status, several maintenance costs arise such as order rescheduling, special handling, expediting, and order follow-up.
- *Lost customers*. Depending on their relationship with suppliers, customers may respond differently to incomplete or late orders. The most serious response is that the customer cancels the order and severs their relationship with the supplier. A stock out that drives a customer to a competitor risks losing that customer forever.
- *Expediting*. Several expediting costs arise when responding to an order shortage. Shortages on production orders often require purchase order expediting, additional supplier charges, premium shipping, expedited receiving, and production order rescheduling.
- *Additional production and purchasing costs*. The effect of shortages on production and purchasing is found in paying premium prices for expedited materials and shipping, disruption of the procurement planning schedule, changes within the production time fences increasing chaos in the plant, costly setups, and possible overtime.
- To track the effect of stock outs on the business, inventory managers can utilize several key service measurements. Among the most important are lost orders, the fill rate, orders shipped on time, average length of time required to satisfy backorders, and percentage of replenishment order cycle in which one or more units are backordered. A simple but powerful measurement is *stock out frequency*. This value refers to the probability that a firm will not have sufficient inventory to meet demand. It is determined by dividing the actual number of occasions when a stock out occurred by the total number of orders. The aggregation of all stock outs across all products occurring at each supply channel node is an indicator of how well a supply chain is positioned to provide its desired customer service commitment.

The most common solution to product shortages is to increase stocked inventories. As safety inventory grows to support higher customer service levels, the cost of lost sales decreases. As customer service increases, however, the costs of carrying the safety inventory increases correspondingly. Inventory managers must be careful to perform a thorough cost-benefit trade-off analysis when making these decisions.

7.3.1.5 Transportation Costs

Inventory does not remain stationary and is often in motion from one point in the supply chain to another. Regardless of the transportation mode and ownership (whether a private fleet or a for-hire carrier), companies must bear several types of cost. Inventory and transportation management must understand these costs and ensure that the revenue generated by the shipment covers at least the transportation cost. There are four types of cost associated with transportation carriage.

- *Fixed*. This type of cost arises with the ownership of physical transportation assets. Examples are motor vehicles and trailers, terminals, ports, pipelines, docking systems, rights-of-way, information systems, taxes, rents, loan interest, and materials handling equipment. The fixed costs of ownership are not directly influenced by shipment volume. In the short term, expenses associated with fixed assets must be covered by revenue contributions above variable costs on a per shipment basis.
- *Variable*. This type of cost arises when transportation equipment and/or services are used to make a shipment. As such, variable cost is significantly affected by shipment volume. Examples of variable cost are fuel, labor, and vehicle maintenance. These expenses are generally determined as a cost per mile or per unit of weight. The variable cost of operations represents the minimum amount a carrier must charge to pay operating expenses.
- *Joint*. These are costs shared by the shipper and carrier to perform a certain transport service. A simple example is the transport of several different sized products with different weights in the same shipment. Should cost be distributed by weight, cube, or some other factor? Another example is the problem of backhaul. When a carrier agrees to transport a shipment, there is an implicit decision to incur a joint cost for the backhaul. Either the original shipper must share in the backhaul cost or another shipper must be found to pay for the cost of the backhaul.
- *Common*. These are costs for equipment such as terminals, rights-of-way, and management expenses that are spread proportionally over all shippers using the service. Normally, these costs are allocated based on the level of activity an individual shipper generates during the shipment process.

7.3.2 Inventory Valuation

Once the components of inventory costs are compiled, the value of a firm's inventory is determined. It is important to note that there is a difference between inventory cost and inventory valuation. Inventory cost is a decision made by management as to what the *internal* financial value of an item is at any time. This is particularly relevant, since as time changes, so do inventory costs. It is important to note that how a company determines its inventory costs may be different from the way it *values* it. As an example, a company may cost inventories using the standard cost method, while reporting its financial value to shareholders using the last-in-first-out (LIFO) method. In addition, multiple costing methods could be used to track different items residing in the same inventory. For example, items that experience wide fluctuations in purchase price may use an actual cost by lot method, while purchased standard components use an average cost.

7.3.2.1 Inventory Accounting Systems

Before inventory is valued, the quantity and cost of each product must be known. There are two common systems for determining the size of a company's inventory as a prelude to valuation: the *periodic inventory system* and the *perpetual inventory system*. The use of these methods depends on company decisions as to the type of inventory transaction data collection. In the periodic inventory system, the size of the inventory is determined by an actual physical count of stocked balances at specific dates, normally no later than year-end. The most significant advantage of this method is ease of record keeping. No daily inventory transactions are made to balance the on-hand record with purchase receipt, in transit, scrap, or finished goods sale. The disadvantages are that the firm does not know exact inventory quantities or total value until the physical inventory is performed. In addition, a complete physical is an expensive, time-consuming process. Periodic inventory systems are often used by companies stocking items that are relatively low in value, very high in volume, difficult to count, or slow moving.

Perpetual inventory systems, on the other hand, are characterized by a careful, timely recording of each inventory transaction as it occurs. In this accounting system, any time an inventory transaction occurs, such as a purchase receipt, adjustment, scrap, movement, issue, or sale, the inventory and accounting records of the item are updated. Advantages of the perpetual inventory system are exact information concerning inventory on-hand balances and costs are available at all times. In addition, through the use of an effective cycle count program, the annual physical inventory, in most cases, can be eliminated. The disadvantages of the method are the maintenance cost of the system is very high and it usually requires a computer and trained users to record transactions. Businesses that carry high- to medium-cost items with constant to high transaction volumes are most likely to use some form of perpetual inventory system to track and value their inventories.

7.3.2.2 Inventory Valuation Methods

Inventory valuation is important for several reasons. To begin with, good inventory accountability is necessary to assure correct reporting of interim and yearly company profits. Accurate inventory valuation enables managers to measure, on a continuous basis, the value of the variances between booked and physical inventories. Also, proper inventory accountability is a requirement for publically traded companies for quarterly submission to the Securities and Exchanges Commission and to inform shareholders of profitability.

There are five recognized methods for valuing inventory. It is important to note that not all countries accept all five as legal methods [5].

- *Standard cost*. This method determines inventory value by assigning cost standards to manufactured and purchased products. A *standard* is defined as an established norm against which measurements are compared. Inventory standards serve as benchmarks permitting managers to determine what inventory costs should be and to measure actual costs against budgets. The standard is computed by using elements such as the purchased materials cost, direct labor expended in operational activities, such as receiving, stock put away, production, order picking and packing, and shipping, and overhead costs such as management salaries and carrying costs. Inventory at any point in the year, up to generation of a new standard, is valued at the given standard regardless of the actual ongoing costs incurred for inventory acquisition. One of the advantages of standard costing is that the company needs to revalue inventory usually only once a year. Furthermore, the cost standard permits managers to calculate all variances occurring between the standard and actual material, labor, or overhead costs. Variance analysis enables managers to investigate root causes of cost change and to take remedial action when necessary. This method is used mostly by manufacturers.

- *First-in-first-out (FIFO)*. This method of inventory valuation assumes that the cost of products sold consists of the oldest inventory cost, and that the remaining balance consists of the most recent costs. Normally, a computer system is used to keep track of each "layer" of cost recorded for each receipt of the product. FIFO is widely used in times of stable pricing. However, in periods of continuous inflation, FIFO tends to result in "inventory profits" stemming from lower fixed inventory cost and increasing sales margins. FIFO methods of inventory are commonly used to inventory perishable goods, such as foods, pharmaceuticals, or other products with short shelf lives. Stockkeeping in a FIFO system requires that the oldest product always be rotated to the front upon the receipt of a new inventory lot.
- *Last-in-first-out (LIFO)*. This method of inventory valuation assumes that the cost most recently incurred in the acquisition of a product is the cost used for sales during that period. By charging current costs to sales, LIFO assumes that remaining inventory at the end of a period reflects the oldest acquisition costs. Like FIFO, a computer system is normally used to keep track of each "layer" of cost recorded for each receipt of the product. The computation of LIFO is perhaps best seen when compared to FIFO. Assume that at the beginning of a period a company starts with ten items. The first five were purchased at US$100 and the second lot of five was purchased at US$110. The selling price is US$150 per item. During the period, five units are sold. The result of the selection of either the LIFO or FIFO method is displayed in Figure 7.6. The difference of US$42.50 constitutes the FIFO profit. Under LIFO, inventory levels are carried on the balance sheet at the original LIFO cost until they are decreased. Increases are added at the current cost in the year the inventory is acquired.

Reference	LIFO	FIFO
Sales	$ 750.00	$ 750.00
Cost of Sales	$ 550.00	$ 500.00
Gross Profit	$ 200.00	$ 250.00
Operating Expense	$ 100.00	$ 100.00
Income Before Taxes	$ 100.00	$ 150.00
Taxes /15%	$ 15.00	$ 22.50
Net Income	$ 85.00	$ 127.50
FIFO Profit		$ 42.50
Ending Inventory Cost	$500.00	$550.00

FIGURE 7.6 LIFO versus FIFO valuation.

The advantage of using LIFO costing depends on whether the economy is experiencing a period of inflation or deflation. When purchase prices are rising, LIFO results in lower inventory valuation, higher cost of goods sold, and lower profits. When prices are declining, the opposite is true. A lower inventory valuation reduces inventory asset and taxes. Disadvantages are that after many years of use, inventory amounts in the balance sheet may be much lower than current inventory assets. Also, if inventory levels are reduced, older LIFO costs are matched with current revenues and reported income becomes inflated.

- *Average cost*. This cost method uses the current cost and the quantity of existing inventory of an item and combines it with the cost and quantity of the item's newest receipt, and then averages them to determine a new inventory value. Usually, firms use some type of weighted average in which inventory invoice cost are weighted by the quantity of the item received. This form of inventory costing is often used with *periodic inventory systems* and for replenishment in a distribution environment.
- *Actual cost*. In this cost method, a specific inventory lot size quantity and price are linked and differentiated from past receipts of the same item by associating it with a unique identifier (usually, a lot number). When the item is transacted, the lot cost is recorded as the cost. Actual costing is used by firms that experience dramatic fluctuations in the acquisition cost of materials and components. By capturing the actual cost, planners can calculate the actual cost of sales and the earned margin when a specific lot of an item is transacted.

If it were possible to continually acquire inventory at the same price, the choice of a costing method would make no difference on either reported income or the balance sheet. However, because costs do change, the costing method is critical in effectively managing inventory investment. The choice of the proper inventory valuation method depends on a matrix of factors such as the general economic environment, the velocity of how fast inventory moves through the supply pipeline, and the financial reporting strategies of individual companies.

7.4 INVENTORY CONTROL

As previously stated, inventory is one of the largest single financial investments for most companies. Unless the firm's management undertakes a serious and detailed plan to control the physical movement of inventories, inaccurate record balances can drain away profitability and inhibit effective performance. Many companies, after the annual physical inventory, experience a large variance between the physical and booked values of their inventories. Such discrepancies send a tidal wave of concern through the firm. Accurate inventories are essential for the correct reporting of assets. Investors and shareholders can become apprehensive about profits that do not appear because of poor inventory management. Executives can be surprisingly disappointed to see that business plan goals are unattainable because of booked inventory losses.

In addition to the impact on financial measurements, poor customer serviceability usually accompanies inaccurate inventories. The litany of performance problems is familiar: declining order volumes and high customer turnover, increasing backorders and order cancellations, increasing inventories and expediting costs, significant inventory inequalities in the supply channel, growing inventory obsolescence, and increases for premium purchase orders and freight. Ineffective inventory control destroys the confidence of the firm to establish meaningful plans and performance measurements and to respond effectively to the competitive challenges of the marketplace.

7.4.1 Transaction Management

One of the ways companies can reduce inventory loss and improve accuracies is by clearly defining the transaction control points as inventory flows through the channel. Accurate inventory records must be kept from the moment inventory is received to the moment it is shipped to the customer. Managers need to closely map the flow of inventory through the organization, noting each point where inventory balance, financial, and location records must be updated through a system transaction.

As illustrated in Figure 7.7, the flow of inventory typically starts with the receipt and put away of production inventories or purchased finished goods into the warehouse. In a production environment, materials and components are then issued into production to build subassemblies and finished goods. As they are completed, the finished goods are moved to the finished goods stockroom. While in stock, items may be moved to other warehouse locations or have their balances adjusted either up or down due to a cycle count. From the finished goods stocking area, the items can be picked and sold to the customer. In a distribution channel network, items are moved into the channel from central warehouses to local warehouses through an *interbranch transfer* and finally sold to the customer. In some organizations an additional inventory transaction is performed when items are returned from the customer and placed back in stock.

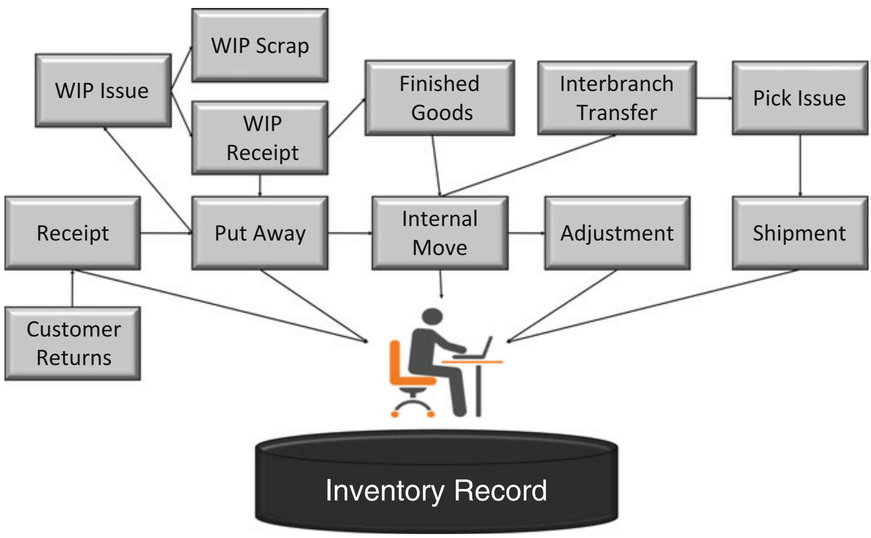


FIGURE 7.7 Transaction points.

Each of the inventory movements described above constitutes an inventory control point. Each time an item is moved into and or out of a control point the action must be accompanied by an inventory transaction that accurately describes the item transacted along with what locations, quantities, and lots were affected. Inventory management must ensure that the proper people and equipment are available at each control point to ensure simplicity, accuracy, and timeliness of recording data. Superior inventory control policies execute effectively the *3P's*:

- *People*. Effective inventory control depends on the people in the organization charged with its maintenance. Have the right people been assigned to maintain inventory accuracy? Have they been given the authority to make it happen? Have they received the necessary training with techniques and systems? The people who touch inventory daily or intermittently are expected to maintain as accurate an account of inventory as possible. Instead of a low-ranking job in the organization, those responsible for inventory accuracy often literally handle thousands of dollars of assets every day. Much like a bank teller, they must be accountable for the movement of inventories.

- *Places*. The places and critical process steps where inventory transactions occur must be carefully identified, adequately manned, and possess the proper equipment to record inventory transactions if inaccuracies are to be prevented. While it is not necessary to have locked stockrooms at each step of inventory flow, inventory managers must identify critical points of inventory transaction reporting and put into place the proper people and equipment to make high inventory accuracy possible. The quest for accuracy is assisted by the implementation of a variety of data collection devices, such as bar code readers, scanners, RFID tags, and hand-held devices. Finally, computer systems display real-time inventory availability, location, and transaction results for activities such as quantity verification and order promising.
- *Paper*. Proper documentation must accompany transactions at each transaction point. Paperwork should be easy to use and permit complete recording of transactions in the inventory control system on a timely basis. Today's computerized inventory management systems have enabled people to dramatically cut the amount of actual paperwork needed to manage inventories. In fact, data collection devices and scanners have enabled many environments to go paperless.

The results of effective inventory transaction control is the ability to keep the physical inventory and the accounting systems in synchronization.

7.4.2 ABC Analysis

A commonly employed tool to ensure inventory accuracy and control is *ABC analysis*. Supply chain inventories can consist of thousands, possibly hundreds of thousands, of items. While it is assumed that all of these items fulfill a purpose, it is important to understand that not all items are to be treated the same way. In fact, the usage rates of a typical company's inventory follows a statistical principle formulated by the nineteenth-century Italian social scientist, Vilfredo Pareto, termed the "Management Principle of Materiality." Simply, the principle states that in any given statistical population, 20 % of the elements in that population will account for 80 % of the data occurrences.

When applied to a company's inventory, the principle means that statistically 20 % of the items will account for 80 % of the inventory transactions. It does not take much insight to notice that a small number of items in an inventory are used more, sell faster, and bring more revenue than the rest of the other items. These items need much more care and consideration than those items with minimal usage. By dividing the inventory into classes based on such criteria as historical usage value or volume, analysts can focus on those items placed in the highest usage classes that account for the bulk of the company's inventory flow. Planning and controlling inventories requires a great deal of effort to input data, check balance records, verify stock put away, accurately pick orders, and other activities. Clearly, the larger an inventory becomes, the less planners are able to work effectively with the entire inventory. Because the firm possesses limited resources, classifying inventory by transaction usage or value greatly assists planners in ascertaining the level of control to be exercised over each item.

For the most part, a typical ABC Classification would divide a company's inventory into the following three divisions:

- *Class A* items are classified as either very expensive and/or high transaction volume items that constitute the bulk of a business's usage and sales and need special attention and control by inventory planners.
- *Class B* items are classified as a much larger number of stocked items with medium usage and sales. These items need periodic attention and are normally controlled by the firm's computer systems.
- *Class C* items are classified as the bulk of the stocked items, characterized by relatively inexpensive or very low transaction volumes that are controlled by methods such as a two-bin system or periodic review.

In a typical inventory, Class A items are under close control, with balance and reordering decisions made by inventory planners after a thorough review of transaction and planning data. Class B items, on the other hand, typically are controlled by a computer. Replenishment and data element update are normally performed automatically by the computer without planner intervention. Finally, Class C items may or may not be included in the computer system. Such items could be satisfactorily controlled by methods such as a two-bin system or periodic review.

The procedure for developing an ABC analysis begins by determining the content of the classification scheme. The most commonly used factors are product annual dollar usage, transaction usage, unit cost, lead time, and quality. In developing product classifications, planners must be careful to use more than one of the above criteria depending on inventory characteristics. A common technique is to use a two-digit coding system that differentiates between, for example, monetary value and actual usage. The first digit determines the class based on descending monetary value. The second code is based on descending usage, serving as an indicator of actual usage. For example, an item coded A-1 (with A and 1 being the highest values) requires close planner review, whereas a C-3 item requires minimal review. However, a C-1 item is given much greater attention than an A-3 item. Table 7.2 illustrates an *ABC distribution by usage and value* calculated by ranking finished goods inventory by transaction and by value.

The results of the ABC classification, detailed in Table 7.2, indicate that the first three items represent 74.7 % of the firm's total sales and have been classified as Class A. The next four products represent about 15 % of total sales and have been assigned to Class B. Finally, the remainder of the inventory, accounting for about 5 % of total sales, has been assigned to Class C. The report also shows four products with no transaction detail at all. These products should be classified as "dead stock" and reviewed for possible removal from active inventory. The last product, #6-900, has a large usage, but because no cost has been applied, the report cannot calculate its dollar usage. This product should be reviewed and a cost assigned. Figure 7.8 illustrates graphically the *distribution by value* principle used to determine the classification in Table 7.2.

Once determined, an ABC classification assists planners assign the proper resources to attain the optimum maintenance of the inventory. For example, Class A products may have their inventory balance status reviewed weekly, possess tight accuracy tolerances, a 99 %

TABLE 7.2. ABC Distribution by Usage and Value

Item	Unit cost	Annual usage	Cumulative % usage	Annual dollar usage	Cummulate % dollar usage	ABC classification
1–100	$.0074	5,750,000	63.9	$42,550.00	41.3	A
1–500	$.0203	1,265,000	78.0	$25,679.50	66.2	A
2–300	$.0800	110,000	79.2	$8,800.00	74.7	A
1–200	$.0800	10,500	80.4	$8,400.00	82.9	B
2–100	$1.0173	7,500	80.4	$7,629.75	90.3	B
2–600	$.0200	115,000	81.7	$2,300.00	92.5	B
1–300	$1.1438	1,500	81.7	$1,715.70	94.2	B
1–400	$3.1999	500	81.7	$1,599.95	96.8	C
3–100	$.0125	110,000	83.0	$1,375.00	97.1	C
3–200	$.0300	25,300	83.2	$759.00	97.8	C
2–700	$.0200	25,300	83.5	$506.00	98.3	C
4–100	$.0799	500	83.5	$439.95	98.8	C
5–100	$4.5438	70	83.5	$318.06	99.1	C
4–200	$.3000	1,000	83.5	$300.00	99.4	C
3–300	$.0100	25,300	83.8	$253.00	99.6	C
4–300	$.3000	600	83.8	$100.00	99.8	C
6–100	$.0050	25,300	84.1	$126.50	99.9	C
7–100	$.2000	126	84.1	$25.30	99.9	C
6–500	$.0200	1,000	84.1	$20.00	99.9	C
5–500	$.0200	500	84.1	$10.00	99.9	C
4–700	$.0010	525	84.1	$0.52	100	C
5–600	$.0000	0	84.1	$0.00	100	C
2–800	$.0000	0	84.1	$0.00	100	C
4–900	$.0000	0	84.1	$0.00	100	C
5–900	$.0000	0	84.1	$0.00	100	C
6–900	$.0000	1,419,400	99.9	$0.00	100	C
Totals		8,991,491.50		$102,988.23		

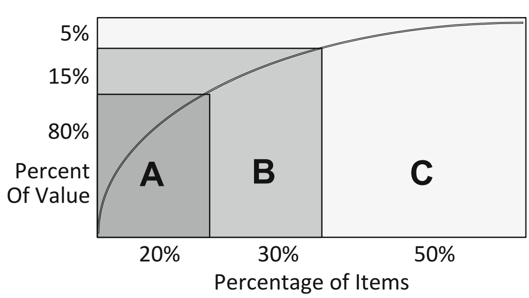


FIGURE 7.8 ABC stratification.

order fill rate, a high safety stock percentage, and close follow-up and possible expediting of replenishment orders. In contrast, Class B and C products require less review, safety stock, and expediting. In addition, in a distribution network, it might be decided that almost all of the Class C and some of the Class B items would be stocked in central distribution centers only, thereby diminishing the amount of low-value products in the channel pipeline.

An important objective of managing Class C items is the elimination of surplus and obsolete inventory. Although periodic sales may seem to validate stocking this inventory, in reality the resulting small stream of revenue does not generate enough profit to justify the cost and is the major reason for low aggregate inventory turnover. Essentially, this inventory falls into the following categories: excess, damaged, recall, rework, outdated, short dated (will soon become outdated), expired, and dead stock. The elimination of these inventories is critical if supply chains are to improve on inventory investment and turnover rates. An effective excess and dead-stock program consists of the following steps:

1. *Prevention.* In this phase, planners should deploy effective inventory planning tools to eliminate the ordering of excess and dead-stock inventories. Effective prevention also requires a tough attitude toward customers, sales staff, and suppliers.
2. *Identification.* In this phase, the creation of effective inventory transaction/usage reporting is critical. Reporting assists planners to focus on products with low to null cost/usage value but have inventory on-hand or zero balances, and a low ratio of cost/usage and available on hand.
3. *Coordination.* In this step, an excess or “dead-stock” project team is formed to tackle the problem.
4. *Disposal.* Once excess and obsolete inventory is identified, the project team must develop a program to: (1) dispose of the inventory, and (2) maximize the dollars generated from the disposition. Such methods as sell at any price above cost, return to supplier, sell at a certain percentage below cost, sell at any price, sell to a reseller or broker, and scrap are used to dispose of inventory.

7.4.3 Periodic Physical Inventory and Cycle Counting

Whether following a perpetual or periodic inventory system, it is essential to periodically review inventory balance records, make adjustments to keep inventory values accurate, and maximize continuous improvement procedures in pursuit of inventory accuracy. A common method of achieving this objective is to conduct a complete physical inventory. The exact timing of a physical inventory audit often depends on the nature of the business and the size of the inventory. Some industries that have very expensive items, such as high-tech electronics, may perform a complete review of all inventory balances once a quarter or even once a month. Companies that are publicly traded (in the United States) are required to perform a physical at least yearly (This requirement can be waived if a firm has a certified cycle counting program from its financial auditors).

A complete physical inventory has two goals. The first is to satisfy the independent financial auditors that inventory records accurately reflect the actual physical inventory. This step is essential for the year-end reporting of the inventory asset valuation. The second objective is to provide inventory planners with an opportunity to correct inventory inaccuracies in the records. While the annual physical does provide an important benefit, it does have disadvantages. To begin with, the focus is really not on inventory at all but on preparing the financial valuation of inventories. Another serious drawback is that factories and warehouses will often need to be closed down during the count. Procedurally, since there is pressure to complete the physical as soon as possible, inaccuracies in counting and adjusting inevitably occur. This is especially the case when non-operations personnel participate in the counting. Finally, the accuracy of the newly verified balances begins to deteriorate steadily as each day moves away from the count date.

A much more effective method of continuously ensuring the accuracy of inventory balance records is to use *cycle counting*. The *APICS Dictionary* defines cycle counting as "an inventory accuracy audit technique where inventory is counted on a cyclic schedule rather than once a year." The rationale behind the technique assumes that the more an item is transacted through time, the greater the probability that errors due to inaccurate transaction management will occur. As such, items with high transaction volumes need to be reviewed frequently to ensure that their inventory balance records are correct. The key elements of the technique are:

- The number of times an item is counted a year is termed its *count frequency*. A simple heuristic, such as count all class "A" items once a month, class "B" items four times a year, and class "C" items twice a year, can be used.
- A cycle count is usually performed on a regular periodic schedule.
- The basic idea is to count a predetermined number of items each day.
- The purpose is to identify and then perform root-cause analysis of any balances in error.

There are several methods that can be used to perform a cycle count.

- *ABC method*. ABC is the most popular method. This method is based on an effective ABC classification. The mechanics of this process consist in establishing a *cycle count frequency* for each of the ABC classifications. For example, high-value or fast-moving products classified as "A" items are reviewed more often than low-value or slow-moving items. An example of the ABC method are to count all class "A" items monthly, all class "B's" quarterly, and all class "C's" twice a year.
- *Zone method*. In some cases, items are stored in specific zones due to their physical properties, the nature of the storage area, or other factors. An example is a frozen food zone in a produce warehouse. Since all items in the zone have a fixed location, the cycle count schedule starts with the first location and continues daily until it reaches the last location. At this point, the count begins again at the first location.
- *Location audit method*. Cycle counting becomes difficult in warehouses where items are stocked randomly. The location audit solves this problem by cycle counting a set number of locations in the warehouse each day. When the whole warehouse is completed, the count begins again at the first warehouse location.
- *Special counts*. An item transaction event is also used to initiate a cycle count. Examples include:
  - *When a replenishment order is placed or received*. Because inventory is low, this event enables a quick count to occur before replenishment put away.
  - *Negative or zero-balance inventory*. This event is triggered when the inventory system indicates that items are at zero balance or are negative. This type of count is completed in a relatively short period of time due to the absence of stock.

– *Demand order pick.* Many enterprise resources planning (ERP) systems provide the ability to have notification of a cycle count appear right on the pick slip as the order picker pulls stock. The picker validates the item balance, indicates the count on the picking slip, and returns it to inventory control.
– *Set number of transactions.* An item is cycle counted when a set number of transactions have occurred to a specific item.
– *Inventory error.* A cycle count is generated when the balance record is found to be incorrect. An example is the generation of a validation count after a shortage appears when a demand order experiences an unanticipated shortage.

Once the parameters of the cycle count technique are formalized, effective execution requires the counting of a certain number of items every workday per the prescribed frequency. Once counting is completed, the count sheet results need to be verified and variances examined by inventory control. When variances occur, items are either recounted or their book inventory values adjusted depending on management policy. Once a week the results of the cycle count program are broadcast, and a summary report prepared at least monthly.

An effective cycle count program provides a number of significant advantages. To begin with, cycle counting assists in the maintenance of a high level of inventory accuracy. When the firm depends solely on a yearly physical to adjust inventory, variances can go unadjusted for long periods of time. Because the focus of the cycle count program is on those products with the most transactions, repeated review ensures a high level of accuracy. Additionally, an effective cycle counting program enables companies to abolish the expense and operations disruption of the annual physical inventory. Finally, the real benefit of cycle counting is the information provided to inventory controllers enabling them to investigate and eliminate the root cause of why inventory variances occurred at all in the transaction flow. This total quality management (TQM) approach focuses the entire inventory control function on continuous performance excellence.

7.5 PERFORMANCE MEASUREMENT

Supply chain inventory performance is measured from two perspectives: *customer service* and *inventory investment*. Neither of these two measurements is considered outside of one another. Customer service performance is meaningless without an understanding of its financial effect on inventories; inventory performance measurements are likewise meaningless without reference to the level of customer service they are designed to support. Figure 7.9 illustrates this relation. Inventory investment is shown along the vertical axis, and customer service is shown along the horizontal axis. When describing a single product, the upward slope of the curve indicates that additional inventory increases the level of customer service. Determination of the effectiveness of inventory and service level trade-off strategies is the subject of inventory performance management.

7.5.1 Customer Service

Earlier in this chapter it was stated that the strategic objective of inventory is to provide supply chains with the ability to maximize on customer service. But while efforts to optimize customer service are the focal point of inventory strategies, choosing the proper measurement criteria to validate objectives is not always easy. For example, a distributor receives the

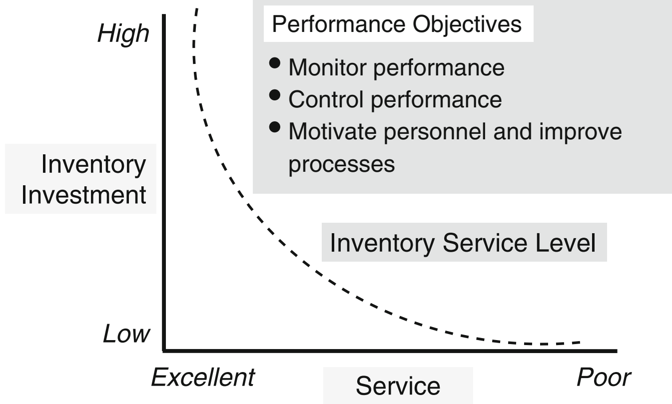


FIGURE 7.9 Inventory/customer service trade-off.

following orders from two customers: four each of item #1-100 at a cost each of $25 and a second line calling for four each of item #2-100 at a cost each of $10 for a total value of $120; and an order for two each item #2-100. There are four each #1-100 on hand, but item #2-100 is stocked out. In determining the customer service measurement for this scenario, there are four possible service measurements:

- 50 % item fill rate
- 71 % dollar fill rate
- 33 % line fill rate
- 0 % order fill rate

The selection of the appropriate customer service performance measurement depends on the marketplace, the nature of the items sold, and the ramifications of the supply channel's inability to completely fill customer orders.

When selecting the most appropriate measurements, managers have the option of selecting from a wide range of activity-based (which focuses on the efficiency and effectiveness of specific work tasks) to entirely process-based (which focuses on the performance of the whole supply chain) measurements. Activity-based metrics center on the performance of processes. Among these metrics are found percentage or value type measurements such as

1. Customer orders shipped on schedule
2. Line items shipped on schedule
3. Total units shipped on schedule
4. Dollar volume shipped on schedule
5. Working days not out of stock
6. Backorders shipped within a specified number of days
7. Order days out of stock
8. Total item days out of stock
9. Average number of days to ship a backorder
10. Backorder aging

Besides customer order service measurements, businesses are normally concerned with other service metrics that impact inventory management. One of these is the *cost* incurred by the company to meet service targets. This measurement tracks how successful is the trade-off between inventory costs and actual sales revenues. Another measurement is tracking how well overall supply chain assets are meeting budgetary objectives. In this area is found the costs for facilities, equipment, personnel, and inventory and how effectively these expenditures are meeting ROI objectives. Finally, *quality* must be measured. Quality can refer to the effectiveness of how well processes are being executed to the standard and how much expediting, exception processing, or manual intervention is being performed. Quality measurement also applies to the fitness of the product itself and takes the form of recorded defects, failures, and returns.

7.5.2 Financial Statements and Inventory

The purpose of inventory is to provide financial value to the business. Inventory enables businesses to grow profits by satisfying the customer by having the right product, at the right quantity, at the right place with superior quality. Inventory assists companies realize these central objectives through the following processes:

- *Lowest cost for revenue value received.* An efficiently managed inventory enables companies to continuously shrink costs while increasing customer service levels. As the variance widens between what the final product is worth to the customer and the costs incurred, businesses expect to increase profits. The basis of all inventory trade-off decisions are determined by how inventory management can decrease cost for revenue value received.
- *Improved channel efficiencies.* By driving demand from the customer through the supply chain to the producer as quickly as possible, channel companies ensure that the inventory balances they stock support channel demand. Improper management of inventories causes two major sources of financial risk. The first is stock out anywhere in the supply chain. Stock out risks the loss of the customer's order and causes channel partners to undertake expediting actions to rush production and inventories through the supply chain. Expediting reduces the gap between costs and profit. The second source of financial loss is the unnecessary build-up in channel inventories due to poor planning and lack of channel visibility.
- *Improved quality.* As excess inventory quantities shrink everywhere in the supply chain, businesses simply cannot afford poor quality. Quality must be resolved at the source if the channel is to reduce costs and expand customer responsiveness. Finally, quality assists companies to reduce the occurrence of damaged, surplus, and obsolete inventories.
- *Supply network simplification.* The efficient management of inventories enables companies to increase the speed of inventory flow through the supply chain pipeline. Properly stocked inventory permits companies to expand production and increase delivery flexibility and agility.
- *Improved channel inventory information.* Information regarding the status of channel inventories enables companies linked in a supply chain to enhance financial value by increasing customer service and preventing stock outs. Stock outs risk lost sales and loss of customer goodwill. An effective way to measure the impact of lost sales on

financial value is by determining the difference between the anticipated revenue and the direct cost of making, selling, and delivering the product. As the fulfillment channel is cleared of obstacles and the flow of goods accelerates, the value of inventory grows in proportion.

An excellent way to understand the magnitude of the investment made in inventory is to compare it to the general revenues and expenses of the typical company. The size of this investment is detailed by consulting two key financial statements: the *balance sheet* and the *income statement*. Below is a discussion of how these documents work and the central role inventory plays in the analysis.

Balance Sheet					
Assets (US$M)			**Liabilities (US$M)**		
Cash	$	10	Current Liabilities	$	30
Receivables	$	20	Accounts Payable	$	20
Inventory	$	200	Long Term Debt	$	250
Total Current Assets	**$**	**230**	**Total Liabilities**	**$**	**300**
Property	$	20			
Plant	$	100	Comon Stock	$	90
Equipment	$	50	Retained Earnings	$	10
Total Fixed Assets	**$**	**170**	**Total Stockholders' Equity**	**$**	**100**
Total Assets	**$**	**400**	**Total Liabilities + Equity**	**$**	**400**

Inventory as Percent of Total Assets	**50%**

FIGURE 7.10 Balance sheet.

The *balance sheet* is a statement of the company's *assets* (what the business owns) minus *liabilities* (what the business owes), which equals *stockholder equity* (what the business is worth) at a specific point in time. As a document, the balance sheet is a statement of the firm's financial strength. As display in Figure 7.10, the assets column on the left states the *total current assets* and the *total fixed assets*. Adding these two assets results in the firm's *total assets*. Note in the example for a distribution company inventory characteristically accounts for 50 % of the firm's total assets. On the right side is found the firm's *liabilities*. Adding the business's current liabilities and long-term debt equals the *total liabilities*. Combining the company's stock and retained earnings (reinvestment) equals the firm's *total stockholders' equity*. Adding *total liabilities* and *total stockholders' equity* equals the business's *total liabilities*. At the bottom of the document, *total assets* must at least equal *total liabilities* plus *total stockholders' equity*. Normally, the results of successive balance sheets are usually compared side-by-side with data from multiple years. This allows managers to perform comparisons to highlight trends.

The *income statement* (Figure 7.11) is a summary of the business's gross revenues minus related costs, general and administrative expenses, and taxes used to determine net income or loss over a given period of time. While the balance sheet is static – often called a "snapshot" of the company's financial position, the income statement is dynamic. It shows managers, investors, and creditors whether the company has made or lost money during a designated period of time. Normally *income statements* are compared over multiple years to indicate trends. To calculate the *income statement,* analysts start with gross *sales* and subtract out *costs of goods sold* (inventory, labor, and overheads used in operations) to arrive at *gross profit*. From *gross profit*, subtract business *expenses* (which include selling, administration, and research and development) to arrive at the *pre-tax income*. Finally, subtract the federal and local taxes to arrive at the business's *net income*. Note in this financial document

Income Statement - Profit and Loss (US$M)		
Sales Revenue	$	400
Direct Labor	$	30
Direct Material	$	60
Factory Overhead	$	30
Cost of Goods Sold	**$**	**120**
Gross Profit	**$**	**280**
General and Administrative Expenses	$	160
Pre-Tax Income	**$**	**120**
Taxes	$	60
Net Income	**$**	**60**

FIGURE 7.11 Income statement.

inventory is considered as cost and is included in *Cost of Goods Sold*.

A simple, yet effective way to see the effect of inventory on the profitability of a business is to calculate the *return on asset* (ROA), which equals the firm's income divided by its assets. Since it is almost impossible to run a production or distribution company without some inventory, there will always be some cost associated with inventory. The real measurement of whether inventory is an asset or a liability is found in how much it increases sales and pays for itself plus the selling margin. An optimal situation is one where inventory assets decline while net income increases, thereby realizing a higher ROA. This relationship is demonstrated by calculating the ROA for the values found on the sample *balance sheet* and *income statement*.

Exercise 7.2: Return on Asset (ROA) Calculation

The executive staff of ABC Electronics wants to see how well the company's asset investment is performing. Based on the balance sheet and income statement values displayed in Figures 7.10 and 7.11, the ROA calculation is displayed in Figure 7.12.

Analysis:

1. The *net income* is calculated by subtracting *total costs* from the *sales*.
2. The *total assets* is calculated by adding all assets on the *balance sheet*.
3. The ROA is determined by dividing *net income* by *total assets*.
4. The ROA is calculated at 15 %.

7.5.3 Inventory Turns and Ratios

There are several other financial measurements of inventory available to inventory managers.

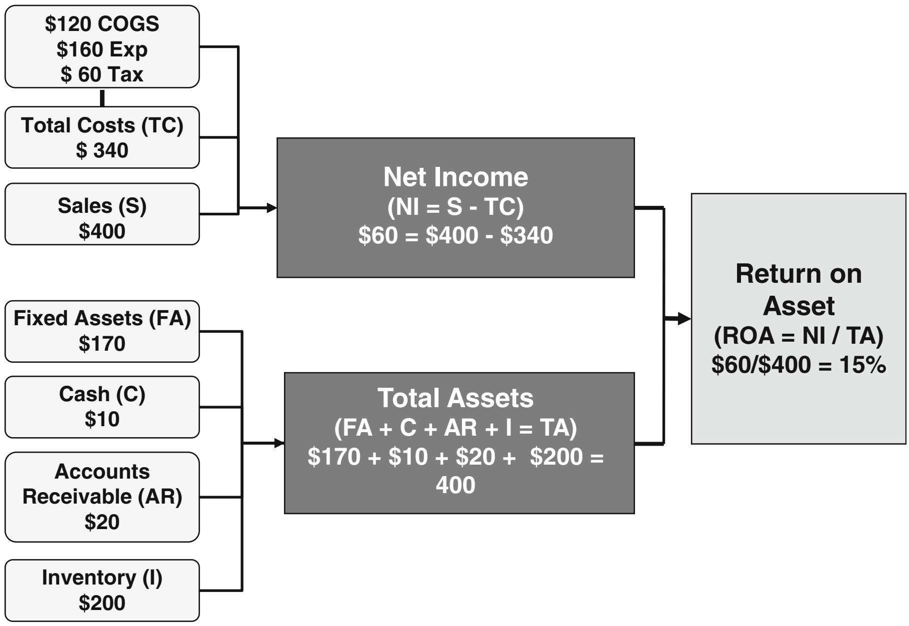


FIGURE 7.12 ROA calculation.

7.5.3.1 Average Inventory Investment

This measurement is calculated by taking the aggregate value of inventory at the beginning of a period (for example, 1 year) and adding it to the inventory value at the end of the period. As an example, the aggregate inventory value at the beginning of a year is US$28 million and at the end of the year it is US$32 million. The *average inventory investment* is calculated by adding these two values and then dividing by two to arrive at a value of US$40 million. Normally, a year is used in the calculation, but shorter periods (such as a quarter or even each month in some fast-paced, high-tech industries) could be used.

7.5.3.2 Inventory Turnover

Measuring the value of inventory is fundamentally a process of determining how quickly inventory cycles through the business to the customer. Simply, the faster inventory is received and sold, the faster the company recovers its cost. The most commonly used technique is to view the aggregate value of inventory investment on a periodic basis. Periodic reviews provide timely data for the analysis and comparison of actual inventory investment to inventory budgets. Resulting variances are then used to investigate root causes and to effect corrective action. In addition, a periodic review assists inventory planners to pinpoint inventory out-of-bounds situations caused by seasonal fluctuations and unusual inventory usage trends. Finally, the periodic inventory measurement provides top management planners with an opportunity to realign projected inventory investment with the business's financial capabilities.

While there are several different ways to calculate inventory turnover, the most popular uses the following formula:

$$\frac{\text{Cost of goods sold during a time period}}{\text{Average inventory valued at cost during the time period}}$$

As an example, if the annual cost of goods sold is US$1 million, and the average inventory is US$500,000, then the inventory turns is calculated as US$1,000,000/US$500,000, or two turns a year. If the business increases turns to five per year, this would mean the same sales would be generated by only US$200,000 of average inventory. If the carrying cost is 20 % of the inventory value, the reduction in inventory of US$300,000 results in a cost reduction and increase in profits of US$60,000.

There is no standard inventory turns formula that is valid for every company. In fact, inventory turnover calculations have little meaning when used as a comparison for even two companies within the same industry. For example, auto assembly plants and oil refiners achieve turnover ratios of 50 or more, whereas department stores and electrical suppliers will generally have stock turnovers below five. What is more, different turn ratio objectives can be developed by inventory class for products within the same inventory. Various other factors are used in the calculation of the turnover formula. In place of cost of goods sold, gross sales, net sales, sales at standard cost, sales at actual cost, or annualized forecast cost of sales, and units sold can be used in the formula. In developing an inventory ratio, planners must establish the purpose of the ratio, who will be using it, the accuracy of company accounting data, the profile of the inventory segment to be measured (product lines, warehouses, classes, and so on), and a plan for implementation. Inventory turn measurements must be used with caution. As purely a means of control, they place emphasis on reducing inventories at the expense of customer service.

7.5.3.3 Inventory to Total Current Assets

Broadly speaking, a firm's *current assets* can be divided into cash, accounts receivable, and inventory. Since inventory comprises such a large part of total current assets (often over 50 %), it has been argued that this value rather than cost of goods or sales revenue should be the ratio driver. Companies using this technique must be careful to measure the impact of variations in accounting periods or seasonality and economies on total assets. This measurement uses the following formula:

$$\frac{\text{Total current assets during a time period}}{\text{Average inventory valued at cost during a time period}}$$

7.5.3.4 Number of Day's Supply

This method is used to measure how many days of inventory are available to support anticipated sales. For example, if sales averages 100 units a day and there is 1,000 units in inventory, there is 10 days of available inventory. This method is useful for deciding when a replenishment order needs to be released. It is also used to balance item inventory levels to have equal days of supply.

7.5.3.5 Number of Month's Supply

In this method, the total amount of inventory is expressed in terms of the amount of supply necessary to support current inventory sales rates. For example, if inventory turns four times a year, the average amount on hand is 3 months' worth. This ratio is most often used to calculate turns for raw materials and component inventories.

7.5.3.6 Inventory to Net Working Capital

Net working capital is expressed as the difference between current assets and current liabilities. The ratio calculated between inventory investment and net working capital demonstrates the amount of cash available to the firm in the short run. If the value of inventory is equal to or greater than the net working capital, then inventories are probably too high and are squeezing cash flow. The ratio calculated should be less than one, indicating that cash and receivables are available for short-term investment.

Similar to other performance measurements, inventory performance ratios can be abused and misapplied to produce the wrong decision based on incorrect assumptions. Nevertheless, the techniques outlined above provide companies with useful measurements if used carefully.

7.6 SUMMARY

With the rise of supply chain management, the role of inventory in the production, distribution, and retail environments has undergone drastic change. Inventory management is no longer viewed as a narrow discipline centered on calculating lot sizes and economic order quantities, and expediting replenishment and customer orders. Increasingly, academics and practitioners alike are assigning inventory management a central role in driving marketplace leadership and integrating it with strategic and competitive planning. Effective inventory management in the twenty-first century is concerned with *overall* inventory performance and customer service levels as inventory affects not just individual companies, but the entire supply chain. Decisions concerning inventory cannot be made in isolation from strategic channel network objectives. Instead, inventory is considered an aggregate resource that spans and connects all nodes in the supply chain network and directs them to aggregate customer service goals.

Reevaluating the role of inventory requires a thorough understanding of the nature, functions, and costs associated with inventory. Inventory is defined as raw materials, components used in the assembly process, and finished goods. The fundamental reason why inventory is held is to serve as a *buffer* decoupling supply chain participants from the vagaries of customer demand on the one hand and limitations in the delivery capacities of suppliers on the other. In managing inventory buffers, planners must be diligent in determining and tracking costs arising out of both operations and inventory decisions. Informed inventory cost decisions are necessary if the firm is to be run effectively and efficiently. Control of inventory cost is paramount if supply channels are to exploit new markets, optimize information and communications systems, explore new forms of transportation, and strengthen the integration of the supply chain.

Without effective inventory control, the supply channel network will experience cost discrepancies and poor customer serviceability. Individual companies can vastly improve inventory accuracies with the use of several control tools. Fundamental is a clear definition of the transaction control points in the flow of inventory as it moves through the supply channel. Transaction control not only ensures that material is properly accounted for, but it also serves as a gateway to minimizing inventory shrinkage and the mismatching of materials and costs as they flow through the system. ABC Classification and cycle counting are additional tools that are employed by inventory managers.

Finally, the true test of channel inventory is how well it measures up to customer service and inventory investment performance objectives. The ability to provide the right product at the time and place desired by the customer at the lowest possible inventory investment is the foremost objective of every node in the channel network. In developing effective customer service performance measurements, companies must be precise in defining the relation of perceived customer wants and the ability of their channel of supply to match those wants. In the final analysis, customer service and inventory performance measurements cannot be considered independently of each other.

7.6.1 Supplement: Inventory Valuation Methods

I. **Standard Cost Method**

This method of determining inventory cost consists of summarizing all of the costs incurred in an item's acquisition. These costs are reviewed and then accepted as the "standard" or benchmark used to determine the cost efficiency of subsequent orders. This method is used mostly for a manufactured item where tracking the cost variances between what *actually* was expended and what *should have been* (the standard) expended during production is critical in determining production performance. The example shown is for establishing a standard cost for a manufactured item. The critical cost drivers are materials, labor, and overhead (*Note:* all monetary values expressed in US$).

1. *Material cost*: (cost of the materials and components used to make the finished good)
   Part A. 3.45 per unit. Quantity required: 3
   Part B. 4.58 per unit. Quantity required: 5
   Part C. 2.23 per unit. Quantity required: 2
2. *Labor cost*: (operators needed to make the finished good)
   Labor. 22.00 per hour
   Setup. 32.50 per hour
   Setup hours required: 2 hrs. (1 setup person)
   Run time to make a lot size of 10: 3 hrs. (3 operators)
3. *Overheads:* (indirect costs needed to make the finished goods)
   122% of the labor cost
4. *Cost calculation* (lot size of 10 units)
   Material:
   Part A: 3 units × 3.45 = 10.35
   Part B: 5 units × 4.58 = 22.90
   Part C: 2 units × 2.23 = 4.46
   Total: 37.71 × 10 units lot-size = 377.10
   Labor/Setup:
   Setup: 2 hrs. × 32.50 × 1 setup person = 65.00
   Labor: 3 hrs. × 22.00 × 3 operators = 198.00
   Total: 65.00 + 198.00 = 263.00
   Overhead:
   122% of labor cost = 1.22 × 198.00 = 241.56
5. *Total cost (roll-up)*

Material	=	377.10
Labor/Setup	=	263.00
Overhead	=	241.56
Standard Cost	=	881.66

II. First In, First Out (FIFO)

This method of inventory valuation assumes that the cost of items sold in a period consists of the oldest inventory cost just prior to sales. By charging the oldest inventory cost to the sale, FIFO assumes that inventory at the end of the period consists of the most recent costs incurred. The rationale behind FIFO is that it reflects the fact that companies generally use the oldest items in inventory first so that they can continually turn over stock and prevent deterioration or obsolescence.

Review the below calculation for cost of goods and inventory balance calculations using the FIFO method (*Note:* all monetary values expressed in US$).

1. *Inventory transaction data*

Beginning inventory (10 units @ 1.00 per unit)		10.00
Purchases:		
No. 1 (25 units @ 1.40 per unit)		35.00
No. 2 (25 units @ 1.80 per unit)		45.00
Total:		80.00
Cost of goods available for sale (60 units)		90.00

2. *FIFO cost detail*

Cost of goods sold (cost of the *first* 40 units available)		
10 units @ 1.00 per unit (all of beginning inventory)	10.00	
25 units @ 1.40 per unit (all of purchase no. 1)	35.00	
5 units @ 1.80 per unit (from purchase no. 2)	9.00	
Total:		54.00
Ending inventory (cost of the *last* 20 units available)		
20 units @ 1.80 per unit (from purchase no. 2)		36.00

Note that the inventory remaining is valued at the last receipt of the item.

III. Last In, First Out (LIFO)

This method of inventory valuation assumes that the cost of items sold in a period consists of the most recent inventory cost just prior to sales. By charging the last inventory cost to the sale, LIFO assumes that inventory at the end of the period consists of the oldest costs incurred. This method is often used in periods of inflation when prices are rising, because it reduces inventory value and taxes (Note that this method is not recognized in some countries, such as Canada).

Review the below calculation for cost of goods and inventory balance calculations using the LIFO method (*Note:* all monetary values expressed in US$).

1. *Inventory transaction data*

Beginning inventory (10 units @ 1.00 per unit)		10.00
Purchases:		
No. 1 (25 units @ 1.40 per unit)	35.00	
No. 2 (25 units @ 1.80 per unit)	45.00	
Total:		80.00
Cost of goods available for sale (60 units)		90.00

2. *LIFO cost detail*

Cost of goods sold (cost of the *first* 40 units available)		
25 units @ 1.80 per unit (all of purchase no. 2)	45.00	
15 units @ 1.40 per unit (all of purchase no. 1)	21.00	
Total:		66.00
Ending inventory (cost of the *last* 20 units available)		
10 units @ 1.00 per unit (all beginning inventory)	10.00	
10 units @ 1.40 per unit (from purchase no. 1)	14.00	
Total:		24.00

Note that the inventory remaining is valued at the opening balance and first receipt of the item.

IV. Average Cost

This method of inventory valuation references the current cost of the existing inventory and the cost of the newest supplier invoice, and then uses some form of average to calculate the new inventory value from these two costs. Usually, firms will use some type of weighted average in which inventory invoice cost will be weighted by the quantity of the item received.

Review the below calculation for cost of goods and inventory balance calculations using the average cost method (*Note:* all monetary values expressed in US$).

1. *Inventory transaction data*

Beginning inventory (10 units @ 1.00 per unit)		10.00
Purchases:		
No. 1 (25 units @ 1.40 per unit)	35.00	
No. 2 (25 units @ 1.80 per unit)	45.00	
Total:		80.00
Cost of goods available for sale (60 units)		90.00

2. *Weighted-average cost* (50 percent weight)

Cost of goods available for sale		
Cost of goods available for sale	90.00	
Number of units available for sale	60	
Average cost per unit 90 / 60	1.50	
Ending inventory		
20 units @ 1.50 per unit		30.00
Cost of goods sold (40 units @ 1.50 per unit)		60.00

V. Actual Cost

In this method of inventory valuation, a specific received quantity and price for a given item are linked together and differentiated from other stocked quantities of the same item by associating the receipt with a unique identifier, usually a lot number. When an inventory issue occurs, it is necessary for the lot number to be chosen as part of the transaction. In this way, the discrete cost associated with the lot can be captured along with the quantity transacted.

Review the below calculation for cost of goods and inventory balance calculations using the actual cost method (*Note:* all monetary values expressed in US$).

1. *Actual cost transaction data*

Beginning inventory (Lot #1 - 10 units @ 1.00 per unit)	10.00
Purchases:	
No. 1 (Lot # 2 - 25 units @ 1.40 per unit)	35.00
No. 2 (Lot # 3 - 25 units @ 1.80 per unit)	45.00
Total:	90.00

2. *Actual cost detail*

Cost of goods sold (cost of the 40 units sold for two orders)	
Order #1 for 25 units	
10 units Lot # 1 @ 1.00 per unit	10.00
15 units Lot # 2 @ 1.40 per unit	21.00
Total:	31.00
Order # 2 for 15 units	
10 units Lot # 2 @ 1.40 per unit	14.00
5 units Lot # 3 @ 1.80 per unit	9.00
Total:	23.00
Ending inventory (20 units available)	
20 units Lot # 3 @ 1.80 per unit	36.00

DISCUSSION QUESTIONS

1. It has been said that customer service and inventory investment are two measurements that cannot be considered separate from one another. Explain.
2. What is meant by cost/benefit trade-offs relating to inventory? How can this management technique be applied to the first question?
3. What are some problems that can arise when each stage of a supply chain focuses solely on its own profits when making decisions? Identify some actions that can help a retailer and a manufacturer work together to improve their strategic fit.
4. Why do businesses carry inventory?
5. Describe the five general functions of inventory.
6. What are the different models by which inventory can be valued?
7. What are the objectives of inventory management?
8. Describe the utilization of trade-off decisions in the management of inventories.
9. Describe the seven classes of inventory.
10. Discuss the role of inventory in the financial life of the typical business. Is inventory an asset or a liability? Explain your answer.

PROBLEMS

1. M & K distributors stocks about 5,000 SKUs in their finished goods inventory. After a recent ABC Classification report was run, it was determined that the firm had 500 A items, 1,750 B items, and 4,750 C items. The business is open 250 days each year. If the cycle counting program requires that A items be counted monthly, B items quarterly, and C items biannually, how many items will cycle counters have to count each day?
2. Develop an ABC classification for the following 10 items.

Item #	Usage	Unit cost ($)	Annual $ usage	Cum $ usage	Cum % of $ usage
1	4,000	50			
2	7,000	13			
3	2,000	45			
4	7,000	9			
5	900	22			
6	400	525			
7	500	1,300			
8	700	15			
9	2,200	9			
10	300	4			

3. At year end, ABC Electronics analyzed its financial situation using the following results from the past year (expressed in US$ millions).

Cash		= 17
Accounts receivable		= 25
Inventory		= 250
Fixed assets		= 240
	Total assets	= 532
Sales		= 600
Total costs (cost of goods, general administration, taxes)		= 480

   a. What is the *net income*?
   b. What is the *return on assets* (ROA)?
   c. What is the effect on ROA if inventory investment is reduced by 10 %?

4. A retailer carries an average inventory of US$300,000. The retailer estimates capital costs at 10 %, storage costs at 25 %, and risk costs at 50 %. What is the annual carrying cost?

5. An inventory item has the following data:

   Daily demand is 100 units.
   Throughput time is 4 days.
   On hand balance is 600 units.

   What would be the throughput quantity?

6. Given the following information, calculate the inventory turnover ratio.

Sales is	US$200 million
Cost of goods is	US$150 million
Average inventory is	US$30 million
Carrying cost is	12 %

7. At year end, the ABC Company analyzed its financial situation using the following results from the past year expressed in millions.

Total costs is	US$480
Sales is	US$600
Fixed assets is	US$240
Cash is	US$17
Accounts receivable is	US$25
Inventory is	US$250

   What is the return on assets (ROA)?

REFERENCES

1. All definitions from the *APICS Dictionary* in this chapter are from the 14th edition (2013).
2. Wilson, Rosalyn. 2014. *25th annual "State of Logistics Report*." Oak Brook: Council of Supply Chain Management Professionals.
3. Reference the discussion in Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operation*, 4th ed. New York: Prentice Hall.
4. Wilson, *25th annual "State of Logistics Report*."
5. Reference the detail for how each one of the five inventory costing methods is calculated by reviewing the supplement at the end of this chapter.

8

Statistical Inventory Management

Chapter 7 discussed the purpose and function of inventory management. Among the major points covered were explaining why companies carry inventory, defining the purpose and function of inventory, detailing the components of inventory decision-making, defining elements of inventory cost, performing inventory valuation, and working with inventory cost-benefit trade-off analysis and performance measurements. This chapter continues the discussion on inventory management by examining how inventory is replenished in an

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_8) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_8, © Springer Science+Business Media New York 2015

independent demand (non-production) environment. Inventory is one of the largest investments made by the typical company. Effectively managing inventory replenishment enables companies to maximize company profits by maximizing customer service, minimizing operations costs, and minimizing inventory investment.

A critical activity required to realize these inventory objectives is determining when replenishment orders are to be released and what the order quantities should be. As inventory is consumed by demand, items must be reordered to prevent stock outs from occurring in the future. Selecting the proper ordering technique is the primary responsibility of the firm's materials/operations planning team. Their goal is to assess the demand and supply characteristics of each item, select the appropriate ordering technique that achieves least total cost and high serviceability, and launch and review replenishment orders to ensure they are delivered in a timely fashion. Ultimately, the materials/operations planning team determines the replenishment parameters guided by inventory cost-benefit trade-offs where the cost of ordering versus the cost of carrying inventories is carefully weighed.

Determining the most effective inventory replenishment techniques is one of a company's most important tasks, requiring a detailed understanding of general inventory concepts and the ability to apply mathematical models and statistical equations. The first section in this chapter details the contents of these techniques. From simple heuristic methods, such as visual and period review, to sophisticated computerized applications, such as the time-phased order point (TPOP), each technique provides planners with mathematical models to determine the inventory replenishment needs of the organization. Following the general overview, the chapter proceeds to a detailed discussion of statistical inventory replenishment, and an in depth exploration of reorder point and order quantity methods. Particular attention is paid to illustrating the relevant mathematical formulas and their proper application.

Once the basics of statistical inventory replenishment have been reviewed, the chapter goes on to outline the inventory planning process linking the inventory plan to the purchasing and postponement functions to be covered in Chapter 11. The chapter concludes with an overview of lean concepts and techniques for replenishment management. This chapter sets the stage for the discussion of statistical inventory replenishment management and distribution requirements planning (DRP) in a multi-echelon channel environment found in Chapter 9.

8.1 STATISTICAL INVENTORY REPLENISHMENT CONCEPTS

Before statistical inventory replenishment techniques are selected, the firm's inventory planners must be thoroughly conversant in the basics of statistical inventory management concepts and applications. These concepts require understanding the nature of inventory demand, the concept of stock replenishment, the replenishment review interval, and the basic terms of statistical inventory replenishment.

8.1.1 Understanding the Demand Driver

The fundamental purpose of inventory is to satisfy demand. Not all demand is, however, the same. Depending on the *nature* of the demand, inventory planners will apply different ordering or replenishment techniques that best match the characteristics of the source of each item's demand. Perhaps the most fundamental concept in replenishment inventory management is the principle of *independent* and *dependent demand*.

The *APICS Dictionary* defines independent demand as

> demand for an item that is unrelated to the demand for other items. Demand for finished goods, parts required for destructive testing, and service parts requirements are examples of independent demand.

For example, inventory in a classic distribution or retail environment is subject only to independent demand. In the management of these items, inventory planners use ordering methods driven by statistical calculations derived from demand history to manage each item individually. Since the goal is to have just the right quantity on hand to service the customer without creating excess inventories, these ordering methods seek to determine the best time to reorder by calculating the correct levels of cycle and safety stocks, and the optimal cost-benefit trade-offs between money spent in carrying inventory versus the cost of lost sales.

The prime characteristics of independent demand are the following:

- Demand is independent of company inventory decisions.
- Demand is subject to a level of random variation.
- Independent demand items are usually planned and managed without reference to other items.
- Planning usually involves the use of forecasting techniques designed to predict future demand based on past historical usage.
- These items are best planned with some form of safety or reserve stock to counterbalance forecasting variability.
- The critical question for inventory availability is one of *quantity* rather than *timing*.

Conversely, an item is subject to *dependent demand* when it is directly related to, or derived from, demand for another item. Item dependencies are described as *vertical*, such as when a component is required to build a subassembly or finished product, or *horizontal*, as in the case of an accessory that must accompany the product. Dependent demand is characteristic of production inventories in a typical manufacturing company. Manufacturers purchase raw materials and components that are not sold as received but are stocked and then issued to production to build the finished products the firm sells. This demand is conceived as being created internally as a function of scheduling items to be converted into higher-level assemblies and finished products. Dependent demand items are described as follows:

- Dependent demand items are always planned and managed in relation to other items as detailed in the bills of material (BOMs) in which they are specified.
- Replenishment quantities for production inventories are precisely determined by establishing the demand on "parent" level assemblies and then using the BOM structure to calculate exactly the "child" item requirements and due dates.
- Future demand for production inventories should not be forecasted.
- Inventory planning decisions directly impact the demand for these items.
- Dependent demand items rarely use safety or reserve stocks.
- The critical question for inventory availability is one of *timing* rather than *quantity*.

In some cases, a raw material item, component, or subassembly is subject to *both* independent as well as dependent demand. A good example of dual demand is an item that is used to build products but at the same time is sold separately as a spare part. Figure 8.1 provides an example of a bill of material structure containing an item (D) subject to *both* independent and dependent demand. In such cases, the portion of the demand on the item that is subject to independent demand must be planned by using some form of forecast. This forecasted demand is then added to the item's calculated dependent demand to provide the total demand.

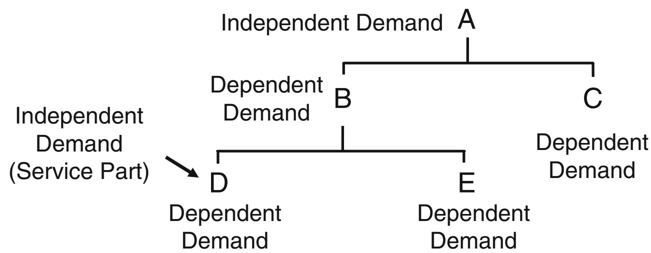


FIGURE 8.1 Independent versus dependent demand.

Determination of item demand status is the first step in selecting the appropriate inventory planning technique. Independent demand items are best planned using ordering methods that utilize forecasts to project demand into future periods. Such techniques plan products based on individual item demand *magnitude* without reference to other items. Dependent demand items, on the other hand, are best planned using time-phased inventory planning techniques, like material requirements planning (MRP), that link items together so that matched sets of items can be ordered together and in the proper quantities as specified by the product structures to which they belong. Statistical methods should not be used to manage dependent demand items.

8.1.2 Concept of Stock Replenishment

Inventory subject to statistical ordering techniques are managed according to the concept of *stock replenishment*. The theory behind stock replenishment is that for each item, an optimal stocking and ordering quantity can be determined either statistically or through some form of validated heuristic. *Replenishment* means to become full again; to restore to a state of original fullness. Simply, the object of stock replenishment is to ensure that the optimum stocking levels for all items is always maintained. Stock replenishment techniques are structured to compensate for the inability of planners to determine the precise timing and quantity of demand and supply in the short-term future. Since it is often difficult to determine exactly when a demand order will occur, planners using replenishment techniques seek to always have sufficient on-hand stock to satisfy the orders that do materialize. Poorly determined inventory levels or failure to launch replenishment orders on a timely basis risks item stock out.

When viewed from the standpoint of planning, inventory balances consist of two functions introduced in Chapter 7. The first function is *cycle* or *working stock* and is described as inventory that provides the firm with the ability to respond to the average level of demand occurring during the period between replenishment order release and receipt. The second function of inventory, termed *safety* or *buffer stock*, is to provide inventory that is added to cycle stock to guard against the event of variance in the normal distribution of demand and supply. The objective is to determine when a resupply order action should occur to preserve the integrity of inventory serviceability in the face of demand and supply variability.

The mechanism that alerts planners to the possibility of an impending stock out is some form of *trigger point*. Whether it is derived using a mathematical model or a rule of thumb, the trigger point provides inventory planners with a signal to order more inventory if a projected stock out is to be avoided. The trigger point is calculated by using the estimated demand during the replenishment lead time to which is added a calculated safety stock to compensate for possible fluctuations in demand and supply.

Once the trigger point is tripped, a stock replenishment order needs to be created. The calculation of the exact quantity to order has historically been a hotly debated topic. Whether it is simple or complex, each replenishment technique attempts to strike a balance between the cost of ordering and the cost of stocking inventory. The more an item is ordered, the less the carrying cost, but the greater the cost of ordering. Conversely, the less an item is ordered, the less the ordering cost, but the greater the carrying cost. Choosing a replenishment technique is, therefore, more than selecting the appropriate model; it is also a strategic decision to choose an inventory replenishment method that requires planners to structure customer service and inventory control around how costs are to be accumulated.

Visually, the inventory replenishment concept is illustrated through the use of a "saw-tooth chart" (Figure 8.2). The chart illustrates the relationship of the elements of replenishment techniques, such as cycle stock, safety stock, trigger point, and order quantity. The model functions as follows. At a given moment in time, the inventory quantity of an item is indicated by ***A***. In the chart, the available quantity is sufficiently large enough to satisfy the normal anticipated demand through time. As demand orders consume inventory, the stocked quantity is reduced, as shown by the downward-sloping line. When the inventory reaches the predetermined trigger point, indicated by ***B***, the system alerts the inventory planner to release a replenishment order that will restore the stock level to some point above the trigger

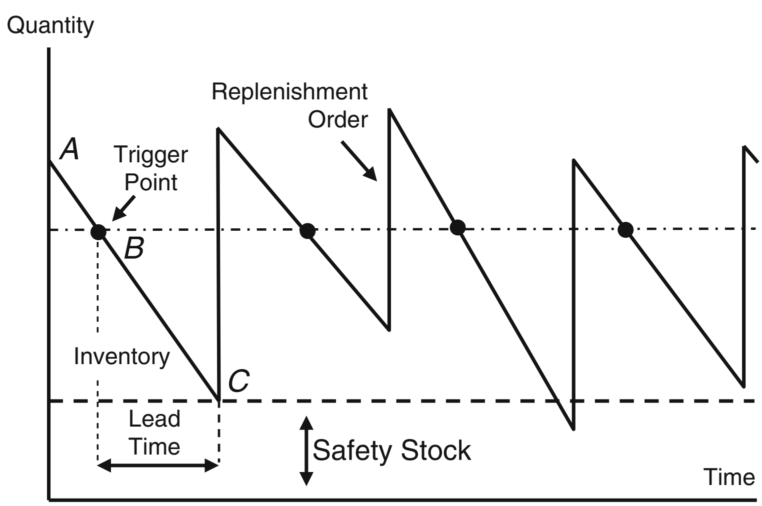


FIGURE 8.2 Basic inventory replenishment model.

point. The remaining inventory continues to be consumed by demand during the replenishment lead time until the supply order is received.

Because it is often difficult to determine just when demand will occur or when the replenishment order will arrive, replenishment techniques are best used with some form of reserve or safety stock. Whether or not this inventory is actually consumed depends on random variations in the pattern of demand and supply. In the first 2 replenishment cycles shown in Figure 8.2, the safety stock was not affected by demand. In the third cycle, however, demand drove available inventory below the safety stock level, and some safety stock was consumed. Once the replenishment order is received, indicated by ***C***, it is added to the remaining on-hand quantity, and the replenishment cycle begins once again.

The following principles should be understood when using stock replenishment techniques.

1. The basic components of the method (trigger points, replenishment quantities, lead times, and safety stock) are fixed, do not reflect short-term variations, and need to be periodically recalculated through time to ensure they reflect the changing dynamics of demand and supply.
2. Exactly when an item will trip its trigger point is unknown until the actual moment it occurs.
3. The size of the replenishment order quantity usually corresponds to some calculation that balances the cost of ordering and the cost of stocking an item.
4. With the exception of the fixed order review technique, the interval between replenishment ordering is variable. The higher the usage, the shorter the order interval, and vice versa.
5. The reserve or safety stock inventory is considered to be on-hand at all times to guard against demand and supply variations.
6. Statistically, the inventory balance of a given item is equal to one-half the reorder point quantity plus the required safety stock.

8.1.3 Replenishment Review Interval

A fundamental decision made when using inventory replenishment techniques is determining *when* an item should be reviewed for possible replenishment action. The inventory review interval is considered from two perspectives. Replenishment techniques are subject to either *continuous* or *periodic* review. Once this choice is made, planners then assign appropriate replenishment techniques to each item that will govern how the company's inventory will be managed.

When using a continuous review system, planners examine an item's balance record each time a change occurs to its inventory level. If it is found that the new balance record is below the item's predetermined trigger point quantity, the item is then reviewed for possible replenishment. To make this system work, it is imperative that all changes to inventory records be recorded in an accurate and timely fashion and that a new balance record is generated for each issue or receipt. This review model is often termed a *variable cycle/fixed order quantity* method because the actual timing of the review is dependent on when a change to the balance record actually occurs. When the order trigger is engaged, usually a fixed quantity replenishment order is suggested. The availability of affordable computers and software has facilitated this time consuming and exacting requirement. Tools such as bar code readers, radio-frequency identification (RFID), and wireless scanners are pushing inventory accuracy and timeliness of reporting to new dimensions necessary to effectively manage the inventory systems of the twenty-first century.

The mechanics of a periodic review system, on the other hand, are very different from continuous review. There are two critical factors that need to be established on an item-by-item basis: (1) a *fixed review interval* and (2) an *order-up-to* target inventory level. The review interval is considered as *fixed* because the balance records of items are reviewed only at a predetermined point in time (for example, every 4 weeks) regardless of the actual inventory balance. As the review interval date for each item arrives, inventory planners review the inventory balance record for each item and generate a replenishment order in sufficient quantities to raise the inventory position to the order-up-to target quantity. During the period between order intervals, inventory stocking level records are not reviewed. This system is often called a *fixed-cycle/variable-order quantity* method because planners review item balances at a set time and then order enough stock to increase the inventory to the order-up-to target quantity.

The use of continuous and periodic review systems each have their separate advantages as illustrated in Table 8.1. The most obvious distinction between the two systems is operational expense. Continuous review requires significant manpower and computerized resources to analyze and keep inventory balance records accurate. A periodic review system, on the other hand, does not need ongoing transaction control and requires item review only when the order interval date occurs. Whereas continuous review systems permit greater overall inventory and item cost control, periodic systems provide planners with replenishment predictability. Because the review cycle is fixed, inventory management can plan resources and budgets for inventory review at a minimum cost. In regard to item control, continuous review is best used to control fast-moving products, whereas periodic review is best used for slow-moving items, bulk commodities, and products ordered together in product families. Finally, continuous review systems provide for higher levels of customer serviceability by providing timely on-hand balance status and safety stock protection against random variations in demand. The choice of continuous or period review systems depends on several factors such as customer satisfaction strategies, product cost, storage and transportation, and the availability of information systems and support staffs.

TABLE 8.1. Advantages of Continuous and Period Review Systems

Issue	Continuous	Periodic
Maintenance expense		X
Ordering by item family		X
Lower inventory investment	X	
Replenishment predictability		X
Overall control	X	
Fast moving items	X	
Slow moving items		X
Higher customer service	X	
Computerization required		X
Lower purchasing costs		X

8.1.4 Basic Terms of Statistical Inventory Replenishment

Inventory replenishment mechanics are driven by nine main components. Although some of these components have already been referenced, it is important to thoroughly grasp the function of each before a full discussion of replenishment techniques begins.

- *Demand*. This component is defined as a need for a particular product or component. Demand comes from any number of sources, such as a customer order, a forecast, an interplant requirement, a request for a service part, or production. Demand reduces the available on-hand balances of items. The more the demand for an item occurs at a stable rate, the easier it is to determine when it will need to be replenished.
- *Cycle stock*. Cycle stock is defined as the average amount of inventory on hand for a product sufficient to satisfy demand during the replenishment lead time. The size of the cycle stock is a function of average usage, ordering lot quantity, and replenishment lead time.
- *Safety stock*. Safety or buffer inventory is defined as a quantity of stock planned to be in inventory to protect against fluctuations in demand or supply. This extra safety inventory is held in stock in addition to the cycle stock. If the exact demand for products was always known and rarely varied, cycle inventories would be sufficient to supply demand. In real life, however, demand is *uncertain*. The purpose of safety inventory is to guard against the possibility of higher than expected demand or variation in supply that will cause a stock out.
- *Replenishment trigger*. The event that alerts planners to start replenishment action is some form of *replenishment trigger*. This trigger could be a visual check of inventory levels, an empty stocking container, or a statistically derived reorder point. The replenishment trigger provides a signal that the current on-hand balance for an item equals the anticipated demand for the item during the replenishment lead time.
- *On-hand balance*. This component establishes the current available inventory balance of an item. This inventory record signifies the quantity of stock that is available for all demand occurring in the future. Basically, as long as the on-hand balance is equal to or greater than demand during the replenishment lead time, no order action is required of inventory planners.
- *Review interval*. This component defines at what point in time inventory planners should review the balance records of items for possible replenishment action. Replenishment techniques are subject to either *continuous review* or *periodic review*.
- *Lead time*. This component defines the span of time from the moment the need for a replenishment order is identified until it has been received. The lead time is composed of several possible time elements such as order preparation, order transmission, supplier production and delivery time, transportation, receiving, and order put away.
- *Reorder quantity*. Once the trigger point is reached, a replenishment order needs to be created that will restore the stocking level to some point above the trigger point. The goal of determining the size of the reorder quantity is to strike a balance between the cost of ordering and the cost of stocking the inventory. Once the replenishment order is received, the quantity is added to the current on-hand balance, and the replenishment cycle begins again.

- *Lot size*. This component determines the standard quantity in which items are either produced or purchased. The lot size must be equal to or greater than the demand during the replenishment lead time. For items that are produced, the lot size is calculated as the quantity that balances the cost to make it and the cost to stock it. For items that are purchased, the lot size is calculated as the quantity that balances the cost to order it and the cost to stock it. In both cases, as the lot quantity increases, the cost for each item in the lot decreases. Planners must be careful, however, not to increase the cost of carrying an item just because the per-unit purchase cost declines when acquired in a large lot size.

8.2 INVENTORY REPLENISHMENT TECHNIQUES

In a business environment where demand is constant and replenishment goods arrive from the supply source just as they are needed, companies can function with little or almost no stocked inventories. In most environments, however, neither of these two conditions is possible. Inventory planners, therefore, must use replenishment techniques that provide sufficient coverage of demand requirements while providing for the lowest ordering and carrying costs. There are several replenishment techniques inventory planners may use to accomplish these objectives. Some are very simple and utilize rule-of-thumb heuristics. Other techniques require the use of mathematical and computerized models. Regardless of the level of sophistication, all replenishment techniques attempt to answer the following fundamental questions:

- What is the demand?
- What is currently available?
- What is on order?
- What will need to be ordered?
- When will orders need to be released?
- How much should be ordered?

How planners answer these questions is critical in selecting the proper inventory replenishment technique. Replenishment decision models for products subject to independent demand take many forms, but they are all related to one of the following:

8.2.1 Visual Review System

This system is a relatively simple inventory ordering technique in which replenishment is determined by physically reviewing the quantity of inventory on hand. If replenishment is required, a target quantity is ordered that restores balances to a preestablished stocking level. The replenishment trigger is determined by such simple decision rules as reorder when the bin is half-full, or when there are two pallets of stock remaining. Visual review systems can be used effectively for very low-volume or low-cost commodity items with short lead times, and for controlling floor stocks located near the point of use. Also, this technique is particularly useful in controlling items such as paints and lubricants that are consumed in difficult to measure quantities. The prime advantage of this system is the low cost of record keeping and minimal training for employees. The disadvantages are that organizations cannot ensure items are being reviewed on a timely basis; random storage of multiple product lots may make it difficult to view all of the stocked inventory on a given item; and ordering rules are rarely updated to reflect changes in current demand, supply, and lead-time patterns, resulting in either possible overstocks or shortages.

8.2.2 Two-Bin System

This technique is defined as a fixed-ordering system in which inventory is carried in two bins (or some other form of container). One of the bins is located in the forward picking or process area, and the other is held in reserve either at the processing area or preferably in a reserve location in the stockroom. Procedurally, when the picking bin is emptied, the reserve bin is brought forward from the stockroom to service the empty bin. The empty bin serves as the trigger for replenishment. Often a control card containing such information as item number, order quantity, supplier, and so on, accompanies each bin and is used for order reference. The quantity required per bin is calculated as the minimum cycle stock necessary to service demand while waiting for the arrival of the replenishment stock from the supply source. When the replenishment quantity arrives, it is placed in the empty bin along with the control card and stocked in a reserve location until the forward picking bin's inventory is depleted.

Visual review and two-bin systems are widely used for inventory control. These techniques are easy to understand and implement and cost very little to operate. Because they are so easy to use, however, they can be abused and misapplied. The following points must be taken into consideration when using this technique:

- It is best used for low-cost, bulk, or low-volume items whose replenishment lead times are short. Items using these methods for the most part would be classified as C items in an ABC classification distribution.
- Because stocking levels are not tied directly to customer demand, a two-bin system results in needlessly high levels of inventory.
- This technique is insensitive to changes in demand patterns. It requires that a specific order quantity be established. For the most part, the bin quantity for an item is determined using the demand characteristics at the time the decision rule is calculated. Often the replenishment quantity is in the form of an economical lot size. Rarely are these quantities adjusted to reflect actual demand through time.
- The advantage of using a two-bin system is discounted if the time and money saved is not used to establish tighter controls over high-value, high-volume items.
- The use of visual controls is usually associated with loose transaction control, whereas perpetual record keeping is associated with tight controls over inventory. Neither is necessarily true. The key to selecting an inventory replenishment technique is to match the level of cost control required with the cost of each stocked item. As an example, because of its very high usage, a low-cost commodity item purchased in bulk, such as a fastener, may be classified as an A item. Using a visual control technique is the appropriate choice for this item because it ensures required availability while eliminating needless high-volume recordkeeping.
- For those companies involved in production or postponement processing, the assembly of a finished good item requires the availability of Class C as well as Class A items.

Poorly controlled C items will result in item shortages, preventing the completion of manufactured products. The basic rule for managing low-cost, commodity-type items using a two-bin system is to "have plenty on-hand."

8.2.3 Periodic Review

In this ordering system, a *fixed review cycle* is established for each product, and replenishment orders are generated at the conclusion of the review to meet a predetermined maximum stocking level. The review cycle is established in days, weeks, months, or quarters, whichever best satisfies the demand requirements. There are several advantages to using this method. It does not require perpetual inventory record keeping and is inexpensive to use. The system, also, can be maintained manually without the use of a computer. Periodic review is best used to control commodity-type inventories characterized by many small issues, such as occurs in a grocery store or an automotive small parts service center.

8.2.4 Reorder Point

In this replenishment system, a targeted stocked quantity is determined as the reorder or trigger point. When the inventory position falls below this reorder point, replenishment action is taken to restore quantities back above the reorder point. The quantity to order is manually determined, or some form of *economic order quantity* (EOQ) can be used. Unlike visual review, two-bin, and periodic review methods, the reorder point technique requires close perpetual inventory transaction control. As receipts, adjustments, scrap, shipments, transfers, and so on occur, inventory control must perform detailed record keeping activities that enable planners to determine whether resulting balances have fallen below the assigned trigger levels and warrant replenishment action.

8.2.5 Time-Phased Order Point (TPOP)

Whereas the replenishment review and action mechanisms of the four methods discussed above are different, conceptually they are all closely related. Each attempts to establish the point *when* a replenishment order needs to be generated to prevent stock out in the face of normal demand and then to suggest an economic or target order quantity to be purchased. In contrast to these systems, TPOP is a computerized replenishment tool that plans inventory needs in a priority-sequenced, time-phased manner to meet customer and forecast demand as it occurs. This technique is at the heart of material requirements planning (MRP) and distribution requirements planning (DRP) systems used for the control of production and distribution channel inventories.

The major advantage of the TPOP method is that inventory order action is triggered by matching supply with *anticipated* demand as it is planned to occur in future time periods. At the point in the future where demand exceeds the supply, the system alerts the inventory planner to order the item according to a predetermined lot size and have it available on the date when the anticipated stock out appears. In addition, each time the TPOP computer application is generated, the system will resequence demand and supply relationships and suggest a new set of required order actions for the planner.

8.2.6 Lean Inventory Systems

During the past decade, the use of lean techniques to run supply chain inventories has been growing. Although the technique originated on the production floor as a way to eliminate waste in the production process, supply chain planners have found that lean offers them an approach targeted at eliminating waste in such logistics system functions as transportation, warehousing, and quality control. In addition, lean provides supply channels with new opportunities for inventory control, purchasing management, and buyer-supplier relationships. Lean replenishment techniques use methods such as *Kanban* cards to trigger inventory replenishment and purchasing contracts that ensure product quality and delivery.

8.3 REORDER POINT SYSTEMS

A common technique used to determine when an item needs to be replenished is the *reorder point system*. The reorder point acts like an alarm alerting planners that the current inventory balance on an item has fallen below its trigger point quantity and needs to be replenished. The reorder point is defined in the *APICS Dictionary* as a “set inventory level where, if the total stock on hand plus on order falls to or below that point, action is taken to replenish the stock.”

8.3.1 Reorder Point Basics

The reorder point (ROP) is classically expressed by the following formula:

$$ROP = \text{Anticipated } demand(D) \times lead\ time(LT) + \text{safety } stock(SS)$$

For example, if the average historical demand for a given item is 100 units a week, the replenishment lead time from the supplier is 2 weeks, and the safety stock is 50 units, then:

$$ROP = 100(D) \times 2(LT) + 50(SS) = 250\,\text{units}$$

In other words, the reorder point consists of sufficient inventory to satisfy projected *demand* during the interval of the 2 week replenishment *lead time*, plus a quantity of reserve inventory (*safety stock*) to account for possible variation in supply and demand. Figure 8.3 provides a visual of the reorder point elements. Before proceeding further, it is important to review in detail each of the elements of the reorder point calculation.

8.3.1.1 Demand

Of the elements of the reorder point formula, calculation of demand is perhaps the most important. *Demand* is defined as the quantity consumed by orders over a designated period of time. Demand originates from a number of sources. It comes from actual customer orders, interbranch resupply requirements originating from satellite warehouses in the distribution network, production processing, and internal company needs. When calculating demand, planners must first be certain that all demand transactions are posted. Inventory history is recorded for all types of transactions from receipts and adjustments to transfers and scrap. In compiling historical demand in the reorder point calculation, only valid demand should be considered. Customer orders, for example, are always considered as historical demand.

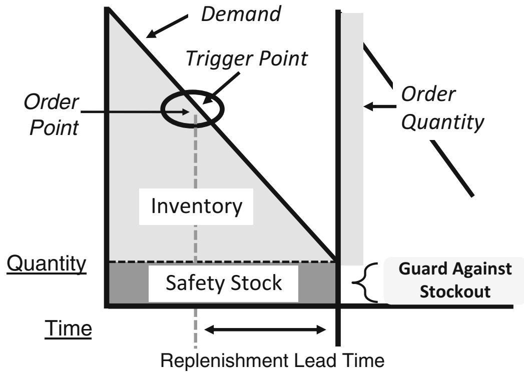


FIGURE 8.3 Reorder point system.

On the other hand, transactions created by interplant transfers and inventory expended for internal use, such as assembly, kits, and so on, need to be closely examined before being counted as reorder point demand. Normally, transactions generated by interplant transfers from the producing plant or the central warehouse to satellite warehouses should be considered as valid reorder point usage. In this case, the satellite warehouse is considered as an *internal customer* whose requirements are as important as the central warehouse's external customers. When, however, a satellite warehouse transfers goods to another satellite warehouse, the transaction should *not* be considered as reorder point demand. The reason for this is simple. When the collective demand for the satellite warehouses is calculated and orders placed on the central supplying warehouse, the demand will be overstated by the satellite-to-satellite warehouse transfers. Replenishment inventory planning in a supply chain environment is further discussed later in this chapter. Finally, all forms of internal usage, that is, for components consumed in the production process, should *never* be included as part of reorder point usage. Such items, in fact, are really subject to *dependent demand* and are best planned through the use of material requirements planning (MRP).

Accurately determining historical demand is a critical part of the reorder point system. Calculating reorder point demand has three requirements:

1. Demand is determined for each inventory item independently of other items.
2. Demand is expressed as a specific number of units.
3. Demand is related to a defined time period.

All three of these requirements rest on a simple assumption: *The actual demand for inventory that occurred in the immediate past will most likely be repeated in the immediate future*. In other words, if sales for the past 6 months of a given item averaged 225 a month, then it can be safely assumed that sales for the next month will average the same amount.

This assumption of uniformity of demand must be used with caution. When demand for an item during replenishment lead time is, indeed, *level* or *deterministic*, inventory planners can safely assume that future demand will be similar to past demand. In reality, planners rarely count on items having such predictable and constant demand. As a result, reorder points are best planned by determining the past demand usage combined with either historically derived or forecasted estimates of the anticipated fluctuation around the mean demand. Adjusting the reorder point demand to account for possible demand deviation is important before using it in the reorder point calculation.

One way to arrive at the adjusted demand value is by establishing how many past periods of demand are necessary to review to arrive at an adequate picture of average demand. The demand during these periods is summed and averaged, and then used as the demand value for the next period's reorder point calculation. An easy way to calculate the demand without having to use large amounts of past history is to apply a smoothing factor to the current and past demand values. The formula for this process is

$$\text{New demand average} = \alpha(Dt) + (1 - \alpha)(Dt - 1)$$

where

α is the smoothing factor
D is the demand
t is the current period

Often inventory planners will observe upward or downward trends in demand for a given item through time. Although the calculation of a new demand average will adjust the current usage to accommodate for variations in the past usage average, the new value will lag behind the demand trend. Determining a *trend percentage* to be factored against the current demand average is the key to solving this problem. In the first step, the *difference* between the previous and the current smoothed demand average is calculated. Next, the new trend is calculated using the following formula:

$$\text{New trend} = trendt - 1(1 - \alpha) + \text{demand difference} \times \alpha$$

Once the trend is calculated, the new expected period demand is calculated as

$$\text{New period demand} = \text{trend}t(1 - \alpha)/\alpha + \text{current demand average}$$

Finally, the new period demand must be multiplied by the item lead time to arrive at the reorder point demand.

Exercise 8.1: Reorder Point Demand Using Trend

The inventory planners at ABC electronics are calculating the reorder point demand for an item exhibiting an increasing weekly sales trend. Six weeks of data is presented as follows:

- The current has had 205 units of demand.
- The α factor is set to 0.1.
- The prior week's smoothed average is 174.46.
- The prior week's trend is 0.58.
- The lead time (*LT*) is 2 weeks.

Current week's adjusted demand is calculated as:

1. The new smoothed average demand = $\alpha(Dt)$ + $(1 - \alpha)$ $(Dt - 1)$ = 0.1 × 205 + 0.9 × 174.46 = 177.51
2. The difference is $Dt1 - Dt$ = 177.51 − 174.46 = 3.05
3. The new trend is Trend $t - 1(1 - \alpha) + \alpha \times$ Difference t = (0.58 × 0.9) + (0.1 × 3.05) = 0.82

4. The new *expected period demand* is ((Trend $t(1 - \alpha)/\alpha$)) + new smoothed average $t = 0.82 \times 0.9/0.1 + 177.5 = 184.93$
5. The new forecast of reorder point demand is new *expected period demand* $\times$ *LT* $= 184.93 \times 2 = 370$ units.

Many companies have inventory subject to cyclical or seasonal patterns. As time passes, demand usage for such products rises and falls according to regularly expected cycles. In addition, trend must be considered as part of the seasonal calculation. Calculating seasonal demand items begins by determining the demand for a cyclical period, such as 1 year. The primary activity is to compare the demand for the current period with the demand for the same period 1 year in the past, or the *base series.* A common method to arrive at the base series is to use the average of the demand of the surrounding quarter from last year. The next step is to calculate the demand by dividing the current demand by the base series. The remaining steps follow closely the trend calculation described above.

Exercise 8.2: Cyclical Order Point Demand Using Trend

The inventory planners at ABC Electronics are calculating the reorder point demand for an item exhibiting cyclical demand. The data have been collected as follows:

- Thirteen months of past demand has been assembled.
- The α factor is set to 0.1.
- The $(1 - \alpha)/\alpha$ factor is calculated as 9.0.
- The current month's demand is 145 units.
- The previous month's average ratio is 1.098.
- The previous month's trend is 0.0034.
- The current base series is 119.7 (calculated by using the surrounding quarter demand from the previous year).
    1. New *demand ratio* = current demand/current base series $= 145/119.7 = 1.211$.
    2. New *average ratio* $= (1 - \alpha) \times$ previous average ratio + ($\alpha \times$ new demand ratio) $= (0.9 \times 1.098) + (0.1 \times 112.11) = 1.109$.
    3. The *difference* is new demand ratio – new average ratio $= 1.211 - 1.109 = 0.011$.
    4. The new *trend* is $(1 - \alpha) \times$ previous trend + ($\alpha \times$ current difference) $= (0.9 \times 0.0034) + (0.1 \times 0.011) = 0.0042$.
    5. The new *expected ratio* is new period average ratio + $(1 - \alpha)/\alpha$ + new trend $= 1.109 + 9 + 0.0042 = 1.148$.
    6. The new *expected demand* is new expected ratio $\times$ current base series $= 1.148 \times 119.7 = 137.36$.

The formulas detailed above represent various methods of calculating maximum reasonable demand during replenishment lead time. Selecting the appropriate formula for each stocked product is a time-consuming affair that must bear the proof of correlation to actual demand through time. The most appropriate test is to simulate each before one is finally selected. Usually, the choice comes down to either a technique that focuses on inventory cost or on customer service. In the final analysis, the choice depends on the strategic inventory objectives of the firm [1].

8.3.1.2 Lead Time

While not as complex a concept as reorder point demand, the identification of the lead times necessary for the reorder point calculation can be a slippery affair. Lead time is defined as:

> the total amount of time that spans the period beginning from the date an inventory replenishment order is identified until the date the stock is received, put away, recorded in the inventory control system, and available for sale or use.

The elements of replenishment lead time are the following:

- *Replenishment order action identification.* This element establishes the time it takes for the inventory planner to review and select products for replenishment order action. Time elements at this stage are composed of such activities as reviewing stock levels, validating replenishment techniques, and analyzing open replenishment orders.
- *Order preparation.* Once products to be ordered are identified, time must be allocated for such preparation actions as replenishment order generation and grouping of product lines to meet supplier discount requirements. Another important element is determining the time it takes to search and select the proper supplier, as well as any pricing or transportation negotiation that must transpire.
- *Order transmission.* Replenishment orders need to be printed, verified, and transmitted to the appropriate supply source. Technology tools, such as electronic data interchange (EDI) and the Internet, have significantly reduced the time required for order transmission almost to a matter of moments.
- *Supply source processing time.* This is the total time required for the supply source to process the order, pick and pack it, and ship it to the ordering source.
- *Receiving.* Once the replenishment order arrives, time is spent in such activities as receiving, checking, quality control, and staging.
- *Item restocking.* This final element of lead time is composed of receipt movement, put-away, and any final information recording. Once the replenishment order is marked as received and ready for customer shipment, the product's lead-time cycle is considered complete.

Lead times are notorious for being approximations or estimates rather than a precise value that inventory planners can consider as a fixed constant. When determining lead times exhibiting variability, several techniques are used. In one method, planners could designate a lead time for a product long enough to include all reasonable resupply timing occurrences. Another technique is to average the actual recorded lead times and use that value, or a smoothed value, as the valid lead time for the next order. In today's computerized business environments, approximations and rule-of-thumb techniques are falling into disfavor. Customer service strategies are not only demanding firm lead times but also process improvement programs aimed at continuously shortening every step in the fulfillment process.

8.3.1.3 Safety Stock

If a company had a totally captive marketplace where customer demand was deterministic, historical usage during the replenishment lead time could be calculated accurately with a great deal of certainty. In such an environment, safety stock would be unnecessary. Supply orders would arrive just in time to replenish stock to meet the next cycle of demand. In reality, demand usage is subject to uncertainties. A wide variety of factors, such as prevailing economic conditions, cycles in popular taste, government regulation, technology, changes in customer buying habits, transit times, order processing times, and production schedules, cause wide variances in demand. In addition, uncertainties caused by variations in supplier lead times and errors in delivery quantity and quality expose the firm to potential stock out. Variances in demand and replenishment lead times have the most unfavorable impact on statistical planning models.

Table 8.2 provides an example of the actual weekly demand for a product for a 10 week time period. The replenishment lead time is 1 week, and demand normally averages about 1,000 units per week. The reorder point calculation places the reorder point for this product at 1,000 units (1 week lead time × 1,000 units). Actual customer orders for the item during the past 10 weeks, however, have ranged from as small as 550 units to as large as 1,425 units. Whereas it is true the 1,000 unit reorder point satisfies the average demand, there were occasions when actual orders exceeded the available inventory and the item was stocked out. In fact, 5 out of the 10 weeks experienced demand that exceeded the average inventory. A possible solution would be to carry an additional 425 units to cover the maximum demand during the 10 periods. However, by stocking the maximum quantity the firm incurs excess inventory carrying costs during the other 9 weeks when demand is less than the high of 1,425 units.

TABLE 8.2. Instance of Item Demand

Week	Sales forecast	Actual sales	Absolute deviation
1	1,000	550	450
2	1,000	1,350	350
3	1,000	1,175	175
4	1,000	1,125	125
5	1,000	750	250
6	1,000	1,425	425
7	1,000	675	325
8	1,000	876	124
9	1,000	1,300	300
10	1,000	875	125

When determining safety inventories, planners decide on just how much of an inventory buffer is to be kept on hand. A firm, obviously, could not possibly carry inventory to cover the maximum demand for all products stocked. If a high level of safety stock is kept, planners can expect high customer service levels but with accompanying high inventory stocking costs. Conversely, if safety stocks are set low and demand is higher than expected, inventory carrying costs will drop, but so will customer service. The question then becomes how much safety coverage is desired: 80 %, 90 %, 100 %?

To begin calculating the safety stock, planners first determine what is termed the *standard deviation* (σ or sigma); that is, the quantity deviation of the actual demand versus the average demand. Using the standard deviation requires understanding the *normal distribution* of demand around the statistical mean of demand for n number of periods. Statistically, the instances of demand tend to cluster around the average demand and are measured by the deviation from the average demand. The assumption of *normality* makes it possible to measure the extent to which actual demand deviates from the mean. Charting how much individual instances of demand differ from the statistical mean assists planners to calculate what level of safety inventory is required to satisfy a targeted level of demand service.

Figure 8.4 illustrates a *normally distributed curve*. Statistically, one standard deviation (or 1σ) accounts for $\pm$68.27 % of demand deviation from the mean. A standard deviation of 2σ would account for $\pm$95.45 % of demand deviation from the mean, and 3σ would account for $\pm$99.73 % of all demand deviation from the mean.

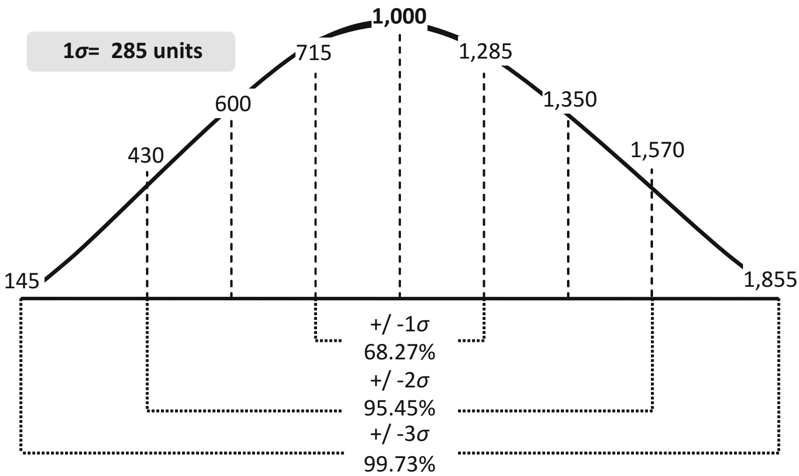


FIGURE 8.4 The normal distribution.

How the standard deviation works is illustrated by establishing a sample value of 1,000 units as the mean and 285 units as the standard deviation. Applying the standard deviation to the diagram shows that 1σ accounts for a quantity of $\pm$285 units from the mean of 1,000. If 1,000 and 1σ are added, the sum of 1,285 units cover 84 % of possible demand (the mean [50 %] plus 34.1 % of all instances of demand that could be expected to occur). 2σ is 1,570 units (1,000 + 285 + 285) and covers 97.7 % instances of expected demand. 3σ is 1,855 units and cover 99.86 % instances of expected demand. Finally, if 4σ is used, the amount of inventory carried is 2,140 units, and covers 99.99 % instances of expected demand.

The first step in calculating the standard deviation for an historical time series is choosing from one of two methods: *squared deviation* or *mean absolute deviation*.

1. The calculation for the squared deviation requires several steps: first, calculate the *absolute deviation* for each period and then square the value for each period. Next, determine the squared average by summing the squared deviations and then divide this value by the number of past periods (*number of periods -1* is used if there are less than 30 past periods). Finally, calculate the square root of the result. The calculated value is the *standard deviation* (σ). Using the data in Table 8.3, one standard deviation would be calculated as
   (a) 841,001/(10−1) periods = 93,444.56
   (b) $1\sigma = \sqrt{93,444.56} = 305.69$
2. A simpler, but less accurate method is to calculate the *mean absolute deviation* or MAD. The MAD is determined by first summing *n* periods of absolute deviations. Next, this value is divided by *n* periods. The *standard deviation* (σ) is then determined by multiplying this value by the *mean absolute deviation safety factor* of 1.25. Using the data in Table 8.3, one standard deviation would be calculated as
   (a) MAD = 2,649/10 = 264.9
   (b) $1\sigma = 264.9 \times 1.25 = 331.13$

TABLE 8.3. Determining Demand Deviation

Week	Sales forecast	Actual sales	Absolute deviation	Deviation^2
1	1,000	550	450	202,500
2	1,000	1,350	350	122,500
3	1,000	1,175	175	30,625
4	1,000	1,125	125	15,625
5	1,000	750	250	62,500
6	1,000	1,425	425	180,625
7	1,000	675	325	105,625
8	1,000	876	124	15,376
9	1,000	1,300	300	90,000
10	1,000	875	125	15,625
			Sum absolute deviation	2,649
			Sum squared deviation	841,001

Notice the difference between the two standard deviations that are calculated. The *squared deviation* method is more precise than the MAD method. The benefit of using the MAD is that is saves a lot of computation and it is usually close enough for most practical inventory control applications.

Once the standard deviation is calculated, its primary use is to assist inventory planners to calculate a meaningful safety stock. The best way to do this is for marketing and sales to determine the desired customer serviceability percentage to be offered for the item. This is an important decision. Normally, fast-selling items have a high service percent, while slow moving items have a low percentage. Once the customer service level has been determined, it is easy to calculate the safety stock. This is done by using the *table of safety factors for normal distribution*. Table 8.4 illustrates a shortened version of the table. The first step is to locate the desired service percentage in column *service level*. The second column contains a list of factors when using the *standard deviation* to calculate the safety stock. The third column contains a list of factors when using the *mean absolute deviation (MAD)* to calculate the safety stock. To calculate the safety stock, calculate the *standard deviation* (σ) of historical data by using either the *squared deviation* or the *MAD* method, determine the desired service level, move to the right on the table and select either the *standard deviation* or *MAD* column, find the corresponding factor, and then multiply it by the *standard deviation* (σ). The result will be the safety stock.

8.3.1.4 Safety Stock and Lead Time

The purpose of safety stock is to guard against the possibility of variances in demand during an item's replenishment period. In the above example, the standard deviation of demand of 305.69 to attain a targeted customer service level is sufficient to cover a one period lead time. As the lead time increases, however, the standard deviation must reflect the increased possibility of stock out. To solve this problem, an intermediate calculation must be performed before the safety stock is calculated. The formula is to calculate the standard deviation of the lead time by first finding the square root of the lead time (L) and then multiplying this value by the standard deviation of demand, or $\sigma L\sqrt{L}\sigma D$. Note that it is important that the time increment used for demand and for the item lead time are the same. For example, if the demand is expressed in weeks, the item lead time must be expressed in weeks.

TABLE 8.4. Table of Safety Factors

Service level (w/o stock out)	Standard deviation	Mean absolute deviation
50 %	0.00	0.00
75 %	0.67	0.84
80 %	0.84	1.05
84.13 %	1.00	1.25
85 %	1.04	1.30
89.44 %	1.25	1.56
90 %	1.28	1.60
93.32 %	1.50	1.88
94 %	1.56	1.95
95 %	1.65	2.06
96 %	1.75	2.19
97 %	1.88	2.35
98 %	2.05	2.56
99 %	2.33	2.91
99.5 %	2.57	3.20
99.6 %	2.65	3.31
99.7 %	2.75	3.44
99.8 %	2.88	3.60
99.9 %	3.09	3.85
99.93 %	3.20	4.00
99.99 %	4.00	5.00

Exercise 8.3: Reorder Point Calculation with Safety Stock

Weekly demand of a popular TV model at ABC Electronics is normally distributed, with a mean of 1,000 and a standard deviation of 305.69. The replenishment lead time is 3 weeks. Sales wants to make sure there is enough inventory to meet a 98 % customer service level (CSL) target. The unit cost is US$235. What is the safety stock, the cost of the safety stock to meet this target, and the reorder point? Using Excel functions, the answer is computed as follows:

1. Demand during the lead time (*DL*): $1,000$ units $\times$ 3 weeks $= 3,000$ units.
2. Standard deviation of the lead time: $\sigma L \sqrt{L} \sigma D = \sqrt{3} \times 305.69 = 529.47$
3. Safety stock: CSL safety factor $\times \sigma L = NORMSINV(0.98) \times 529.47 = 1,087.40$ units.
4. Reorder point $= DL + SS = 3,000 + 1,087.40 = 4,087.40$ units.
5. Safety stock cost $=$ Unit cost $\times$ SS $=$ US\$235 $\times$ $1,087.4$ units $=$ US\$255,538.93.

An alternative method for calculating safety stock is to determine what the resulting cost would be if there was no safety stock or if there was insufficient safety stock to cover demand. The objective of the exercise is to find a safety stock that minimizes the total cost of carrying inventory above the order point, as well as the cost of incurring a stock out, on an annual basis.

Exercise 8.4: Reorder Point Calculation Using Probability

The inventory planner at ABC Electronics wants to determine a safety stock quantity for a product that exhibits a wide swing in demand. The planner has assembled the following base data:

- Average weekly demand is 1,000 units with a replenishment lead time of 2 weeks.
- The carrying cost per unit is US$30.
- The cost of item stock out is US$100.
- The optimum number of replenishment orders per year is 26.

ABC Electronics has experienced the following probability distribution of demand (above the reorder point of 2,000 units) during the reorder point period:

Number of units	Probability (%)
OP = 2,000	24
2,100	15
2,200	8
2,300	2
2,400	1

To determine the optimal safety stock using this information, inventory planners perform two calculations.

1. *Safety stock carrying cost*. The value is calculated by multiplying the carrying cost times the safety stock. For example, 400 units of safety stock results in US$12,000 of carrying cost.
2. *Stock out cost*. The stock out cost is computed by multiplying the shortage by the probability of demand at that level, by the stock out cost, by the number of times per year the stock out can occur (which is the number of orders per year). Then, the stock out costs for each possible stock out level are added to the carrying cost to give a total cost for each level. The level with the lowest total cost is the optimal safety stock. Finally, this value is added to the reorder point.

Using the stock out formula and the item data, the following table illustrates the optimal safety stock:

Safety stock	Carrying cost	+ Stock out cost =	Total cost
2,000	0	(100 × 0.15 × US$100 × 26) +	US$106,600
		(200 × 0.08 × US$100 × 26) +	
		(300 × 0.02 × US$100 × 26) +	
		(400 × 0.01 × US$100 × 26) =	
2,100	100 × US$30 = US$3,000	(100 × 0.08 × US$100 × 26) +	US$42,000
		(200 × 0.02 × US$100 × 26) +	
		(300 × 0.01 × US$100 × 26) =	
2,200	200 × US$30 = US$6,000	(100 × 0.02 × US$100 × 26) +	US$16,400
		(200 × 0.01 × US$100 × 26) =	
2,300	300 × US$30 = US$9,000	(100 × 0.01 × US$100 × 26) =	US$11,600
2,400	400 × US$30 = US$12,000	US$0.00	US$12,000

Based on the results, the optimum safety stock is 300 units. The new reorder point is then calculated as 2,000 + 300 = 2,300 units.

Up to this point, we have been exploring inventory management solutions where demand uncertainty is the focal point. In the discussion on the calculation of safety stocks, the replenishment lead time was considered to be fixed and unchanging. There are many situations, however, when companies are also subject to uncertainty in supply. This uncertainty could originate from poor delivery times from the supplier or the failure of a supplier to deliver all the ordered quantity when promised. Similar to managing uncertainty in demand, uncertainty in supply requires companies to hold safety stock to guard against item stock out during the replenishment lead time. The question then becomes, "How do you calculate safety stock for items subject to uncertainty in both demand and supply?"

To properly calculate safety stocks subject to supply uncertainties the following data elements are required:

- average demand per period
- standard deviation of demand per period (σD)
- lead time during the replenishment cycle
- standard deviation of lead time (σLT)

Exercise 8.5: Supply Uncertainty and Safety Stock

ABC Electronics has determined that supply lead time uncertainty has consistently caused a stock out of a fast-selling item. It has been determined that a level of safety stock should be added to the item. Even though the quoted lead time is 9 days, the inventory planner has found that the actual lead time has been as much as 14 days. The inventory planner has also compiled the following information about the item:

- Average demand per day (D) = 250 units
- Lead time (LT) = 9 days
- Standard deviation of demand (σD) = 85 units
- Target customer service level (CSL) = 95 %
- Standard deviation of lead time (σLT) = 5 days

The first step is to calculate the standard deviation of demand during the lead time (σL) using the formula:

$$\sigma L = \sqrt{LT \times \sigma D^2 + D^2 \times \sigma LT^2}$$

Applying this formula to the data shows:

$$\sigma L = \sqrt{\left[9 \times \left(85^2\right)\right] + \left[\left(250^2\right) \times \left(5^2\right)\right]} = 1,275.74$$

The second step is to solve for the safety stock:

$$\textit{Safety stock} = \sigma L \times \text{Service level standard deviation safety factor}$$

The service level factor is selected from the table of safety factors (Table 8.4). To achieve a CSL of 95 %, 1.65 is chosen. To arrive at the new safety stock, the standard deviation of demand during the lead time is then multiplied by the safety factor, or

$1.65 \times 1{,}275 = 2{,}105$ (rounded). When this value is added to the demand times the lead time, the new reorder point is 4,355 units.

8.3.2 Min/Max and Periodic Review

Beyond the basic reorder point method, there are two other replenishment techniques that use reorder point logic.

8.3.2.1 Minimum/Maximum

This ordering technique requires continuous review and generation of a replenishment order whenever the inventory position drops below the defined minimum reorder point. In contrast to the fixed order quantity found in the statistical reorder point, the order quantity in this technique is a variable, sufficient to raise the inventory level to a predetermined maximum quantity. The technique is called a *min/max* system because the inventory position should always be a quantity located between the minimum and maximum stocking values. The minimum quantity is calculated using the standard reorder point formula.

Determining the maximum inventory quantity is a function of the average daily demand, lead time, and the standard deviation. At a minimum, the max stock amount should provide enough inventory to protect against a stock out until the next replenishment order arrives. To guard against variance in demand, a safety stock is normally added. As an example, if the average daily demand (D) is 50 units, the minimum quantity is 125 units, the replenishment lead time (LT) is 4 days, the standard deviation (σ) is 20, and the desired customer service level (CSL) is 98 %, the maximum quantity is calculated as follows:

$$\begin{aligned}\text{Max} &= (D \times LT) + \left(CSL \times \sigma \times \sqrt{LT}\right) = (50 \times 4) + \left(2.05 \times 20 \ \times \sqrt{4}\right) = 200 + 82 \\ &= 282 \text{ units}\end{aligned}$$

When the minimum quantity is triggered, the order quantity used in the calculation is always a variable because it represents the max quantity minus the current inventory balance. In the case of the above example, if the inventory balance was 100 units (25 units below the min inventory value), the replenishment order quantity is calculated as $282 - 100 = 182$ units.

Planners often misuse the min/max technique, confusing it with the statistical reorder point. Min/max should not be used to order from an outside supplier. Statistical reorder points are equipped to handle the problems caused by variations found in historical usage, lead times, and order quantity unit cost issues. Min/max, on the other hand, is best used by satellite warehouses that receive their inventories from a supplying distribution center. Interbranch resupply is not subject to the same variations as replenishment from a supplier. First of all, the lead time between supply nodes in an internal supply chain network is usually very short with little or no variation. In addition, because lead times are short, the satellite warehouse does not have to order as large a lot as would be necessary if inventory was ordered from a supplier. The calculations for min/max are designed to assist satellite warehouse planners keep inventories within restricted stocking space, avoid stock outs, and maximize inventory turns by setting appropriate upper and lower control limits.

8.3.2.2 Periodic Review

Often supply chain planners are faced with replenishing products that do not lend themselves to *continuous review* techniques. Usually, these products are characterized by the following conditions:

1. It is difficult to record withdrawals and additions to and from stock on a continuous basis. Process-type products, such as liquids or bulk materials, fall within this category.
2. Items are ordered in product families where economies of scale in order preparation and supplier discounting make it economical to combine items into one order. Fasteners, small tools, and office supplies are products that fit this category.
3. Items have a limited shelf life. Farm produce, chemicals, pharmaceuticals, and food products are in this class.
4. Significant economies are gained by ordering in bulk quantities.

Such products are managed best by a *periodic review* system. Items utilizing this method are reviewed periodically and replenishment orders are launched for items at each review. The order quantity contains sufficient stock to bring the inventory position up to a predetermined quantity or *target inventory* level. The periodic review system has often been called the *fixed-cycle technique*. Figure 8.5 presents a visual representation of the mechanics of the technique.

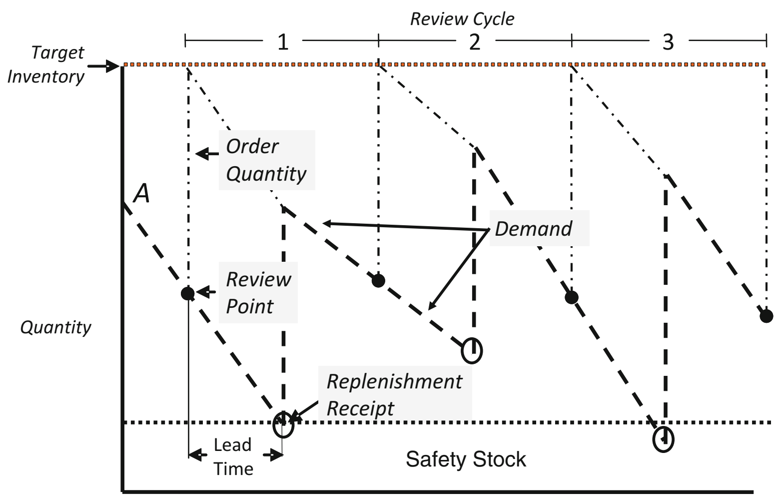


FIGURE 8.5 Periodic review system.

Functionally, the system works as follows:

1. A review cycle is established. This determines how many times a year/month/week an item is to be reviewed for possible replenishment.
2. A target inventory max level is established. This level acts as the *order-up-to-level* or *target inventory*.
3. When the inventory planner reviews the item at the assigned time, the current on-hand balance is subtracted from the target inventory value.
4. The difference then constitutes the quantity for the replenishment order.
5. The item is not again reviewed until the next assigned review time.

Mathematically, the periodic review technique is governed by two formulas: the first determines the *order review cycle* and the other determines the *target inventory* (*TI*) level. The review period is calculated by dividing an item's units sold annually by the standard lot quantity. For example, if the annual usage is 1,500 units, the standard lot quantity is 100 units, and there are 360 working days in the year, then the review cycle is calculated as 365/(1,500/100), or 24 days. The formula for calculating the *inventory target* level is expressed as

$$TI = (D(L+T)) + \left(SS\sigma D\sqrt{L+T}\right)$$

where *TI* is the target inventory level, *D* is the demand rate, *L* is the item lead time, *T* is the review period, and *SS* is the safety stock.

Exercise 8.6: Periodic Review System

The inventory planner is reviewing an item managed by a periodic review system for possible inventory replenishment. The inventory planner has compiled the relevant information about the item as follows:

Usage rate (D) $=$ 1,000 units/week
Standard deviation of demand (σD) $=$ 100 units
Replenishment lead time (L) $=$ 2 weeks
Review cycle (T) $=$ 4 weeks
Customer service level (CSL) $=$ 98 %
On-hand balance (I) $=$ 2,250 units

Since the current date marks a review cycle date, the planner begins the calculation to see how much should be ordered.

1. Average demand during the lead time and review cycle:

$$D(L+T) = 1{,}000 \times (2+4) = 6{,}000 \text{ units}$$

2. Standard deviation of demand during the review cycle:

$$\sigma \mathrm{L} + \mathrm{T} = (\sigma \mathrm{D}) \times \sqrt{L+T} = 100 \times \sqrt{2+4} = 244.95$$

3. Safety stock:

$$\begin{aligned} SS &= \mathrm{NORMSINV(CSL)} \times (\sigma L + T) = \mathrm{NORMSINV}(98\%) \times 244.95 \text{ units} \\ &= 503.06 \text{ units} \end{aligned}$$

4. Target inventory:

$$TI = \big(SS + D(L+T) = 503.06 + \big(1{,}000 \times (2+4) = 6{,}503.06 \text{ units}$$

5. Replenishment order quantity:

$$= TII = 6{,}5032{,}250 = 4{,}253 \text{ units}$$

The planner has decided to release a replenishment order with the supplier for 4,253 units to return the item back to its target inventory level of 6,503 units.

8.3.2.3 Combining Techniques

On occasion, inventory planners may combine aspects of continuous and periodic review systems to resolve distinct inventory ordering problems. As an example, for expensive products that experience excessive lead-time variation, planners can use a mixture of reorder point and periodic review techniques. Procedurally, as inventory is deducted and the reorder point is tripped, planners buy up to the maximum quantity. If the reorder point is not triggered, the planner has the option of replenishing stock up to the target inventory level at cycle review time. The only requirement for the effective use of such a hybrid system is an inventory control mechanism that provides for perpetual inventory control.

Another combination is to use the inverse of the above. A reorder point and a maximum target inventory level are established, and a perpetual inventory record is kept for each transaction. If the inventory quantity trips the reorder point *before* the review cycle is reached, a replenishment order is generated restoring the item balance back to the inventory target. If, on the other hand, the quantity is *greater* than the reorder point at review cycle time, no replenishment order is created even though the inventory position is less than the target maximum.

8.4 ORDER QUANTITY TECHNIQUES

The objective of the reorder point is to provide inventory planners with answers to such questions as "What should the safety stock of an item be?" and "When should a replenishment order be released?" The question the reorder point does not answer is, "What quantity should be reordered once the order point has been triggered?" Effectively answering this question begins by determining the nature of item demand. Products subject to lumpy and erratic demand are best controlled by *fixed order cycle, variable order quantity* systems. Items subject to continuous and incremental demand, on the other hand, work well with order quantity techniques based on *variable order cycles and fixed order quantities*. Because their order quantities are fixed, planners must search for methods that enable them to order the most economic quantity while still satisfying customer service levels.

In making inventory replenishment ordering decisions, the fundamental responsibility of planners is to constantly seek ways to reduce *relevant costs*. Costs in ordering are relevant costs because the size of the replenishment quantity will directly impact the firm's operational costs. There are two critical costs involved in inventory replenishment. The first relates to *order costs*. There are several costs related to the frequency inventory replenishment orders are placed. Some of the costs incurred include the maintenance of the firm's perpetual inventory system and salaries for planners. Other costs are incurred with purchasing activities such as supplier negotiations, purchase order preparation, order transmission, order status tracking, receiving, inspection, and stock put-away.

The second cost area consists of *inventory carrying costs*. The decision to stock inventory commits the firm to costs arising from the size, value, and length of time that inventory is stocked. Capital invested in inventory, taxes, insurance, obsolescence, facilities, and handling are all forms of cost that increase as the level of inventory rises. Other costing issues revolve around *shortage* or *stock out costs* and *incremental costs*. Shortage costs result from decisions to increase inventory quantities that require the firm to incur costs above current overhead costs. For example, a decision to increase inventories may require hiring a new buyer, improving existing inventory control systems, or buying additional materials handling equipment.

8.4.1 The Economic Order Quantity

Understanding the effect of cost when determining an economic order quantity first requires reviewing how inventory order and carrying costs are calculated. The first calculation is concerned with determining the *order cost*. To arrive at an answer, the inventory planner first determines the annual inventory usage for each item, the cost to create an order, and a potential order quantity. The order cost is then calculated by using the following equation:

$$\text{Ordering cost} \times \text{annual inventory}/\text{order quantity}$$

The second calculation determines the *carrying cost*. To determine this cost the order quantity is first divided by 2 (average inventory) and then multiplied by the unit cost and the carrying cost percent. The equation is:

$$(\text{Order quantity}/2) \times \text{unit cost} \times \text{carrying cost percent}$$

Finally, the order and carrying costs are added together to provide the *total cost*.

Once these calculations are done, the question then becomes, “Is the order quantity going to provide an economical cost?” To find out, the planner would have to go through a trial-and-error process, trying various order quantities, recalculating ordering and carrying costs, and comparing resultant total costs. The order quantity with the lowest cost is the winner!

Exercise 8.7: Trial-and-Error Approach to the Economic Order Quantity

An item has an annual usage of 24,000 units, the unit cost is US$0.25, the ordering cost is US $20, and the carrying cost is 24 %. Based on this data, several possible quantities could be selected when a replenishment order is created. The problem facing the planner is which quantity is the optimum one to use. The optimum order quantity is defined as the quantity that provides sufficient inventory to satisfy projected demand while minimizing ordering and carrying costs. To assist in the calculation, the planner has created the following chart (Figure 8.6):

Order Quantity	Orders/Year	Carrying Cost	Order Cost	Total Cost
2,000	12	$ 60	$ 240.00	$ 300.00
4,000	6	$ 120	$ 120.00	$ 240.00
8,000	3	$ 240	$ 60.00	$ 300.00
12,000	2	$ 360	$ 40.00	$ 400.00
24,000	1	$ 720	$ 20.00	$ 740.00

FIGURE 8.6 Trial-and-error EOQ.

For example, if the item is ordered 12 times a year, the annual carrying cost is $60 and the annual cost of ordering the item is $240, for a total annual cost of $300. When the other order quantities and the total costs are reviewed, the optimum order quantity is 4,000 units. The

EOQ solution can also be expressed by using a graph. As illustrated in Figure 8.7, the lowest point in the curve where carrying, ordering, and total cost intersect occurs at an order quantity of 4,000 units.

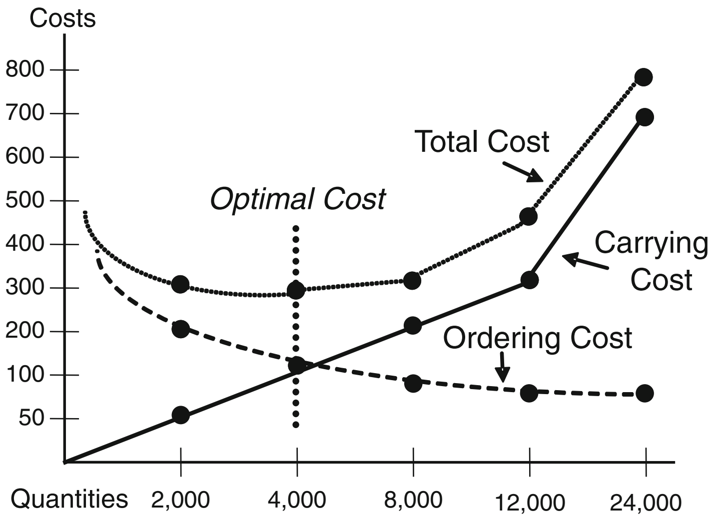


FIGURE 8.7 EOQ graph.

The trial-and-error approach to finding the economic order quantity (EOQ) would clearly be impossible in real life where planners are often responsible for managing thousands of items. Fortunately, there is a simple formula that provides planners with a way to quickly arrive at the EOQ. By using the yearly demand, cost of ordering, the carrying cost, and the unit cost, the formula enables planners to easily calculate the EOQ. Modern enterprise resources planning (ERP) and supply chain management (SCM) computer systems provide this functionality so the calculation can be done automatically for thousands of items in a very short time. The EOQ formula is described as such:

$$EOQ = \sqrt{\frac{2 \times \text{Demand } (D) \times \text{Ordering cost } (OC)}{\text{Carrying cost } \%(k) \times \text{Unit cost}(UC)}}$$

Exercise 8.8: EOQ Calculation

The inventory planner must calculate the economic order quantity for a bestselling item. The planning data for the item is as follows:

- Annual demand (D) is 20,000 units
- Ordering cost (OC) is US$125
- Item unit cost (UC) is US$34
- Carrying cost (k) is 21 %

Based on this data and using the EOQ formula, the EOQ for the item is

$$EOQ = \sqrt{\frac{2 \times 20,000 \times \text{US\$125}}{21\% \times \text{US\$34}}} = 837\ (836.83)$$

The EOQ formula also provides information relating to the optimal order interval, associated variable cost, and total annual cost. The *optimal order interval* (OI) is calculated using the above values as follows:

$$OI = \sqrt{\frac{2 \times \text{Ordering cost } (OC)}{\text{Demand}(D) \times (\text{Carrying cost}\%(k) \times \text{Unit cost } (UC))}}$$

$$= \sqrt{\frac{2 \times \text{US\$125}}{20{,}000 \times (21\% \times \text{US\$34})}} = 0.04 \text{ (25 times a year)}$$

The associated total order cost (TOC) is calculated using the above values as follows:

$$TOC = \sqrt{2OC(kUC)D =}$$

$$\sqrt{2 \times \text{US\$125} \times (21\% \times \text{US\$34}) \times 20{,}000 =}\text{US\$5,975}$$

By inserting the variable cost into the following equation, the total yearly cost (TC) is attained:

$$TC = UCR + TOC = \text{US\$34} \times 20{,}000 + \text{US\$5,975} = \text{US\$685,974.95 a year.}$$

8.4.1.1 EOQ Assumptions

The effective utilization of the EOQ technique rests on certain assumptions concerning item usage and costs. The following are the basic assumptions underlying the effective use of the EOQ technique:

- The cost of the product does not depend on the replenishment quantity. This means that the cost quoted by the supplier is not affected by the purchase quantity or the unit transportation cost.
- There are no minimum or maximum restrictions on the replenishment quantity.
- Items are considered totally independent of other items. This means that the items are not subject to dependent demand, nor do they enjoy any benefits from joint replenishment.
- Lead time is zero (delivery is received as soon as the order is placed).
- No shortages are permitted and the *entire* order quantity is delivered at the same time.
- The minimum purchase quantity from the supplier is not three or four times the calculated EOQ.
- Purchase order preparation and carrying costs are known and constant.
- Very high or very low item usage needs to be reviewed in relation to unit costs before applying the EOQ technique [2].

Based on these stringent requirements, many of the finished goods carried in the typical supply channel, maybe as high as 30 %, have difficulty using the EOQ when determining the replenishment quantity. In addition, the natures of other products make the application of EOQ difficult. Items produced in a process environment, such as petroleum, chemicals, and products with short shelf life, are examples.

Although the EOQ calculation is relatively easy to use, there are other conditions that affect its application. These conditions consist of various adjustments necessary to accommodate special situations. Three major variations of the basic EOQ formula are quality discounts, joint replenishment, and determination of order quantities to accommodate transportation rates.

8.4.1.2 Quantity Discounts

Often suppliers will offer a discount when a product is purchased in large quantities. The supplier can offer a lower price because supplying in a large lot size permits the supplier to take advantage of economies of scale in production. The more that is made, the cheaper the cost per unit. To take advantage of the discount, the buyer must be prepared, however, to accept an increase in the carrying cost. Buying in a larger lot size means the purchaser is stocking more inventory in between replenishment orders. Determining whether the buyer should accept a proposed price discount requires careful analysis to make sure the cost of carrying the extra inventory does not outweigh the cheaper purchase price.

Determining the optimum discount price is attained by applying the EOQ formula to each of the suggested discounts. The discount with the lowest cost per order lot (ordering cost + carrying cost + material cost) is the discount choice.

Exercise 8.9: Quantity Discounts

The buyer at ABC Electronics has received request for quote (RFQ) responses from two suppliers for a critical item. The planning data for the item appears as follows:

- Annual demand (D) is 30,000 units
- Ordering cost (OC) is US$200
- Item unit cost (UC) is US$15
- Carrying cost (k) is 22 %

Based on this data, the planner calculates the EOQ formula for the current item as

$$EOQ = \sqrt{\frac{2 \times 30,000 \times \text{US\$200}}{22\% \times \text{US\$15}}} = 1,907\ (1,906.93)$$

Ordering 30,000 units per year with an EOQ of 1,907 units, means that the planner would have to release 16 (rounded) orders per year (30,000/1,906.93). To calculate the total cost of the orders for the year using this EOQ is as follows:

1. Material cost = EOQ × number of orders per year × item unit cost = US$450,000 (rounded)
2. Ordering cost = order cost × number of orders per year = US$3,146.43(rounded)
3. Carrying cost = (EOQ/2) × unit cost × carrying cost percent = US$3,146.43 (rounded)
4. Total order cost = material cost + ordering cost + carrying cost = US$456,292.85 (rounded)

Against this base data, the buyer has received an RFQ response from Supplier 1 proposing a 3 % discount off the standard price of US$15 per unit for orders exceeding a lot size of 5,000 units (or US$72,950). The new unit price would be reduced to US$14.55 a unit and results in six orders being created each year. Using the steps detailed above, the proposal would result in a total cost of:

1. Material cost = US$436,500
2. Ordering cost = US$1,200
3. Carrying cost = US$8,002.50
4. Total order cost = US$445,702.50

Supplier 2 proposes a 5 % discount for orders with a lot size exceeding 12,000 units (or US $171,200). The new unit price would be reduced to US$14.25 a unit and would result in 2.5 orders being created each year. Using the steps detailed above, the proposal would result in a total cost of:

1. Material cost = US$427,500
2. Ordering cost = US$500
3. Carrying cost = US$18,810
4. Total order cost = US$446,810

Based on the results, the proposal made by Supplier 1 contains the lowest cost and should be selected by the buyer.

8.4.1.3 Joint Replenishment [3]

Often buyers are faced with the problem of replenishing items sold only in a group (such as an assortment). Literally, when a given item is required, the supplier will only sell it as part of a group of related items. As a result, the planner will have to purchase the entire family consisting of some items that may not yet be ready to be reordered. Joint replenishment poses a unique challenge to the reorder point method. Normally, an individual item is flagged for replenishment when the reorder point is tripped. But, because all items using statistical replenishment are independent of one another, their reorder points are usually triggered at different times, making it impossible to group items together for economical purchasing. In addition, items within product families usually experience different demand usages, making it even more difficult to link fast-moving items that need to be ordered and slow movers that do not. Often planners will purchase product families regardless of the actual replenishment needs of individual items. The result is that inventory becomes imbalanced, as fast movers stock out waiting for slow movers to be ordered, and slow movers become overstocked as they are prematurely purchased to prevent stock out of fast-moving items.

Buyers have three possible options when planning items ordered jointly:

1. Each item in the ordering family is ordered independently of the other family items.
2. All items in the ordering family are ordered jointly.
3. If permissible, items are ordered jointly but not every order contains all items in the product family.

The first option results in high carrying costs and is not optimal. The second option will result in lower carrying costs than the first option, but it still results in higher costs for the slow moving items in the order family. The third option, while providing for a joint order, results in a lower cost for the lower demand items. This option presents the optimal solution.

Exercise 8.10: No Joint Replenishment: Items Are Ordered Independently

The buyer at ABC Electronics is searching for a method to economically order three items, #3925, #3819, and #3442, jointly. The problem is that the items have different demands. The first solution is to assign to each item an EOQ value based on its usage history. When it is time to reorder, the items are ordered *independently* of each other. After researching the three items, the planner has identified the following data:

- Annual demand #3925 = 6,000 units
- Annual demand #3819 = 3,575 units
- Annual demand #3442 = 1,250 units
- Ordering cost (common cost) is US$200
- Transportation cost (common cost) is US$350
- Item unit cost (common cost) is US$45
- Carrying cost (k) is 20 %

Based on this data and using the EOQ formula, the EOQs for the three items are as follows:

$$\#3925 \ \ EOQ = \sqrt{\frac{2 \times 6,000 \times (\text{US\$200} + \text{US\$350})}{20\% \times \text{US\$45}}} = 856.3$$

$$\#3819 \ \ EOQ = \sqrt{\frac{2 \times 3,575 \times (\text{US\$200} + \text{US\$350})}{20\% \times \text{US\$45}}} = 661$$

$$\#3442 EOQ = \sqrt{\frac{2 \times 1,250 \times (\text{US\$200} + \text{US\$350})}{20\% \times \text{US\$45}}} = 390.9$$

The total cost for item #3925 is calculated as follows:

1. Ordering cost = (Demand/EOQ) × (Order cost + Transportation cost) = US $3,853.57
2. Carrying cost = (EOQ/2) × unit cost × carrying cost = US$3,853.57 (rounded)
3. Total order cost = order cost + carrying cost = US$7,707.14

Using the same formulas, the total cost for ordering the three items independently is as follows:

Item	EOQ	Carrying cost ($)	Ordering cost ($)	Total cost ($)
#3925	856.3	3853.75	3853.75	7,707.14
#3819	661	2,974.58	2,974.58	5,949.16
#3442	390.9	1,758.91	1,758.91	3,517.81
			Total cost	17,174.11

The second option in the joint ordering problem is to combine all the items in the order family into a single order. This option is performed through a variation to the standard EOQ model. The goal is to arrive at a common order cycle that allows all the items in the family to be ordered at the same time. The change to the classic EOQ formula to accomplish this task requires inverting the ordering and transportation costs, and the unit and carrying costs in the formula.

Exercise 8.11: Joint Replenishment: Items Are Ordered Together

The buyer at ABC Electronics uses the following variation of the EOQ formula to solve for a common ordering cycle (OC) that is used for all three items. The EOQ variation is as follows:

$$OC = \sqrt{\frac{D1(kUC1) + D2(kUC2) + D3(kUC3)}{2R}}$$

$$OC = \sqrt{\frac{(6{,}000 \times (20\% \times \text{US\$45})) + (3{,}575 \times (20\% \times \text{US\$45})) + (1{,}250 \times (20\% \times \text{US\$45}))}{2\ (\$350 + (200 \times 3))}} = 7.16$$

The common order cycle for the three items is 7.16 times a year. The order lot size for each of the items is then determined by dividing the annual demand by the OC. For example, the order lot size for item #3925 is calculated as 6,000 units divided by 7.16 or 837.9. Using the same formulas for calculating the carrying, ordering, and total costs for ordering the three items independently as detailed above, the item and aggregate costs for the joint ordering method is as follows:

Item	Order cycle	EOQ	Carrying cost ($)	Ordering cost ($)	Total cost ($)
#3925	7.16	837.9	3,770.56	3,938.41	7,708.97
#3819	7.16	499.2	2,246.62	1,432.15	3,678.77
#3442	7.16	174.6	785.53	1,432.15	2,217.68
				Total cost	13,605.32

The use of a joint replenishment EOQ versus ordering each item independently results in a savings of US$3,568.69 annually (US$17,174.11–US$13,605.42).

The third option in the joint ordering problem is to create a joint order for a selected subset of these items. The first step in the process is to identify those items that are ordered most frequently, assuming each item is ordered independently. Once identified, the next step is to determine the frequency f for each successive product i, where i is ordered every m deliveries. Once the ordering frequency of each family item is determined, the frequency of the most frequently order product is then recalculated.

Exercise 8.12: Joint Replenishment: Selected Family Items

The buyer at ABC Electronics has decided to order items #3925, #3819, and #3442 jointly, but to be selective about which of the items are to be ordered. The first step in the process is to identify the most frequently ordered item (i). The data are the yearly demand for each item (D), the carrying cost percent (k), the unit cost (UC), the common transportation cost (TC) for all orders, and the ordering cost (R) common to each of the three items. To determine the frequency of ordering, the following variation of the EOQ is used:

$$fi = \sqrt{\frac{DikUCi}{2(TC + R)}}$$

Using this formula, the order frequency of item #3925 ($f1$) is

$$f1 = \sqrt{\frac{6{,}000 \times 20\% \times US\$45}{2 \times (US\$350 + US\$200)}} = 7.01$$

The ordering frequency of items #3819 and #3442 use the same formula with the exception that the transportation cost is removed (it is already factored into the #3925 item). The ordering frequency of item #3819 is 8.97 and item #3442 is 5.30.

The next step in the calculation is determining the order frequency for each item as a multiple of the order frequency of the most ordered item (*mi*). This value is calculated as:

$$mi = f1/fin$$

For item #3925, the calculation is 7.01/7.01 equals 1. For item #3819, the calculation is 7.01/8.97 equals 0.78 and for item #3442, 7.01/5.30 equals 1.32. For each item other than the most frequently ordered, the frequency of each item is rounded up to the next whole number.

Next, the ordering frequency of each of the three items needs to be recalculated. There are four steps to the calculation as follows:

1. *Calculate the frequency order cost*. For item #3925, *kUCfi1Di1* or 20 % × US $45 × 1 × 6,000 equals US$54,000. Using the same formula, the values for item #3819 is US$32,175 and item #3442 is US$22,500.
2. *Divide the standard order cost by the order frequency*. For item #3925, *R*/*f1* equals 200/1 equals US$200. Using the same formula, the values for item #3819 is US$200 and item #3442 is US$100.
3. *The values of steps 1 and 2 above are summed*. In the exercise, the summed values for step 1 are US$108,675 (*ΣkUCfiDi*) and for step 2, US$500 + the transportation cost (US$350) or US$850 (*TC* + *ΣR*/*fi*).
4. The new order frequency for item #3925 is then calculated using the following EOQ variation:

$$nf = \sqrt{\frac{\Sigma kUCfiDi}{2 \times (TC + \Sigma R/fi)}} =$$

$$nf = \sqrt{\frac{\text{US\$108,675}}{\text{US\$850}}} = 8\,\text{orders}$$

   The new order frequency for item #3819 is calculated as eight orders divided by one (order frequency) and #3442 is calculated as eight orders divided by two (order frequency).

The total cost of each of the three items is then calculated using the standard calculations for number of orders per year, order lot size, carrying cost, and order cost. By summing these individual item total costs, the joint delivery cost is determined. When this value is compared to the cost of ordering each of the three items individually or jointly, joint replenishment should provide the lowest cost.

8.4.1.4 Transportation EOQ [4]

The EOQ calculation discussion so far has not taken into consideration the cost of transportation. Determination of the cost effective replenishment lot quantities that minimize total cost by factoring in the cost of transportation, regardless of EOQ, are essential to sound logistics arrangements. As a general rule, the greater the weight of an order, the lower the cost of transportation. A freight-rate discount for a large shipment is common across all transportation modes. This factor is critical, because transportation costs can constitute an enormous portion of the total cost of an item beyond just the EOQ total cost.

Often, when transportation costs are factored in, the total cost for ordering a large quantity is far smaller than if the standard EOQ was used as the order quantity. Larger lots have, however, several consequences. Large lots increase stocked inventories and carrying costs. Then again, ordering in larger lot sizes reduce the number of orders and the cost of ordering. Ultimately, determining the actual ordering quantity is an activity that requires inventory planners to carefully weigh the cost of transportation in the replenishment order calculation.

Exercise 8.13: Transportation EOQ

The buyer at ABC Electronics is working with a freight carrier to determine what the most cost effective replenishment quantity is for an important purchased item. The first step the buyer takes is to calculate the EOQ for the item to attain a base order quantity that can be used in transportation negotiations. After researching the item, the buyer has identified the following data:

- Annual demand is 25,000 units
- Ordering cost is US$100
- Item unit cost is US$10
- Carrying cost (k) is 22 %

Using the standard EOQ formula, the yearly cost for stocking the EOQ lot size is detailed as follows:

Item	EOQ	Orders/year	Carrying cost ($)	Ordering cost ($)	Total cost ($)
#3925	1,507.56	17	1,658.31	1,658.31	3,316.62

When discussion with the transportation company begins, the buyer finds that the EOQ replenishment quantity is too low and qualifies only as a small shipment. The rate for small shipments is US$1.25 per unit. The freight calculation uses the following formula:

$$(\text{Rate} \times \text{Order quantity}) \times \text{Number of order per year}$$
$$(\text{US\$}1.25 \times 1,507.56) \times 17 = \$31,250$$

When the freight cost is calculated into the EOQ cost, the total cost is as follows:

Ord qty	Orders/year	Carrying cost ($)	Ordering cost ($)	Shipment cost ($)	Total cost ($)
1,507.56	17	1,658.31	1,658.31	31,250	34,566.62

To qualify for the transportation company's volume discount rate of US$0.75 per unit, the buyer must order a minimum of 5,000 units. To determine whether the higher replenishment lot size is more economical, the buyer calculates the cost of the new lot size:

Ord qty	Orders/year	Carrying cost ($)	Ordering cost ($)	Shipment cost ($)	Total cost ($)
5,000	5	5,500	500	18,750	24,750

Based on the review analysis, the inventory planner finds that ordering in larger lot quantities to take advantage of lower transportation rates results in a yearly savings of (US $34,566.62–US$24,750) = US$9,816.62.

8.4.2 Replenishment by Item Class

A simple method of determining inventory replenishment quantities is to use the practice of dividing inventory into classes based on volume usage, dollar usage, or other factors. Statistically, class “A” items constitute the fast-selling items, class “B” items the medium sellers, and class “C” items the slow sellers. By linking the inventory classification scheme to an expected inventory turnover target, it is easy to calculate a replenishment quantity. An inventory planner could create as many classes of items as desired.

The steps in using ABC classification for replenishment are as follows:

1. Divide the inventory into classes based on volume usage, dollar value, or other parameters.
2. Link items to classes.
3. Assign an inventory turnover target for each class.
4. Determine the level below which only dead and obsolete products reside and eliminate this class from the procedure.
5. Establish the replenishment quantity for each class by dividing the annual usage of each item by the turnover value. For example, if an item turned 12 times a year, the inventory system should recommend that the planner purchase 1 month’s worth of stock each month.
6. Recalculate the inventory classification scheme for all items at least once a month, depending on the expected inventory turnover.

Exercise 8.14: Replenishment by Item Class

By reviewing the company’s ABC classification scheme and turnover ratios, the inventory planner at ABC Electronics has developed the following table to aid in replenishing some of the company’s items by using the item class method:

ABC class	# of total items	Expected turns	Order interval
A	1,200	24	15 days
B	10,500	12	1 month
C	25,250	6	2 months
D	8,000	3	4 months
E	6,500	1	12 months

The planner has assigned item #3954 to ABC class “A”. The established order release interval for class “A” items is 0.5 times each month. The annual demand for the item is 24,000 units. As such, the replenishment order quantity is calculated as:

$$24,000 \text{ units}/24 = 1,000 \text{ units}$$

The advantages of using the ABC Classification as an order quantity technique are readily apparent. To begin with, the method is easy to understand and manipulate. Furthermore, although not as exact as the EOQ, it does provide for effective replenishment based on past usage.

8.4.2.1 Order Investment Limit [5]

The acquisition and storage of inventory represents a significant capital investment for most businesses. Because of the large capital investment involved, management may limit the amount of inventory carrying cost permissible on certain items and families. When items to be ordered exceed the investment limit, planners must reduce order quantities below the allowable limit. Calculating this reduced amount is performed by using a modification to the EOQ formula.

Exercise 8.15: Order Investment Limit

The inventory planner at ABC Electronics is reviewing demand quantities by item for next year. Three of the items, #3925, #3819, and #3442, have a cumulative average inventory investment limit of US$16,000 for the year. After reviewing these items using the standard EOQ, the planner has noticed that the item order totals exceed the US$16,000 limit. At this point, the planner must now use an alternative to the standard EOQ to arrive at a reduced order quantity that places aggregate investment at or below the target limit.

The first step in the process is to use the standard EOQ formula to arrive at the order quantities for each item. Based on the following data, the planner calculates the EOQ for each item as follows:

- Annual demand (*D1*) for #3925 = 14,000 units
- Annual demand (*D2*) #3819 = 9,500 units
- Annual demand (*D3*) #3442 = 7,000 units
- Unit cost #3925 (*UC*) = US$20.00
- Unit cost #3819 (*UC*) = US$10.00
- Unit cost #3442 (*UC*) = US$15.00
- Ordering cost (*OC*) is US$100
- Carrying cost (*k*) is 20 %
- Investment limit (*IL*) = US$16,000

$$\#3925\,EOQ = \sqrt{\frac{2 \times 14,000 \times \text{US\$}100}{20\% \times \text{US\$}20}} = 836.66$$

$$\#3819\,EOQ = \sqrt{\frac{2 \times 7,000 \times \text{US\$}100}{20\% \times \text{US\$}15}} = 683.13$$

$$\#3442\,EOQ = \sqrt{\frac{2 \times 1,250 \times (\text{US\$}200 + 350)}{20\% \times \text{US\$}45}} = 390.9$$

The next step is to determine the total inventory investment represented by these three EOQs by solving the following equation:

$$\begin{aligned} Inventory\,investment &= UC1(Q1/2) + UC2(Q2/2) + UC3(Q3/2) \\ &= \text{US\$}20(836.66/2) + US\$10(974.68/2) + \text{US\$}15(683.13/2) \\ &= \text{US\$}18,363.47 \end{aligned}$$

Since this value exceeds the target inventory limit, the original EOQ quantities need to be reduced to meet the US$16,000 investment limit. A way to do this is to inflate the carrying cost (k) to a quantity large enough to reduce the stocking levels. The action will increase the number of orders placed per year and the corresponding ordering cost, but will decrease carrying costs. This function is performed by first identifying a factor (α) that is added to the carrying cost (k). The formula for this function is

$$\alpha = \left(\frac{\Sigma\sqrt{2DiOCiUCi}}{2IL}\right)^2 - (k)$$

$$\alpha = \left(\frac{\sqrt{2(14,000)(100)(20)} + \sqrt{2(9,500)(100)(10)} + \sqrt{2(7,000)(100)(15)}}{2IL}\right)^2 - (0.20) = 0.063$$

In the final step, the (α) factor is placed in the EOQ formula for the three items using the following formula:

$$\#3442\,EOQ = \sqrt{\frac{2D1OC}{UC1(k+\alpha)}} = \sqrt{\frac{2 \times 14,000 \times 100}{20 \times (0.20 + 0.063)}} = 728.98\,\text{units}$$

Using the same formula, the new EOQ for item #3819 is 849.23 units and for item #3442 is 595.21 units. Cumulatively, the average investment totals the target investment level of US $16,000.

8.5 LEAN INVENTORY MANAGEMENT

The story of the rise of lean business process management was introduced in Chapter 1. In this chapter the lean concepts of *zero inventories* and *stockless production* is explored in greater depth. As it relates to inventory management lean theory and practice encompasses the following paradigms:

- *Inventory management excellence*. In its broadest context, this principle requires the enterprise to be dedicated to the continuous improvement of inventory management and the reduction of excess pools of inventory found in all echelons of the supply chain.
- *Value-added processes*. This principle requires companies to critically examine and eliminate all forms of inventory that do not add value to the customer. Such non-value-added inventory simply adds cost and erodes company and supply chain competitive advantage.
- *Continuous improvement*. A focus on increases in customer value and decreasing inventory cost are considered to be continuous by all members of the supply chain. This means that every aspect of production, logistics support, and supply chain throughput must be dedicated to enhancing the value of inventory to the marketplace in ways great and small.
- *Lean/TQM*. This term suggests a combination of lean techniques focused on productivity, total quality management (TQM), and people empowerment. The abbreviation encapsulates the need for enterprise dedication to customer service, elimination of wastes, simplification, flexibility in responding to customer and channel demands, and enterprise centered performance measurements.

8.5.1 Lean and Supply Chain Management

The critical question confronting lean inventory management is not "How much inventory is needed?" but rather "*Why* is inventory needed at all?" The goal of lean inventory management is the elimination of all inventory that is not actively in process. While this seems an impossible ideal, when the causes of inventory at rest are investigated, they reveal a history of mistakes: transaction errors, excess safety stock, scrap and waste, needlessly large order quantities, extra stock just in case, and so on. In the end, companies have inventories for two central reasons:

1. The flow of inventory is constricted in the plant or the warehouse.
2. Inventory is not linked to production, which means the plant is not producing to the drumbeat of the demand pull and is producing excess inventory.

Several lean tactics can be deployed to continuously shrink the size of inventory.

- *Focus on continuous inventory reduction*. Tirelessly search for ways to shrink lot sizes and lead times, smooth the flow, and synchronize inventory with production.
- *Implement an inventory pull system*. Align all inventories to be available *just in time* to meet the need of producing to actual customer demand.
- *Establish lean ordering and delivery with suppliers*. Order products in lot sizes sufficient to meet demand and synchronize their delivery with the needs of production.
- *Deliver inventory directly to the point of use*. When inventory is received, it should be brought to the point where it will be used rather than placed in a stockroom. The quantity received must, at least, match the requirement needed for production.
- *Map and streamline inventory flows*. Trace the flow of inventory from the moment it is received until it is consumed. Remove all impediments causing inventory to be at rest.
- *Reduce batch sizes and production queues*. Reduce the size of production order batches and continuously shorten the time orders rest in queue before production.
- *Reduce setup times*. Continuously reduce the length of time it takes for production order release and setup. Small ordering costs have a dramatic impact on the size of production order quantities.

A fundamental measurement of inventory management is determining how long it takes for products to flow through the plant or warehouse. Perhaps the best way to measure the impact of inventory flow and its impact on flow time and throughput is to understand the simple math of calculating how long it takes inventory to flow through the firm's facilities. For example, if the inventory throughput of a process is 100 units a day and it takes 5 days for a unit to flow through the process, then the total expected work-in-process (WIP) inventory in the factory would be 100 units times 5 days, or 500 units. If inventory is divided by throughput, the flow time is calculated as: 500 units divided by 100 units, or 5 days. If inventory is divided by flow time, the throughput is calculated as: 500 units divided by 5 days, or 100 units. If a lean project was able to increase the flow of inventory so that 100 units could be completed in 4 days, WIP inventories would decrease to 400 units, resulting in an increase in throughput of 20 %. What this means is that the business could shrink the production lot size by 100 units each week while still meeting the target of 100 units produced each day.

To accomplish such a reduction in inventories, lean inventory reduction teams would examine the barriers to flow at work centers, warehouses, anywhere that inventory passes through on its way to the customer. Figure 8.8 illustrates the impact of an increase in inventory flow by using the analogy of a stream. In a *clogged supply channel,* deep pools of excess inventories can be found. These pools are the result of poor inventory and production management practices. These barriers unnecessary build inventories and slow the flow of items as they move downstream on their way to the customer. In contrast, an *open supply channel* has no barriers blocking the flow of inventories. Without barriers, the stagnant pools of inventory disappear. In addition, the flow of inventories accelerates as it moves downstream.

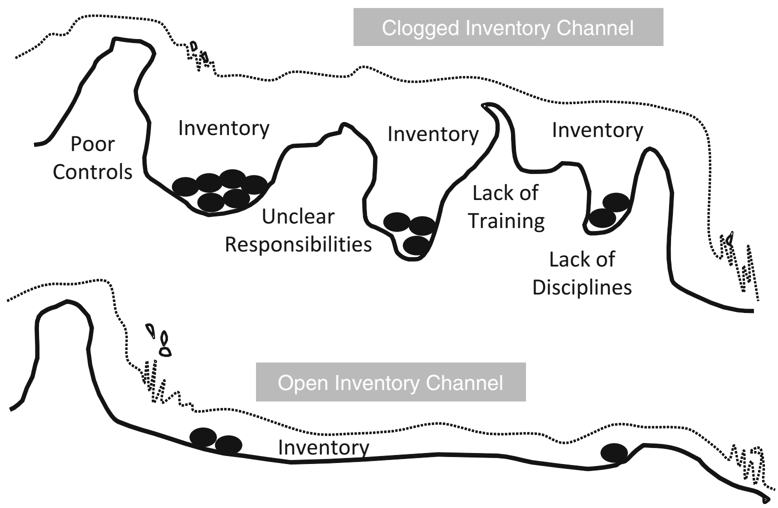


FIGURE 8.8 Lean inventory flow analogy.

Reducing inventories is accomplished from several directions. By reducing the amount of water in the stream, the barriers inhibiting inventory flow are revealed. Removing these barriers one-by-one accelerates the flow of inventory. Even though there is less water, the increased velocity enables the output of the stream to remain the same or even accelerate.

Lean assists companies to solve many of the challenges facing them today: shortening product life cycles, increased competition, downward pressures on prices, the impact of new technologies, and the high cost of capital. By keeping inventory in motion, companies achieve a number of critical objectives that result in the decrease of costs normally absorbed by the company. Examples of process improvements include:

- *Reduction in inventory carrying costs.* As the size of inventory at rest shrinks, the cost of holding inventory accordingly declines. For example, if the aggregate inventory value of a business equals US$50 million and the carrying cost equals 22 %, the cost of holding the inventory is US$11 million. If the inventory is decreased by just 5 %, the carrying cost would decrease by US$550,000.
- *Reduction in warehouse storage space.* As inventories shrink, money invested in facilities and structures to store inventories declines.
- *Decline in the use of storage equipment and labor.* As inventories shrink, the requirement for equipment and people to move and store inventories also declines.

- *Decline in inventory accuracy management effort*. As inventories shrink, the need for inventory control personnel and the effort spent in cycle counting, transaction control, and shrinkage write-offs also declines.
- *Reduction in yield, scrap, and rework*. As defects are reduced in production, the cost of material yields, production scrap, and rework also declines.
- *Decline in purchasing management problems*. As inventory is more closely synchronized to the demand pull, purchase lot sizes decrease and on-time delivery increases.
- *Decline in shop floor scheduling problems*. As production is matched to the demand flow, the practice of staging inventory at work centers in advance of releasing orders to the shop floor diminishes or is eliminated.
- *Reduction in loss from theft, damage, and obsolescence*. As inventory at rest shrinks, the probability of loss from theft, damage, and obsolescence declines.

8.5.2 The Lean Inventory Replenishment Pull System

There are basically two ways of initiating inventory replenishment orders in an independent demand environment. The traditional method is to generate a replenishment order when the reorder point is triggered and then to *pull* the requirement from the supplying source. Regardless of how the replenishment order is identified, a lot-sized order is generated and pulled through the fulfillment channel regardless of timeliness and resource availability.

The other method is to use the *lean pull system*. Instead of generating a replenishment order when the reorder point is triggered, a pull system generates a replenishment order *only* when item quantities, being held at a buffer stocking location, are removed. The demand signal can be a kanban card, a flag, a light, or another indicator that is activated once inventory is removed from a buffer area. The key points of a lean-pull system are noted as:

- Produce products only to customer order.
- Create a level schedule so that production may proceed according to a desired flow rate.
- Schedule a mix of products in varying lot sizes so that the factory or the supplier produces and delivers inventory to the same mix of products that will be sold that day.
- Link scheduling management to pull production through the use of visual demand signals.
- Maximize process flow-through by maximizing the flexibility of people and machinery.

Figure 8.9 provides an illustration of a basic pull system consisting of two workstations and a buffer inventory. Workstation #1 supplies inventory to the buffer area used by workstation #2.

The lean pull system works as follows:

- In event A, operator #2 pulls inventory from the buffer to begin work at workstation #2.
- In event B, as inventory is removed from the buffer, it triggers a *demand pull signal*. The requirement is sent back to workstation #1.

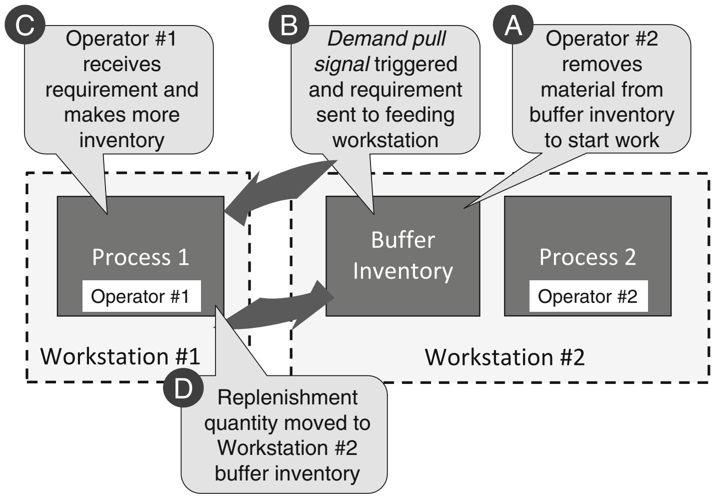


FIGURE 8.9 Pull system basics.

- In event C, the requirement to replenish the inventory removed from the workstation buffer is passed back to operator #1, authorizing work to begin to replenish the buffer inventory at workstation #2.
- In event D, the completed item quantities are moved from workstation #1 to the buffer area located at workstation #2.

Note that in a lean pull system replenishment occurs only when the *demand pull signal* is activated in the system.

While a kanban (which in Japanese means a card or signal) has been chosen to illustrate the example of a pull system, the mechanics of other signals would basically work the same way. Before a pull system is implemented, the following critical preliminary points regarding the use of kanbans must first be discussed.

- The optimal type of lean kanban is chosen.
    1. *Production kanbans* specify the quantity of product to be produced by upstream production work centers. The kanban is actually an *authorization* for the next container of material to be produced.
    2. *Move kanbans* specify the quantity (or number of containers) of product that is to be moved from a reserve or remote buffer location to the requesting buffer area.
    3. *Supplier kanbans* are used to trigger replenish products to be purchased from an outside supplier.
- A *one-card* (a production kanban only) or a *two-card kanban system* (production and move kanbans) can be used to manage a production system.
- Kanbans contain critical item replenishment information, such as the item number, description, production location, move to location, quantities, and lead times.

Lean kanban replenishment operates in a manner similar to the two bin system described earlier in the chapter. As inventory is pulled to meet order demand fulfillment, a trigger, in the form of a replenishment signal, will eventually be tripped, alerting planners that replenishment from suppliers is necessary to avoid future stock out. An order is then placed utilizing some form of authorization, such as a simple kanban card or empty container(s) that are picked up by the supply source, filled to specification, and returned. The assumption is that the entire channel inventory system works the same way from customer to supplier to producer, and, ultimately, raw materials acquisition. Instead of elaborate computer systems or complicated EOQs that create safety buffers to guard against unplanned demand, the replenishment signal determines when resupply order action should occur. In addition, since inventory quantities must be consumed in order to release a replenishment signal, the system responds to real-world changes and is self-regulating.

Kanbans can be used to replenish inventories from an outside supplier. A supplier kanban is considered as a form of *external* move kanban. To make a supplier kanban system work, planners first establish the relationship between a kanban and a specific quantity of an item. Normally, this quantity is determined as the amount of stock for an item that will fit in the kanban "container" – such as a box, basket, or pallet. Once this value has been determined, the next step is to determine the demand, the production and transportation lead time to make and ship the kanban, and the desired safety stock percentage. At a minimum, the kanban quantity should be sufficient to cover normal demand during the replenishment cycle.

The use of supplier kanbans requires close coordination between buyer and supplier. Since the supplier kanban replaces the traditional purchase order, the details related to the purchase, such as quantity per kanban, purchase cost, delivery lead time, accounts payables, and so on, must be firmly established and agreed upon by both buyer and supplier. Functionally, when a kanban is in need of replenishment, the card, container, box, or other form of kanban, is retrieved by the stockkeeper. Classically, the replenishment notice is communicated to purchasing which then verifies and passes the kanban to the supplier either electronically or physically. When the supplier receives the kanban, it is filled with the quantity of inventory specified by the kanban and is then shipped to the company. When it is received, the kanban is either placed in a forward buffer area or a reserve stocking location.

The critical task for the inventory planner in a kanban system is determining how many kanbans are needed to satisfy demand requirements. The equation for calculating the number of supplier kanbans is basically the same as a production or move kanban with a few exceptions. In place of *production lead time*, the equation incorporates the time required for communicating the kanban to the supplier and the time for transporting the replenished kanban back to the buyer. The equation to calculate the number of supplier kanbans is as follows:

$$\#kanban = \frac{D(Td + Tp)(1 + SS)}{QR}$$

where

$$\begin{aligned}
&\text{Demand} = D \\
&\text{Transit delay(pickup)} = Tp \\
&\text{Transit delay(delivery)} = Td \\
&\text{Safety stock} = SS \\
&\text{Container(Kanban)quantity} = Q \\
&\text{Deliveries per day} = R
\end{aligned}$$

Exercise 8.16: Calculating Supplier Kanbans

The inventory planner at ABC Electronics is charged with the task of calculating the number of kanban cards for an item. The detail planning data for the item is as follows:

$$\begin{aligned}
&\text{Daily demand}(D) && = 300\,\text{units}\\
&\text{Transit delay pick up}(Tp) && = 2\,\text{days}\\
&\text{Transit delay delivery}(Td) && = 2\,\text{days}\\
&\text{Safety stock}(SS) && = 50\%\\
&\text{Kanban container size}(Q) && = 50\,\text{units}\\
&\text{Deliveries per day}(R) && = 1\,\text{delivery/day}
\end{aligned}$$

Using the kanban card formula, the number of purchasing kanbans (containers) is

$$((300 \times (2+2)) \times (1+0.50)/(1 \times 50) = \textbf{36 kanbans}$$

Using a lean kanban system to manage inventories in a supply chain requires that demand and supply be synchronized at each stage of the supply pipeline. The key is to regard the entire supply network as a single customer satisfying entity. Instead of each supply node planning and executing demand plans in isolation, each channel entity pulls inventories from their supplying partners driven by the drum beat of the pull of actual demand beginning with the customer and ending with materials suppliers. Kanban buffers are found at each supply node to absorb demand in the system (Figure 8.10). The key to the synchronized supply chain is *communication* of demand and replenishment requirements as close to real-time as possible. In addition, the pursuit of continuous improvement objectives dedicated to removing wastes and maximizing the velocity of channel product flow would tame the bull-whip effect and ever more closely link the entire supply chain to the end customer.

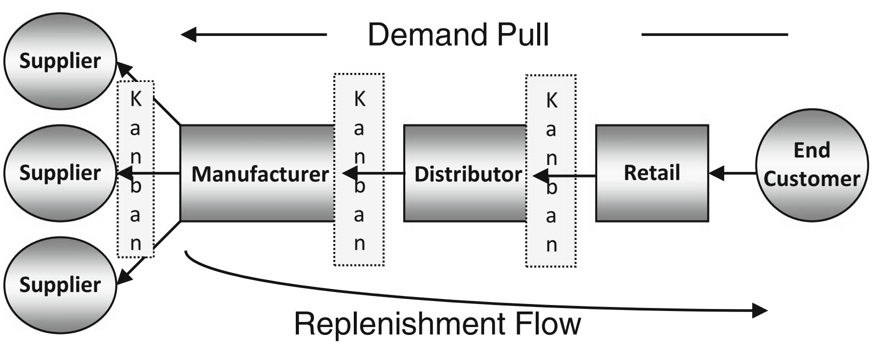


FIGURE 8.10 Lean synchronized supply chain.

The advantages of such a control system are obvious. Beyond its apparent simplicity, however, reside a number of critical assumptions. To begin with, the system demands 100 % quality. Without large inventory buffers at every channel node, defective products will quickly result in stock out. Second, a very close collaborative relationship must exist between channel partners. This element requires consensus on a range of issues from standardization of processes and equipment and agreed upon levels of service and flexibility to a mutual sharing of benefits and risks. Finally, lean replenishment requires channel partners to jointly undertake programs designed to pursue the continuous improvement of the system.

While lean does resemble a two bin system, the differences between the two are dramatic. The two bin technique seeks to arrive at a stable system that invariably services demand. Lean continuous improvement, on the other hand, seeks to disrupt the system stasis by removing one of the kanbans from the control system, identify the problem areas that arise, determine a solution, and evolve to a new stasis. Once this occurs, however, it is time to upset the system by removing another kanban and begin the improvement process all over again with the eventual objective of minimizing or eliminating channel inventories altogether.

8.6 SUMMARY

Providing solutions to the challenges surrounding inventory replenishment is one of the most important tasks of supply chain management. Answering effectively the critical inventory planning questions of *what* products to review for resupply, the precise timing of *when* resupply order release should take place before stock out occurs, and *how much* inventory should be ordered when replenishment is triggered is essential if each channel partner is to leverage the resources of the entire supply channel to gain and sustain competitive advantage. The responsibility for effective inventory planning and execution resides with inventory management who must facilitate the attainment of customer service targets while simultaneously achieving least total cost for inventory, transportation, warehousing, and staffing.

At the core of all statistical replenishment systems resides a very simple principle: For each product, there is an optimal stocking and ordering quantity in which the total cost of carrying inventory is balanced against the cost of ordering. By calculating optimal reorder points and order quantities through a variety of statistical replenishment techniques, planners are provided with a triggering mechanism alerting them on an item-by-item basis when order action needs to occur and what the resultant reorder quantities should be. The effective use of statistical inventory replenishment methods involves a thorough understanding of the elements necessary to calculate reorder points and order quantities. A firsthand knowledge of such components as demand *usage, lead time*, and *safety stock* are critical for the effective use of such ordering techniques as statistical reorder point, min/max, joint replenishment, and periodic review. Equally important is knowledge of the components of various *order quantity* techniques. Computing the economic order quantity (EOQ), determining order size when there are quantity discounts, and replenishing by ABC classification are examples.

This chapter focused on managing independent demand items in a single plant environment. Often planners are faced with planning inventories in a multi-echelon environment. In Chapter 9, determining replenishment techniques in an environment characterized by multiple levels of manufacturing and distribution points will be discussed.

DISCUSSION QUESTIONS

1. Inventory planners have to make critical decisions about how much inventory to stock. What key components of inventory management must the planner take into consideration when planning for inventories?
2. Explain the distinction between independent and dependent demand in the management of inventories.
3. Discuss the various techniques of replenishing inventory available to the inventory planner.
4. Discuss the difference between *continuous review* and *periodic review* systems.
5. Describe the components of the reorder point model.
6. What are the key components in calculating the optimal order quantity?
7. Discuss the two forms of inventory demand. Why are they so important to inventory planners?
8. Explain the concept of stock replenishment.
9. Why is the EOQ such a valuable tool for calculating inventory order quantities?
10. Why is the customer service level so important in calculating safety stock?

PROBLEMS

1. Demand for a best-selling TV at ABC Electronics has been averaging 550 units a month. ABC incurs a fixed ordering, transportation, and receiving cost of US$3,500 each time an order is placed. Each TV costs ABC US$245.00. The holding cost for the retailer is 21 %. What should be the number of TVs the inventory planer at ABC Electronics buys?
2. The inventory planner at ABC Electronics is trying to calculate a new safety stock on the best-selling TV described in question 1 above. The first step is to find out the standard deviation for the pattern of sales occurring over the past 10 weeks. The planner has assembled the below demand. Calculate the standard deviation for this TV.

Week	Average sales	Actual sales
1	550	525
2	550	585
3	550	603
4	550	601
5	550	575
6	550	520
7	550	502
8	550	530
9	550	590
10	550	610

3. Demand for a 50″ plasma TV at ABC Electronics has been averaging 600 units a month. ABC incurs a fixed ordering, transportation, and receiving cost of US$2,500 each time an order is placed. Each TV costs ABC US$200. The holding cost for the retailer is 21 %. What is the carrying cost for this item?

4. The planner at ABC Electronics is trying to calculate the safety stock and order point for the 50 in. plasma TV it stocks. After researching past sales, the planner has determined that weekly sales have been averaging 125 TVs a week with a standard deviation of 18 units. The lead time from the supplier is currently 3 weeks. Management has determined that the customer service level should be set at 98 % (2.05 safety factor). The unit cost is US$435.00. What is the safety stock and reorder point for the item?
5. A supplier maintains a 15-day lead time for delivery of their software packages. The customer maintains an inventory with a safety stock of 200 units based on a usage of 400 per week. Given that there are 50 weeks in the year and the customer works 5 days a week, calculate the order point the customer should consider.
6. A buyer has received a requisition for 150 units of a polyethylene container. The containers get damaged in use and need replacement. Six hundred have been used each year. The cost per container is US$30.00, and the buyer estimates that it costs US$50.00 to place an order. Inventory carrying costs are 20 % of the value of average inventory each year for this class of item. What quantity, in units, should the buyer order to obtain the lowest annual cost for the containers?
7. ABC Electronics stocks low cost batteries that are ordered from a local supplier. Planners use a periodic order system to control replenishment. One of the batteries, a two-volt SKU, is review every 2 weeks (10 days), lead time is 2 days, the average demand is 125 per week (5 days), and a safety stock of 3 days is maintained on the item. The battery is being reviewed today for replenishment and there are 100 units currently on hand.
   (a) What is the target inventory (TI)?
   (b) How many two-volt batteries should be ordered?
8. The inventory planner at ABC Electronics must replenish an item subject to periodic review management. The data for the item has changed and the item ordering values will have to be recalculated. The following data has been determined by the planner:

Inputs	
Daily demand	50
Lead time (days)	12
Review cycle (days)	30
On hand balance	1,400
Target customer service level	95.00%
Standard deviation of demand per day	12

Please calculate the following values:

What is the mean demand during the replenishment lead time?
Answer: _________.
What is the standard deviation of demand during the lead time?
Answer: _________ days.
What is the safety stock?
Answer: _________.
What is the target inventory (*TI*)?
Answer: _________.
What is the replenishment order quantity?
Answer: _________.

9. The inventory planners at ABC Electronics have recently become aware that variation in the delivery of a key item from the supplier was causing a shortage problem. It has been decided that safety stock should be added to the order quantity to prevent stock out. After researching the item, the following planning data was detailed:
   - Average demand per day is 25 units
   - Replenishment lead time is 10 days
   - Standard deviation of supply lead time is 3 days
   - Standard deviation of demand is 2 units
   - Target customer service level is 98 % (hint: 2.0537)

   (a) What would be the safety stock on this item?

   (b) What would be the new reorder point?

10. The planner at ABC Electronics needs to purchase three products, #03925, #3819, and #03442, jointly. The problem is that the items have different demands. The planner has established the planning data as follows:
    - Annual demand for item #03925 is 13,000 units.
    - Annual demand for item #03819 is 9,000 units.
    - Annual demand for item #03442 is 4,500 units.
    - Ordering cost (for all orders) is US$120.
    - Transportation cost (fixed for all orders) is US$1,500.
    - Item unit cost (same for all three texts) is US$20
    - Carrying cost is 20 %.

    Calculate the solution by using the joint ordering technique.

    (a) How many times should the three items be released each year?

    (b) What is the total yearly cost for ordering the three items?

REFERENCES

1. Reference the demand calculation in Brown, Robert G. 1959. *Statistical forecasting for inventory control*, 136–147. New York: McGraw Hill.
2. See the discussion in Waters, C.D.J. 1992. *Inventory control and management*, 33–34. New York: Wiley; Silver, Edward A., and Rein Peterson. 1985. *Decision systems for inventory management and production control*, 2nd ed, 174. New York: Wiley.
3. Elements of this topic have been adapted from Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: strategy, planning, and operation*, 4th ed, 256–263. New York: Prentice Hall.
4. Reference Bowersox, Donald J., David J. Closs, and M. Bixby Cooper. 2010. *Supply chain logistics management*, 3rd ed, 166–167. New York: McGraw-Hill Irwin.
5. Reference Ballou, Ronald H. 1999. *Business logistics management*, 4th ed, 358–360. New Jersey: Prentice Hall.

9

Replenishment in a Multi-echelon Channel Environment

Chapter 8 was concerned with a discussion of statistical inventory management in an independent demand environment where items are stocked at a single facility. Many firms, however, must contend with the planning and deployment of items in a multi-echelon distribution channel. Perhaps the critical characteristics of supply channel planning is the fact that items are stocked at more than one geographical facility and that many of the facilities are *dependent* on one or more supplying facilities in the channel for replenishment. Distribution network structures are expressed in much the same manner as production bills

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_9) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_9,

of material (BOMs). Facility dependencies are linked by echelon (level) to their respective parent supplying facilities that, in turn, may be dependent on still higher echelons of facilities for resupply. The highest echelon in the structure is the supplier or product manufacturer. When independent company supply chains are linked to other company supply chains, they become multi-company networks and are at the center of supply chain inventory management.

Inventory planners have two choices when applying replenishment techniques in a multi-echelon supply chain. The first option is to apply the techniques of statistical inventory management to the supply network. Techniques, such as order point and economic order quantity (EOQ), can be used to manage multi-echelon channel inventory replenishment.

The second option is to apply the concepts and techniques of distribution requirements planning (DRP). Unlike replenishment methods that utilize statistical calculations to arrive at replenishment order timing and quantities, DRP determines inventory requirements by *time-phasing* supply to meet demand for each item at each facility in the distribution channel. Utilizing the same computerized logic as material requirements planning (MRP), DRP first compiles the inventory replenishment needs of each channel facility out through the planning horizon. When demand exceeds available supply, the system generates a *planned resupply order* and alerts the planner that replenishment action is required if stock out is to be avoided. At this point, DRP drives the requirements up through the distribution network and places the resupply order on the pre-determined supplying facility. The parent facility then responds by transferring the required items and quantities back down the channel to the child facility. The choice of using DRP or statistical replenishment techniques for channel replenishment is a management decision requiring an understanding of the nature of customer demand, the dynamics of the distribution channel, inventory and supplier characteristics, and the application of the necessary computerized tools.

This chapter begins with a review of managing multi-echelon distribution demand and supply inventories. Central to the discussion is an understanding of channel “push” and “pull” methods of replenishment management. A detailed description of the application of statistical replenishment in a multi-echelon channel follows. The remainder of the chapter concentrates on the theory and processing logic of DRP. After detailing the data elements and format of DRP, the mechanics of DRP computer logic are reviewed. Particular attention is paid to analyzing how DRP uses *time-phased* demand and supply input to generate output information that is used by the inventory planner to guide resupply order action. The chapter concludes with a brief review of the application of DRP to the management of supply chain capacities. Discussed are determining the impact of the DRP priority plan on financial capital planning, transportation capacity requirements, warehouse space requirements, and labor and equipment capabilities.

9.1 DISTRIBUTION CHANNEL BASICS

Inventory management in a multi-echelon channel environment is determined by the structure and objectives of a firm’s distribution channel. Companies create a channel of distribution because they have determined that the best way to serve the marketplace is to have inventory geographically close to the customer. As represented in Figure 9.1, distribution channels consist of two basic flows: *inventory* flows from the plant or main warehouse through the various echelons in the distribution channel until the customer is reached, while *information* about channel performance, the customer experience, and financial settlement flows up the channel to the supply source. Creating a distribution channel affects inventory in that each facility in each echelon acts as an inventory decoupling point.

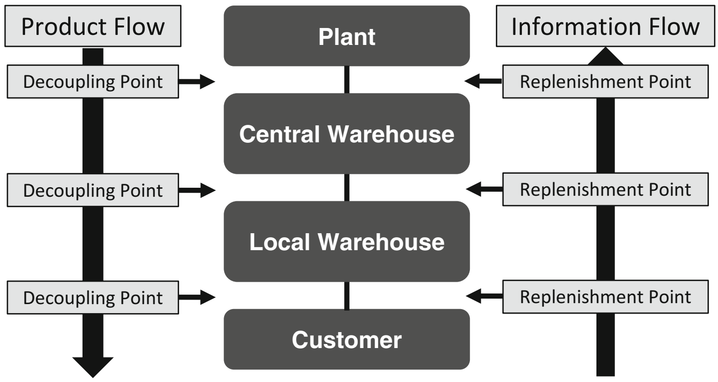


FIGURE 9.1 Distribution channel flows.

How many echelons exist in a supply channel is dependent on how deeply businesses must penetrate into the marketplace. The desired level of penetration requires the formulation of strategies associated with capabilities and costs (storing inventory and performing transportation activities), channel power (distribution of influence among channel players), and competitive actions (presence of competitors and buying alternatives). If the customer is willing to wait for delivery, suppliers can limit the number of channel echelons. On the other hand, the pressure of competition or the nature of the product may force suppliers to create intricate supply channels where product delivery depends on the presence of channel partners to provide product access to the customer. For example, Coca Cola depends on a complex network of channel partners and retailers who move product from the bottling operation to the grocery store shelves.

As the number of channel echelons grow, demand information is severed between the original supply source and the customer and is replaced by inventory buffers staged at strategic points in the delivery channel. The decision to decouple inventory from direct demand, however, comes with a price. Beyond inventory carrying cost, channel members must shoulder the responsibility for inventory planning at each facility in each echelon. The more echelons in the channel, the higher the cost and the more complex the replenishment process.

There are basically two ways to replenish inventory in a distribution channel: *push* or *pull*. As illustrated in Figure 9.2, in a *coupled deployment* ("push") *system,* all channel resupply activities are conducted by the central supplying facility. Since replenishment planning is centralized, channel resupply is performed first by aggregating the demand arising from all dependent facilities in lower echelons, and then using an allocation metric to push or disburse the replenishment inventory from the plant to these dependent facilities.

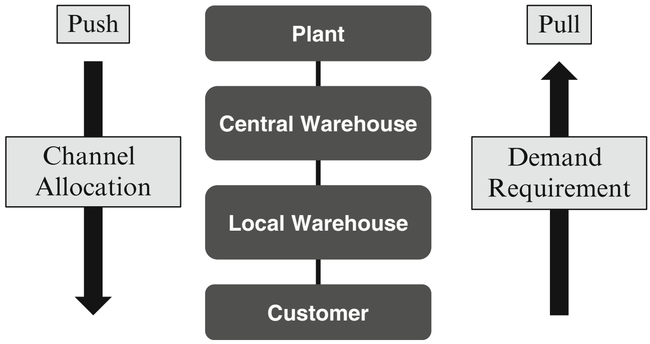


FIGURE 9.2 "Push" or "pull".

In contrast, in distribution channels characterized by an *independent deployment* ("pull") *system,* inventory planning is decentralized. Each facility in the channel maintains its own inventory management system and determines its own replenishment requirements. When the local facility's planning system indicates that inventory needs to be replenished, a resupply order is placed on the pre-determined supplying facility. The use of either method is not exclusive: aspects of the two systems can be combined in a distribution channel to respond to specific network needs.

9.1.1 Coupled Deployment "Push" Systems

Inventory replenishment in a coupled deployment system is *pushed* from supply points through intermediate echelon facilities all the way to the lowest channel location. In a "push" system the supplying location possesses resupply authority. In addition, the supply point also has the ability to adjust the actual replenishment items and quantities to improve overall channel service or reduce total channel costs. The key to successfully executing a "push" system is effective central inventory planning. Inventory managers must have accurate and timely information as to the stock status of all satellite locations. Whether gathered on a transaction-by-transaction basis or periodically, channel inventory requirements provide the data necessary for aggregate planning and efficient resupply allocation. Functionally, whether using min/max rules, reorder point, or other techniques, each satellite warehouse's inventory is controlled by a combination of cycle stock used to cover customer demand during replenishment lead time and safety stock to provide for unplanned demand variations. The role of central deployment locations is to calculate and resupply inventory requirements for the whole channel in accordance with the company's customer delivery responsiveness.

As illustrated in Figure 9.3, "push" system planners begin by assembling the demand history for all items transacted for a planning period occurring in the distribution channel. This data is then manipulated by applying forecasting or replenishment techniques to arrive at the total inventory requirement for the entire channel needed to satisfy customer demand. At this point, the available inventory across the channel is reviewed to validate individual facility inventory balances and what is needed at each satellite facility. If sufficient inventory exists, the planners use predetermined algorithms to allocate a share of the aggregate inventory at the parent facility to each of the facilities on the next echelon level. If inventory is insufficient to meet the total demands of each channel facility, planners may choose to divide the inventory among the facilities using predetermined rules, such as *fair shares allocation* or market-based judgments.

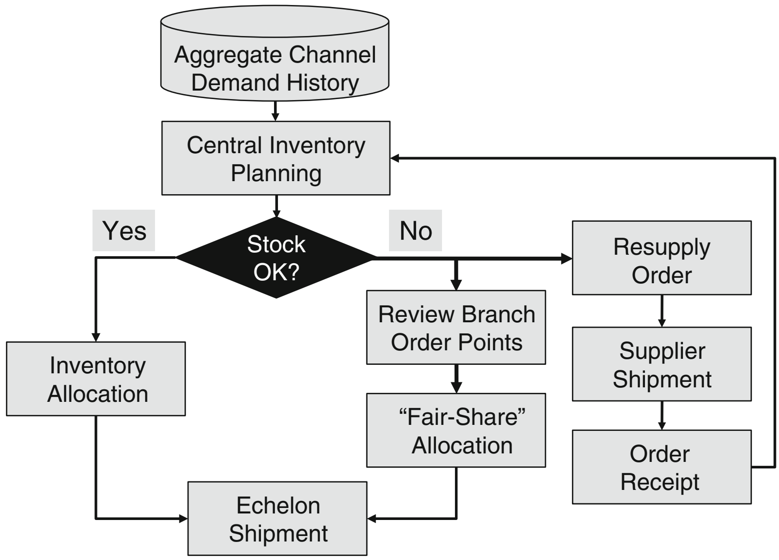


FIGURE 9.3 "Push" system flow.

The partial inventory quantities are then "pushed" to each facility in the channel. Inventory planners at the parent facility may then launch a resupply order with suppliers or the supplying production plant to acquire the remaining demand balance inventory to satisfy the projected shortage.

An example of a push system appears in Figure 9.4. The supply channel consists of a supplying manufacturing plant, two distribution centers (DCs), and four remote warehouses supplied by the DCs. The movement of historical demand information moves upstream from the warehouses to the plant and replenishment orders (inventory) moves downstream from the plant to the warehouses. The process begins at the plant where inventory planners determine the total requirements of the channel by aggregating demand and creating the forecasts that they then will use to determine production lot sizes and replenishment order release.

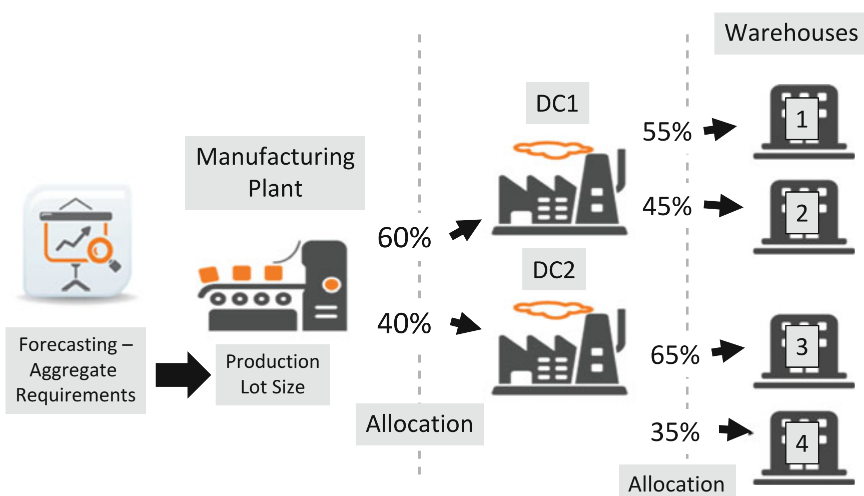


FIGURE 9.4 "Push" system example.

Once production is completed, the channel inventory quantities are allocated to the two DCs. In the example illustrated in Figure 9.4, 60 % of the output of the plant will be "pushed" to DC1 with the remaining 40 % pushed to DC2. The DCs are each responsible for resupplying two remote warehouses. Based on predetermined criteria, 55 % of DC1's inventory is pushed to warehouse 1 and 45 % pushed to warehouse 2. Likewise, DC2 pushes 65 % of its inventory to warehouse 3 and 35 % to warehouse 4. The expectation is that the allocation percents follow closely actual channel demand requirements through time.

The advantages of a "push" system are described as follows:

- *Performance measurement*. The "push" system enables corporate planners to leverage the total inventory and channel historical demand to meet shipment goals while minimizing channel inventories. Performance is measured not just on the success of discrete stocking points, but on how well the whole channel is meeting corporate sales and asset management targets.
- *Central planning*. By centralizing all inventory planning and replenishment allocation, channel planners can create a *single* inventory plan for the ongoing ordering and deployment of channel inventory. Central planning enables planners to determine global channel inventories and to remove the normal supply point stock redundancies caused by inaccuracies in local replenishment decision making. In addition, by strategically deploying inventory resources throughout the channel, stocking inequalities among branches is reduced, further cutting costs arising from interbranch transfer and lost customer sales.
- *Cost reductions*. By centralizing inventory planning and deployment, companies can reduce the total working capital necessary to stock the supply channel. In addition, operating costs are reduced by economies attained in transportation and purchasing. Instead of ordering products to satisfy individual branch demand, central purchasing can combine requirements from all branches, thereby reducing inbound transportation and acquisition costs while gaining quantity price breaks and other order discounts. In addition, the presence of costly inventory planners and planning functions can be removed from satellite warehouses.
- *Safety stock control*. Whereas safety stock is a characteristic feature of inventories subject to independent demand, a "push" system enables planners to centralize safety stocks at the central facility. By eliminating unnecessary safety stocks carried at each channel location, "push" systems reduce total inventory costs while maintaining high channel serviceability.

Disadvantages of a "push" system center on organizational issues. An effective "push" system requires a professionally trained central planning staff that can work with aggregate data and demand forecasting techniques. In addition, inventory accuracy and timely transaction record posting normally requires a computer system that combines the historical demand resident at each channel location. Finally, the introduction of a "push" system requires changes in operational roles. As central planning is now responsible for resupply planning and execution, branch management's role migrates from a focus on detailed inventory replenishment management to ensuring transmission of accurate stock status and sales usage information to the channel's central planning functions.

9.1.1.1 Push System Allocation: Example

Figure 9.5 provides an illustration of how a "push" system allocation is used to determine the inventory replenishment quantities in a complex distribution channel. The grid appearing on the figure details the national sales forecast for an item for a large apparel retailer operating in the U.S. Such a period-level forecast is developed by the marketing department using special statistical software that takes past sales history combined with correlational factors and market estimates. The goal of the planners is to allocate the national forecast for the item across a complex distribution channel consisting of regional and area distribution facilities which, in turn, supply local retail stores.

			Forecast Periods							
		Percent	1	2	3	4	5	6	7	8
National forecast		100%	15,000	15,000	18,000	18,000	19,000	19,000	20,000	21,000
Regional forecast	Region 1	12%	1,800	[illegible]	[illegible]	[illegible]	[illegible]	2,280	2,400	2,520
	Region 2	28%	4,[illegible]00	4,200	5,040	5,040	5,320	5,320	5,600	5,880
	Region 3	38%	5,[illegible]00	5,700	6,840	6,840	7,220	7,220	7,600	7,980
	Region 4	22%	3,[illegible]00	3,300	3,960	3,960	4,180	4,180	4,400	4,620
		100%								
Region 1 Area forecast	Area 1	40%	720	[illegible]	[illegible]	[illegible]	912	912	960	1,008
	Area 2	25%	[illegible]50	450	540	540	570	570	600	630
	Area 3	15%	[illegible]70	270	324	324	342	342	360	378
	Area 4	20%	[illegible]60	360	432	432	456	456	480	504
		100%								
Region 1, Area 1, Store forecast	Store 1	30%	216	[illegible]	[illegible]	[illegible]	274	274	288	302
	Store 2	15%	108	108	130	130	137	137	144	151
	Store 3	50%	360	360	432	432	456	456	480	504
	Store 4	5%	36	36	43	43	46	46	48	50
		100%								
Region 1, Area 2, Store forecast	Store 1	20%	43	43	52	52	55	55	58	60
	Store 2	15%	32	32	39	39	41	41	43	45

15,000 x 12% = 1,800 units

1,800 x 40% = 720 units

720 x 30% = 216 units

FIGURE 9.5 "Push" system allocation – example.

The top row of the grid displays the national forecast for an item spread over an 8-month planning horizon. The national forecast is used to determine the inventory allocation across the company's four regional facilities. The example shows the allocation information for Region 1. The goal is to calculate the quantity of the national forecast to be "pushed" or allocated to each region. This is easily done by multiplying each period's national forecast by each region's historical demand percent. For example, the quantity to be "pushed" to Region 1 is calculated by multiplying the national forecast of 15,000 units by 12 % to arrive at a quantity of 1,800 units in period 1, 1,800 units in period 2, and so on.

The same logic is applied to calculating the inventory requirements at the four channel *areas* comprising Region 1. For example, the forecast for Region 1, Period 1 is 1,800 units. The allocation for Region 1, area 1 is calculated by multiplying the 1,800 units by 40 % (the historical percentage of demand at area 1), or 720 units. Finally the same logic is used to calculate the inventory requirements at the four channel *stores*. For example, the forecast for area 1, Period 1 is 720 units. The allocation for area 1, store 1 is calculated by multiplying the

720 units by 30 % (the historical percentage of demand at store 1), or 216 units. Once the national forecast allocation is performed for all channel echelon levels, the inventory quantities are then physically shipped or "pushed" through the distribution channel down to the store level.

9.1.2 Independent Deployment "Pull" Systems

Under an *independent deployment system*, each location in the supply channel is responsible for determining its own ordering techniques, cost factors, service objectives, and resupply lead times. Each location calculates its replenishment requirements and then draws inventory through the channel network by resupply order from the supplying location. The branch warehouse determines order timing, which items are to be ordered, and what are the resupply order quantities and delivery requirements. The next higher echelon could be a regional distribution center within the internal channel network or an independent channel intermediary. The distribution centers, in turn, receive a sequence of resupply orders by due date from their branches and attempt to fill and ship them according to some priority rule, usually *first-come first-serve*. Finally, the distribution center acquires its replenishment inventory directly from the manufacturer or the supplier.

As illustrated on Figure 9.6, in a "pull" system each facility in the distribution channel is responsible for inventory reordering based on demand requirements. Facilities have a choice of selecting either statistical order point or distribution requirements planning (DRP) or a combination of both as their ordering system. Normally, executing a pull system requires the presence of an enterprise resources planning (ERP) system shared by all facilities in the channel network. Based on the ordering method, each facility generates its own resupply orders consisting of the items and resupply quantities to be ordered. These orders, in turn, are transmitted to predetermined supplying facilities located upstream in the distribution network. Supply facilities, in turn, receive the resupply orders from their satellite warehouses and attempt to fill and ship them according to order due date. The supplying facilities, in turn, pull their resupply inventory from higher channel echelon supplying facilities, the supplying production plant, or outside suppliers.

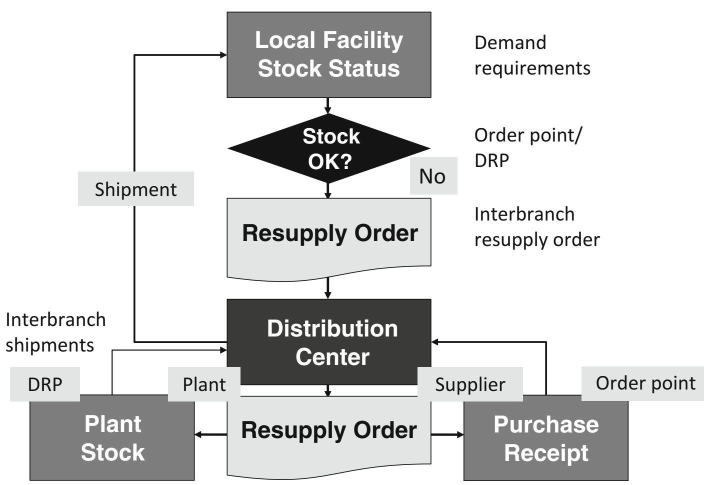


FIGURE 9.6 "Pull" system flow.

An example of a pull system appears in Figure 9.7. The supply channel consists of a supplying manufacturing plant, two distribution centers (DCs), and four remote warehouses. The movement of replenishment orders moves upstream from the warehouses to the plant, and resupply inventory moves downstream from the plant to the warehouses. The process begins on the warehouse level where resupply orders are generated using either reorder point techniques or DRP. The resupply orders are generated by the computerized planning system at the supplying DCs. A warehouse could draw all of its requirements from one DC, or split the requirements by drawing a predetermined percent from multiple supplying DCs. If the DCs have sufficient inventories, the items are picked and shipped based on the resupply orders generated by the warehouses. If there are insufficient inventories, the DCs use a predetermined algorithm to split the existing inventories by percent to the warehouses with the unsatisfied quantities going on backorder.

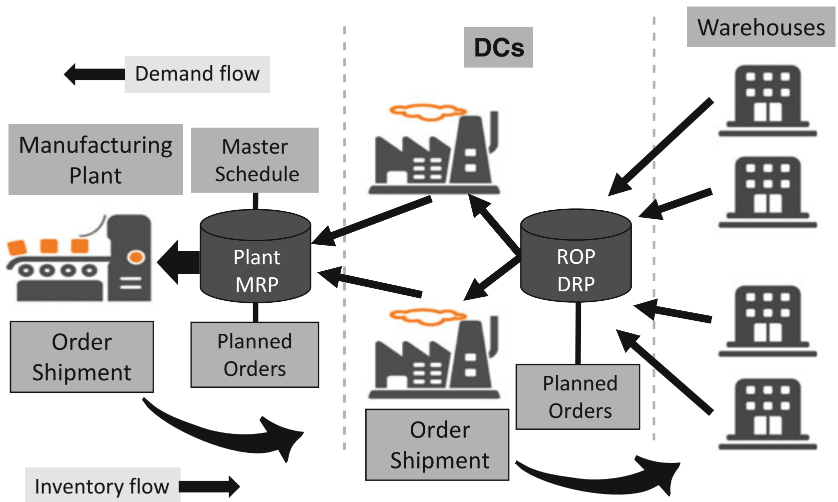


FIGURE 9.7 "Pull" system example.

In turn, the DCs independently manage their own requirements as inventory decreases. Just like the warehouses, the DCs generate resupply orders through the computerized planning system. Normally, the DCs would be using the same ordering method (reorder point or DRP) used by the warehouses they supply. Once resupply orders are generated, they are placed into the planning system of the next higher channel echelon, which in the example, is the manufacturing plant. The resupply orders are placed as demand in the plant's master production schedule (MPS) for scheduling, production, and shipment to the DCs.

The advantages of a pull system are the following:

1. *Planning simplicity*. Pull systems are easy to operate. Because each supply node is responsible for inventory planning, there is no need of a centralized planning DC or plant and there is no need for the laborious process of aggregating channel demand and developing allocation plans. Upper-level supplying echelons must plan only for the total requirements placed on them by the lower-level echelon warehouses they resupply.
2. *Turnover*. Because satellite locations draw exactly the necessary resupply quantities they need versus being shipped large lot quantities characteristic of a push system,

inventory carrying costs at the warehouse level normally decline. Since they have just the right amount of inventory turnover to satisfy the projected demand quantities, they can operate with lower stock levels, turning inventory faster than would be possible in a push system.

3. *Overhead cost reduction*. Branch locations in a pull system leverage the economies of scale resulting from lower inventory acquisition and material distribution costs incurred by central functions in planning for the entire supply channel while receiving the benefits of short delivery and planned storage and warehouse space allocation.
4. *Use of replenishment and DRP ordering techniques*. Standard reorder point and DRP computer system logic provide excellent tools to operate pull systems. Both techniques enable local warehouses to determine the exact timing and quantities of replenishment orders. Once these requirements have been calculated, the computer system can then pass the resupply orders through the *bill of distribution* (BOD) directly to the supplying warehouse or production facilities so that resupply can then be passed back down the channel to respond to the pull of the demand source.

The disadvantages of a pull system, for the most part, center on overall inventory carrying costs and deficiencies in information flows, particularly in a supply chain driven by statistical replenishment techniques. Although it is true that branch inventory turns will be high and overhead costs low, the exact opposite can be said of the profitability of the central supplying facilities who must shoulder the cost of housing resupply inventories versus simply being transition points where push inventories are disaggregated and immediately passed on to the end-level echelon warehouses. Channel systems using a "pull" system must be sure that aggregate costs incurred are offset by higher inventory turns in the branch locations.

Furthermore, because each location in the network is responsible for their own service levels, there is a tendency to duplicate safety stock at multiple echelons in the channel. In addition, because each location pulls inventory from their supplying location, medium- to long-range information concerning downstream inventory requirements is not available to regional and national locations in the network. Supplying warehouses are usually unaware of branch requirements until the resupply order arrives. Finally, the objectives and performance measurements inherent in a pull system may actually militate against overall corporate profitability by inflating channel inventories in an effort to improve branch sales levels.

To counterbalance pull system deficiencies, a number of techniques may be deployed. Inventory planning can be governed by implementing a channel-wide *periodic review* system. Operationally, branch warehouse inventories are reviewed periodically and resupply orders generated with sufficient quantities necessary to restore channel-wide stocks to a targeted level. Another technique is to utilize a *double reorder point*. Each branch's inventory has its reorder point set by calculating the normal reorder point *plus* the average demand during the central warehouse's procurement, transportation, and production lead time. Theoretically, this technique enables the central supplying location to review its inventory levels relative to anticipated branch orders and plan acquisition and transportation accordingly.

Another method, the *base stock system*, requires each location in the channel to maintain a base level of inventory determined as the facility's statistically computed demand *plus* stock at all upstream warehouses. The inventory position at each level is indicated by

$$IP = ES + RO$$

where IP is the echelon inventory position, ES is the echelon stock, and RO is the replenishment order. For example, branch facility A is resupplied from warehouse 1. For a given item, branch facility A stocks 100 units and warehouse 1 stocks 300 units. There are also 50 units in transit to branch facility A, and warehouse 1 has an unfilled replenishment order from the supplier for 100 units. Finally, branch facility A has a customer order backlog of 125 units. Then, warehouse 1's inventory position is

$$IP = (100 + 300 + 50 - 125) + 100 = 425 \text{ units}$$

Either on a periodic basis or after each transaction, the branch location compares the inventory position to the reorder point (usually a minimum), and when the reorder point is triggered, inventory is ordered to raise the inventory position to the base stock level. At the supplying warehouse, total demand from all satellite warehouses are planned and economical shipping quantities accumulated for transfer to meet channel requirements.

9.1.2.1 Bill of Distribution (BOD)

The mechanics of both push and pull systems require inventory planners to formally determine the linkages and dependencies between the various entities constituting a multi-echelon channel. When inventory replenishment is required, the supply channel structure enables planners and their planning systems to know exactly where orders and information is moving in the supply network. The technique that enables these linkages is termed the *bill of distribution* (BOD).

Utilizing the logic and mechanics of the production *bill of material* (BOM), the BOD links supplying and satellite warehouses together similar to the way the BOM links manufacturing inventory to their assembly parents (Figure 9.8). The difference between the two is subtle but critical. In production, when demand is posted on a parent assembly item, the MRP processor references the assembly's BOM and "explodes" the requirement through the product structure, placing demand on the child items and specifying the quantities and due dates needed to build the assembly.

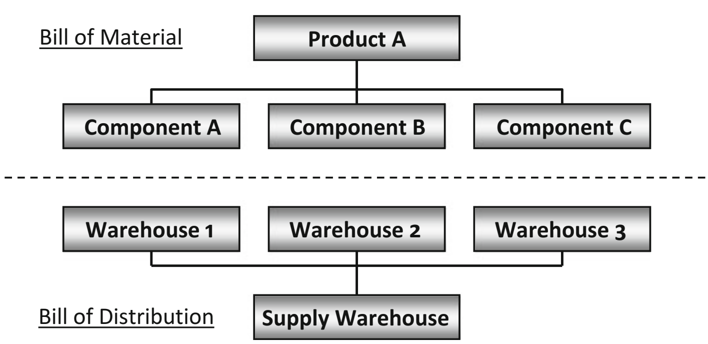


FIGURE 9.8 BOMs and BODs.

In contrast, the BOD inverts this process. The mechanics of the BOD are designed to facilitate the transfer of requirements from the components (the dependent satellite warehouses) to the parent (the supplying warehouse). This structure performs an *implosion* where requirements are passed up the structure rather than down. The exact structure of a BOD is configured to match a variety of channel inventory flows. A complex BOD consists of a supplying plant, regional distribution centers, local distribution centers, and warehouses all the way down to the retail level. In addition, a BOD could contain items that are pushed, reorder pointed, or use distribution requirements planning (DRP).

In addition, the BOD is capable of handling a variety of inventory storage strategies. For example, not all items may be stocked in every warehouse. The central warehouse stocks all items sold in the channel, while channel satellite warehouses stock only those items that sell to local customers or are characterized by high sales volumes. In any case, inventory planners must ensure that the proper items and planning data are attached to the correct channel facilities for the BOD implosion to work effectively. In the end, the BOD structure details the flow of each and every item in the distribution channel.

The benefits of using the BOD are summarized as follows:

- The BOD enables the structuring of a comprehensive distribution channel that guides the computerized implosion process and provides planners with full visibility of supply and demand relationships up and down the channel.
- Supplying and satellite warehouse dependencies are clearly established.
- The DRP processor begins its low level coding by beginning with the last warehouse (s) in the channel and then progresses up through each echelon to the appropriate supplying facility. This process ensures that the resupply orders are posted to the correct supplying facilities and that shipments will follow channel dependencies.
- The BOD establishes the framework for total inventory control originating with the inventory source and progressing through each channel echelon, ending with the customer.

9.1.3 Which to Choose: Order Points or DRP?

Choosing a replenishment technique for a pull system with multi-channel echelons requires a thorough understanding of the channel environment. When a company decides to adopt a pull system strategy, it can choose from two possible techniques to manage channel resupply: *reorder point (ROP)* and *distribution requirements planning (DRP)*. The decision to use one or the other technique depends on how inventory moves through the multi-echelon channel and the level of control required by management.

9.1.3.1 It's a Matter of Lead Time

The decision to choose between ROP and DRP is fundamentally driven by two essential factors.

- The first centers on the length and homogeneity of the lead time it takes for items to flow from facility to facility in the supply channel.
- The second factor is driven by how items enter the supply chain. There are two basic ways supply chains acquire items. In the first, finished goods are purchased from suppliers and then transported through the various channel echelons until they reach the end-use customer. In the second, items originate at an internal company production plant.

These two ordering methods are illustrated in Figures 9.9 and 9.11.

9.1.3.2 ROP Mechanics in a Multi-echelon Supply Channel

Figure 9.9 illustrates a classic bill of distribution (BOD) flow for companies that are pure distributors. This type of channel stocks only finished goods originating from outside suppliers. The key factor to note is the shortness (expressed in days) of the replenishment lead times separating each channel facility. In essence, the only factor driving item lead times everywhere in the channel is the time it takes to identify a resupply order and have it transported from the supplying facility in the next higher echelon in the channel to the satellite facility. Planners in this type of channel structure normally use *reorder points*. The technique works in this environment because the lead times necessary to replenish items in the supplying facility are the same or less than the lead time to transport those items from the supplying to the satellite facility. If it took significantly longer to replenish inventory at the supplying facility than the lead time to replenish the satellite facility, the supplying facility would soon be starved for inventory and would eventually stock out. Without this homogeneity of channel replenishment lead times, the ROP method results in the entire supply network quickly coming to a grinding halt.

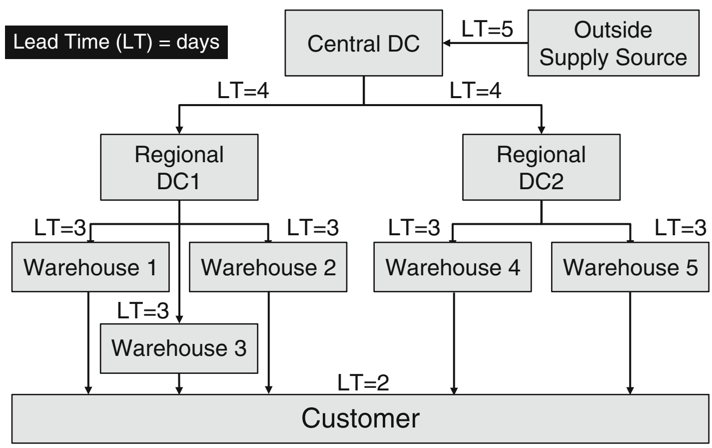


FIGURE 9.9 Purchased finished product flow.

Figure 9.10 provides an example of the mechanics of how the ROP works in a multi-echelon environment. The scenario focuses on ROP functions involving Warehouses 1, 2, and 3; their supplying facility, Regional DC1; and DC1's supply facility, the Central DC. When an item at Warehouse 1 triggers its ROP, a resupply order is sent directly to DC1. After shipment, the inventory balance is reduced at DC1. The same process occurs if the same item in Warehouse 2's inventory triggers its ROP. The result is that DC1's inventory balance of the item is further reduced. At this point, there is still enough inventory at DC1 for the item to keep it above its own ROP. However, the ROP for the item at Warehouse 3 is soon afterwards triggered with the result that a resupply order is sent to DC1. However, when the item is shipped, this time the inventory balance for the item triggers DC1's ROP. At this point, DC1 releases a resupply order for replenishment from the Central DC. Eventually, when the ROP is tripped at the Central DC, a purchase order is generated and sent to the outside supply source.

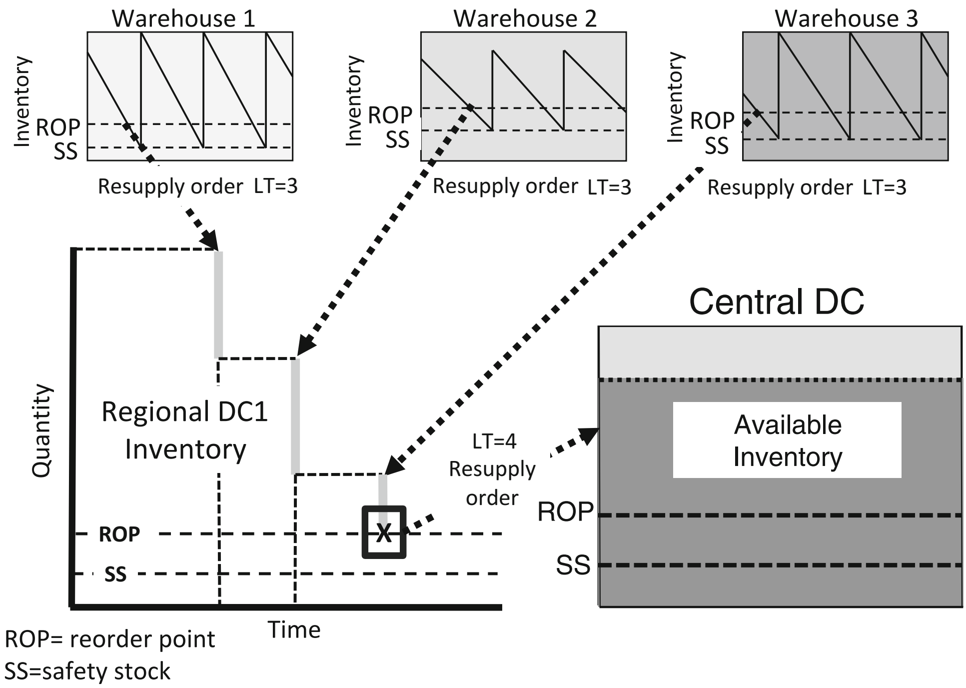


FIGURE 9.10 Reorder point channel management.

An obvious drawback of the ROP technique in the example is that DC1 has no window into downstream warehouse requirements out through time until they actually occur. Also note that each occasion of resupply is unconnected. Requirements appear at DC1 randomly. For the most part, this weakness in the system is not serious. When it is remembered that channel replenishment lead times are short (for the most part a matter of days to transport stock from one location to another) reorder point logic is the logical choice to manage effectively channel resupply. In fact, a small amount of safety stock at supplying facilities easily solves the problem of differences in replenishment lead times.

9.1.3.3 DRP Mechanics in a Multi-echelon Supply Channel

For distribution channels supplied from a production plant or have long-lead time items made-to-order at outside suppliers, planners would most likely choose to use the distribution requirements planning (DRP) technique. To understand what DRP is, it is advantageous to begin with the definition from the *APICS Dictionary*.

> The function of determining the need to replenish inventory at branch warehouses. A time-phased order point approach is used where the planned orders at the branch warehouse level are "exploded" via MRP logic to become gross requirements on the supplying source. In the case of multilevel distribution networks, this explosion process can continue down through the various levels of regional warehouses (master warehouse, factory warehouse, etc.) and become input to the master production schedule. Demand on the supplying sources is recognized as dependent and standard MRP logic applies.

Note the following key concepts in the definition:

- *Replenish inventory at branch warehouses*. DRP is the most effective tool for companies that build their own products and then distribute them through a distribution channel.
- *Time-phased order point approach*. Unlike reorder point systems that do not look at *future* requirements, DRP provides distribution channel planners with a window into demand across a time horizon. This feature is absolutely necessary for the effective planning of production items.
- *Explosion of planned orders* via *MRP logic*. DRP uses a material requirements planning (MRP) implosion technique by which the time-phased requirements from local facilities are driven up the distribution channel to become gross requirements on a predetermined supplying facility or facilities using bill of distribution (BOD) logic. Similar to ROP logic, the satellite facility will transmit a planned resupply order directly to the supplying facility. The difference is that instead of a single resupply order characteristic of ROP, the DRP system transmits a schedule of planned order requirements as far out as is permitted by the item-planning horizons set at each satellite facility.
- *Input to the master schedule*. The end point of the DRP channel explosion process is to drive demand through the various echelons of the distribution channel and end in the product plant's master production schedule (MPS). At this point, normal MRP scheduling communicates build requirements to the production function. Following production order completion, the item quantities are distributed to the satellite warehouses based on their original resupply order requirements.

The reason that planners use DRP when the supply source is a company plant or an outside make-to-order producer is purely one of *lead time*. In a distribution channel that does not produce its own inventory, replenishment lead times are normally short, consisting literally of the time it takes to transport inventory from facility to facility plus some administration time for order management. Reorder point techniques work very well in this environment.

On the other hand, in a distribution channel fed from a production plant, lead times are much more complicated. Production planners often must manage significant processing and purchasing lead times before finished goods are made and shipped through the supply channel. As such, planners using a material requirements planning (MRP) system plan out at least as far as the time it takes to buy the components and make the products (the cumulative lead time). An example of a distribution channel fed by a production plant is illustrated in Figure 9.11.

Note that the channel structure is identical to Figure 9.9, with one major exception. The cumulative lead time between the production plant and the Central DC is 25 days. Obviously there is a mismatch of distribution lead times to move inventory through the channel (which is only a few days) and the production lead time. If the channel was using a reorder point system, when the ROP was triggered for an item at the Central DC, it would need replenishment within 4 days to cover requirements arising from the Regional DCs. Obviously, with a 25-day cumulative lead time at the plant, the ROP system would result in stock outs at the Regional DC level and, therefore, is a poor replenishment system choice in this environment.

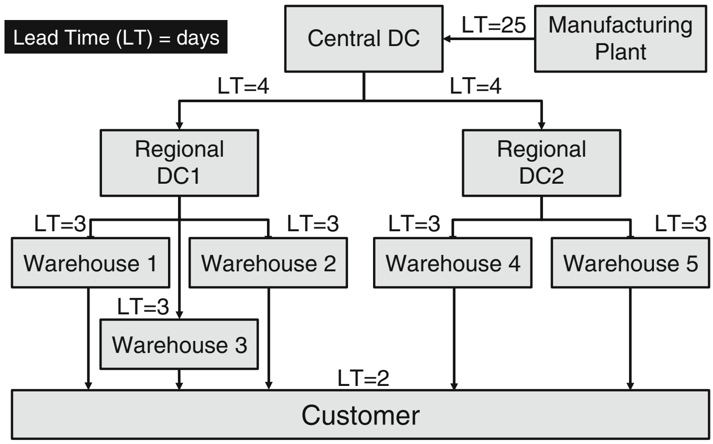


FIGURE 9.11 Manufactured finished product flow.

To solve this problem, planners need to implement a replenishment system that provides a time-phased plan of product requirements originating in the supply channel and extending into the future that can be fed directly into the plant's master production schedule (MPS). Once channel demand is in the MRP system, planners can effectively schedule production and purchase the necessary components and materials to meet future demand. Since the ROP generates a single replenishment order, it cannot perform this function and should not be used in distribution channels where finished goods are derived from production plants.

The place to begin understanding DRP is to discuss how it enables channel planners to time phase supply and demand to plan for future requirements. Often termed the time-phased order point (TPOP), Figure 9.12 provides an example of a typical time-phased grid. The item to be reviewed has a 2-day lead time to transport product from the production plant to a Central DC. There are 55 units currently in stock. Replenishment order quantities are in increments of 50 units. The time periods used for planning are days.

Product	KL-2000-10						
Safety Stock/units	0						
Min Order Qty/units	0						
Lead Time/days	2						
Lot size/units	50	DAILY PERIODS					
On Hand/units	55	1	2	3	4	5	6
Gross Requirements		20	35	25	25	45	65
Projected Available Balance		35	0	25	0	5	40
DRP Planned Order Receipt				50		50	100
DRP Planned Order Release		50		50	100		

FIGURE 9.12 TPOP grid.

On day 1, there is a requirement due for 20 units. Fortunately, there are 55 units in stock. If the demand does not change, a total of 35 units (55–20) are projected to be left at the end of day 1. On day 2, the demand for 35 units is covered by the remaining 35 units from day 1. No order action is required because there are no demands left. A problem arises, however, on day 3 where there is a demand for 25 units but there is no inventory projected to be available from day 2. In this case, the time-phased system generates a planned replenishment order for 50 units to cover the demand and supply imbalance for this period. At the end of day 3, it is projected that there will be a balance left of 25 units. The time phasing also offsets the release of replenishment orders by the item's 2-day delivery lead time. As such, the planner would have to release the order at the beginning of day 1 to ensure it arrives in time by day 3. The system performs the same calculation for each subsequent day, generating planned orders to cover impending shortages.

The advantage of DRP is that the system will not only automatically generate planned resupply orders whenever demand exceeds supply, it will also use the date requirements on the orders as the dates replenishment orders must arrive at the DC. As the planning horizon expands out for weeks and months, these planned resupply orders will be automatically positioned in the demand row of the time-phased master schedule for the plant. As a result, planners at the production plant have visibility to resupply order demand as it occurs not only inside the cumulative lead time, but as far as the planning horizon extends.

9.2 THE BASICS OF DRP

Utilizing DRP to manage supply chains when inventory originates from a manufacturing plant requires a firm understanding of the concepts and applications of DRP. The first place to start is to investigate the *DRP grid*.

9.2.1 Introduction to the DRP Grid

Before functions of the DRP planning grid can be discussed, it is essential to define the data rows constituting the grid as illustrated in Figure 9.13.

	DAILY PERIODS		
	1	2	3
Gross Requirements	115	115	125
DRP In Transit Receipts		200	
Projected Available Balance	0	85	0
Net Requirements	115	0	40
DRP Planned Order Receipt	115	0	40
DRP Planned Order Release	40	0	0

FIGURE 9.13 DRP grid rows.

1. *Time Periods.* Since timing is the critical driver of DRP, the DRP grid is organized around periods or *time buckets*. A period can be as short as a day or less, or as long as a week, a month, or even longer. The exact size of the period and the placement of inventory data within it are governed by several conventions. Period size is usually determined by the planner and consists of an array of buckets all with the same size,

or a mixture of sizes. Figure 9.14 illustrates a grid with *days* as the first 5 time periods containing demand requirements for 10 units each; the next 4 time periods are in *weeks* and contain demand requirements for 50 units each week; and the last 4 time periods are in *months* and contain demand requirements for 200 units each month.

	Day					Week				Month			
	1	2	3	4	5	2	3	4	5	2	3	4	5
Requirement	10	10	10	10	10	50	50	50	50	200	200	200	200

FIGURE 9.14 DRP period variations.

Once the size of the periods is determined, the next decision is to decide exactly *when* a demand requirement originating with a forecast is due within the period. If the period is of 1 day in duration or less, this is not an issue. For periods of longer duration, however, it must be determined whether forecast demand is due on the first day of the period, midpoint in the period, on the last day of the period, or anytime during the period but no later than the last day. For the most part, the convention is to use the first day of the period. As a rule, actual customer and interchannel resupply orders are due on the date specified on the order and are not dependent on time bucket size.

2. *Gross Requirements*. This row in the DRP grid defines the total demand placed on an item. Demand on an item originates from forecasts, the backlog of open customer orders, and resupply orders originating from dependent warehouses. Each form of gross requirement contains the following base data for the DRP to function properly: a discrete item number, the demand quantity, and the date each requirement is due. Time-phasing summarizes the demand arising from each of these sources by due date and then places the total requirements in the appropriate time bucket. The content of the gross requirements is normally determined by the type of distribution activity. For example, in a retail distribution point, forecasts form the gross requirements. Customer backorders are very few, if at all. A regional distribution center's gross requirements, on the other hand, may consist solely of interbranch resupply orders from satellite warehouses in the channel network it supplies. Finally, a regional distribution center may have gross requirements stemming from both customer orders and interbranch resupply orders.
3. *DRP in transit receipts*. This term defines the total quantity of released replenishment orders for an item due within a specific time period. Replenishment orders in the distribution environment can take three forms: supplier purchase, postponement, and interbranch resupply orders. *Purchase orders* specify products and inventory quantities purchased from the firm's suppliers. A second form is a *postponement order* where a channel member performs functions such as bulk breaking, sorting, kitting, light assembly, and other processing activities. Finally, for companies with distribution channels, branch warehouses draw replenishment inventories from their parent warehouses through the use of a *resupply order*. Inventory in transit from one

warehouse to another is considered a form of resupply order. Each of these forms of replenishment order must contain the following basic elements for DRP to function: a discrete order number, the products being resupplied, the quantities being shipped, and the date the order is due. These orders represent *firm* commitments on the part of the supply source to deliver the orders complete on the date required. As such, DRP considers on-order quantities as equivalent to available inventory in the calculation of projected on-hand quantities in the time periods in which they appear.

4. *Projected available balance (PAB)*. Unlike the statistical replenishment calculation, which only shows the current available balance of an item, DRP provides the planner visibility to current and *projected* on-hand quantities in all periods constituting the planning horizon. The calculation of the on-hand computation is expressed as:

   the opening inventory balance at the beginning of each period,
   plus the total of scheduled receipts due in the current period
   minus the total of gross requirements in the current period
   equals the projected on-hand balance at the end of the current period.

   Based on transaction activity occurring in a period, the projected on-hand balance from the previous period is carried forward to the next. The projected on-hand balance calculation is illustrated in Figure 9.15. Note that by period 3 all current inventory plus the *DRP in transit receipt* in period 2 are consumed by the gross requirements, leaving the projected available balance negative out through the 10-day planning horizon.

Product	KL-2000-10										
Safety Stock/units	0										
Min Order Qty/units	0										
Lead Time/months	2										
Lot size/units	75	DAILY PERIODS									
On Hand/units	200	1	2	3	4	5	6	7	8	9	10
Gross Requirements		100	110	125	130	120	110	150	135	165	145
DRP Intransit Receipts			75								
Projected Available Balance		100	65	-60	-190	-310	-420	-570	-705	-870	-1,015

FIGURE 9.15 Projected available balance calculation.

5. *Net requirements*. Once the gross requirements and the PAB have been determined, the next task for the planner is to calculate the *net requirements* row on the DRP grid. The *net requirements* row is extremely important. It indicates in which time periods the *gross requirements* (demand) exceed the available inventory supply. If the resulting PAB is negative, that value becomes a net requirement and is entered into the *net requirements* row for that period. The net requirements calculation is illustrated in Figure 9.16. Note that the first net requirements appears in period 3.

Product	KL-2000-10									
Safety Stock/units	0									
Min Order Qty/units	0									
Lead Time/months	2									
Lot size/units	75	**DAILY PERIODS**								
On Hand/units	200	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Requirements		100	110	125	130	120	110	150	135	165	145
DRP Intransit Receipts			75								
Projected Available Balance		100	65	-60	-190	-310	-420	-570	-705	-870	-1,015
Net Requirements		0	0	60	190	310	420	570	705	870	1,015

FIGURE 9.16 Net requirements calculation.

6. *DRP planned order receipt*. A net requirement indicates that demand for a product is projected to exceed supply in that period. The DRP system will respond to this impending shortage by generating a *DRP planned order receipt*. The order is considered as "planned" because it has not been released into an actual order and placed at the supply source. The quantity of the distribution order is determined by the product's *order policy*. The generation of a planned order is governed by the following elements:
   (a) The date when the net requirement is recorded.
   (b) The order policy rule which determines the lot-size quantity necessary to satisfy the net requirement.

   An important characteristic about a planned resupply order is that it is placed by the DRP software in the requirements row of the parent's (ship from) facility DRP grid. This enables planners at the parent facility to gain full visibility to planned demand out through the planning horizon. The DRP planned order receipts row is illustrated in Figure 9.17.

Product	KL-2000-10										
Safety Stock/units	0										
Min Order Qty/units	0										
Lead Time/days	2										
Lot size/units	75	**DAILY PERIODS**									
On Hand/units	200	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Requirements		100	110	125	130	120	110	150	135	165	145
DRP Intransit Receipts			75								
Projected Available Balance		100	65	15	35	65	30	30	45	30	35
Net Requirements		0	0	60	115	85	45	120	105	120	115
DRP Planned Order Receipt		0	0	75	150	150	75	150	150	150	150

FIGURE 9.17 DRP planned order receipt.

The replenishment lot-size quantity must equal or exceed the net requirement in the first period in which a net requirement is found. The due date of the planned order is the required date of the source of the demand that triggered the net requirement. If there are multiple sources of demand, an order policy is normally used that covers at least all demand sources in the period starting with the due date of the first demand and ending at the date of the last demand order in the period. Because of the standard quantity of the lot size, it may be large enough to cover the net requirements of one or more subsequent time periods.

7. *DRP planned Order Release*. Once a planned resupply order is generated, the DRP system will determine the release date of the order. The date a DRP planned order is to be released is calculated by subtracting the item's *replenishment lead time* from the planned order receipt date. As an example, in Figure 9.18 the lead time is 2 days. If a planned resupply order is generated due at day 5, the DRP system will back schedule the resupply order by the lead time (2 days) and place the order release in the period 2 days prior to the due date. Finally, the planner is alerted to transform the planned order into an actual resupply order if the release date and the current time period coincide. The DRP planned order release is illustrated in Figure 9.18. Note the lead-time offset of the DRP planned order receipt of 2 days for the receipt quantity of 75 due in period 3.

Product	KL-2000-10
Safety Stock/units	0
Min Order Qty/units	0
Lead Time/days	2
Lot size/units	75
On Hand/units	200

DAILY PERIODS	1	2	3	4	5	6	7	8	9	10
Gross Requirements	100	110	125	130	120	110	150	135	165	145
DRP Intransit Receipts		75								
Projected Available Balance	100	65	15	35	65	30	30	45	30	35
Net Requirements	0	0	60	115	85	45	120	105	120	115
DRP Planned Order Receipt	0	0	75	150	150	75	150	150	150	150
DRP Planned Order Release	75	150	150	75	150	150	150	150	0	0

Two day lead-time offset

FIGURE 9.18 DRP planned order release.

The DRP time-phased format outlined above is designed to assist the inventory planner to visually understand the interaction of supply and demand as they appear in the planning horizon. The DRP system will populate each time bucket with the appropriate demand and supply orders by due date and then calculate the required planned orders. The planner, in turn, must be able to interpret the data and respond with the recommended order action.

9.2.1.1 PAB and Net Requirements Recalculation

The generation of DRP planned replenishment orders requires recalculation of the *projected available balance (PAB)* and *net requirements* rows to reflect the planned availability of the additional quantities of inventory. Figure 9.19 illustrates the recalculation of both of these rows.

Product	KL-2000-10									
Safety Stock/units	0									
Min Order Qty/units	0									
Lead Time/days	2									
Lot size/units	75	DAILY PERIODS								
On Hand/units	200	1	2	3	4	5	6	7	8	9	10
Gross Requirements		100	110	125	130	120	110	150	135	165	145
DRP Intransit Receipts			75								
Projected Available Balance		100	65	15	35	65	30	30	45	30	35
Net Requirements		0	0	60	115	85	45	120	105	120	115
DRP Planned Order Receipt		0	0	75	150	150	75	150	150	150	150
DRP Planned Order Release		75	150	150	75	150	150	150	150	0	0

FIGURE 9.19 DRP recalculation.

The formulas for the recalculations are described as follows:

- *PAB row*. Two formulas are needed to calculate the PAB row. The first determines the PAB cell in the first period. The calculation starts by taking the opening inventory balance and adding any resupply orders in the *DRP in transit receipts* and *DRP planned order receipts* rows occurring in the first period. The *gross requirements* in the first period are then subtracted from this value. The ending value provides the PAB at the end of the first period. For example, in Figure 9.19, the beginning on-hand inventory is 200 units. Since there are no DRP in transit or planned receipts, the total supply is 200 units. The *gross requirements* of 100 units are then subtracted from the 200 units to arrive at the projected ending balance of 100 units in the period 1 PAB cell.

  The second formula determines the PAB for all periods beyond the first period. Starting with the second period PAB, the calculation begins by first taking the PAB from the past period and adding all *DRP in transit receipts* and *DRP planned order receipts* as they occur in each period. The *gross requirements* are then subtracted from this value to determine the PAB at the end of each successive period. For example, in Figure 9.19, the ending PAB in period 1 is 100 units. When combined with the *DRP in transit receipt* of 75 units in period 2, the total planned available inventory in period 2 is 175 units. The *gross requirements* of 110 units are then subtracted from the 175 units, leaving a PAB of 65 units at the end of period 2.
- *Net requirements row*. Similar to the PAB, there are two formulas for calculating the *net requirements* row. The first calculation occurs in period 1 by taking the beginning

on-hand inventory plus any *DRP in transit receipts* and then subtracting the *gross requirements*. If the resulting value is negative, it is placed in the *net requirements* row. For example, in Figure 9.19, the beginning on-hand inventory is 200 units. Since there are no *DRP in transit receipts* in period 1, the total supply is 200 units. The *gross requirements* of 100 units are then subtracted from the 200 units. Since there is a surplus of 100 units, nothing is placed in the *net requirements* row.

For all periods beyond period 1, the calculation starts with the PAB from the past period plus all *DRP in transit receipts* occurring in each successive period. The *gross requirements* occurring in each period are then subtracted from the total projected available inventory in each period. If the requirements exceed the available inventory, the quantity short is placed in the *net requirements* row for that period. For example, in Figure 9.19, the beginning PAB for period 3 is 65 units. There are no *DRP in transit receipts*. When the *gross requirements* of 125 units in period 3 are subtracted from the 65 units, a projected shortage of 60 units occurs. This value is then entered into the *net requirements* row. Note that the DRP will then generate a *DRP planned order receipt* of 75 units to cover the shortage. When the *gross requirements* of 125 units are subtracted from the order for 75 units plus the PAB of 65 units, the ending PAB for period 3 is 15 units.

9.2.2 DRP Order Policies and Safety Stock

Before the DRP system can effectively process demand and supply data, other key pieces of additional item-level information must be added to the equation. In the standard DRP system, these data are input into each product's planning data master file.

9.2.2.1 Order Policies

When a resupply order action is triggered for an item, the system must know the replenishment quantity lot-size associated with the product. In contrast to a reorder point system, which usually uses some form of economic order quantity (EOQ) to determine order quantities, a DRP system uses one of several possible order policies which calculate the order lot size based on demand requirements. The most common order policies used in DRP systems are the following:

- *Discrete* (lot-for-lot). This order policy recommends a resupply quantity that matches exactly each item's net requirements by due date. This technique must be used with caution. It will generate a planned order pegged to each requirement, even if multiple requirements occur on the same day. The faulty use of this technique results in potentially masses of planned orders that will have to be managed by the inventory planners.
- *Fixed period requirements*. In this technique, the system calculates the replenishment quantity based on a simple rule of ordering *n* period's supply. A field in the item record is input with a value representing the number of periods forward the DRP looks when processing begins. All the net requirements spanning the periods defined are then summed, and a single discrete planned order quantity matching this sum is placed in the *DRP Planned Order Release* row in the first of the defined set of periods.
- *Discrete above the standard lot size*. Often an item is resupplied in quantities of a certain lot size because of discounting, minimum quantity lot sizes, or shipping purposes. This order policy requires the user to set the required lot-size quantity in the item's master record. In the first period in which the product has a net requirement,

the system will recommend purchase of a minimum of the lot size *plus* additional quantities sufficient to cover exactly the remaining net requirement. If the net requirement is less than the lot size, then only the lot size is purchased. As an example, if the order lot size is 100 units and the requirement is for 127, the DRP will generate an order for 127. If, on the other hand, the requirement is for 87 units, the DRP planned order will be for a quantity of 100 units.

- *Incremental above the standard lot size*. This order policy is based on two values entered in the item master record: the lot size and an incremental quantity that is added to the lot size when the net requirement is greater than the lot size. For example, if the lot size is 100 units and the incremental quantity is 25 units, a net requirement for 130 units will result in the system calculating a planned order quantity of 150 units.
- *Multiples of a standard lot size*. When using this order policy, the system will attempt to satisfy the net requirement with the item's replenishment lot size. If the requirement is greater than the lot size, the system will counter with multiples of the lot size until the planned order quantity covers the net requirement. For example, if the standard lot size is 100 units, a net requirement of 130 units results in the generation of a planned order for 200 units.
- *Min/max order quantity*. This model uses the minimum/maximum logic detailed in Chapter 8. When requirements occur during the DRP planned order generation for an item with a min/max order policy, the suggested DRP planned resupply order cannot be less than the preset minimum nor greater than the preset maximum. If demand exceeds the maximum, the DRP generation will create two orders, one with the maximum quantity, and one containing the remaining balance, but not less than the minimum quantity. Both are combined to provide the total replenishment inventory for the period.
- *Lot costing models*. The final order policy model is based on some form of lot size that, like the EOQ, seeks to minimize the sum of inventory carrying costs. *Least unit cost, least total cost,* and various forms of mathematical or computerized lot sizing techniques, such as the *Wagner-Whitin algorithm*, fall within this model.

9.2.2.2 Safety Stock

The use of *safety stock* plays an important role in distribution inventory planning. The *APICS Dictionary* defines safety stock as "a quantity of stock planned to be in inventory to protect against fluctuations in demand or supply." Safety stock is used to cover instances of unplanned variability in demand and supply. Variability arises from changes to customer demand that exceeds the forecast or variability in in-transit delivery times. Safety stock acts as a buffer to probabilistic variability, decoupling demand from stocked inventories thereby sheltering inventory from the threat of stock out. The safety stock quantity is normally based on a company decision to support a targeted customer service percentage. The higher the targeted service percentage, the higher the safety stock.

There are several methods that DRP uses to determine the safety stock quantity. A simple model is a predetermined safety stock quantity entered into the item master record. A more robust method is to use a predetermined "number of days" of safety stock multiplied by the daily average usage. Another, yet more sophisticated model is to set a safety stock percentage that is then multiplied first by the item lead time and then by the daily consumption. The most sophisticated model is the standard deviation and MAD discussed in Chapter 8.

DRP uses safety stock in a very different way than statistical reorder point. When the DRP computer processor generates resupply planned orders to respond to uncovered demand through the planning horizon, it first seeks to preserve the integrity of the safety quantity associated with the item. If the beginning on hand balance of the item is below the safety stock value, the DRP system generates a planned replenishment order using the associated item order policy and assigns it first priority before all other subsequent planned orders. The DRP system, in essence, treats a safety stock violation with a higher urgency than any other unfulfilled demand.

Exercise 9.1: DRP Safety Stock

Item K-2000-10 is replenished through DRP. The item takes 3 days to be delivered from the supplying distribution center. The order quantity is in lot sizes of 200 units. There is an opening balance of 275 units on hand. Demand occurs in the form of gross requirements through the planning horizon. When the DRP computer processor is run, the following results are evident in the DRP grid detailed in Figure 9.20.

Product	KL-2000-10									
Safety Stock/units	0									
Min Order Qty/units	0									
Lead Time/days	3									
Lot size/units	200	DAILY PERIODS								
On Hand/units	275	1	2	3	4	5	6	7	8	9	10
Gross Requirements		200	200	230	230	250	250	275	275	280	280
DRP Intransit Receipts			200								
Projected Available Balance		75	75	45	15	165	115	40	165	85	5
Net Requirements		0	0	155	185	235	85	160	235	115	195
DRP Planned Order Receipt		0	0	200	200	400	200	200	400	200	200
DRP Planned Order Release		200	400	200	200	400	200	200	0	0	0

FIGURE 9.20 DRP no safety stock.

As it stands, the grid's total supply covers all *net requirements*. However, if a safety stock of 75 units is added to the planning data, the grid falls out of balance (Figure 9.21). The *projected available balance* (PAB) in periods 3, 4, 7, and 10 have ending balances that fall below the 75 safety stock units and clearly constitute a safety stock violation.

Safety stock violations

Product	KL-2000-10										
Safety Stock/units	75										
Min Order Qty/units	0										
Lead Time/days	3										
Lot size/units	200	DAILY PERIODS									
On Hand/units	275	1	2	3	4	5	6	7	8	9	10
Gross Requirements		200	200	230	230	250	250	275	275	280	280
DRP Intransit Receipts			200								
Projected Available Balance		75	75	45	15	165	115	40	165	85	5
Net Requirements		0	0	230	260	310	160	235	310	190	270
DRP Planned Order Receipt		0	0	400	400	400	200	400	400	200	400
DRP Planned Order Release		400	400	200	400	400	200	400	0	0	0

FIGURE 9.21 DRP safety stock violations.

By adding the safety stock into the DRP calculation, the DRP will generate planned orders sufficient in quantity to eliminate all safety stock violations out through the planning horizon as displayed in Figure 9.22.

Product	KL-2000-10									
Safety Stock/units	75									
Min Order Qty/units	0									
Lead Time/days	3									
Lot size/units	200	DAILY PERIODS								
On Hand/units	275	1	2	3	4	5	6	7	8	9	10
Gross Requirements		200	200	230	230	250	250	275	275	280	280
DRP Intransit Receipts			200								
Projected Available Balance		75	75	245	215	165	115	240	165	85	205
Net Requirements		0	0	230	60	110	160	235	110	190	270
DRP Planned Order Receipt		0	0	400	200	200	200	400	200	200	400
DRP Planned Order Release		200	200	200	400	200	200	400	0	0	0

FIGURE 9.22 DRP safety stock recalculation.

9.3 THE DRP CALCULATION

The generation of *planned orders* to cover all future item net requirements is the cornerstone of the DRP planning process. For each product with a net requirement, DRP develops a schedule of planned replenishment orders necessary to cover all net requirements out through the planning horizon. Finally, the DRP schedules inventory resupply action that will have to be taken in the future if stock out is to be avoided.

9.3.1 Basic Data Elements

The DRP process is generated by using the data input from the following sources:

- Length of the planning horizon
- Size of the planning buckets
- Item forecasts by due date
- Open customer orders by item by due date
- Beginning on-hand quantities by item
- Open purchase, interbranch, and postponement orders by item by due date
- Replenishment lead times by item
- Safety stock by item
- Order policy code by item
- Supply sources based on the bill of distribution (BOD)

Using these critical database files, the DRP processor populates the contents of each planning grid bucket. As the first net requirement appears, the system generates a matching planned resupply order with a quantity determined by the item's order policy code. When the DRP calculation is complete, the inventory planner is provided with output information that is used to guide resupply order action.

The outputs from the DRP calculation are the following:

1. *Exception reporting.* Current commercial DRP systems provide planners with the ability to view, through online displays, dashboards, or reports, the results of the DRP generation. An important feature of these sources of DRP output is the availability of *planning by exception.* Depending on the size and complexity of the DRP generation, the volume of output data can be immense. Data exception selecting greatly assists planners to easily identify those items that require resupply order action while ignoring the remainder of the items that have sufficient inventories to satisfy demand, at least in the short term. Many DRP systems have sophisticated "workbench-type" maintenance screens in which planners can review, change resupply recommendations, and generate resupply orders automatically.
2. *Planned orders.* The DRP generation provides planners with a window into the schedule of planned resupply order release. At a minimum, planners ***must*** release planned into actual resupply orders for all items that have a value greater than zero in their current period *planned order release bucket*. If order action is not taken, the item will slip inside its replenishment lead time, causing expediting and possible premium ordering costs. This first period is often termed the *action bucket period.* Planned resupply orders are at the core of the DRP system, illuminating future item requirements, and forming the basis for such projections as on-hand inventory, supplier scheduling, and logistic capacity planning.
3. *Action messages.* As an aid to the planner in interpreting DRP exception reporting and performing order maintenance, commercial DRP systems provide detailed *action messages.* These messages inform the planner what actions are needed to solve planning and scheduling problems. The following are core DRP action messages.
    (a) *Release planned order.* The planned resupply order has reached the replenishment lead time and must be converted into a released order.
    (b) *Lead-time violation.* The planned resupply order has slipped inside the replenishment lead time. Immediate order action should be taken and the order expedited.
    (c) *Expedite in scheduled receipt.* The due date of a released resupply order should be scheduled in to cover a new net requirement.
    (d) *De-expedite a scheduled receipt.* The due date of a released resupply order should be moved out because of changes in the item's original net requirements.
    (e) *Cancel.* A released resupply order should be canceled due to changes in net requirements.
4. *Pegged requirements.* The pegging of requirements provides the planner with the ability to trace item resupply orders back to their sources. A window into the actual source of demand assists planners to perform purposeful resupply order action.

9.3.2 Bucketless DRP

Although DRP permits the planner to define system output in the form of time periods (buckets), in reality the system records all demand and supply orders by actual due date. The time bucket format is merely a convenient way to aggregate demand and supply data for viewing purposes. Most commercial DRP systems provide a bucketless display, permitting the planner to see the orders in ascending or descending order by actual due dates and quantities along with a running projected available balance (PAB) total. Figure 9.23 provides an example of a bucketless display. Note that released and planned supply orders are included in the PAB calculation. The bucketless format provides a more detailed display of item status in that it provides full visibility to demand and supply orders when they actually occur. A little more skill is required to use this format than the bucketed approach, but it provides the planner with the ability to exercise more detail control over inventory planning.

Item # KL-2000-10		Safety Stock	75		
Lead time 3 days		OHB	275		
Date	**Type**	**Gross Reqs**	**Scheduled Receipts**	**Ref #**	**OHB**
01/01/XX	FORECAST	200			75
01/08/XX	PUR Ord		200	PO#789654	275
01/08/XX	FORECAST	175			100
01/09/XX	CUST Ord	25		CO#8754456	75
01/15/XX	PLN Ord		400	PL#76543	475
01/15/XX	FORECAST	175			300
01/15/XX	CUST Ord	10		CO#8754457	290
01/15/XX	CUST Ord	15		CO#8754458	275
01/15/XX	CUST Ord	30		CO#8754459	245

FIGURE 9.23 Bucketless DRP display.

9.3.3 DRP Regeneration Frequency

The frequency of DRP regeneration is a critical decision in system use and needs to be set as a policy standard by each planning organization. Each DRP regeneration represents a complete repositioning of requirements and supply orders and the deletion and recalculation of planned orders in the DRP grid. Although some DRP systems recalculate product statuses, such as open order and projected available balances, dynamically in between regenerations, actual planned order creation is reserved for the DRP processor. As a general rule, the more dynamic the planning environment, the more frequently the DRP will have to be regenerated to keep demand and supply in balance. As a rule of thumb, the DRP processor should ***not*** be re-run until all *actions messages* generated from the previous run are reviewed and acted upon. Failure to satisfy all action messages results in a persistent demand and supply imbalance. Normally, most firms using DRP generate the system at least weekly. In addition, DRP is essentially a *continuous* rather than a *cyclical* planning tool. The DRP planning information is in reality a snapshot of current demand and inventory availability. However, because item balances change immediately after generation, frequent regeneration will constantly realign demand priorities necessary for timely order action.

9.4 DRP IN A MULTI-ECHELON ENVIRONMENT

The value of DRP time phasing is seen when the technique is applied to a distribution channel. For purposes of illustration, the two-echelon distribution channel for item KL-2000-10 detailed on Figure 9.24 will be used. The channel consists of three distribution centers (DCs) that are supplied from a single production plant. Item KL-2000-10 is produced at the production plant. The three DCs pull the item from the production plant based on the DRP planned resupply order generation.

DISTRIBUTION CENTER 1

Lead Time/weeks	1
Min Order Qty/units	0
Order Quantity	600
On Hand/units	240

WEEKLY PERIODS								
PRODUCT KL-2000-10	1	2	3	4	5	6	7	8
Gross Requirements	210	210	210	210	210	210	210	210
DRP In Transit Receipts		600						
Projected Available Balance	30	420	210	0	390	180	570	360
Net Requirements	0	0	0	0	210	0	30	0
DRP Planned Order Receipt	0	0	0	0	600	0	600	0
DRP Planned Order Release	0	0	0	600	0	600	0	0

DISTRIBUTION CENTER 2

Lead Time/weeks	1
Min Order Qty/units	0
Order Quantity	225
On Hand/units	25

WEEKLY PERIODS								
PRODUCT KL-2000-10	1	2	3	4	5	6	7	8
Gross Requirements	100	100	100	100	100	100	100	100
DRP In Transit Receipts	225							
Projected Available Balance	150	50	175	75	200	100	0	125
Net Requirements	0	0	50	0	25	0	0	100
DRP Planned Order Receipt	0	0	225	0	225	0	0	225
DRP Planned Order Release	0	225	0	225	0	0	225	0

DISTRIBUTION CENTER 3

Lead Time/weeks	1
Min Order Qty/units	0
Order Quantity	250
On Hand/units	350

WEEKLY PERIODS								
PRODUCT KL-2000-10	1	2	3	4	5	6	7	8
Gross Requirements	200	200	200	200	200	200	200	200
DRP In Transit Receipts								
Projected Available Balance	150	200	0	50	100	150	200	0
Net Requirements	0	50	0	200	150	100	50	0
DRP Planned Order Receipt	0	250	0	250	250	250	250	0
DRP Planned Order Release	250	0	250	250	250	250	0	0

SUMMARY

WEEKLY PERIODS								
PRODUCT KL-2000-10	1	2	3	4	5	6	7	8
Distribution Center 1	0	0	0	600	0	600	0	0
Distribution Center 2	0	225	0	225	0	0	225	0
Distribution Center 3	250	0	250	250	250	250	0	0
TOTAL	250	225	250	1,075	250	850	225	0

MANUFACTURING PLANT

Lead Time/weeks	2
Min Order Qty/units	550
Order Quantity	1
On Hand/units	25

WEEKLY PERIODS								
PRODUCT KL-2000-10	1	2	3	4	5	6	7	8
Gross Requirements	250	225	250	1,075	250	850	225	0
MRP Scheduled Receipts	550							
Projected Available Balance	325	100	400	0	300	0	325	325
Net Requirements	0	0	150	675	250	550	225	0
MRP Planned Order Receipt	0	0	550	675	550	550	550	0
MRP Planned Order Release	550	675	550	550	550	0	0	0

FIGURE 9.24 DRP multi-echelon channel implosion.

The first step involves the generation of the DRP for item KL-2000-10 at each of the three DCs. This step could be performed by the planners at each DC or globally from a central location. Replenishment orders are received *only* from the production plant. The resulting DRP grids use the statement of customer orders and forecasts for the item to populate the *gross requirements* row for each DC. Resupply orders in the process of being shipped are visible in the *DRP in transit receipts* row. Finally, the DRP processor uses the replenishment order quantities, lead times, and current on hand inventories to calculate the projected available inventory, net requirements, and planned order rows for item KL-2000-10 at each DC.

Next, the DRP processor uses the bill of distribution (BOD) file to determine the relationship of each DC in the channel to its supplying facility (in this case, the production plant). The *DRP planned orders* from the DC are then placed by the DRP system directly into the *gross requirements* of the "parent" production plant. In a distribution channel with several echelons, the resupply orders could be sent to a regional DC or perhaps another local DC. In some environments, the satellite facility could be supplied from multiple parent facilities by assigning a percentage of the resupply requirement to be fulfilled by each supplying facility. Figure 9.24 illustrates how the resupply orders for the KL-2000-10 occurring at all three DCs is summarized and then passed to the production plant as demand.

In the final stage, all of the planned resupply orders for the three DCs are loaded directly into the *gross requirements* of the production plant. Since the plant produces the item for the entire supply channel, it uses material requirements planning (MRP) to determine when production needs to begin to satisfy channel demand through the planning horizon.

The channel structure depicted in Figure 9.24 is an example of how DRP solves the problem of the differences of lead time between the various echelons in the supply chain. There are two types of lead times depicted in the channel structure: the 1 week transportation lead time between the DCs and the plant and the longer 2 week production lead time. Simply, item KL-2000-10 can be shipped *faster* than it can be produced. If a reorder point is used, demand from the DCs would appear with only a 1 week lead time, too short for the production plant to serve the DCs without stocking sufficient safety inventories to prevent stock out.

DRP solves this timing problem by providing ABC's plant with a schedule of future KL-2000-10 demand that is loaded directly into the *net requirements* of the plant's MRP system. Provided with a window into future demand, the plant can then plan for the timely generation of purchase orders for components, raw materials, and product assembly that enables it to service the shorter delivery lead times needed to prevent downstream DC stock outs.

9.4.1 DRP Planning Process

Now that the concepts and processing logic of DRP have been described, it is possible to explore the planning process used by distribution planners. Overall, the objectives of DRP are the creation of an inventory replenishment plan that optimizes targeted customer service levels while minimizing channel inventory costs. In developing the DRP plan, inventory planners consider questions such as the following:

- Is the planning data for each DRP planned item accurate and up-to-date?
- Have BODs been created that accurately reflect the structure of the distribution channel?
- Are on-hand balances being updated accurately and on a timely basis?
- Are open customer and purchase order due dates and quantities accurate?
- Have replenishment order policies been accurately defined?
- Do product replenishment lead times reflect current delivery realities?
- Have safety stocks been calculated correctly?
- Have DRP regeneration and planning procedures been formalized?

As illustrated in Figure 9.25, the DRP planning process consists of several steps. The process begins with the generation of the DRP replenishment plan. This could be done on a facility-by-facility basis or once across the entire distribution channel on a set recurring date. The first step for inventory planners at each facility is to review and validate the gross requirements on all items and ask, "*Is the total demand OK?*" To be effective, it is necessary for all sources of demand to be available for the DRP computation. Demand normally consists of forecasts and resupply orders by planning time period. Each requirement is pegged to a demand source and has a due date and quantity. The system records planned interbranch order requirements as gross requirements in the demand records of supplying facilities at each level of the bill of distribution (BOD).

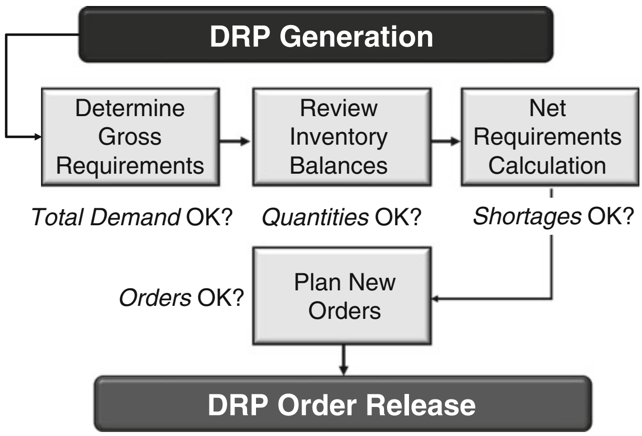


FIGURE 9.25 DRP planning process.

The second step in the DRP planning process focuses on running the DRP processor and reviewing the resulting *net requirements* and generated DRP resupply planned orders. This step is the core of DRP and should be closely monitored by inventory planners. Net requirements occur in a given period when the anticipated gross requirements for an item exceed projected available supply. Each time a net requirement occurs and there are insufficient supply quantities in the planning horizon, DRP generates a planned order governed by replenishment order policies and aligns the order by due date with the demand. In addition, the resupply order's release date is determined by backdating the item resupply lead time from the due date. The schedule of *planned order releases* defines the scope of replenishment order action to be performed by the planner. Most commercial DRP systems provide online displays and output reports advising planners of required order release and reschedule activities (Figure 9.26). The generation of net requirements is often compared to

Item #	Order #	Order Quantity	Release	Due	Revised Due	Action Message
1425	Plan	5,000	01/01/XX	01/14/XX		Release
1551	Plan	5,000	01/07/XX	01/14/XX		No Action
2300	1234	345		01/24/XX	01/17/XX	Expedite
4110	Plan	4,500		01/14/XX		Release
3320	1267	1,234	01/07/XX	01/23/XX		De-expedite
3345	1275	4,567		01/25/XX		Cancel

FIGURE 9.26 DRP order action report.

using a shortage list. The critical difference is that items appear on a shortage list when there is demand and no available stock. DRP, on the other hand, provides a window into *projected* shortages before they occur.

Once net requirements are identified, DRP references each item's *DRP in transit receipts* to ensure that the replenishment order due dates are correctly scheduled to satisfy demand. If a particular order's due date does not correspond to a planning period's gross requirements, the order needs to be rescheduled in or out. For example, if a new customer order caused a net requirement to occur in a period *before* a previously released resupply order, DRP would prompt the planner to *expedite in* the resupply order to meet the new statement of demand. If the scheduled resupply order quantity is insufficient to cover the new demand, the system generates a new planned resupply order to cover the balance of the requirement. Likewise, if a demand is canceled or moved back, DRP responds by prompting the planner to *de-expedite* the resupply order to a future period or cancel it if not needed. DRP's ability to provide the planner with timely order action information necessary for effective open supply order rescheduling is one of the technique's most powerful features that is lacking in statistical replenishment planning.

The final step in the DRP planning process is the calculation and review of the logistics capacities necessary to deliver the schedule of resupply planned orders. Logistics capacities are composed of four elements: inventory investment, transportation, warehouse space, and labor and equipment. If the priority plan of inventory requirements established by the DRP process is to be executed successfully, it is essential that planners ensure that logistics functions have the required capacities. By extending the schedule of resupply planned orders by the planning factors found in each capacity area, planners can review the viability of the inventory plan. If insufficient capacities are found in any of the four areas, either the inventory plan must be changed or additional resources acquired to supplement the shortfall. Once the priority and the capacity plans are in place, planners can confidently begin the process of inventory procurement.

DRP offers the distribution enterprise a new opportunity for attaining the highest levels of customer service while maintaining low inventory costs. By illuminating the relationship of supply and demand through the planning horizon, the DRP planning process provides inventory planners on all echelons in the distribution network with a detailed window into the status of inventory in the channel. By effectively linking together marketing and sales planning with inventory investment, warehouse size, labor and equipment, and existing transportation capacities, DRP offers distribution functions an effective method of integrating the resources of the entire channel with the requirements of the marketplace.

9.5 STOCKING MULTI-ECHELON SUPPLY CHANNELS

An important problem facing planners is determining which items are to be stocked at each warehouse and in what quantities. Obviously, not every item the firm offers for sale can be stored at the same inventory level at every location in the network. Solving this basic multi-echelon problem is often perceived as consolidating inventories into fewer stocking locations in order to reduce total inventory costs. The downside to this strategy is that supply chains will require flexible transportation and information resources to ensure targeted customer service levels are maintained everywhere in the channel. This problem dramatically expands when a company distributes its products by using various independent channel intermediaries such as wholesalers and retailers. Not only can imbalances in inventory availability occur in the supply channel, but variability in demand can significantly affect how inventory is ordered and stored in the channel.

9.5.1 Bullwhip Effect

If the demand in a multi-echelon supply chain was stable, channel inventory imbalances would be insignificant, channel producers and intermediaries would be able to stock the right products in the right quantities close to the demand pull, and reservoirs of safety inventories stationed in the supply chain would be minimal. Regrettably, several dynamics make this condition impossible. To begin with, demand *is uncertain* with the result that supply channel nodes must keep inventory reserves to avoid stock out. What is worse, because of replenishment lot-sizing, demand variability tends to be magnified up the supply chain from the retailer back to the producer. Additionally, uncertainty arises because companies occupying positions in the supply chain often have conflicting objectives or because information moving between channel echelons is delayed or distorted.

While there are several outcomes due to these channel dynamics, one of the most important is termed the *bullwhip effect*. The *APICS Dictionary* defines the bullwhip effect as "An extreme change in the supply position upstream in a supply chain generated by a small change in demand downstream in the supply chain." Basically, this phenomenon occurs when a small variation in customer demand ripples back up the supply chain in successively wider peaks and troughs. The bullwhip effect was explored in a classic article concerning the baby diaper supply chain at Proctor & Gamble [1]. Planners noted that, while there was some minor fluctuation in sales at the retail level, diaper consumption exhibited a very steady rate. However, when they examined the derived demand passed to channel intermediaries, they were surprised by the wide degrees of order quantity variability. When they looked at P&G' orders for materials from their suppliers, they discovered that the swings were even greater. Graphically, their findings are illustrated in the below Figure 9.27.

After deeper analysis, it was found that other industries beyond consumer packaged goods experienced the same bullwhip phenomenon. Even though customer demand does not vary much over time, there is a pronounced variability in the size of the fulfillment orders as they make their way up the supply chain to the supplier.

Several dynamics have been identified as the cause of the bullwhip effect.

- *Lack of collaboration and information sharing*. Probably the foremost cause of the bullwhip effect is a lack of collaboration and information sharing among supply channel members as to the actual state of demand and supply. The application of demand sensing and demand event management technologies, for example, provide visibility to all channel members of impending inventory shortages and overstocks so that appropriate action can be taken ahead of time. For example, if a defective component is found at a channel manufacturer, suppliers and suppliers' suppliers can respond to the problem as a team instead of individually being blindsided by large replacement orders making their way back up the supply chain.
- *Demand forecast updating*. A critical feature of the bullwhip effect is the nature of the forecasts generated in the channel. In past chapters, the difference between independent, derived, and dependent demand was emphasized as a critical component in

FIGURE 9.27 Increasing variability of orders in a supply chain [2].

channel replenishment planning. Retailers, who experience independent demand, create forecasts based on past sales histories consisting of small, incremental drawdowns in stock by end-use customers. When they generate replenishment orders for their distributors, however, demand is aggregated, and passed up the supply chain in large lot-sized quantities with longer lead times. Item quantities of derived demand orders increase at each channel node ending with the producer. Finally, the producer generates large-quantity supplier orders based on the MRP output. What is worse, often extra lead times and safety stocks are added to the forecasts to cover for unplanned channel delivery variability.

- *Order batching.* Disconnected channel forecasting is further heightened by the practice of order batching. Instead of generating resupply orders based on the demand pull, planners wait until an economical order quantity, an MRP order policy driven lot size, or a periodic review occurs. Cycles could be weekly, biweekly, or monthly. These order cycles are directed at realizing economies of scale in pricing and delivery costs. The results are very large orders pushed upstream followed by periods of no orders at all which destroys previously constructed forecasts.
- *Price fluctuations and promotions.* Pricing issues can lead to an increase in demand variability. For example, a decision to offer a discount on large lot-size quantities results in large resupply order quantities that magnify the bull whip effect. Trade promotions and other short-term discounts offered by producers and distributors result in *forward buying* by which large quantities are purchased during the discount period

and used to cover demand during future periods. Beyond the promotion, smaller lot sizes are purchased, further increasing channel demand variability. Finally, sales force incentives may cause channel members to purchase more inventory than needed as the sales team offers discounts as the sales campaign cycle draws to a close so that volume targets are reached.

- *Rationing and shortage gaming*. When demand exceeds supply, channel nodes may respond by partially filling replenishment orders. The result is inventory planners "gaming" the system by hiding their real needs from the supplier. Suppliers misinterpret the demand and alter forecasts, acquire additional capacity, and build more product. Trouble begins when the shortage period passes and waves of cancelled orders are received further distorting real channel demand and supply requirements.

Solving the bullwhip effect requires entire supply chains to work closely together to overcome obstacles and achieve channel coordination. According to Chopra and Meindl, there are five basic actions that can be pursued to tame the sting of the bullwhip effect [3].

- *Aligning of channel goals and profitability*. Achieving synchronization of goals and profitability requires channel members to develop strategies that ensure profitability and risk are shared equally by all channel nodes. Pushing risk to the weakest member of the supply chain simply increases the likelihood that the weakest link will break, endangering the entire supply chain system. In addition, all facility, transportation, and inventory decisions should be evaluated on profitability versus total cost, or even worse, just local cost. For example, an approach to centralize inventories to cut costs should not be done at the expense of customer service flow through. Finally, managers should use programs, such as sales incentives based on a rolling horizon and reduction in forward buying, to help reduce fluctuations in the order stream.
- *Improved information accuracy*. A variety of computerized applications provide planners with increased visibility to supply chain disruptions and improve the accuracy of available information. For example, sharing point-of-sale (POS) data helps reduce the bullwhip effect by providing the entire supply chain with the latest sales information so that forecasts are more accurately determined. Electronic data interchange (EDI) enables supply chains to formalize data sharing through rapid, automatic transmission of demand data to all channel network nodes. Another important application is collaborative planning, forecasting, and replenishment (CPFR). This application enables supply chain companies to automatically pass demand data into each trading partners' planning and forecasting systems.
- *Improved operational performance*. By improving operational performance, planners can reduce the bullwhip effect. Reducing replenishment lead times and lot sizes will significantly assist in decreasing demand uncertainty during the replenishment process. Activities, such a deploying EDI, increased operational flexibility, advanced shipping notices (ASN), and cross-docking, dampens channel demand distortions. Also, planners must discourage channel partners from distorting demand information by using rationing schemes that inflate forecasts and cause inventory buildup at channel distribution points. Channel partners can enact more stringent cancellation policies to prevent the effects of over-order gaming by imposing penalties for cancelled and returned orders.

- *Designing pricing strategies to stabilize orders*. Effective pricing strategies encourages smaller lot-sized ordering and inhibits forward buying practices. An important pricing strategy is to move from lot-size to volume-based quantity discounts. Another practice is to restrict or eliminate promotions and to establish standardized prices with the goal of linking prices directly to customer sales. These practices directly translate to everyday-low-cost pricing at the retail level.
- *Building strategic partnership and trust*. Supply chain planners can significantly reduce the bullwhip effect by building a culture of trust and strategic partnership within the supply chain. Supply chain coordination takes the form of two broad categories. The first, *action-oriented levers*, includes information sharing, changing incentives, operational improvements, and stabilizing of pricing. The second category, *relationship-oriented levers*, involves the construction of cooperation and trust within the supply chain by detailing the benefits to each party, identifying operational roles and decision rights for each channel member, establishing effective contracts, and designing effective conflict-resolution mechanisms.

9.5.1.1 Selective Stocking

A simple technique to stock channel locations is a technique known as *selective stocking*. The objective of this technique is to provide planners with a method of maximizing available warehouse space in the channel by determining which items are to be stocked at what channel echelon based on item ABC classification. As an example, Class A items might be carried by all locations in the channel. Class B items, on the other hand, might reside at regional distribution centers servicing several local warehouses. Finally, Class C items might only be stocked at the firm's national distribution center. In determining stocking levels, planners must be careful to calculate the trade-off costs of lowering channel carrying costs against increases to other logistics costs and decreasing customer service. Savings realized by centralizing certain classes of items might be lost to increased transportation costs.

9.5.1.2 Square-Root Rule

The *square-root rule* is a technique that assists planners to calculate the advantage gained through a channel inventory consolidation strategy. The assumption is that the greater the number of channel locations, the greater the amount of inventory needed to maintain targeted customer service levels. The square-root rule seeks to attain the inverse by assuming that as inventories are consolidated into fewer stocking locations, total channel costs will decline. The square-root rule formula is expressed as

$$CI = SI\sqrt{n} \tag{9.1}$$

where CI is the inventory value of an item if the entire network stock is centralized at n number of stocking locations, SI is the amount of inventory stocked at n distribution locations, and n is the number of stocking points in the channel.

Exercise 9.2: Impact of the Square-Root Rule on Channel Inventory Costs

The square-root rule can achieve several different objectives. If a planner wanted to determine the cost of carrying an item in multiple channel distribution points, the first step is to determine the total average inventory value for stocking the item in a single warehouse. The next step is calculating the square root of each additional location beyond one. The final step is multiplying the square root value associated with a determined number of warehouses by the base average inventory value of stocking the item in a single warehouse by using formula (9.1). This calculation is illustrated in Table 9.1.

TABLE 9.1. Square-Root Rule

Number of warehouses (n)	SQRT n	Total average inventory (value) ($)	Percent change (%)
1	1	6,500.00	0.00
2	1.41	9,192.39	141.42
3	1.73	11,258.33	173.21
6	2.45	15,921.68	244.95
10	3.16	20,554.80	316.23
14	3.74	24,320.77	374.17
20	4.47	29,068.88	447.21

For example, if the planner wanted to calculate the cost of stocking an item in the same quantity with the same cost in two locations, the first step would be to find the square root of two, which is 1.41. To find the total channel cost of stocking the item in two locations, the planner would use the following square-root rule equation variation:

$$CI_2 = \sqrt{nCI1_1} = \sqrt{1.41 \times US\$6{,}500 = US\$9{,}192.39}$$

The square-root law could be used to find the inverse of the above problem. In the scenario, the distribution channel contains US$20,554.80 in inventory, warehoused in 10 facilities. The goal is to find out what the total cost would be if the channel is reduced from 10 to 3 facilities. To find the answer the planner uses a variation of the square-root rule as follows:

$$CIn_3 = (X1)\sqrt{n_2/n_1}$$

where:

CIn_3 is the total cost for three facilities
n_2 is the number of targeted facilities
n_1 is the number of existing facilities
X_1 is the total unit cost for 10 facilities

The equation renders the following answer:

$$CIn_3 = US\$20{,}554.80\sqrt{3/10} = \text{US\$11,258.33}$$

The square-root rule assumes several conditions if it is to provide meaningful data. To begin with, interbranch transfers rarely occur. Second, the lead times do not vary and thus inbound transportation is not greatly impacted by centralization. Third, customer service targets are constant regardless of the number of facilities. Fourth, customer demand at each facility is normally distributed.

9.5.1.3 Channel Distribution Using a Push System with Facility Stocking Constraints [4]

As detailed earlier in this chapter, the strategy of a "push" system is to stock inventory in a centralized location and then allocate quantities to satellite warehouses based on a predetermined percentage. A potential problem arises when the total replenishment quantities to be pushed through the channel system exceed the original push percentages. If these excess inventories cannot be stored at the central distribution site, they must be allocated to the channel warehouses. In solving this problem, several questions must be answered. How much inventory is targeted to be stored at each channel location? When an item is to be pushed out to the channel, how much should be allocated to each warehouse? If there is an excess, how should the extra inventory be apportioned among the channel stocking points?

The procedure for managing this problem involves the following steps:

1. Determine the quantity of the production run or supplier purchase.
2. Determine the forecast requirements of each of the channel locations between the current time and the next expected production run or supplier purchase.
3. Calculate the *adjusted requirements forecast* by using the predetermined *stocking target* and the *forecast error* (standard deviation).
4. Tally the existing on-hand balances at each channel location.
5. Subtract the *adjusted requirements forecast* from the current on-hand balances at each warehouse to arrive at the warehouse's *net allocation.* This value represents how much inventory is to be pushed to each warehouse from the *adjusted requirements forecast*.
6. Sum the *net allocations* and then subtract the quantity from the total push quantity determined in step 1.
7. Apportion the inventory excess over the *adjusted requirements forecast* to arrive at the *proration of excess*.
8. Add each warehouse's *net allocation* and the *proration of excess* to arrive at the new push allocation for each warehouse.
9. Establish the normal capacity target for storing inventories at each channel location and the *max stock quantity target*.
10. Divide the *max stock quantity target* by the *prorated allocation* to arrive at the percent utilization of capacity for each warehouse.

Exercise 9.3: Multi-echelon Push System Allocation

The planner at ABC electronics is reviewing the impact of an opportunity supply order. The supplier has offered a deep discount for a critical item if a certain purchase quantity (55,000 units) is met. The planner's first step is to determine the push requirements for the four warehouses that stock the item. The goal is to see how closely the supplier's offer matches the current requirements of the four channel warehouses and what would be the impact of quantities in excess of the capacities of the warehouses. The relevant requirements data has been assembled in Table 9.2.

TABLE 9.2. Multi-Echelon Push System – Data

Inventory quantities					
Product #	KL-1000-20				
Inventory Qty	55,000				
Warehouses	Forecasted requirements	Forecast percent(%)	Forecast error (σ)	Current inventory balance	Service percent target(%)
1	5,000	15.15	500	2,500	90.0
2	7,000	21.21	1,000	3,000	90.0
3	9,000	27.27	1,500	5,000	95.0
4	12,000	36.36	2,000	6,000	95.0
Total	33,000		Total	16,500	

In the next step, the forecasted allocations at each warehouse are adjusted by determining the total quantity *forecasted requirements* for each warehouse plus the quantity needed to assure the *service percent target*. The equation to calculate this value is expressed as:

$$\text{Adjusted requirements forecast} = \text{Forecast} + \text{NORMSINV} \times [\text{Service target}] \times \sigma \qquad (9.2)$$

Based on this data, the planner has assembled the relevant data as illustrated in Table 9.3.

TABLE 9.3. Multi-Echelon Push System – Allocation

Allocation					
Warehouses	Adjusted requirements forecast	Current inventory balance	Net allocation	Proration allocation	Adjusted allocation
1	5,640.78	2,500	3,140.78	4,669.80	7,810.58
2	8,281.55	3,000	5,281.55	6,537.72	11,819.00
3	11,467.28	5,000	6,467.28	8,405.64	14,872.92
4	15,289.71	6,000	9,289.71	11,207.52	20,497.00
Total	40,679.32	Totals	24,179.32	30,820.68	54,999.50

The column *net allocation* is determined by subtracting the *current inventory balance* from the *adjusted requirements forecast*. The total *proration allocation* is determined by subtracting the total *net allocation* from the supplier's purchase requirement of 55,000 units, or 30,822 (rounded) units. From these values the planner then calculates the individual warehouse *prorated allocation* of the excess inventory by dividing the original *forecast requirements* by the total of the original *forecast requirements* multiplied by the total *prorated allocation*. Finally, by adding the *net allocation* to the *proration allocation*, the planner is able to arrive at the *adjusted allocation* for each of the four warehouses.

The final step in the process is to see if the capacity of each of the warehouses can assimilate the *adjusted allocation* quantities. To assist in the decision, the planner has assembled the data illustrated in Table 9.4. The *stocking capacity target* and *max quantity target* are predetermined for each warehouse. This value represents the percent of utilization each warehouse can comfortably handle for the item quantity.

TABLE 9.4. Multi-Echelon Push System – Capacity

Capacity				
Warehouses	Stocking capacity target(%)	Max quantity target	Prorated allocation	Capacity percent of prorated allocation(%)
1	90.00	8,500	7,810.58	91.89
2	90.00	12,000	11,819.00	98.49
3	95.00	15,500	14,872.92	95.95
4	95.00	20,000	20,497.00	102.49
	Totals	56,000	54,999.50	97.21

Determining the capacity of each the warehouses to handle the prorated allocations uses the following equation:

$$\text{Capacity percent} = \textit{prorated allocation}/\textit{max quantity target}$$

Based on the results, the planner has decided to purchase the special offer of 55,000 units.

9.5.2 Adjusting Channel Imbalances

From time to time, inventory quantities in the channel network will get out of balance. Because of variances in demand and supply over time, some locations will have excess quantities of an item while other warehouses may be out of stock. Normally, there is a group of corporate planners whose job it is to monitor channel-wide stocking imbalances and then generate interbranch transfers to redistribute excess inventory in the channel rather than purchasing or producing more inventory. This function requires the existence of inventory control systems that permit visibility into both aggregate inventory levels and the detail plans of each channel location. Currently, there are a number of computerized applications available that not only provide for the timely update of local inventory records but also present corporate planners with the information necessary to keep channel inventories in balance. Two conventional methods of solving this problem are *least-cost redistribution* and the *fair-shares technique*.

9.5.2.1 Least-Cost Redistribution

The objective of this method is to restore channel imbalances at the least cost. Assume that a distribution channel consists of a distribution center (DC) in Chicago and satellite warehouses in New York, Dallas, Denver, and Los Angeles. For a given item, also assume that the Dallas and Los Angeles warehouses are stocked out and have open customer backorders for 50 and 60 units, respectively. In contrast, the Chicago DC has 75 units extra, New York 60, and Denver 50. To summarize, the channel has open customer orders totaling 110 units that cannot be filled from the current warehouse stocks, but an excess of 185 units exists in the channel. The goal of the exercise is to redistribute the inventory imbalance in as cost-effective a manner as possible.

A common technique used to address this problem is to set up a sequence of default interbranch transfer relationships. For example, Denver would always attempt to replenish shortages by first ordering from the Los Angeles warehouse, then from Dallas, Chicago, and lastly from New York. The resupply sequence is determined by comparing the normal transportation cost from the source to the destination, the cheapest being the first in the sequence and so on. The problem with the technique is that when more than one channel warehouse requires inventory and excesses exist in several other warehouses, it becomes difficult to determine the least-cost interbranch transfer.

TABLE 9.5. Price-Delivery Matrix

On-hand balance	Warehouse	Chicago ($)	New York ($)	Dallas ($)	Denver ($)	Los Angeles ($)
75	Chicago	–	1.35	1.63	1.70	2.10
60	New York	1.45	–	1.82	1.80	2.40
−50	Dallas	1.65	1.85	–	1.70	2.00
50	Denver	1.75	1.95	1.65	–	1.10
−60	Los Angles	2.05	2.25	2.03	1.25	–

A more effective method is to develop a transportation cost matrix that will enable planners to calculate the least-cost redistribution of items. A sample matrix with the cost of transporting product by pound from and to each warehouse in the above distribution channel is illustrated (Table 9.5). The cost is computed in US dollars per pound. The object of the procedure is to redistribute excess inventories among channel warehouses in such a way as to minimize total transportation costs. Assuming that the product that is in imbalance in the channel is 1 lb per unit, the results of the calculation would be as follows (Table 9.6).

TABLE 9.6. Delivery Cost Solution

On-hand balance	Warehouse	Chicago ($)	New York ($)	Dallas ($)	Denver ($)	Los Angeles ($)
75	Chicago					
60	New York					
−50	Dallas	81.50	91.00	–	82.50	–
50	Denver					
−60	Los Angles	126.00	144.00	–	66.00	–

The results of the computation indicates that the Dallas warehouse requirement is most economically satisfied by shipping all of the 50 units from Chicago for a total shipment cost of $81.50. The Los Angeles shortage is best filled with a shipment of all of the Denver warehouse excess of 50 units, plus 10 units from Chicago for a total delivery cost of $76. It is important to note that interbranch shipments designed to remedy channel inventory imbalances should not be posted as *demand* in the computation of sales usage used in developing warehouse level forecasts. Although it is true that the stock is deducted from the supplying warehouse's inventory balance, the interbranch inventory transaction must be coded so as not to post such shipments in the demand files used to compute forecasts.

9.5.2.2 "Fair Share" Techniques [5]

Despite the added control offered by centralized channel planning, there are often occasions when distribution centers possess insufficient stock to fill the inventory needs of the entire distribution network. Such an event could occur because of the normal lag time in channel information and material flows or because of unplanned demand or supplier stock out. In responding to such a problem, inventory managers often use a technique called "fair share." The basis of this technique is to provide branch locations with equal run-out replenishment resupply that should be sufficient to prevent stock out during the lead time until supplier receipts arrive at the deployment warehouse.

The first step in the process is to determine how many days of total inventory are in all facilities in the channel. The formula for this calculation is

$$DS = \frac{AQ + \sum_{b=1}^{n} I_b}{\sum_{b=1}^{n} D_b}$$

where

DS is the common days supply for branch inventories
AQ is the inventory units to be allocated from the DC
Ib is the inventory in units for branch *b*
Db is the daily demand for branch *b*

Once the common days supply for the branches (*DS*) has been calculated, it is now possible to determine a fair share allocation for each branch warehouse. The formula for this step is

$$Ab = (DS - Ib/Db)Db$$

where

Ab is the amount allocated to branch *b*

Exercise 9.4: "Fair share" Allocation

The planner at the channel DC is charged with the task of allocating 200 units of item PC1501-01 across the supply channel. There is a problem in that the next resupply order for the item at the DC is not due for another 10 days. The planner needs to determine if it is possible to allocate the 200 units to the three branch warehouses so that they each have a minimum of 10 days of daily usage. To assist in the calculation, the planner has created a matrix showing on hand inventories and channel demands. Table 9.7 shows the assembled data.

TABLE 9.7. "Fair Shares" Allocation

		Weekly requirements					
Location	On-hand	Week 1	Week 2	Week 3	Week 4	Week 5	Daily usage
DC	200						
Branch A	30	40	40	40	40	40	8
Branch B	37	50	50	50	50	50	10
Branch C	33	60	60	60	60	60	12
Totals	300	150	150	150	150	150	30

The first step is to determine the common days supply available in the entire channel network. This is calculated as follows:

$$DS = \frac{AQ + \sum_{b=1}^{n} I_b}{\sum_{b=1}^{n} D_b} = \frac{200 + (30 + 37 + 33)}{(8 + 10 + 12)} = 10 \ \ days$$

At this point, the planner feels assured that, at least in the aggregate, there is sufficient inventory in the channel system to sustain demand until the receipt of the replenishment order from the supplier. The next step is to allocate the 200 units from the DC to each branch warehouse to cover 10 days of demand. The planner begins at Branch A. The calculation for the fair share is

$$Ab = (DS - Ib/Db)Db = ((10 - (30/8)) \times 8) = 50 \text{ units}$$

Branch A can expect to receive 50 units. Using the same calculation, Branch B will receive 63 and Branch C will receive 87 units.

While the fair share technique enables planners to allocate equal shares of stock across a supply channel, it suffers from limitations. It does not consider differences in performance cycle times, EOQs, or safety stock requirements, and is, therefore, limited in its ability to manage multi-echelon channel systems.

9.6 SUPPLY CHAIN CAPACITY PLANNING

The capability to maintain effective multi-echelon inventory control is only half of the benefit a DRP system offers supply chain planners. Just as important as maintaining the critical balance between supply and demand is the balance that is maintained between demand requirements and supply chain operations *capacities*. A distribution channel that blindly pursues a policy of demand management without critical attention to channel facility capacities is courting disaster. The following scenario is all too familiar: Marketing and sales embarks on an ambitious campaign that calls for significant growth in inventories. Unfortunately, no one explores the effect this strategy has on logistics capacities. The result is that existing warehouses are unable to store the new inventory quantities, resulting in costly alternative warehousing and extra overhead costs. In addition, the existing company-owned transportation fleet cannot keep up with the demand, and other, more costly carriers have to be contracted. What profits the new sales strategy initially intended to realize are soon consumed in added logistics costs.

While the effective management of inventory is fundamental in assuring channel responsiveness, the ability to also effectively manage supply chain *constraints* is absolutely critical for a competitive supply chain network. Today, producers have computerized tools, such as capacity requirements planning (CRP), advanced planning systems (APS), theory of constraints (TOC), and constraint programming (CP) technologies, to assist in managing production bottlenecks. Distribution planners have similar toolsets to assist in removing capacity constraints in channel inventory deployment by providing visibility to possible bottlenecks in capital, the work force, equipment, and space availability. Being able to *optimize* the supply chain means that distribution points anywhere in the channel network are agile enough to overcome current and future constraints that threaten to impede the flow of goods through the distribution pipeline. Achieving these goals requires that supply chain planners possess information systems that provide a *schedule* of priority requirements that is translated quickly and accurately into detailed channel capacity planning elements. DRP provides planners with such a window into required channel capacities.

9.6.1 Financial Estimating

The fundamental responsibility of inventory management is to ensure that inventory is on hand to respond to customer demand. But in planning for inventory, it is also important that companies possess sufficient capital to fund the replenishment plan. Although inventory is considered a *current asset* on the financial statement, it is not cash, and poor inventory planning can drive a company to financial ruin. Businesses utilizing statistical replenishment techniques have difficulty estimating the investment necessary to support marketing and sales plans. For the most part, estimates are made using spreadsheet simulators based on aggregate item usage histories.

With the use of DRP, on the other hand, inventory planners have the ability to view, as part of the DRP process, output that is used to project the financial investment necessary to support the inventory stocking plan through the planning horizon. This process could be performed by individual warehouse as well as for the whole distribution channel. The steps in developing a DRP inventory asset plan are relatively simple. To begin with, the size of the DRP *planning horizon* is defined. The length should correspond to the length of the financial time period: for example, 6 months, 1 year, or multiple years. Second, expected forecasts are developed for each product family or each stocked item matching the length of the planning horizon. Finally, the cost of product families or individual items determined by the firm's costing method are calculated. Once these elements are defined, the DRP processor is then run.

The results of the DRP generation is easily turned into a projected cost report by multiplying the generated planned order quantities by the cost for each item by period in the planning horizon. Table 9.8 illustrates a projected aggregated inventory cost report by product family. Notice that the report lists the total on-hand balance, DRP generated planned order quantities by product family, the cost of each product family, a projected cost summary by product family, and, finally, a summary cost by warehouse.

The advantages of using DRP in developing inventory asset planning are the following:

- *Ease of planning*. Instead of laborious data calculation and spreadsheet development needed for statistical inventory management, DRP provides planners with the projected costs over a specified planning horizon by family and by total warehouse. The system, in fact, calculates the necessary data elements as part of the normal DRP generation. Planners merely have to format the required output reporting.
- *Accuracy*. DRP provides planners with an accurate calculation of projected inventory costs driven by estimated forecast demand. By extending each product family's planned orders by the cost, DRP provides a window into the financial assets necessary to respond to each family's schedule of *net requirements*. The more accurate the forecast, the more accurate the financial projection.

TABLE 9.8. Costed DRP Inventory Report

Warehouse: Chicago		Date From: 01/01/20XX	Date To: 12/31/20XX	
Product family	On hand	Planned order qty	Cost($)	Projected value($)
1,425	2,550	15,300	16.50	294,525.00
1,551	2,250	18,000	9.50	192,375.00
2,300	1,250	14,000	4.50	68,625.00
4,100	900	11,500	42.50	527,000.00
3,320	250	7,500	35.80	277,450.00
5,673	11,000	55,500	3.65	242,725.00
7,836	15,000	45,500	2.40	145,200.00
9,835	20,000	100,000	12.50	1,500,000.00
3,478	8,000	54,000	26.50	1,643,000.00
5,903	2,000	1,000	13.75	41,250.00
2,237	3,250	21,000	27.50	666,875.00
3,410	670	8,500	22.75	208,617.50
Totals	67,120	351,800	Totals	5,807,642.50

- *Simulation*. By inputting alternate forecasts into the system, DRP provides planners with the ability to simulate product level, individual warehouse, and aggregate channel costs. By analyzing each DRP simulation generation, the optimal forecast that fits both the inventory plan and the firm's asset budget can be selected.
- *Productivity*. The choice of the right inventory plan is critical for the success of the enterprise and the entire supply chain. DRP permits planners to make the right inventory decisions so that targeted customer service levels are met while reducing inventory costs.

9.6.2 Transportation Planning

Perhaps the single most important factor inhibiting transportation planners from effectively controlling transportation costs is lack of visibility into future shipping requirements. Often firms are faced with the problem of having to ship products in quantities that do not take full advantage of rate structures. For example, transportation is forced to ship less-than-full truckloads (LTL) because of low current shipments. What transportation planners really need is to be able to view not only current but also the anticipated shipping requirements of future periods when developing a cost-effective shipping plan. Instead of just shipping those products due for current shipment, visibility into the schedule of demand for the next couple of days and weeks provides transportation planners with the ability to move in and combine future shipments with current requirements so that full truckloads are shipped.

Because of its ability to *time-phase* supply and demand, DRP provides transportation planners with a window into both current and future shipping requirements. By referencing individual item master information relating to weight, volume, number of pallets, and other relevant data, DRP easily converts each product family's schedule of planned orders into transportation planning data elements. Table 9.9 provides an example of a shipping schedule for the month of January in a current year for all of the product families in the Chicago warehouse. By referencing aggregate weight and cube dimensions associated with each product family, total weight, number of pallets, and pallet cubes are calculated. With this information, transportation planners could start negotiating with carriers to attain the best rates for the January shipping schedule.

TABLE 9.9. Transportation Report

Warehouse: Chicago		Date From: 01/01/20XX	Date To: 01/31/20XX	
Standard pallet cube (inches)		64		
Product family	Forecasted shipments	Total weight (lbs.)	Number of pallets	Cube (pallet)
1,425	1,488	11,345	149	9,536
1,551	1,688	12,356	169	10,816
2,300	1,271	8,525	128	8,192
4,100	1,033	8,400	104	6,656
3,320	645	4,278	65	4,160
5,673	5,542	48,500	278	17,792
7,836	5,042	51,000	252	16,128
9,835	10,000	1,670	500	32,000
3,478	5,167	62,000	259	16,576
5,903	250	1,125	25	1,600
2,237	2,020	19,357	10	640
3,410	765	6,350	77	4,928
Totals	34,910	234,906	2,016	129,024

The above shipping report is used by transportation planners in the following manner. The distribution center ships items by truck. The standard trailer has the following capacity: maximum weight is 50,000 lb, with a volume of 2,000 cubic feet, and a max of 35 pallets. The goal is to develop a shipping plan that optimizes truck capacities. Using this aggregate data, the shipping schedule indicates that, by weight, 5 (rounded) truckloads (TL) (234,906/50,000) are necessary. However, because all products are shipped in full pallets, the total pallets to be shipped indicate that a total of 57.6 truckloads (2,016/35) are necessary. By cubic volume, a total of 64.5 truckloads (129,024/2,000) are necessary. For more detailed planning, the aggregate shipping plan illustrated in Table 9.9 is further broken down by week to reveal a weekly shipping schedule (Table 9.10). This weekly schedule shows the item, order quantity, whether the demand is from a customer order (CO) or from a planned order (PLN ORD), weight, pallets, and cube.

The advantages provided by DRP in assisting transportation managers to plan and control transportation capacities are significant. There are four key areas to review:

- The transportation planner has the critical information necessary to schedule cost-effective transportation and loading. DRP provides a window into future requirements, permitting planners to develop transportation plans that extend beyond just today's shipping requirements.
- Through the use of simulation, planners have the ability to see the effect of different forecast plans and provide essential input into selecting the optimal forecast that minimizes total transportation cost. For example, planners may total the shipping

TABLE 9.10. Detailed Shipping Schedule

Warehouse: Chicago			Date From: 01/01/20XX		Date To: 01/31/20XX	
Standard pallet cube (inches)		64				
Week	Item #	Quantity	Order type	Weight (lbs.)	Pallets	Cube (pallet)
1	1425-01	70	CO	280	7	448
	1425-03	35	CO	145	4	256
	1425-04	21	CO	125	2	128
	2300-01	36	CO	148	4	256
	2300-04	43	PLN ORD	153	5	320
	5673-01	76	CO	175	4	256
	5673-02	25	PLN ORD	125	2	128
	5673-04	48	CO	165	5	320
	9835-02	125	CO	245	7	448
	9835-04	257	PLN ORD	450	13	832
	9835-06	310	CO	625	16	1,024
	9835-07	223	PLN ORD	460	23	1,472
	3410-01	10	PLN ORD	45	2	128
	Totals	1,279		3,141	94	6,016

requirements for the entire year and then contrast them against available capacity. This would be particularly important if the firm possessed its own transportation fleet.

- The aggregate shipping schedule assists in planning other critical logistics components. It could be used to develop transportation freight budgets, negotiate freight rates, and justify the acquisition of additional equipment such as trucks, trailers, and rail cars.
- Because the schedule of planned orders generated by DRP is truly a schedule of what is planned to happen, the shipping plan represents what the firm is planning to ship. This information can be used by other business functions, such as accounting and sales, in their planning processes.

9.6.3 Warehouse Space Planning

Calculating warehouse capacities is one of the most neglected of the four areas of logistics capacity planning. The failure to effectively plan warehouse space can have an enormous financial impact on the whole distribution channel. When it is considered that warehousing activities account for roughly one-fifth of a typical distributor's logistics expenditure, effective warehouse management is an important element in increasing company profitability. Poor warehouse planning results in such problems as unnecessary material handling costs, item damage and obsolescence, record-keeping redundancies and errors, time wasted in item search, excess transportation costs, the cost of public warehousing or other extra storage facilities, or the opposite, the cost of unused warehouse space and equipment.

Generating warehouse capacities involves the addition of the following data elements to the DRP output.

- *Item level storage profile*. The starting point of the capacity calculation is defining the weight, volume, and number of pallets required to store the stocking unit of measure for each item in the DRP plan by time period. Most commercial DRP systems provide these data elements as part of the item master record. Planners must make sure that the data are loaded correctly and that there is an audit program in place to keep item sizing profiles up to date.
- *Warehouse storage capacities*. Each storage type in the warehouse must be defined in the DRP system's location master record. Shelf racks, bins, bin boxes, barrels, floor space, and pallets are possible examples of storage types. Next, each of these storage types must be assigned a *stocking volume* based on their space dimensions and allowable weight capacities. Finally, each stocked item is assigned a storage-type code based on its size and projected stocked quantities. The result of the process is a list of total available locations in the warehouse. Figure 9.26 illustrates an abbreviated report broken down by storage type, weight, and volume. Note that the report details the total capacity available in the warehouse by type (Table 9.11).

TABLE 9.11. Warehouse Capacity Report by Type

Warehouse: Chicago		Date From: 01/01/20xx		Date To: 01/31/20xx	
Storage type	Location	Code	Weight	Dimensions (ft)	Volume (ft^3)
Shelf rack	7010101	SR4	1,500	4×8×4	128
Shelf rack	7010102	SR4	1,500	4×8×4	128
Shelf rack	7010103	SR4	1,500	4×8×4	128
Shelf rack	7010104	SR2	750	2×8×4	64
Shelf rack	7010201	SR4	1,500	4×8×4	128
Shelf rack	7010202	SR2	1,500	2×8×4	64
				Totals	25,000

Storage type	Location	Code	Weight	Dimensions (in)	Volume (in^3)
Bin	6010101	B6	450	6×36×24	5,184
Bin	6010102	B6	450	6×36×24	5,184
Bin	6010103	B12	450	12×36×24	10,368
Bin	6010104	B12	450	12×36×24	10,368
Bin	6010105	B6	450	6×36×24	5,184
Bin	6010106	B6	450	6×36×24	5,184
				Totals	1,550,000

- *Warehouse space calculation*. Computing storage space requirements from DRP output consists of two calculations. In the first, the capacity requirements for each stocked item is determined by extending the schedule of actual and planned orders by each item's storage profile. Next, the storage requirements are computed by dividing each item's available capacity requirements by time period by the storage type. For example, a given item's storage volume requirements total 192 cubic feet. Because of its unit size, the item is stored in the shelf rack area of the warehouse. By dividing the requirement by the storage type, the product would require 1.5, (192/128) 4 $\times$ 8 shelf rack space.

By reviewing warehouse space capacities each time the DRP is generated, logistics planners can plan for both long- and short-term capacity requirements. As the schedule of planned orders changes, DRP assists planners to assess the ability of existing warehouses to meet storage requirements, and to reveal serious under-capacity and overcapacity conditions. Effective capacity reporting assists planners in controlling storage costs and improving overall operating efficiency and profitability.

9.6.4 Labor and Equipment Capacity

Effective logistics planning requires planners to predict labor and equipment capacities. Too much or too little labor is expensive, as is the cost of unused equipment or poor customer service due to equipment shortages. DRP significantly assists logistics managers keep their labor and equipment needs in balance with demand requirements. The schedule of *planned orders* provides managers with a statement of *which* and *when* products have to be ordered, received, put-away, picked, and shipped. Warehouse managers, in turn, have to develop material handling standards for these critical warehouse functions. As an example, after a time study was performed, one distributor set the order picking standard in their bin warehouse to 60 lines per operator-hour, and the stock put-away in the same area to 30 receipts per operator-hour. By matching the schedule of planned order requirements by time period to standard labor and equipment capacities, warehouse managers can readily ascertain each warehouse's total daily, weekly, and period capacities, identify capacity constraints and excesses, and plan accordingly.

9.7 SUMMARY

Inventory management in a multi-echelon channel environment is determined by the structure and objectives of a firm's distribution channel. Companies create a channel of distribution because they have determined that the best way to serve the marketplace is to have inventory close to the customer. The problem is to determine the best method of ensuring the highest level of channel customer service while pursuing the lowest inventory cost alternatives. There are basically two ways to replenish inventory in a distribution channel: *push* or *pull*. In a "push" system, all channel resupply activities are conducted by the supplying facilities. Channel resupply is performed first by aggregating the demand requirements from all lower echelon stocking points, forecasting methods applied, and then replenishment inventory is pushed back down the channel using some form of allocation algorithm. In contrast, in a "pull" system each downstream facility maintains its own inventory system and determines the timing and quantity of replenishment from designated upstream channel supply points.

When a "pull" system strategy is chosen, inventory managers can choose from two possible techniques: reorder point (ROP) or distribution requirements planning (DRP). The decision to choose one of the techniques depends on how inventory moves through the channel and the level of control required by managers. A ROP technique is mostly chosen by channels that only stock finished goods acquired from outside suppliers. When the reorder point of any facility in the channel is triggered, a resupply order is created and sent to the designated supply facility (or the outside supplier). A key factor to note in the selection of the ROP technique is the relative shortness (expressed in days) of the replenishment lead times separating each channel facility. Outside of some order preparation time, almost the entirety of lead time in a ROP-driven channel is composed of transportation time. ROP works because the resupply lead time necessary to replenish inventory in the supplying facility is the same or less than the lead time to transport those items from the supplying to the satellite facility.

For distribution channels supplied from an intracompany production plant or have long-lead time items made-to-order at outside suppliers, planners would most likely choose the DRP technique. The decision to use DRP is purely one of lead time. Unlike the short lead times characteristic of a ROP supply channel, DRP is best used to manage the much longer production lead times required by production plants at the beginning of the supply chain. DRP works well with the time-phased manufacturing resources planning (MRP) systems used by producers to plan inventories. By providing a schedule of planned demand that extends out into the planning horizon, DRP is able to directly input demand into the production plant's master schedule. As a result, planners at the production plant have the necessary visibility to total channel demand through the planning horizon so that component inventories are purchased and production orders are started and completed on time.

The logic of time-phasing is at the very foundation of the DRP technique. The DRP computer system retrieves key input from such data source files as forecast, open customer order, open replenishment order, on-hand balance, supplier lead times, order policy codes, and safety stock. Once these data elements are collected, the DRP processor begins the process of populating the DRP grid by referencing forecast, customer, and replenishment order due dates. The system then performs a gross-to-net requirements calculation, time period by time period. When the first net requirement appears, the system generates a *planned resupply order* with a quantity sufficient to cover the demand based on the item's order policy code. Finally, once the schedule of planned resupply orders for all items is compiled, DRP provides action messages to guide the inventory planner in making effective replenishment order decisions.

A significant advantage of DRP is also found in the ability of planners to use the DRP output to maintain the balance between demand requirements and supply chain resource *capacities*. Distribution planners can use the DRP-generated schedule to identify and remove capacity constraints in channel inventory deployment by providing visibility to possible constraints in capital, the work force, equipment, and space availability. Being able to *optimize* the supply chain means that distribution points anywhere in the channel network are agile enough to overcome current and future constraints that threaten to impede the flow of goods through the distribution pipeline. Achieving these goals requires that supply chain planners possess information systems that provide a *schedule* of priority requirements that are translated quickly and accurately into detailed capacity planning elements.

DISCUSSION QUESTIONS

1. What is the impact on inventory planning when a decision is made to create a distribution channel?
2. What is the impact on inventory planning when a decision is made to establish a "pull" system for channel inventory management?
3. What would be the criteria driving a company to adopt the use of an order point system or DRP to run their channel networks?
4. What are the differences between a "push" and a "pull" system?
5. Briefly describe the functioning of a distribution requirements planning (DRP) system.
6. The issue of lead time is critical in deciding whether order point or distribution requirements planning (DRP) technique should be used. Why is this statement important?
7. Explain the calculation of the *projected available balance* (PAB) row in the DRP grid.
8. Explain the calculation of the net requirements row in the DRP grid.
9. What is the *bill of distribution (BOD)* and why is it important to a valid DRP calculation?

PROBLEMS

1. Complete the calculation for the DRP grid for item K200-10 appearing below. Place your answers directly into the grid.

Product	**KL-2000-10**								
Lead time/days	**2**								
Order quantity	**200**	**Daily periods**							
On hand inventory/units	**225**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross requirements		150	140	170	185	160	170	190	205
DRP in transit receipts			200						
Projected available balance									
Net requirements									
DRP planned order receipt									
DRP planned order release									

2. The inventory planners at the company's central distribution center (DC) must compute the inventory position of a critical item. The item is also stocked in two satellite warehouses. Currently inventory information for the item in the channel is as follows:
   - The DC stocks 550 units
   - Satellite warehouse 1 stocks 125 units
   - Satellite warehouse 2 stocks 200 units
   - The DC has an open purchase order for 250 units
   - There are 150 units of current unshipped customer orders

   Based on this information, calculate the inventory position (IP) for the item in the distribution system.

3. In the below DRP grid, what is the *net requirement* for day 3?

Product	KL-2000-10				
Lead time/days	2				
Order quantity	150	Daily periods			
On hand inventory/units	200	1	2	3	4
Gross requirements		150	140	170	185
DRP in transit receipts			150		
Projected available balance					
Net requirements					

4. In the below grid, item KL-2000-10 must be ordered in lots of 50 units. What would be the *projected available balance* of item KL-2000-10 at the end of period 4?

Product	KL-2000-10				
Lead time/days	2				
Order quantity	50	Daily periods			
On hand inventory/units	150	1	2	3	4
Gross requirements		150	140	170	185
DRP in transit receipts			150		
Projected available balance					
Net requirements					
DRP planned order receipt					

5. In the below grid, item KL-2000-10 has been assigned a safety stock. Calculate the grid for the 10 daily periods starting with the current date.

Product	KL-2000-10										
Safety stock/units	100										
Min order qty/units	0										
Lead time/days	2										
Lot size/units	700	Daily periods									
On hand/units	700	1	2	3	4	5	6	7	8	9	10
Gross requirements		500	500	525	525	525	510	510	530	530	540
DRP intransit receipts			700								
Projected available balance											
Net requirements											
DRP planned order receipt											
DRP planned order release											

6. The inventory planner at ACME Distributors has been asked to calculate what the savings would be for the company if the existing eight channel warehouses were reduced to six. If the total inventory cost for the existing warehouse channel is US$20,500,000, what would be the new cost?
7. The inventory planner at ACME Distributors has received notification that a popular item currently only stocked at the company's main distribution center is to be now stocked in the 5 regional warehouses in the same quantity to meet increasing customer demand. The average cost of the item at the main distribution center is US$10,000. What is the cost of stocking the item at all five of the warehouses? What is the percent change (increase) on the stocking of the item?
8. One of the remote warehouses at ACME Distributors orders a critical item every 3 weeks from the company's main distribution center. The transportation time to deliver the product is

1 week. The average demand on the item is 500 units per week and the safety stock is held at 2 weeks supply. What would be the target inventory level at the remote warehouse?

9. ACME Distributors stocks an item in two remote warehouses and at the central distribution warehouse. Calculate the projected available, planned order release and gross requirements rows in the below DRP grids. Reference the planning data for each warehouse.

Warehouse 1						
Transit time/wks	2					
Order quantity/units	150					
On hand/units	100					
Week	1	2	3	4	5	6
Gross requirements	90	120	100	110	110	105
DRP in transit		150				
Projected available balance						
Planned order release						

Warehouse 2						
Transit time/wks	1					
Order quantity/units	300					
On hand/units	125					
Week	1	2	3	4	5	6
Gross requirements	200	225	210	205	220	200
Drp in transit	300					
Projected available balance						
Planned order release						

Central DC						
Lead time/wks	2					
Order quantity/units	1,000					
On hand/units	700					
Week	1	2	3	4	5	6
Gross requirements						
Scheduled receipts						
Projected available balance						
Planned order release						

10. ACME Distributors stocks an item in two remote warehouses and at the central distribution warehouse. Calculate the projected available, planned order release and gross requirements rows in the below DRP grids. Reference the planning data for each warehouse.

Warehouse 1	KL-2000-10						
Safety stock/units	50						
Min order qty/units	0						
Transit time/days	2						
Lot size/units	250	DAILY PERIODS					
On hand/units	300	1	2	3	4	5	6
Gross requirements		200	220	220	230	230	230
DRP intransit receipts			250				
Projected available balance							
Net requirements							
DRP planned order receipt							
DRP planned order release							

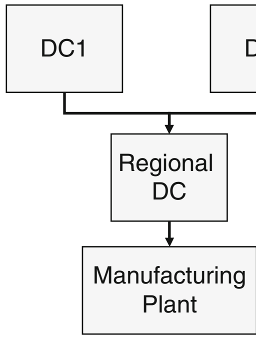
Warehouse 2	KL-2000-10						
Safety stock/units	100						
Min order qty/units	0						
Transit time/days	1						
Lot size/units	500	DAILY PERIODS					
On hand/units	625	1	2	3	4	5	6
Gross requirements		520	520	525	525	525	510
DRP intransit receipts			500				
Projected available balance							
Net requirements							
DRP planned order receipt							
DRP planned order release							

Central DC	KL-2000-10						
Safety stock/units	150						
Min order qty/units	0						
Lead time/days	2						
Lot size/units	600	DAILY PERIODS					
On hand/units	900	1	2	3	4	5	6
Gross requirements		0	0	0	0	0	0
DRP intransit receipts			600				
Projected available balance							
Net requirements							
DRP planned order receipt							
DRP planned order release							

CASE STUDY

As the distribution inventory planning manager for ABC Electronics, you have been contacted by the manufacturing plant manager regarding the projected channel demand for a high-volume item stocked everywhere in the company's distribution channel, the K200-10, DVD video recorder. The manufacturing manager needs to see the projected demand for this product over the next 8 weeks.

To begin the process, you have reviewed the bill of distribution kept in ABC's DRP system and have found that the distribution channel contains three echelons. You have diagramed the distribution channel and it appears as follows:



The DRP planning system also provides some critical information.

1. All of the distribution centers (DCs) are distribution facilities only. The plant is the only facility that makes the product.
2. DCs 1 and 2 are supplied only from the Regional DC.
3. The Regional DC is supplied directly from the Manufacturing Plant.
4. All of the facilities in the channel sell product to the customer, including the Manufacturing Plant.
5. Since all of the facilities are subject to independent demand, each facility has a forecast. The forecasts for DC1 and DC2 appear in the *gross requirements* rows on the DRP grid displayed on the next page.
6. The DRP grid for the K200-10 item also shows the *DRP in-transit receipts* that are awaiting arrival at each of the facilities.
7. Each of the distribution facilities has a ***minimum order quantity*** governing planned order releases. For example, the minimum order quantity for the item that can be placed at Distribution Center 1 is 200 units. If a net requirement exceeds 200 units, the DRP will add the discrete amount above 200 to the min quantity of 200 as the planned order quantity.
8. Based on this information, and the planning data provided on the DRP grids displayed on the next page, calculate the projected channel demand on the Manufacturing Plant for item K200-

10. Also, assist the manufacturing manager calculate the MRP plan.

Distribution Center 1

Lead time/weeks	1
Order quantity/min	200
On hand inventory/units	50

	WEEKLY PERIODS							
Product - K200-10	1	2	3	4	5	6	7	8
Gross requirements	250	250	300	300	350	350	370	375
DRP in transit receipts	300							
Projected available balance								
Net requirements								
DRP planned order receipt								
DRP planned order release								

Distribution Center 2

Lead time/weeks	1
Order quantity/min	100
On hand inventory/units	50

	WEEKLY PERIODS							
Product - K200-10	1	2	3	4	5	6	7	8
Gross requirements	175	175	200	200	200	225	225	250
DRP in transit receipts	175							
Projected available balance								
Net requirements								
DRP planned order receipt								
DRP planned order release								

Regional distribution center

Lead time/weeks	1
Order quantity/min	525
Forecast/weekly	200
On hand inventory/units	100

	WEEKLY PERIODS							
Product - K200-10	1	2	3	4	5	6	7	8
Gross requirements	200	200	200	200	200	200	200	200
DRP in transit receipts	525							
Projected available balance								
Net requirements								
DRP planned order receipt								
DRP planned order release								

Manufacturing Plant

Lead time/weeks	2
Order quantity	1,000
Forecast/weekly	200
On hand inventory/units	700

	WEEKLY PERIODS							
Product - K200-10	1	2	3	4	5	6	7	8
Gross requirements	200	200	200	200	200	200	200	200
MRP scheduled receipts								
Projected available balance								
Net requirements								
MRP planned order receipt								
MRP planned order release								

REFERENCES

1. Lee, Haul L., V. Padmanabhan, and Seungjin Whang. 1997. The bull whip effect in supply chains. *Sloan Management Review* 38(3): 93–102.
2. Adapted from Ibid., 94.
3. See the discussion in Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operation*, 4th ed, 473–477. New York: Prentice Hall.
4. This subject is based on the discussion in Ballou, Ronald H. 1999. *Business logistics management*, 4th ed, 319–321. New Jersey: Prentice Hall.
5. Reference Bowersox, Donald J., David J. Closs, M. Bixby Cooper, and John C. Bowersox. 2013. *Supply chain logistics management*, 4th ed, 176–177. New York: McGraw-Hill.

PART 4

SUPPLY CHAIN OPERATIONS EXECUTION

CHAPTERS

Part 4 continues the discussion of supply chain management by examining the next steps in the channel network planning process: management of the customers, suppliers, warehouses, and transportation functions found in the supply chain. Chapter 10 explores how today's supply chains must be capable of building deep relationships with their customers, uncovering their wants and needs, how they should be marketed to, how they can be made into lifetime customers, and what they value most from their channel supply partners. These objectives are built around quality and responsiveness techniques that enable channel partners to respond quickly to ongoing changes in customer needs and expectations wherever they occur in the supply channel. Topics discussed are understanding the revolution in customer management, the content of customer relationship management (CRM), creating world-class customer order management functions, exploring the components of customer service management, and identifying performance gaps. The chapter concludes with an overview of a nine step process for achieving effective customer service management.

The performance of procurement management functions is the focus of Chapter 11. The chapter begins by defining procurement and exploring essential activities such as inventory planning, request for quotation, supplier selection, purchase order generation, and receiving. Other important topics include examining the anatomy of purchasing strategy, theory and practice of supplier relationship management (SRM), managing the sourcing process, supplier and procurement performance measurement, and tracing the impact of Internet commerce on procurement.

Chapter 12 is concerned with warehousing. Warehousing is an integral part of every supply chain. Warehousing enables channel systems to fulfill time and place marketing utilities necessary to satisfy customer delivery and product availability expectations. The chapter begins with a review of the nature and types of warehousing, and then progresses to a discussion of the development of warehouse strategies, facility location, and design. The chapter then continues with an in-depth review of warehouse operations, equipment, and productivity measurements. The chapter concludes with a discussion of how today's concern with environmental sustainability is incorporated into warehouse design and operations functions.

Chapter 13 describes how transportation provides the vehicle for the movement of goods and services through the supply channel pipeline. Without efficient transportation, supply chain time and place utilities cannot be realized. The chapter begins with a discussion of the principles, scope of operations, financial impact, and interaction of transportation with other enterprise functions and channel partners. Next, the various legal forms, performance characteristics, and modes of transportation are reviewed. Special consideration is given to detailing the transportation management process, beginning with the establishment of private fleet and public carrier cost and price standards, and concluding with the development of effective performance measurement standards. The chapter ends with an analysis of logistics service providers (LSPs) and the role of transportation management software systems (TMS) in contemporary transportation theory and practice.

10

Customer Management

As far back as the turn of the twentieth century, business strategists have been wrestling with the theory and practice of integrating the customer with the supply chain. Writing in 1915, supply chain pioneer Arch W. Shaw described distribution as composed of two separate yet interconnected functions: *demand creation* and *physical supply*. Demand creation consists in the communication of the *value* found in the array of products and services a company offers

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_10) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_10,

that fulfills the wants and needs of the customer. However, even if a company has the best products and services in the marketplace, they possess no value if they are not available at the desired time, place, and cost wanted by the customer. It was *physical supply's* (the supply chain's) role to solve this basic problem of creating exchange value by ensuring that the flow of the output of production was matched to the customer's requirements as efficiently and cost effectively as possible. Shaw felt that finding a solution "was the most pressing problem of the business man today" and "in this great task he must enlist the trained minds of the economist and the psychologist. He must introduce the laboratory point of view [1]."

Although the science and practice of marketing, production, and channel management are today infinitely more refined and robust than they were in the early 1900s, Shaw's comments have lost none of their pertinence. Regardless of the industry, the ability to anticipate, understand, even engineer the wants and needs of the customer and then construct fulfillment processes that possess the immediacy and agility necessary to provide the optimal product/service solution has never been more compelling and unforgiving. With their expectations set by radically new and exciting buying experiences led by world class companies like Wal-Mart, Apple, and Amazon.com, today's customers are demanding to be treated as unique individuals and requiring their supply chains to consistently provide high-quality, configurable combinations of products, services, and information available through ever-more responsive and interactive order management and customer service technologies. Companies today are under no illusion that unless they can structure the agile infrastructures and interoperable supply chains necessary to guarantee personalized, quick-response delivery even their best customers will not hesitate to search the Internet for a global supplier who will provide the service value they desire.

This chapter explores the range of customer management functions in the Internet Age. The chapter begins by defining today's customer, what are their wants and needs, how they should be marketed to, how they can be made into lifetime customers, and what they value most from the products and services they buy and the relationships they build with their suppliers. Next, the chapter moves to a full definition and review of the components and mission of customer relationship management (CRM). CRM is characterized as both a strategic customer management tool and as a software application technology. Following this review of CRM, the chapter turns to an analysis of order and fulfillment management. In contrast to traditional treatments of the subject, order management is seen as the avenue to align the resources of the entire supply channel in the pursuit of total service value. Next, the chapter discusses the elements of effective customer service management. Topics covered center on the organizational requirements necessary for "world-class" service leadership, defining performance gaps, determining cost trade-offs, developing the service strategy, utilization of Web-based tools, and establishing performance benchmarks. The chapter concludes with a detailed review of customer service management performance measurements.

10.1 THE REVOLUTION IN CUSTOMER MANAGEMENT

Today there is wide acceptance that the dramatic changes that are occurring in the "voice" of the customer demanding superlative service and value are requiring the dynamic restructuring of supply chains on a global basis. It seems a cliché to state the obvious: *customers are the most important assets of a company* and that competitive dominance goes to those companies that are *customer-oriented*. Yet, despite the almost universal agreement on the importance of the customer, companies often find themselves pursuing customer service strategies that are centered purely on internal measurements of product and departmental profitability and are out of touch with what customers actually want and need. The destructive nature of such centripetal objectives has only become more perilous as companies and their supply chains struggle to survive in an increasingly networked, global marketplace where product, quality, and delivery failures can destroy the strongest of brands, the best marketing plans, and the most robust supply chains.

10.1.1 Understanding Today's Customer

The supply chains that will survive and thrive in the twenty-first century are those that understand that the relationship of power between the customer and the business has dramatically changed and will continue to evolve into radically new forms presenting exciting new challenges. In the past, the producer and the distributor determined product and service content, pricing, methods of transaction, fulfillment, and information transfer. In contrast, today's customers are exerting an ever-expanding influence over product development, the way content concerning product and service is communicated, and the terms of order management. By using the power of today's networking technologies, customers no longer feel invisible, are demanding to be treated as individuals, and requiring their supply partners to provide them with configurable, solutions-oriented bundles of products, services, and information custom designed and priced to meet a specific want or need.

In addition, the power of the customer has been heightened by their ability to use Internet technologies to source their products and services from a range of delivery mediums, providing access to potential suppliers from anywhere, at any time on the earth. Whether it is a traditional "bricks-and-mortar" retailer, a catalog available over the Internet, or an impulse buy through an I-Phone app, suppliers are driven to pursue multi- and omni-channel strategies where customer wants and fulfillment expectations are instantly met from anywhere in the supply channel. Today's customer is simply demanding more control over the buying experience; easy to use order management tools that empower them to design their own solutions; flawless and speedy fulfillment; robust information content; ease of search, ordering, and self-service follow-up; and effortless and transparent methods for financial settlement.

Finally, customers increasingly feel that the individualized buying experience, whether online or in person, should be as value-packed and fulfilling as the product or service received. It is no secret that the more emotionally and psychologically satisfied customers are with both the buying experience and the goods and services they purchase, the deeper their sense of engagement, connectivity, and loyalty when they deal with their favorite companies and brands. In an environment where a company's customers have access to virtually any product from a wide variety of channels formats, increasingly they are striving for connection and solutions to the complexity and change found everywhere in their lives. Satisfying this desire for positive, satisfying engagement, in turn, grows relationship value and customer equity for firms and their supporting supply chains.

The migration of power from the producer/distributor to the customer has placed today's company in a life-and-death struggle to continuously develop adaptive business models that enable them to attract and build sustainable customer loyalty. But, before they can architect the type of flexible organizations and supply chains necessary to be more "customer-centric," companies need first to define exactly who the customer is and, secondly, what the increasing power of the customer means to all facets of the supply chain, from product design and production, to fulfillment and financial settlement.

10.1.2 Defining the Customer

All businesses, whether product or service oriented, have a single, all-encompassing objective: *retaining and making more profitable existing customers and utilizing whatever means possible to acquire new customers*. Realizing this objective in today's fiercely competitive marketplace is easier said than done. The classical approach of most companies was, after much marketing analysis, to develop product and service mixes that *they* felt best fit each of their major customer segments, devise the necessary pricing and promotional schemes to ensure brand loyalty, and reset distribution channels to ensure timely fulfillment.

Recently, companies have begun to realize that competitive differentiation lies much deeper than simply matters of global size, the array of available products and services, organizational agility and "leanness," or even the robustness of supply chain networks. In fact, what makes companies successful is that they are *customer-centered*. Marketplace leaders see themselves, not simply as aggregates of brands, sales territories, and productive resources, but rather as a "*portfolio of customers* [2]" organized for the sole purpose of enhancing customer equity by conceiving, communicating, and executing superior value.

Who exactly then are a company's customers? The *APICS Dictionary* defines the customer simply as "A person or organization receiving a good, service, or information [3]." While such a definition at first glance appears to be intuitive, in reality there are several types of customers found in the supply chain. As illustrated in Figure 10.1, beginning with the initial supplier, customers are defined as:

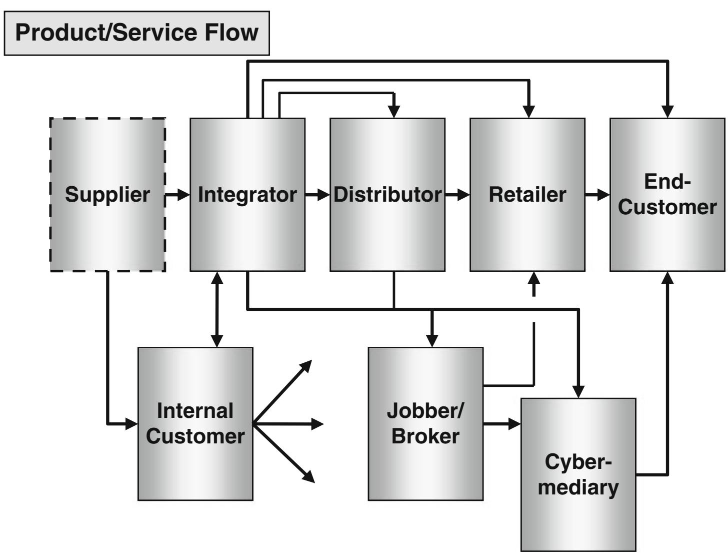


FIGURE 10.1 Types of customers.

- *Integrators.* This type of customer normally buys raw materials and finished components from channel suppliers for the purpose of consuming them in the production of finished goods. As the originator of products and services, integrators stand at a pivotal point in the supply chain and, depending on channel strategies, sell to several types of downstream buyers.
- *Internal customers.* This type of customer pulls materials and products from channel suppliers or has products pushed to them from upstream channel integrators *internal* to the business. The demand on the supplying integrator from an internal customer is accorded the same level of importance as demand from an external customer. Products are either consumed internally or further processed and sent back upstream to company integrators, distributed to downstream stocking points, sold to external partners in the supply chain, or sold to end-customers.
- *Distributors.* This type of customer normally acquires products in large lot sizes in a finished or semi-finished state from either an integrator or another intermediary higher up in the supply channel. These products are then processed to a finished state or sold as-is to downstream channel intermediaries for resale or to be consumed by other integrators. Important functions performed by the distributor are sorting, accumulation, allocation, assorting, and postponement processing.
- *Agents or brokers.* This category of customer differs from a distributor in two important regards: they rarely take ownership of inventory and they offer a very limited range of services. For the most part, their function is to act as middlemen, who for a commission, facilitate the buying and selling of products between suppliers and customers.
- *Cybermediaries.* The application of the Internet has spawned a radically new type of customer that, while occupying a position in the supply chain, may never actually physically own inventory. This type of customer takes the form of a buying exchange or a virtual supplier that leverages Internet technologies to perform matching of products and buyers and to coordinate marketing and transaction processes for network partners. Cybermediaries can have product shipped to them or utilize drop-ship strategies where the product is shipped to the end-customer from integrators and distributors. Examples of cybermediaries are Amazon.com and e-Bay.
- *Retailers.* Retailers are normally considered as occupying a position at the terminal point in the distribution process. The function of retailing is to acquire and deliver finished products and services directly to the end-customer for their personal, non-business use. Retailers can operate bricks-and-mortar stores or leverage *omni-channel* strategies.
- *End-customers.* The end-customer occupies the terminal point of the supply chain process. End-customers normally buy products for private, non-production use. In today's environment, end-customers have the ability to leverage traditional sources of supply, such as retailers or distributors, as well as radically new sources, such as cybermediaries, accessible through the Internet.

It is useful to separate this array of customers into two groups: *business customers* and *consumers*. In general, the first grouping consists of supply chain participants—suppliers, integrators, distributors, and retailers. For the most part, these customers are characterized as consumers of goods and services for the purpose of value-added processing or movement to the end-customer. The second grouping consists of individual consumers resident at the termination of the supply chain process who use goods and services for their personal use.

Managing these two customer groups is very different, each requiring different strategies. Business customers buy goods and services for company use. They usually buy a narrow range of goods in large quantities based on derived demand, and are dependent on close relationships with a narrow range of suppliers who customize processes to fit their specific demands. Business company buyers judge the value of their experiences by the ease of the purchasing and payment process, personal connection with supplier sales staffs, cost, quality, utility of the products received, and willingness of the supplier to work with them in a constructive manner that provides a win-win situation for both.

The experiences demanded by consumers are quite different. They are susceptible to marketing and advertising targeted at a mass market and are heavily influenced by product design, brand loyalty, and lifestyle contents when making a buying decision. Although many consumer decisions are driven by practical necessity, they just as easily are driven by impulse, emotion, and irrational predilections. Intimacy with business customers, on the other hand, means knowing about their business plans, product life cycles, and desired levels of supply channel relationship. In contrast, intimacy with the customer means knowing about their emotional needs, appealing to their intuition, and meeting the psychological desires for buying experiences that just make them feel better. Of course these two customer groupings do merge and can be considered as members of the same supply chain ecosystem. In today's closely interdependent supply networks, failure at any point is often immediately transparent to all forms of customer to be matched by the equally speedy return flow of complaints, excess expediting costs, and possible loss of business up and down the supply chain.

When considered as an archetype, a customer is as *any entity in the supply chain that creates demand for products and services*. Determining just what this definition means hinges on the nature of the supply chain customer strategy. There are three possible strategies [4]. In a *vertically integrated* channel the producer performs all customer value-satisfying activities, beginning with receipt of customer demand, continuing with product configuration, pricing, delivery promising, discounting, and other services, and concluding with product delivery and after sales services. In this model the producer is directly connected to the end-customer without the use of sell-side channel partners. The benefits of such a strategy center on retaining direct control of product distribution, pricing and promotions, marketing information, after-sales services, and degree of customer intimacy. The disadvantages center on absorbing responsibility for managing complex channels of distribution and channel transaction management, and performing *product sorting* (conversion of production quantities into the assortments and lot sizes demanded by the marketplace), and *specialization* functions (performance of channel tasks such as postponement, merchandizing, selling and promoting, warehousing, transportation, and financial settlement).

In the second customer channel strategy, *third-party delegated*, the producer relies on channel partners to perform customer delivery functions. In this model, the producer rarely has direct contact with the end-customer. The advantage of this strategy is that channel intermediaries assume responsibility for some or all product sorting and specialization functions. Disadvantages center on loss of control of pricing, branding, margins, and immediacy and accuracy of marketplace feedback. In addition, in delegated channels producers are dependent on the quality of sell-side channel partner understanding of the nature of customer expectations and risk the potential of debilitating power struggles with channel intermediaries over costs, pricing, and product distribution restrictions.

The final category of channel strategy is termed a *hybrid selling model*. In this option, the producer selectively performs some of the customer management functions while surrendering control of the remaining activities to sell-side channel partners. The advantages of this model are significant. Producers can maintain control of critical marketing elements such as pricing, promotions, and brand recognition while utilizing channel partners to optimize selling, fulfillment, and service capabilities. However, this model does pose several problems. Suppliers cannot directly control their partners' operations and they must recognize their limited ability to dictate partner practices, policies, pricing, and promotional activities. Furthermore, supply channels are often non-exclusive with the result that partners can offer concurrently the products and services of a competitor. Finally, the use of any intermediary risks loss of intelligence regarding customer wants and needs or even loss of the producer's brand identity.

Regardless of the channel system that emerges, companies need to be very clear as to who is the targeted customer or customer group. Performing such a task can be confusing, especially as the number, nature, and type of channel intermediaries expands. Often players in the supply chain get confused with regard to who the end-customer in the demand chain really is. A channel intermediary is rarely an end-customer. Firms servicing business customers, for example, usually have difficulty focusing on their end-customers because they often view the entity they are selling to as the customer. Keeping focused requires always viewing the product from the vantage point of where the end-customer perceives value to reside. For example, a food processor should view the value of their product as it appears to the end-customer, not how it is sold to distributors or retailers. The company that provides the product packaging, on the other hand, sees channel intermediaries involved in bulk-breaking as the true customer and not the consumer who is buying the food and not the packaging.

10.1.3 Understanding Customer Wants and Needs

What customers want from their suppliers are complete solutions to their wants and needs that create superior value at the lowest cost attained with the minimum in effort and time expended. What is customer value? Classically, there are two types of exchange value. In the first type, value arises with the transfer of possession of the physical "worth" or "usefulness" of a good or service for the comparable "worth" or "usefulness" found in another good or service. The most basic form of this exchange process is barter. In the second type of exchange, value is described as the transfer of the value found in a physical good or service for the acquisition of abstract value, such as status, want, perceived need, or caprice, deemed desirable by the buyer. In this type of exchange, value always involves a tradeoff between the actual or perceived benefit received against the effort and cost to obtain it. The strength of the attributes associated with a transaction, such as availability, service, quality, image, and price, experienced by the customer determine the level of satisfaction received.

In the past, companies sought to provide value to their customers by seeking to control and influence what goods and services customers could buy. For the most part, profitably managing the customer centered on the efficient execution of the exchange transaction.

The goal was to determine how more goods and services could be sold to the customer, how the cost of serving the customer could be reduced, and how efficiently production and distribution functions could be conducted while remaining within the boundaries of acceptable customer service. Concepts of brand and mass marketing were defined around the standardization of products and services, a product-centric approach to the marketplace, product-driven pricing and discounting, mass distribution, and an assumed uniformity of customer wants and needs. Following this concept too closely, however, can result in a form of "marketing myopia," where products are designed, built, and distributed without really discovering what customers truly want or need. Offering only one kind of color for an automobile as long as it is black is an example of the dangers of this concept. Once captured, it was felt that customers would remain loyal to their brands and the company's unique product/service value story bolstered by advertising and mass-market recognition.

The traditional management of the customer described above was based on a simple assumption: it viewed the customer as a fairly passive agent in the buying process whose prime role is to provide a steady stream of profits to the supplier. While the customer might have unique wants and needs and wished to have a more personal experience, suppliers focused their efforts instead on defining the most broadly-based mix of products and services that appealed to the greatest number of customers, priced and promoted uniformly, and driven by performance measurements based on acceptable delivery and service response. In short, traditional marketing approaches were fundamentally oriented around developing and managing the product/service, selling, and distribution and not on understanding the unique requirements of each individual customer.

Recently, these assumptions about serving customers and what constitutes exchange value have been seriously called into question. There is little doubt that customers still consider the exchange process as providing them with goods and services that possess "worth" or that meet a particular desire or need. However, instead of a passive recipient of the marketing process, today's customer is an active driver in the structuring of the exchange event itself as well as in the design, production, and distribution of products and services. The customer is increasingly demanding a say in issues relating to pricing, the use of technology, order management, delivery, reverse logistics, and what brands they will or will not give their loyalty. Past marketing strategies focused on the value garnered by the supplier and were driven by such attributes as optimizing economies of scale and scope, mass production and distribution, and cost efficiencies. Today's customers, on the other hand, want their suppliers to orient their businesses around what adds value *to them*, not what adds value to the supplier.

10.1.4 MARKETING TO TODAY'S CUSTOMER

Past marketing approaches rested on the assumption that marketplace leadership is attained by searching through customer transactions, categorizing them into groups based on specific value filters, and then designing a product and service mix strategy that best appealed to each customer segment that was identified. It was then the role of marketing to design promotional, pricing, and distribution initiatives that supported the customer strategy. Finally, it was the role of the company's operations functions to execute the production and inventory management strategies that increased customer responsiveness at the highest possible levels of efficiency. In the end, such a strategy really focused on determining the value customers had on enterprise goals, such as product-line revenue generation and divisional/territorial profitability, rather than on the firm's value *to* the customer.

Today, as marketplace power continues to shift to the customer, this model has become increasingly obsolete. While revolutions in media and communications have provided the mechanism, the real driver of this transformation is the ability of each customer to assert their *uniqueness*. Rather than being placed within an aggregate homogeneous market segment serviced by standardized products and supporting services that the company wants to sell, today's customer is demanding that their suppliers instead understand and provide solutions that they want to buy. That they be, in short, *intimate* with what product and service solutions each of their customers want and how they are to be serviced without telling the supplier how they are to do it. Rather than marketing a product or service to as wide a group of customers as possible, companies are being required to devise value propositions that offer unique solutions that capable of evolving with the requirements of each individual customer.

The "individualization" of the customer is perhaps no more evident than in the revolution in computer-to-computer networking, mobile, cloud computing, and device and software interoperability. The ubiquitous presence of Internet-enabled technologies has created an array of "customer-centric" drivers previously thought unthinkable. To begin with, customers have been provided with an almost limitless variety of choices and unprecedented access to information. Also, advances in connectivity have opened markets across the globe, enabling customers to search virtually anywhere for just the right product or service solution at the right price. Customers now assume they can view marketing materials, catalogs, and price lists, configure orders as well as comparison shop, negotiate contracts, execute aggregate buys, participate in on-line auctions, receive a variety of information from correspondence to training, and review delivery and financial account status online and in real time. To be successful, today's business understands that survival means structuring an organization that is continuously reinventing itself to treat customers differently rather than anchoring hopes on even the most seemingly unassailable brand or marketplace presence in the search for competitive advantage.

While technology has enabled customers to exert their power to freely roam a global marketplace in search of suppliers capable of providing unique, configured solutions that at the same time are convenient, easy to transact, and cost effective, it has also enabled businesses to focus on each individual customer. As pointed out above, such a capability, however, requires a veritable revolution in the way companies and their supply chains have traditional approached the customer. Peppers and Rogers have effectively summarized this transformation:

> Instead of focusing on one product or service at a time, in order to sell that product to as many customers as possible, you must focus on one customer at a time and try to sell that customer as may products and services as possible—over the entire lifetime of the customer's patronage. Rather than try to figure out what *all* your customers need, in other words, you now have to figure out what *each* of your customers need, one customer at a time [5].

Until very recently, most companies focused their energies on the revenue-generating value of their products and services, regardless of who was doing the buying. Nowadays, globalization and the continuous growth of online shopping have altered forever past marketing paradigms. The ability of the customer to easily choose (and change) who they buy from has forced all companies to shift their strategic focus from "what" they are selling to "who" they are selling to.

10.1.5 Creating Lifetime Customers

Knowing which customers are a firm's best customers is critical in identifying the types of relationships and levels of service that should be rendered to each customer so that their needs and the corresponding value to the business are realized. The foundations for developing the customer base begins with the often quoted phrase that "not all customers are created equal." In the past, companies treated customers as if they were all the same. Each received the same level of service, each were charged the same price for products and services regardless of whether they afforded the company a profit. In reality, a small percentage of a firm's customer base provides most of the profits. This means that anywhere from 70 % to 80 % of the customer base either provides little or no profit; as much as 40 % actually will cost more to service than the profits received.

One of the central goals of customer management today is to convert the top and as many of the second tier of customers as possible into lifetime customers. Pursuing this objective means that companies shift their attention away from a transaction perception of customer value to one centered on building strong relationships. Lifetime customers provide unique sources of value by

- *Lowering the total cost of marketing*. Since the majority of the cost in customer management occurs in customer acquisition, the greater the proportion of lifetime customers, the less the long-term total costs of marketing and sales.
- *Satisfying customer experiences*. Today's CRM technologies enable marketers to construct a precise profile of customer wants, needs, and buying habits. The longer customers do business with a supplier, the easier it is for marketers to create unique product, pricing, discounting, and other offerings targeted at retaining and enriching their relationships with their best customers.
- *Providing increased revenue and profit opportunities*. As customer-supplier relationships grow, marketers can expect lifetime customers to increase their purchase of company products and services. As revenue grows and the cost of customer maintenance declines, profits and margins increase.

An important method of determining customer profitability is the use of a metric called the *life-time customer value* (LCV). LCV is defined as a prediction of the net present value of the future profits attributed to the entire future relationship with a customer. The model has varying levels of sophistication and accuracy, ranging from crude heuristics to the use of complex predictive analytics [6]. LCV is a key metric because it encourages firms to shift their focus from quarterly profits to the long-term health of their customer relationships. LCV provides metrics that require marketing teams to move beyond traditional concerns with sales and market share, product profitability, and satisfaction, to customer-oriented metrics focused on customer profitability, rate and cost of customer acquisition, growth in customer margins, and cost and success in customer retention.

Another important customer management metric is *customer profitability analysis*. Kotler and Keller define a *profitable customer* as "a person, household, or company that over time yields a revenue stream that exceeds by an acceptable amount the company's cost stream of attracting, selling, and servicing that customer [7]." When developing markets, planners must be careful to measure customer profitability. In every customer base there are "stars" that provide the bulk of the firm's sales, a broad mass of customers whose revenue contribution varies from good to fair, and a group of "dogs" that are not only a severe drain on resources but also divert effort away from servicing the "stars" and expose them to be lost to competitors. One way to rank customers is to calculate an *operating profit contribution* for each. A simple equation is as follows:

$$\text{Gross profit}(12\,\text{months}) - [\text{Invoices}(12\,\text{months}) \times \text{Average Cost Per Invoice}] \\ = \textit{Operating profit contribution}$$

The average cost per invoice is calculated by taking the entire operating cost of running the business for the year and dividing it by the grand total of invoices for the same period.

The next step is to rank all of the accounts from high to low by their estimated profit contribution and then to calculate cumulative percentages for customers and profits. A possible breakdown for a sample company is illustrated as follows:

Customers in the top 10 % provide 90 % of the profits
Customers in the top 20 % provide 130 % of the profits
Customers in the top 40 % provide 140 % of the profits
Customers in the bottom 60 % provide $<-40\,\%>$ of the profits

This analysis suggests that the top 40 % of the customer base generates 140 % of the profits, whereas the bottom 40 % actually results in a loss of 40 %. Marketing and sales management need to identify and develop strategies to protect the top 20 %, cultivate the 60 % in the middle, and individually review and eliminate losers residing at the bottom 20 %. Another reporting mechanism is to rank all customers by their ratio of credits issued divided by the number of invoices billed for a 12 month period. Exception ranking for slow-paying customers also assists in pinpointing losing accounts. As companies are increasingly forced to turn to growing profits and market share by finding new customers in existing markets and better penetrating existing accounts, developing lifetime customers becomes more critical. Fundamental to survival is the ability to understand who the best customers are and what extra steps should be taken to further secure and proactively anticipate their changing needs.

10.1.6 Dimensions of Customer Values

Creating customer management strategies that enable businesses to retain their existing customer base, acquire new customers, and expand their margins is centered on understanding what constitutes value to today's customer [8]. Being "customer-centered" is said to consist in effectively managing the five customer value dimensions portrayed in Figure 10.2.

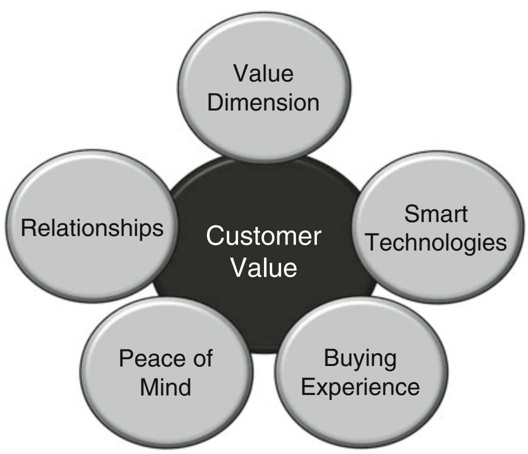


FIGURE 10.2 Dimensions of customer value.

10.1.6.1 Value Dimension

Businesses have long known how customers provide value to them—by increasing profits and market share. When customers have a good experience with suppliers they are likely to buy from those suppliers again and again. Similar to the way an investment increases in value over time as interest compounds, so the value of a customer likewise increases as each positive experience increases the probability that the customer will not only continue to buy, but will buy more often.

Understanding what provides value to the customer, however, is decidedly a much different thing. While creating winning organizations that increase the lifetime value of their customer portfolios is important, companies must focus on increasing value to the customer, by viewing the business and its offerings through the wants and needs of the customer. Why do customers buy from you and not your competitors? What special solutions do you provide that the customer simply cannot find elsewhere? What additional product/service composites can you offer that will not only lock in but increase the value customers feel they receive from you?

Basically, what customers want from their suppliers depends on the value of perceived solutions and benefits attained from their suppliers and the cost to acquire them. The issue of what provides value to the customer is a complex one indeed and should not be confused with the cost to the supplier. A widget that costs pennies to make may provide significant value to the customer who will pay many times its cost because it is wanted or needed. In general, the contents of what provides value to the customer is decomposed into three regions [9].

- *Economic value*. Customers receive economic value when they leverage a product or service to generate additional value beyond the initial cost. Value is also acquired when the customer applies the product or service to reduce associated production, carrying, or other costs which exceed the original cost of the purchase.
- *Solution value*. The acquisition of a product or service provides benefits to the customer by providing access to certain functions, features, or attributes that provide a level of desired performance or capability. While such value may in some cases be difficult to quantify (owning a Mercedes versus a Lexus), in other cases it is possible to calculate the cost of certain features against alternatives to determine those with the optimum trade-off (selecting a compact car versus an SUV when gas mileage is the dominant value).
- *Psychological*. There is no doubt that intangible factors have a significant effect on customers' perception of product or service value. Psychological preferences are often subliminal (brand loyalty or image), and lead customers to believe they are receiving value beyond direct economic or solution-driven benefits. Normally focused around the concept of *brand,* customers feel that they receive increased benefits and reduced risk when they buy from a trusted supplier. Brand becomes increasingly more important as the differentiation between competitive product or service features, functions, and costs erodes through market and technological maturity.

10.1.6.2 Relationships

Despite all the talk of their supposed fickleness, today's customer is searching more than ever to build close relationships with their supply chains. Classically, companies focused on *brand* as the medium by which they could lock in customers. Brand-loyalty was the bond that enabled company and customer to consciously (and unconsciously) solidify expectations about specific products and services while establishing the boundaries of values such as availability, quality, price, and delivery.

While brand still provides significant customer-supplier bonding strength, it has been altered in today's marketplace in a fundamental way. Although customers will bypass cheaper alternatives to purchase brands such as Toyota, Nordstrom's, or Starbuck's, increasingly the value of brand loyalty is being transferred from the feature-function envelop surrounding the product or service to the expected value of the solution attained in the buyer's past experience. For companies, this means that their interaction with the customer must enhance a relationship that is enriching and develops over time with each successfully executed transaction. At bottom, relationships make customers feel that they will consistently receive an expected level of value, that they are in control of their purchasing experience, and that they are confident that the product or service provides the solution they seek.

Finally, suppliers and customers understand that the strength of their relationship is two sided: companies are assured that continuous attention to providing value to the customer increases brand equity; customers, on the other hand, can count on the relationship to provide a buying experience that competitors simply cannot duplicate. The accumulated experience of a customer gives them confidence in what they buy and who they are buying from. Relationships affirm customers' feelings that the dialogue with their suppliers provides them with an unmistakable sense of empowerment as well as partnership that will be replicated over and over again.

10.1.6.3 Peace of Mind

When it is said that in the exchange process customers expect to receive value, it is important to note that the value they seek extends beyond the receipt of a product or service at a particular price or quality. If every transaction was an isolated event and there was no connection in the customer's mind between any series of buying events, then the simple acquisition of goods or services would constitute the totality of the buying experience. Inherent in every transaction, however, are values that extend beyond simple product/service possession, and these values provide for the customer an emotion, an expectation that can be broadly called "peace of mind." Stated simply, in every transaction customers are keenly aware of seeking and receiving a sense of well-being and affirmation when they buy a particular good or service. Whether it is a convenience commodity or a complex, expensive product, customers will often decide on a certain "brand" because they feel they can count on a wide array of associated attributes that provide a "field of comfort" surrounding and permeating both the product and the buying experience.

"Peace of mind" is broken down into two interconnected components: *conformance* and *assurance*. Conformance is concerned with how effectively the product or service consistently matches expected specifications without the customer continuously verifying the contents of the goods or measuring the results once applied to the want or need. Possible dimensions of conformance extend to such attributes as

- *Performance* or the capability of the product or service to consistently perform as it has in the past or will perform according to new features.
- *Reliability* or the capability of the product or service to always perform within a previously identified and acceptable range without failure.

- *Durability* or the expectation that a product or service will continue to provide value in terms of both its technical and economic dimensions.
- *Aesthetics* or how the physical appearance or the harmonious complexity of a product awakens a sense of pleasure in the customer.
- *Value/price tradeoff* or whether the customer feels the price of a product or service is worth the value received.

While conformance focuses on the *physical* attributes customers have come to expect from a particular brand or service, assurance is focused more on the confidence or trust, often subliminal, that dealing with a tried-and-true product or supplier brings to a transaction. Possible dimensions of assurance are

- *Acceptability of risk* or freedom from worry about the efficacy of the value or usefulness of a product or service.
- *Tangibles* or the image of quality (state-of-the-art or availability of highly qualified personnel) or permanence (facilities or a strong history) a customer receives from a supplier. Tangibles give the customer a sense of confidence the products or services they are receiving are truly "world class."
- *Responsiveness* or the consistency and promptness with which customers expect their post-transaction service needs will be meet.
- *Competence* or the knowledge that the supplier possesses the required skills and knowledge that extends from the design of the product or service through post-sales support.
- *Courtesy* or the level of politeness, respect, consideration, and professionalism customers have consistently come to expect from their top suppliers.
- *Credibility* or the high standards of honesty, trustworthiness, and believability customers feel when dealing with their best suppliers.
- *Security* or the knowledge that sensitive data customers share with their suppliers are kept in confidence and will not be compromised.
- *Access* or the degree of ease by which customers order and communicate with their suppliers and receive their purchases within a desired time limit.

In a world of instant access to suppliers and products from across the globe, "peace of mind" is easily overlooked as a critical determinant of customer buying behavior. "Peace of mind" permits customers to eliminate the anxiety, worry, and hassle associated with the buying experience. "Peace of mind" enables customers to be assured that they can trust their suppliers to protect and nurture the special intimacy they share with their supply chain partners.

10.1.6.4 Buying Experience

In today's global marketplace, customers have come to measure value based, not only on the products and services, but equally on the *experiences* they receive when they interact with a supplier. In turn, today's best companies are succeeding by unearthing and nurturing a special intimacy with their customers aimed at capturing unmistakable competitive advantage and new levels of profitability. This concern with providing customers with an ultimate buying experience is termed customer experience management (CEM) and it is defined as "the customer's perception of interactions with a brand, from marketing communications to sales and service processes to the use of the product or service [10].” CEM is about understanding and effectively managing the content of customer interactions while building brand equity and long-term profitability. Although the hard elements of customer interaction, such as transaction management, information transfer, and brand identification reinforcement, are critical, they constitute only part of customer relationship dynamics. Of equal importance are the perceptions and interactions customers come away with from a buying experience that demonstrate a supplier’s value to them, their feelings of assurance and peace of mind aroused when dealing with the supplier’s people and systems, and the emotional content of the products and services they receive. In short supply chains must be shaped to provide customers with an overwhelming buying experience, a veritable “wow!” experience that distances them from the competition and cements in customer loyalty.

CEM is often confused with customer relationship management (CRM). By way of contrast, CRM is focused on determining customers’ value *to* the organization, while CEM is focused on understanding the level of value customers receive *from* the organization. At heart, CRM is a technical and information mapping tool used to assist a company’s marketing team in identifying, capturing, and retaining customers. CEM, on the other hand, attempts to look at the business from the customer’s point of view, to ensure the portfolio of product and services resonates with the type of experiences customers expect. In fact it has been suggested that the ability of a business to actually “manage” the customer’s experience at all is fading. As the buying experience continues to shift from company-directed to self-service, customers are increasingly taking charge of their own buying experiences rather than having them managed for them. In fact the best companies can do today is ensure that every touch point in the customer experience, from products and services, to pricing, promotions, and after-sales service, is carefully tailored to add value and expand the positive experience of the customer.

In their analysis of what today’s customer really want from their suppliers, Womack and Jones have come up with a shortlist or what they call the *Principles of Lean Consumption* to guide companies in shaping marketing objectives. The new manifesto of winning and retaining customers consists of the following six points [11].

1. Customers want suppliers to provide them with a complete solution to their problems. A partial solution (one where the customer must search for other providers to complete the solution) is no solution.
2. The solution should be attained and implemented with as little cost, time, and effort on the part of the customer as possible.
3. Customers would like to obtain exactly what they need to solve their problem, including all the necessary goods and services in the exact specification required.
4. Suppliers need to provide a complete solution *where* the customer expects to find it without having to merge disconnected sources.
5. The components of the solution must be available *when* the customer wants it.
6. Bundle products and services so that the solution is acquired by the customer with a minimum number of decisions and with ease of effort.

The key point is that it is the satisfaction gained through ease of sourcing and completeness of the *solution* and not the *product or service* that constitutes the key value for the customer. This means that supply chains that are focused inward, on attempting to manage the marketplace rather than critically examining customers and their individual experiences, can never really provide the encompassing solutions today's customers so deeply value. An intimate supply chain, on the other hand, is continuously searching to identify just who its best customers really are and adapting its business to provide the optimal value propositions desired by its most profitable customers.

10.1.6.5 Smart Technologies

Customers today expect their suppliers to provide a robust array of mechanisms that facilitate their search and sourcing needs while resonating with their demands for personalized service. Among these mechanisms are found the following:

- *Customer-centric value chains*. Satisfying today's customer requires supply chains to deconstruct their traditional networks and their focus on cost efficiencies that stressed acceptable service, standardized one-size-fits-all product lines, and dysfunctional flows of goods and data. These faulty values simply result in time delays, mismatches of supply and demand, and costly channel inventory buffers. Once dismantled, supply channels must then be reassembled into customer-focused webs that provide any-to-any connections. Customers require that every node in the supply chain be capable of linking in real time with every channel resource to provide the best and fastest solution to their needs. Customer buying decisions should trigger targeted marketing, sourcing, and customized product/services activities and assign the fulfillment task to the channel partner best able to satisfy it.
- *Agile and scalable suppliers*. Customer-focused management requires nimble supply chains that quickly adapt to provide unique product and service solutions that are low-cost and capable of rapid change as the needs of the customer evolve through time. Customer requirements for order customization and configurability require suppliers to structure nimble organizations based on flexible production, distribution, and information processing. Such lean, scalable supply chains seek to build customer value through the real-time synchronization of demand and supply, use of outsourcing to support internal weaknesses, and deployment of technologies to ensure vital marketplace information capture.
- *Fast-flow fulfillment*. Today's customer expects products and services to be delivered as quickly and completely as possible. Satisfying this expectation requires that suppliers streamline and fast flow all points along the demand fulfillment cycle.

As illustrated in Figure 10.3, the process begins with effective *marketing*. Customers want their suppliers to be intimate with their long- and short-term buying behaviors and present to them tailored options to address specific needs. The goal is to have supply chains pre-engineer product and service selections that provide targeted value to the customer without forcing them to spend needless time searching through alternatives that inhibit them from quickly finding the solutions they need. An example of customer needs-based marketing are online *product* and *service catalogs* configurable to meet the exact needs of the customer. These catalogues should allow customers to quickly locate the goods and services they want with the minimum effort in navigation and search.

Once the desired products and services are identified, the process of tendering an order should be as simple and seamless as possible. Effective *order management* begins by providing customers with online access to critical product, pricing, and fulfillment information. Customers should be presented with online tools to comparison shop, search for desired quality specifications, view product/service aggregations, participate in online auctions,

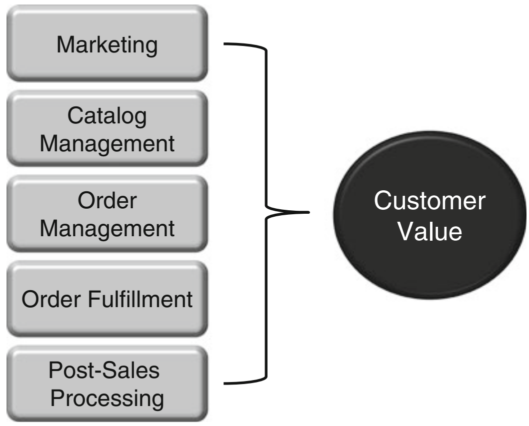


FIGURE 10.3 Components of demand fulfillment.

design their own product/service solutions through configuration capabilities, and access related product/service mixes.

The convenience of order management should be matched by *order fulfillment* functions that provide for the speedy and accurate transfer of goods, services, and order information to the customer. Key elements are very short cycle times, availability of products and services, dependability of fulfillment to meet published services standards, convenience, and quality and performance. Finally, fast flow fulfillment requires effective *post-sales processing*. This area contains two dynamics: customer service management and financial settlement. Most customers perceive service as an extended part of the purchase and, as such, increases the value they receive from their supplier. Similarly, customers are demanding convenient financial settlement complete with electronic payment systems that enable them to receive bills; authorize payment through credit and purchase cards, or direct debit; match payments to purchase orders; and download statement information directly into customers' systems.

- *Networking*. Past technologies lacked the capability for customers and suppliers to engage in continuous peer-to-peer networking. With the breakthroughs in today's web technologies, it is now possible to connect different computers and devices along with their databases in a network. The advantage of networked systems is that buyer and supplier can now communicate information directly without regard to system architectures. Networking empowers customers to cut across functional barriers within their own and their suppliers' organizations and interweave common and specialized knowledge to provide unique solutions to their sourcing requirements.
- *Digitizing sourcing*. The rise of Internet technologies has dramatically altered forever traditional methods of supplier search. On the surface of things, the Internet has enabled customers to utilize applications that provide simple, self-directed tools for browsing and locating solutions to product and service needs from anywhere on the globe. Web-enabled tools have made it easy for customers to execute request for quotation and pricing negotiations, engage in bidirectional communications that increase personalization of transactions, and source directly from suppliers, thereby by-passing channel intermediaries that simply add time and cost. Finally, today's order management technologies permit customers to be self-directed with access to 24×7 service, real-time information, online support, digital documentation and

training, and Web-page customization that provides them with personalized methods of influencing their suppliers' value propositions in order to dramatically increase individual customer value.

10.1.7 Creating the Customer-Centric Organization

Creating a customer-centric company capable of consistently delivering unique value while building customer loyalty is a multi-phased process that involves reshaping the infrastructures of both individual organizations and accompanying supply chains. The following steps are essential in creating organizations that are culturally and structurally capable of providing customers with a superior experience.

1. *Establish a customer-centric organization*. Migrating the enterprise from a product- to a customer-centric focus requires changes in the way companies have traditionally managed everything from customer service to product design. Literally, every customer touch point needs to be oriented around how each business function can continuously delight the customer with an exceptional experience and world-class service. An emerging management position responsible for generating customer-centric organizations is the *chief customer officer*. As defined by the *Chief Customer Officer Council*, the CCO "is an executive that provides the comprehensive and authoritative view of the customer and creates corporate and customer strategy at the highest levels of the company to maximize customer acquisition, retention, and profitability [12]." The goals of the chief customer officer are:
   - *Drive profitable customer behavior*. To help customers spend more, and buy more often, the CCO must focus on strategies such as profitability segmentation, customer retention, customer loyalty, satisfaction, and improving the customer experience.
   - *Create a customer-centric culture*. One of the most important roles of the CCO is to help create a strong, customer-centric culture complete with accountability and ownership at all levels in the company.
   - *Delivering and demonstrating value to the CEO, the board of directors, peers, and employees*. The CCO must strive to deliver demonstrable value to all stakeholders, especially the company's executive team and operations-level peers.
2. *Determine existing customer positioning*. Understanding the customer is fundamental to a customer-centric focus. The goal is to unearth what each individual customer values and to design the products, services, and communication infrastructure that will drive increasing customer loyalty. The process begins by measuring the customer landscape. This is accomplished by identifying the customers with the best lifetime customer value (LTV). Their buying practices should be detailed and contrasted with low LTV or lost customers. Next, qualitative research, through surveys, face-to-face interviews, and other techniques, should be conducted with each customer segment identified. The goal is to learn first-hand how customers view their relationship with their suppliers and with the competition. Finally, quantitative research tools should be applied to reveal concrete metrics associated with customer notions of need, behavior, motivation, and attitude identified in the qualitative review. A critical problem is knowing what to do with this data. In this area a CCO could spearhead the analysis

and devise action plans to turn the feedback into results for strategic planning or resource allocation.

3. *Devise a map of customer segments.* The qualitative and quantitative data arising from step 2 provides a clear geography of the customer base and illuminate key drivers, such as convenience, price, reliability, loyalty, value, and satisfaction. The goal is to focus the firm's marketing efforts to stimulate the buying behavior of the firm's top customers and motivate middle-tier marketplace segments. By pinpointing how the firm's products and services provide marketplace differentiation, competitive advantage factors are leveraged to consistently enhance customer value at every touch point across the supply chain. In addition, the customer map also reveals the effectiveness of the core customer-satisfying competencies of the internal organization. Businesses need to be diligent in assuring there is not a mismatch between their offerings and what the customer base truly values.
4. *Develop and implement the solution.* An effective customer management program should be tireless in the search for opportunities for enhancing customer experiences. Transforming these efforts into meaningful marketplace initiatives, promotions, and supply chain points of customer contact that improve company visibility, confirm customer value expectations, and cement loyalties is the next step in the process of generating a customer-centric organization. Unfortunately, there is no simple template that companies can easily snap into place. Each company must painstakingly investigate its own customer-centric strengths and weaknesses. During the investigation, companies must be careful to ensure estimates of customer profitability match corporate financial measurements such as return on investment (ROI) and net present value (NPV). Once these customer-focused initiatives are validated, marketers can then "mine" the data warehouse to locate the company's best customers and how retention and new customer acquisition programs are best applied.
5. *Monitor, Measure, and Refine.* The steps for creating the customer-centric organization are performed interactively. The driver of customer management review is the metrics arising out of the record of customer contact and exchange. Without such processes in place the quest will ultimately fail. Marketers must be careful to continuously research and document what is working and what is not by utilizing the analytical tools available within most customer relationship management (CRM) software applications or performance tools such as the SCOR® improvement framework or the balanced scorecard. These technologies provide continuous quantitative tracking of buying patterns, customer attitudes, and degrees of satisfaction for all market segments and points of contact. CRM analytical tools enable effective monitoring of the qualitative input to assist in massaging the quantitative results of performance metrics.

The successful implementation of a customer-centric organization requires that everyone in the business be aware and prepared to execute the enterprise's customer management strategy. Driving the strategy requires, in turn, that the firm gains the active participation of senior management who needs to provide the vision and to focus the energies of the organization on communicating the customer management objectives to customers and supply chain partners as well as to the internal staff. Without such direction and sponsorship, most CRM programs will quickly decay and revert to previous "silo" operating methods.

10.2 CUSTOMER RELATIONSHIP MANAGEMENT

While customers have decidedly become more demanding and more sophisticated in their use of technologies that provide them with almost limitless choices and unprecedented access to information, they have also become more capricious in their buying habits and less inclined to remain faithful to supplier relationships despite their desire for long-term partnership. To counter these marketplace realities, many companies are in a life and death struggle to continuously develop business models that bring their businesses and their supply chains together in the search for the right mechanisms to attract and build sustainable customer loyalty: in short, how they can become more "customer-centric."

Realizing this goal in today's fiercely competitive marketplace is, however, easier said than done. Until very recently, most companies focused their energies on selling products and services regardless of who was doing the buying. Nowadays, the tables have dramatically turned. Companies have shifted their strategic focus from "what" they are selling to "who" they are selling to. This dramatic transformation in the goals of customer management from a product to a customer-centric focus has coalesced around the customer relationship management (CRM) concept.

10.2.1 Defining Customer Relationship Management (CRM)

There are several comprehensive definition of CRM available. According to Greenberg, the leading CRM guru [13],

> CRM is a complete system that (1) provides a means and method to enhance the experience of individual customers so that they will remain customers for life, (2) provides both technological and functional means of identifying, capturing, and retaining customers, and (3) provides a unified view of the customer across an enterprise.

The *APICS Dictionary* defines CRM as

> A marketing philosophy based on putting the customer first. The collection and analysis of information designed for sales and marketing decision support to understand and support existing and potential customer needs. It includes account management, catalog and order entry, payment processing, credits and adjustments, and other functions.

A final definition is from Dyche who feels that CRM is "The infrastructure that enables delineation of and increase in customer value, and the correct means by which to motivate valuable customers to remain loyal – indeed to buy again [14]."

Based on these definitions, CRM is characterized as follows:

1. *CRM is both a management concept and a software technology*. As a management concept, CRM is a philosophy that requires companies to migrate to a customer-focused way of doing business. CRM requires a retooling of all business processes that touch the customer, from customer acquisition to financial settlement. Its goal is nurturing a lifetime customer through the establishment of a long-term relationship. As a technology, CRM describes a set of software applications used to manage and analyze marketplace sales, promotion, pricing, and shipment history to gain greater insight and intimacy into customer buying habits. CRM systems can be used "stand-alone" or as part of an ERP system.

2. *CRM is a strategic management tool.* CRM is a strategic technology focused on increasing profitability, enhancing the marketing plan, and expanding competitiveness by understanding and growing the customer. While the software applications provide marketers with critical tools to gather, segment, and query customer sales data for effective decision-making, its real value resides in the strategic advantage it provides the organization. CRM is a comprehensive toolkit encompassing marketing, sales, service, and supporting technologies focused on forging customer relationships that provide mutual value, revenue, efficiency, and unique solutions to business problems.
3. *CRM is focused on facilitating the customer service process.* Being more responsive to the customer requires that sales and service functions be able to make effective customer management decisions and design strategies enabling superior responsiveness based on their capability to identify what brings value to the customer. In an environment where too much information is just as bad as not enough, CRM provides database analysis tools specific to the needs of executives, marketing, product and brand management, sales, operations, and other functions. Often success requires the availability of metrics and analytical tools that provide a comprehensive, cohesive, and centralized portrait of the customer.
4. *CRM is focused on optimizing the customer's experience.* A fundamental objective of CRM is "owning the customer experience." CRM enables companies to continually win customers through an array of objectives from providing a level of personalized service and customized products to utilizing advertising, ease in ordering a product, or ensuring a service call-back that will positively influence a customer's perception of the buying experience. The end result is to make customers feel they are dealing with a winner and are personally connected to their supplier.
5. *CRM provides a window into the customer.* CRM functions ensure that all fulfillment nodes along the supply chain are provided with critical information about the customer, what that customer values the most, and how they can ensure the customer has a positive buying experience each and every time. CRM enables companies to target the service attributes that each and every customer desires the most by providing all-pervasive, integrated, and insightful intelligence, such as individual buying habits, pricing and promotions histories, channel preferences, and historical contact information.
6. *CRM assists suppliers to measure customer profitability.* Effective customer management requires that companies be able to determine which customer segments, if not each individual customer, are profitable and which are not, what product and service values drive profitability for each customer, and how marketers can architect processes that consistently deliver to each customer the values they desire the most.
7. *CRM is about partnership management.* Market-winning customer management is about knowing the needs, values, and visions of each customer. CRM is about nurturing mutually beneficial, long-term relationships intimate enough to provide improvement opportunities and tailored solutions to meet the short- and long-term goals of both supplier and customer beyond the immediacy of physical product and service delivery. The goal is to build unbreakable customer loyalty regardless of what actions are pursued by the competition.

8. *CRM is a major facilitator of supply chain collaboration.* No customer transaction is executed in a vacuum but is actually an instance in what is often a long chain of events as products and information progress from one supply chain entity to the next. Firms that create integrated, synchronized processes that satisfy the customer seamlessly across the supply channel network will be the ones that will have the most loyal customers, are the most attractive to new customers, have the deepest collaborative relationships, generate the highest revenues, and have sustainable competitive advantage.

10.2.2 Components of CRM

CRM is divided into four major functions: *marketing*—the activities associated with relationship building, creating company branding, identifying the customer, selecting product/service offerings, and designing promotions, advertising, and pricing; *sales*—the selling and distribution of products; *service*—activities encompassing customer support, call-center management, and customer communication; and *performance analytics*—utilization of database inquiry and reporting tools that reveal information about customers, products, and performance. The mission of CRM is to inform the organization of who its customers are, how to better understand what they want and need, what is the product and service mix to be taken to market, and how to provide the ongoing services and values that provide profitability and expand relationships that increase lifetime customer value.

CRM functions also detail the methods that are used to market to the customer base, conduct transactions, respond to customer service issues, collect marketplace metrics, and format customer contact information for review and analysis. These functions also assist in the development of the strategies governing how the supply channel network is constructed and the nature of trading relationships. Finally, these functions provide the information and motivation necessary to continuously reshape the organization's perception of customer service, reengineer vestiges of "silo" management styles, and architect infrastructures that foster customer collaboration.

In the past, the functions of marketing, sales, and service were, at best, loosely connected with each other and utilized varying levels of technology to transact business, collect information, and communicate with the customer. Even the software tools that had evolved, such as enterprise resources planning (ERP), were developed in isolation or heavily focused on the transaction engine while leaving the marketing and service component fairly underdeveloped. Marketing in the "Industrial Age" focused on direct contact with the customer and relied heavily on printed matter such as catalogs, direct marketing, and mass media advertising. Until the 1980s, sales had relatively little to do with technology and perceived their function as centered around salesmanship and leveraging personal relationships. Customer service, while always open to adopting the latest technologies to communicate with the customer, was often separated from the product producing and sales functions of the business. Up to just a few years ago, customer service consisted mainly in employing banks of service reps fielding customer inquiries by mail, phone, or fax. Finally, past software applications either did not capture or did not have the functionality to mine the customer and sales databases to retrieve critical information necessary for effective customer management [15].

While it can be argued that many companies have for years utilized CRM methods to deal with their customers, the rise of Internet technologies has rendered obsolete many of the traditional concepts of customer management through the creation of new technology toolsets that have significantly expanded existing CRM functions and capabilities. Today's Internet-enabled applications provide companies with radically new avenues to gain visibility to customer value, retain and attract new customers, enhance transaction and service capabilities, and generate integrated, customer-centric infrastructures that enable businesses to realize opportunities for profitability while providing the customer with a level of seamless end-to-end service impossible less than a decade ago. In fact, over the past decade or so CRM software has remained one of the hottest segments in the business software solutions marketplace. According to a February 2014 report published by the Gartner Group, the estimate for CRM software sales alone will topped $23.9 billion (as a benchmark, the 2001 revenues were $5.6 billion) [16].

10.2.3 The Range of CRM Application Functions

Businesses of all types, from manufacturers and distributors to high tech, banking, and consumer goods, are leveraging CRM technologies as a major part of their digital initiatives to enhance the customer experience. The demand for additional ways of using modern technology to expand customer relationships is driving refreshed or expanded integration and usage of all areas of CRM software. The hottest technology drivers are cloud computing, social networking, mobile devices, big data, and a fifth driver, the "Internet of Things," where sensors connecting things (devices of all types) to the Internet create new services previously not thought of. Figure 10.4 illustrates the full range of applications encapsulated in today's CRM suite.

FIGURE 10.4 Range of CRM functions.

10.2.3.1 Relationship Building

Regardless of the depth of application features available in any one CRM system, the goal of CRM is the development of lifetime customers by enabling the organization to optimize each customer's experience at each supply channel interaction point. A key enabler of CRM is the collection, analysis, and dissemination of customer data that assists each channel node that touches the customer to be intimate with customer preferences, buying habits, brand predilections, length of loyalty, and other factors that show that the entire supply chain is truly involved in building a relationship with each individual customer. CRM tools focus company efforts to design policies and procedures that seek to acquire and retain customers. It may also involve working with customers to develop ideas on products, services, and delivery resulting in profitable solutions to actual customer problems. The goal of relationship building is to develop customer loyalty or even mutual dependence that results in the emergence of a lifetime customer.

Key CRM tools for relationship building include:

- Real-time updates on contacts, accounts, opportunities, and documents.
- Ability to consolidate account history, customer communications, and contacts.
- Social media insight.
- Integrated reporting, analytics, data mining, market segmentation, campaign management, and closed-loop reporting.
- Creation of business connections across CRM activities and entities.
- Measuring performance of organizations, business units, teams, and individuals.
- Central software application where all departments of a company can share necessary information to collaborate and provide detailed communication with customers.

10.2.3.2 CRM Marketing

Effective marketing is founded on a simple premise: customers are won by personalizing the communication between seller and buyer. In a pre-industrial economy, selling is always a one-to-one affair and is characterized by personal contact whereby the buyer examines physically the array of available goods and services and the seller negotiates a contract to sell. In the Industrial Age, the concept of *brand* and *mass marketing* replaced personal relationship and direct review of available goods and services. Mass marketing meant standardization of products and services, as well as pricing, and assumed uniformity of customer wants and needs. The prospect for marketplace success was focused on the availability and choice of the product and service mixes companies offered. Although by the mid-1990s modifications to the mass marketing approach, such as *direct-marketing, target marketing,* and *relationship marketing,* began to point the way toward a return to one-to-one buyer-seller contact, marketers lacked the mechanism to initiate what could be termed *personal marketing*. This approach is defined as the capability of companies to present their goods and services customized to fit the distinct personal interests and requirements of the customer.

With the advent of the Internet, marketers were finally provided with a mechanism to activate *personal marketing*. Computer networking provided buyer and seller with a medium whereby the interactive, two-way dialogue between customer and supplier, so necessary for the establishment of true one-to-one relationships, could be established. When it is considered that the cost of gaining a new customer is five to eight times greater than marketing to an existing one, companies capable of leveraging the power of *personal marketing* are infinitely better positioned to keep their customer base intact. One-to-one marketing involves four steps: (1) Identify best prospects and customers and use CRM tools to mine the customer database to build deep customer relationships; (2) Apply CRM tools to ensure marketing spend is focused on the most valuable customers with high lifetime value; (3) Based on CRM analytical tools, develop a personalized knowledge of each customer's individual requirements and what provides value in their relationship with suppliers; (4) Use CRM and Internet networking tools to customized products, services, and messages that appeal to customers in a personal way; and (5) use CRM marketing processes to reduce customer defection, grow the depth of customer relationships, and focus high effort on high-value customers.

An important component of today's CRM is the automation of the marketing function. Marketing automation is a module within CRM that enables companies to compile, search, and utilize customer databases to define and segment who the customer is and then to generate targeted marketing campaigns via e-mail, e-fax, the Web, social media, and other technology tools to reach the marketplace. Today's CRM automation applications provide the capability to automate the entire campaign process. The suite of toolsets available include:

- Customer intelligence and data extraction
- Advanced data mining and reporting capabilities
- Campaign definition, planning, and program launch
- Scheduling of activities and continuous performance measurement
- Managing and track campaigns across multiple channels
- Collaborative communications via the customer's preferred method of contact
- Driving customer loyalty and demand through targeted, personalized e-marketing campaigns

The major activities of an automated marketing campaign are:

- *Promotions*. CRM-driven marketing automation enables companies to bring the promotional side of a campaign directly before a customer as never before. Whether it be giveaways, contests, or discounting, Web page *opt in, opt out* capabilities provide an immediacy to customers' willingness to engage in the promotion impossible with past methods. Once data is captured, it is directly input into the CRM database and used for on-going review and campaign modification.
- *Cross-selling and up-selling*. Cross-selling is the practice of offering to the customer related products or services during the buying process. Up-selling is the practice of motivating customers to purchase more expensive (and more profitable) products. To be effective, Web-sites must be able to analyze the customer and instantly propose an array of additional product and service offerings that will truly arouse their interest.
- *Marketing Events*. In the past, trade-shows and exhibitions provided buyers with opportunities to view new products and services. Today, marketers can broadcast the latest marketing information through online newsletters, web-based seminars, and special webcasts. Marketing automation tools enable real-time dialogues with customers when and where they choose to engage—on the Internet, through their mobile devices, or on social media sites.

- *Customer retention*. While companies spend lavishly to attract new customers, it is with resignation that marketers must accept the fact that statistically as high as 50 % of their customers are lost over a 5 year period. CRM market automation assists companies not only to isolate and rank customers most likely to leave but also to weigh the possible impact of promotional efforts. The goal is to mine the customer data and devise models that assist in the prediction of customer behavior.
- *Response management*. Once data from a marketing campaign begins to stream in, marketers need to utilize the information to perform several crucial tasks. First, they must gather, extract, and analyze the data. Second, they must determine the impact of the campaign by calculating actual customer profitability. A value model, such as a customer's lifetime value (LTV), can assist in the process of making sense of the deluge of data collected. And, finally, the marketing automation tools must be able to assist in refining and possibly altering the course of an existing campaign.

10.2.3.3 Sales Force Automation (SFA)

Arising in the early 1990s, SFA was conceived as an electronic method to collect and analyze customer information from marketing and contact center organizations that in turn could be used to advance opportunities for customer retention and acquisition as well as enhancing marketplace relationships and revenues. Today, SFA provides computerized tools to assist the sales function to more effectively manage existing accounts; prospect for new customers; track the impact of pricing, promotions, campaigns, forecasts, and other sales efforts in their pipelines; generate meaningful analysis and statistics from their customer database; become more mobile; organize their contact lists; have real-time customer information in an easily accessed presentation; and evaluate sales personnel performance. Using today's powerful networking technologies, SFA applications are capable of synchronizing data from unconnected sources, such as laptops, mobile devices, and tablets, and utilizing flexible and scalable databases, such as Microsoft SQL or Oracle, and PC and mobile device applications equipped with scoreboards and reporting functionality that provide real-time information sharing.

While the SFA marketplace contains a number of software vendors and competing products, they all possess to some degree the following functionality:

- *Contact management*. This application is one of the original components of the SFA product suite. The basic function of the software is to enable the organization and management of prospect and customer data, such as name, address, phone numbers, titles, and so on; the creation and display of organizational charts; the ability to maintain marketing notes; identification of decision makers; and capability to link to supplementary databases. Today's packages also provide sales reps with enhanced contact lists and calendars, and the functionality to merge them with customer contact efforts or automated workflow programs capable of assigning and routing appointments. According to Dyche [17], "The real value of contact management CRM is in its capability to track not only where customers are but also *who* they are in terms of their influence and decision-making clout."
- *Account Management*. Often individual sales reps and managers are responsible for large territories and hundreds of customers. Account management applications are designed to provide detailed information regarding account data and sales activity that

is accessed on-demand. In addition, these tools permit managers to effectively develop and assign field sales and marketing teams to match customer characteristics.

- *Sales Process/Activity Management.* Many SFA applications provide imbedded, customizable sales process methodologies designed to serve as a road map guiding sales activity management. Each of the steps comprises an aspect of the sales cycle and details a defined set of activities to be followed by the sales rep. In addition, SFA tools ensure that major sales events, such as product demos or proposal deadlines, trigger alarms as they become due and remind sales reps of closing dates. While such tools are currently emerging, they do assist in promoting sales process standardization and, ultimately, greater productivity.
- *Opportunity Management.* Also known as *pipeline management,* this aspect of SFA assists in converting leads into sales. In general these toolsets detail the specific opportunity, the company involved, the assigned sales team, the revenue credits, details about deals the sales team is pursuing, the status of the opportunity, and the proposed closing date. Some applications provide for the automated distribution of leads to sales teams, who the competition is, and what are their advantages/disadvantages, product/service/pricing competitive matrices, and even the probability of a successful closing. Still other tools provide performance metrics compiled for each sales person/team/business unit opportunities won and lost. Ultimately, the goal is to unify all of the disparate data and communication methods that sales teams use to track leads, event calendars, and customer contacts.
- *Quotation Management.* SFA systems assist in the development of quotations for complex orders requiring product configuration and pricing. Some CRM vendors provide applications that use graphical tools to map and calculate the quotation process. Once completed, the order is transmitted via e-mail, mobile device, or social media for management authorization and inventory and process availability checks, and then quickly returned back to the sales rep for final review and signoff by the prospect.
- *Knowledge Management.* Much of the software composing today's suite of SFA products is focused on the standardization and automation of sales processes. However, effective sales management also requires access to resources that provide sources of information that reside in each company and are difficult to automate. Important information includes documentation, such as policy handbooks, sales/marketing presentation materials, standardized forms and templates for contracts and estimating, historical sales and marketing reporting, and industry and competitor analysis. Often termed *knowledge management* systems, these applications act as a repository for all forms of information that is easily added to and referenced through online tools such as Web-based browsers.

10.2.3.4 Customer Service Management (CSM)

The role of *customer care* is today considered as the cornerstone of the customer-centric organization. Over the past 25 years, CSM has emerged from a manual person-to-person process, marked by letters and phone calls, to a suite of sophisticated online networked tools located within today's CRM software module. CSM functionality enables sales, support, service, and fulfillment access to complete customer service data in real time. CSM provides sales and service reps with a 360° view of the customer, providing visibility into customer issues and enhancing service center capabilities to assign, track, escalate problem issues quickly, and accelerate case resolution times [reference Dell's customer service Web page in Figure 10.5].

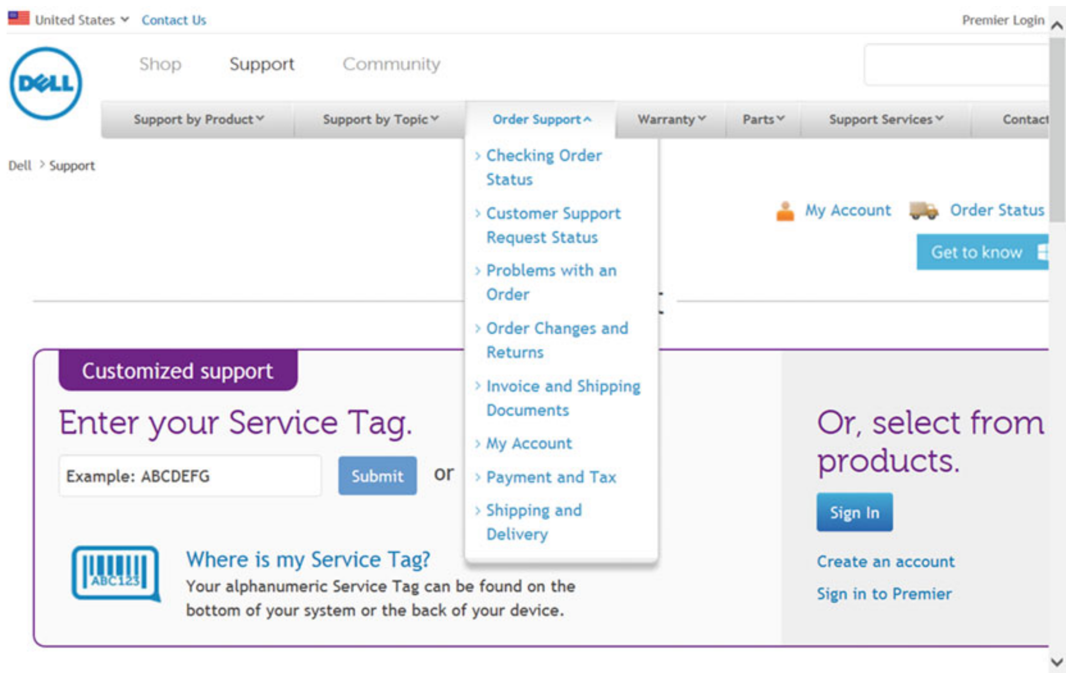


FIGURE 10.5 Dells' customer service Internet page.

Today's CSM capabilities have been pushed to a new dimension with the advent of exciting new technologies, such as Web-based networking, social media, cloud computing, speech recognition, and video, joined to older technologies, such as phone, caller-ID, fax, e-mail, and EDI. Such applications provide customers with even more opportunities for control of service dimensions while enabling companies to integrate all avenues of customer interaction on a central platform. Self-service opens a new dimension of customer service at less cost while service databases improve knowledge of customer behavior that enable the delivery of customized sales and service one customer at a time. The mission of CSM technologies is to activate open, productive dialogues with the customer that are *personalized* in that they reflect each individual customer's needs, *self-activating* in that they permit the customer to successfully self-service their questions, *immediacy* in that critical information is conveyed in real-time, and *intimate* in that the customer feels the supplier is sincerely interested in their issues and that the outcome will provide a basis for future sales and service interaction. CSM technologies are separated into four areas.

- *Case management*. Technologies in this area cut service costs and improve workflow management by automating processes associated with customer support case assignment, management, and escalation; the effective and fast routing and prioritization of cases; ability to correspond with customers across a variety of mediums; and the online creation of cases and self-service case updates.

- *Case history knowledge database*. Technologies in this area enable the construction of comprehensive online knowledge databases to assist customers locate the answers they need, when they need them; provide customers with 24/7 access to case knowledge repositories; and provide service reps with a complete knowledge base that enables them to respond faster and reduce new service rep learning curves.
- *Customer portal*. Technologies in this area provide customers with the ability to enter problem tickets online; access order statuses, order tracking, and returns authorization in real time; and create one-to-one marketing campaigns targeted at specific prospects, customers, or market groups.
- *Time tracking*. Technologies in this area automate and streamline the time-tracking process, consolidating it with reporting and billing in the CRM system; enable complete visibility into how service and support teams are apportioning their time; and track time more accurately and use real-time metrics to improve time management practices.

10.2.3.5 Customer Experience Management

As detailed earlier in this chapter, the realization that the customer, and not products or companies, rules the marketplace has become a recognized fact. It is the customer who has assumed the power to direct the design of product and service content, pricing, transaction management, and the medium by which business is conducted. Today's customer expects to be treated as an individual and requires suppliers to provide them with configurable, solutions-oriented product bundles, services, and information custom designed to meet their unique wants and needs. Customers are simply demanding more control over the buying experience that empowers them to design their own solutions, tap into robust sources of information content, and deploy user-friendly tools for order management, self-service follow-up, and financial settlement.

Companies have responded to this challenge by leveraging their CRM systems to architect organizations that are more customer-centered. While not minimizing the "hard" components of CRM for data collection and analysis, of equal, if not greater importance, is the ability to use CRM to help mold the perceptions and attitudes customers come away with from a buying experience. In a word, customers have come to base equal value on both the products and services they receive and on the feelings and expectations, tangible and intangible, which surround their interaction with a supplier, its organization, and its processes. Today's best supply chains are succeeding by unearthing and nurturing this special intimacy with their customers aimed at capturing their loyalty, as well as unmistakable competitive advantage, by listening to the customer experience.

Although some advocates feel that CEM should be split-off from CRM and given a special status on its own, most marketing professionals consider CRM as both a technology and a customer experience management tool. CRM defines what the company wants from the customer relationship and gathers the intelligence and insight necessary to unearth what products and services to market and sell into what customer profiles. CEM, on the other hand, is the mechanism by which marketers clearly identify and build customer loyalty and long-term value. The CEM side of CRM provides an understanding of what creates a positive emotional experience that bonds customers and their favorite suppliers. Greenberg has come up with an interesting analogy that encompasses these two dimensions of CRM.

He calls it "whole-brained CRM [18]." Similar to the human brain, which is divided into right and left spheres of cognition, so, Greenberg feels, CRM should be considered as consisting of two separate but integrated customer management spheres. The left side of the human brain is described as the "rational" side and governs language, logic, interpretation, and mathematics (or classic CRM). The right side of the brain is described as the "intuitional/emotional" side and governs nonverbal processes, visual pattern recognition, perceptions, and interactions (or CEM). The left side of CRM looks at customers from the viewpoint of "functional value" while the right side views them from the perspective of the "emotional value" the company provides to them.

Effective use of today's CRM systems require the application not only of optimization tools for effective customer analytics but also customer knowledge repositories that enable the timely accumulation and transfer of critical intelligence about the experiences customers are having with a company's products and services. The objective is to not only close the gap between what customers want and what supply chains are actually providing, but also about the intensity of the experience customers are receiving from their interaction with a company's organization, products, and services. CRM systems call on the following array of application technologies to obtain visibility to the data and decision support priorities necessary to closely integrate the customer and the supply chain.

- *ERP system*. ERP acts as a transaction engine and information repository for the establishment of critical customer database information. ERP provides companies with an institutional memory about each customer's lifetime relationship to the organization and its brands.
- *Demand sensing*. If the essence of customer management is the capture of demand signals as they occur, then demand sensing tools illuminating customer experiences with products, services, and information constitute a critical CRM component. Technology applications in this area receive intelligence concerning the flow of customer demands as they occur at any point in the supply network, which in turn, is translated and immediately broadcast to all supply chain levels. Technologies in this space are critical to improving the buying experience by putting the customer in the driver's seat and employing the right CRM programs. Technologies in this area are used t*o provide a complete view of customer interactions across all channels*.
- *Operations optimization*. Once repositories of customer information are available, planners can network their business system backbones to streamline pipeline supply and delivery processes that exactly match customer requirements. Besides enabling supply chain partners to link and fine-tune their operations to ensure customer expectations, these software pieces enable supply points to optimize revenues based on a dynamic assessment of cost versus value trade-offs. CRM technologies in this area are used to *engage lean concepts and practices to reduce costs and wastes at each channel customer touchpoint*.
- *Demand shaping*. As intelligence about actual demand arising from customer buying events is broadcast through the supply chain, order management and pricing software is used to open new opportunities for cross-selling and up-selling. In addition, as metrics regarding the actual level of customer experience is captured and passed to each supply channel node, companies can invent entirely new approaches to the existing product/service mix that are more closely in alignment with customers'

expectations. CRM technologies in this area are used to *provide customer-facing functions with focused order management tools and information to service the customer.*

10.2.3.6 Partner Relationship Management (PRM)

Simplistically, the mission of PRM is defined as a business strategy and a set of application tools designed to increase the long-term value of a firm's channel network. The PRM suite of applications assists companies to select the right sales partners and then supports them by offering timely and accurate information and knowledge management resources to deal successfully with channel customers. In addition, PRM enables collective searching for ways to improve sales, productivity, and competitiveness; tools for joint marketing campaigns, lead management, sales forecasting, order processing, commissions and royalties; and assurance that each trading partner contributes to customer satisfaction. PRM provides tools to automate and enhance communications, processes, and transactions throughout the supply chain system.

PRM was created as a means to facilitate channel sales and gather metrics based on the marketing and sales efforts of network trading partners. Today, PRM functionality can be separated into five categories.

- *Partner recruitment, development, and profiling.* A critical function of PRM is the ability assist in the recruitment and qualification of potential channel partners. An essential activity is the population of a *partner profile*. This database details the capabilities of each partner from contact information and infrastructure to past sales contribution and general performance. By standardizing the partner channel, PRM enables companies to manage the life cycles of their partners by providing visibility to partnership risks and rewards, on-going contract maintenance, forecast of planned revenues, and availability of metrics bearing on profitability and loss.
- *Lead and marketing management.* This function of PRM is concerned with communicating marketplace opportunities to the partner network. *Lead generation* enables companies to match customer leads with partners based on their capability profiles. Procedurally, marketers use the system to analyze the lead, assign it to the most qualified partner, and then capture partner win/loss results. This category of PRM also includes functions to link channel partners to campaigns and promotions and to measure their results. Finally, it also provides for the allocation and budgeting of co-operative marketing funding, charts the productivity of marketing spending, and illuminates methods for improving accountability of partners and promotional campaigns.
- *Sales management.* This function of PRM consists of team selling, catalog management, needs analysis, commission management, and partner-driven order management and tracking. Other toolsets provide for quotation management and configuration capabilities that activate interactive selling tools for customizing partner resources in response to marketplace needs. Finally, a PRM system provides partners with a window into channel product availability, order status, and service requests and warranties.
- *Services management.* An important function of PRM is the on-going training and certification of partners and activation of support capabilities. For example, a partner

can get trained on a certain product line and become certified. The PRM system will then route to that partner leads associated with that line. Also of importance is the ability to provide partners with interactive demos and presentation software that combine content and configurability that partners can use to present to prospects.

- *PRM collaboration*. PRM systems also facilitate co-development marketing programs and joint business plans among channel partners. Effective collaboration requires the transmission of analytics and metrics of customer performance, channel sales forecasts, and general marketplace feedback that increases the channel network's chances of joint success and profitability.

10.2.3.7 Analytics

In today's data-rich business environment, companies are often suffering, not from a want of information about their markets and customers, but from a glut of too much data or what is currently termed "big data." Enterprise systems, marketing and customer service departments, and now social networking and the Internet are burying business analysts in a flood of information. The goal of CRM analytics is to provide companies with statistical, modeling, and optimization toolsets that empower them to deploy real-time dashboards and reporting to analyze, combine, and stratify their data to better understand the state of their businesses and provide drill-down visibility to sales opportunities, customer profiles, sales quote details, and other data to enable quick action. Ultimately, the goal is to provide an information conduit enabling decision makers to quickly configure their organizations to continually identify and exploit opportunities wherever they may arise in the supply chain.

The key features of CRM-driven analytics are:

- *Real-time CRM dashboards*. Today's CRM applications provide real-time dashboards for sales, customer service, marketing, and executives detailing information such as actual sales vs. sales forecasts, call volumes and tends, and financial measurements, such as bookings and billing, robustness of sales pipelines, and customer service performance.
- *Daily activities*. An important function of CRM analytics is providing sales, service, and marketing teams with the latest information to manage their day-to-day activities, whether viewing opportunities, closing business, or closing customer service tickets.
- *Ad hoc reporting*. Today's CRM functionality enables customer-facing teams to create custom reports and online displays without waiting for IT to develop the needed reports or depending on spreadsheets. These customer reports can be shared and provide key data from anywhere, whether from a web browser or a mobile device such as the Apple iPhone.

As analysts search to enhance the capability of their CRM systems, the incorporation of analytical functions that span marketing, sales, and service (operational CRM) and partners and suppliers (collaborative CRM) have become the newest "killer-apps." Figure 10.6 provides a view of CRM analytical functions.

The process begins when transactions, clickstream logs, and other customer data is entered through CRM and business system applications into the company's data warehouse. Once the data is assembled, marketers then apply reporting, modeling, and data mining toolsets to identify relationships and patterns in the data that enable predictive analysis. Critical output for analysts consists of customer value measurement, risk scoring, campaign

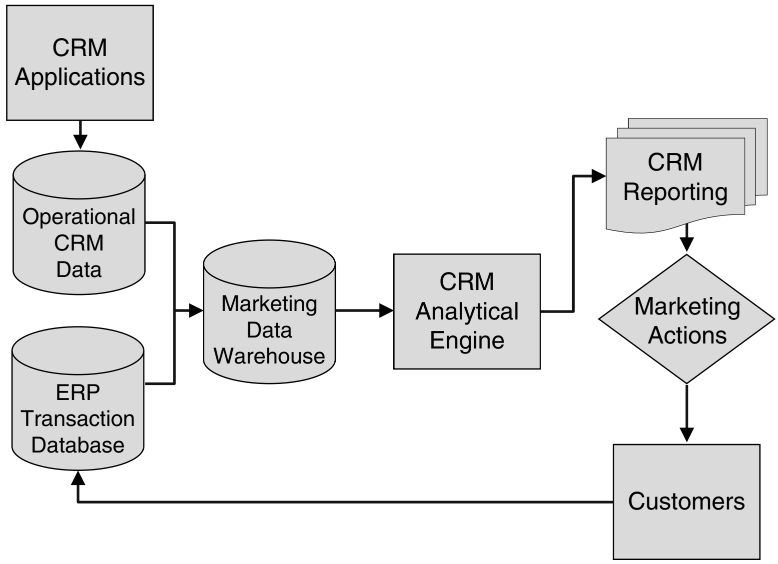


FIGURE 10.6 CRM analytics technical architecture.

measurement, channel analysis, churn analysis and prediction, personalization and collaborative filtering, and revenue analysis. Finally, marketers utilize the intelligence to drive the development of programs designed to pinpoint individual customer touch points. For example, interactive analytics enable marketers to perform what-if scenarios that are used to create a promotions campaign.

While today's CRM analytics platforms are being effectively used to perform a variety of important marketing tasks such as profiling customers for up-selling/cross selling opportunities, predicting customer churn and profitability, and assembling the proper mixture of product, price, and channels that maximizes individual customer profitability, some experts feel that CRM needs to be recalibrated, starting with a "true customer focus" and evolve into a customer-adaptive enterprise (CAE) approach [19]. The application of CAE to customer management seeks to establish a framework that matches and synchronizes goods and services supply and demand at all times. CAE attributes include a team-based collaborative ecosystem, an engaged workforce, decentralized decision-making, ethical guiding values, and a customer-focused vision. CAE understands that customers can literally force companies to change their products and service approach—in real time. This means that customer-facing functions must be prepared to innovate and adapt fast to be able to continuously create and deliver sustainable value.

10.3 CUSTOMER ORDER MANAGEMENT

Perhaps the most widely deployed set of CRM processes are customer order and service management. The order processing function is the primary contact between customers and the business. It serves as the gateway into how orders are placed, priced, allocated, tracked, and the goods and services delivered to the customer. As such, the quality, speed, and accuracy of the order management function has a fundamental impact on the level of customer responsiveness and the cost and efficiency of channel labor, equipment, delivery, and operating systems. Order processing functions that provide for the low cost, quick, complete, and timely transfer of goods, services, and order information facilitate demand management functions and act as the foundation for competitive advantage. Ineffective, inaccurate, and unresponsive order management adds cost to the customer, builds excess inventories in the distribution channel, results in higher transportation and storage costs, and masks poor quality and performance measurements.

10.3.1 Charting Customer Order Management Attributes

Researchers have identified several fundamental dimensions commonly associated with world-class order management and service. In a survey conducted by Peerless Research Group in June 2013, respondents listed their most critical customer order management concerns. The top six concerns are detailed in Figure 10.7 [20].

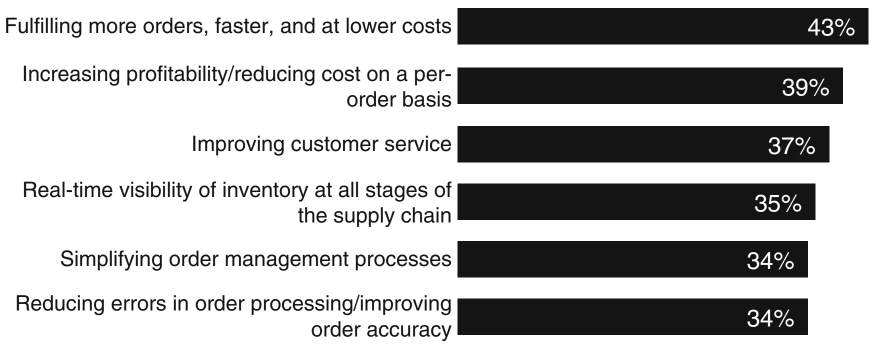


FIGURE 10.7 Order management, fulfillment, and distribution issues.

These concerns are summarized in the following five critical attributes [Figure 10.8].

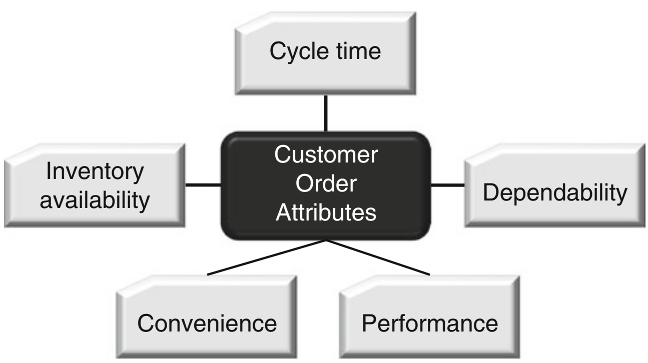


FIGURE 10.8 Critical customer order management attributes.

- *Cycle time*. As indicated by the Peerless Research Group survey, the most critical attribute of effective order management is order cycle times. Cycle time is defined as the total elapsed time from the moment the customer identifies a product or service need to the moment stock is placed into the customer's inventory or the service is performed. Normally order cycle time is divided into the following subprocesses: *order transmission* is the time it takes for a customer to transmit an order to a supplier; *order entry* is the time required for the supplier to enter an order into their business system; *order allocation and picking* is the time required to verify product availability and to perform picking functions; *order packing* is the time it takes to package the order; *order delivery* is the time required to perform logistics functions such as carrier selection, documentation, transport, and delivery; and, *order invoicing and payment* is the time necessary to generate payment documentation, billing transmission, and actual payment.

Continuously reducing these cycle times is critical to effective customer order management. Cycle times are attacked from two approaches: the application of lean methods and the implementation of information technology tools. Lean programs targeted at the elimination of waste in each of the order processing steps is an inexpensive yet powerful method for cycle time reduction. By eliminating redundancies in the order flow, useless paperwork, procedures, red tape, inaccuracies in information, costly order handling, checking and re-checking, and a host of other snags that add time to order processing cycle times, are reduced. Also, computer tools such as Web-based order entry, mobile devices, bar coding, carton labeling, and others eliminate cycle time by facilitating speedy and accurate information entry and ongoing maintenance.

Exercise 10.1: Financial Impact of Cycle Time Reduction

ABC Electronics has decided to move an important product line to Internet sales. By decreasing the average order cycle time (OCT) from 13 days to 6, the cost of carrying the product line should be reduced. The inventory manager has been charged with calculating the savings to the company. After review, the following data was assembled for the product family:

Data	Current/days	Proposed/days	
Average order cycle time	13	6	
Standard deviation	4	2	
Demand per day (units)	250	250	z-value
Service level	98.0 %	98.0 %	2.05
Unit cost	$350.00	$350.00	
Carrying cost	21 %	21 %	

The first step to be performed is calculation of the safety stocks for both the current and proposed cycle times. The pivotal factor is determining the standard deviation for the 98 % serviceability expected from the product. Using the standard z-table, the manager has determined this value to be 2.05. With this data, the safety stock (SS) is computed using the following formula:

$$SS = \left[\left(\left(\text{Demand per day} \times \left(\left(\text{OCT} + \left(z \times \text{standard deviation of OCT}\right)\right)\right]\right.\right.\right. \\ - \left(\text{Demand per day} \times \text{OCT}\right)$$

Using the formula, the safety stock is calculated as follows:

$$\text{Current SS} = \left[\left(\left(250 \times \left(\left(13 + \left(2.05 \times 4\right)\right)\right] - \left(250 \times 13\right) = 2{,}050 \text{ units}\right.\right.\right.$$

$$\text{Proposed SS} = \left[\left(\left(250 \times \left(\left(6 + \left(2.05 \times 2\right) - \left(250 \times 6\right) = 1{,}025 \text{ units}\right.\right.\right.\right.\right.$$

The next step is to calculate the value of the safety stock reduction. This is performed by multiplying the reduction in safety stock units times the unit cost times the inventory carrying cost, or 1,025 units × US$350 × 21 % = US$75,337.50. The next step is to calculate the absolute order cycle time by multiplying the difference in absolute cycle time by the daily demand by the unit cost by the carrying cost, or (13 days – 6 days = 7 days) × 250 × US$350 × 21 % = US$128,625. Finally, the improvement in cash flow for ABC Electronics by moving to Internet sales is calculated by adding the safety stock reduction and the cycle time reduction, or US$75,337.50 + US$128,625 = US$203,962.50.

- *Availability*. This order management attribute refers to the capacity of the supply chain to have the products or services available when desired by the customer. Several inventory strategies can be chosen depending on competitive marketplace cycle times and logistics capabilities. One method is to stock products in anticipation of customer orders. This model requires decisions regarding the size and value of inventory and the number, location, and stocking policies of channel warehouses. Another model, followed by many manufacturers, is assemble-to-order or make-to-order production. In this model, the business stocks no finished goods, only materials, components, and subassemblies. When a customer order is received, production builds the finished good exactly to the configuration detailed in the customer order. Building to the demand pull instead of stocking finished goods dramatically cuts inventory and warehousing costs. A negative is that it adds to order lead times and to processing complexity.
- *Dependability*. Effective order management requires businesses to match actual cycle times, inventory availability, and operational performance with the expectations of the customer. Although it is absent in the Peerless Research Group research detailed above, it can be argued that *dependability* is perhaps the most important service value. The timely receipt of replenishment orders enables customers to continuously reduce their dependence on internal buffer inventories, and shrink order processing, planning, receiving, and other plant costs. In addition, increased supply reliability enables channel customers to better service their own customers by reducing the chance of stock out.
- *Convenience*. In today's web-enabled, multichannel distribution environment, ease of product and price search, order entry, and robust services are critical customer-winning values. In the past, customers had to search through printed catalogs and trade magazines, attend trade-shows, and consult supplier registers to find the suppliers and products they needed. Once located, they had to utilize cumbersome and time consuming methods, such as ordering by phone, fax, or EDI, to place orders. Often they had to wait for validation of requested product configurations, quantities, prices and discounts, delivery dates, associated support services, and delivery options. Today's Internet-based solutions have dramatically changed customers' expectations regarding ease of ordering. Web browsers enable customers to see online information about supplier products and services, work with online catalogs, perform research and comparison shopping, review inventory availability, configure and enter orders directly online, determine delivery options, and perform self-service order tracking.

- *Performance*. This final attribute refers to the ability of suppliers to perform order management functions within published and competitive standards. There are four specific performance values to consider. The first is the speed of *cycle times* necessary to meet customer expectations. Generally, the shorter the order fulfillment cycle, the greater the competitive edge. The second is the *consistency* with which suppliers' order management, service, and logistics functions execute accurate orders and deliver products on time. The third performance standard measures how *agile and flexible* are fulfillment functions and their ability to respond to customer requirements, manage new product introduction and product phase-out, customize logistics capabilities, and perform reverse logistics activities. The final customer order performance value is concerned with the ability of suppliers to handle *out-of-bounds* situations such as massive logistics or system failures, quality problems, new technology introduction, and order changes.

10.3.2 Order Management Process

The order management cycle is the place where the order management attributes are activated. Order management is traditionally the responsibility of sales and service whose job it is to work with the customer base, enter request for quotations and orders into the demand management system, maintain valid order due date priorities and quantities, prepare orders for picking and shipping, and validate the terms of financial settlement. Planning and controlling the order management process requires sales and service to determine answers to such questions as:

- Are customer master file records accurate?
- Have the proper prices for products been determined?
- Are there any promotions or special prices in effect?
- Is there sufficient inventory to meet order requirements?
- When should inventory be allocated to open orders?
- What are the policies governing returns and backorders?
- How is customer credit being reviewed?
- Are current open order due dates accurate?
- How are order processing performance measurements to be determined?

The order management planning process (illustrated in Figure 10.9) begins with the maintenance of the database components used in the timely and accurate preparation of customer orders. Customer order databases consist of files such as the customer master, price and discount master, accounts receivable terms, and the product available-to-promise files, as well as variable database files such as customer quotations, open sales orders, and sales history. The next step in the sales order management process is executing the steps in the order processing cycle. The processing of customer orders consist of three distinct cycles: order receipt and entry, inventory allocation and picking, and order shipment and invoicing. Two external activities performed by the customer also accompany this process: order preparation and transmission at the beginning of the process, and order receipt and financial settlement at the end.

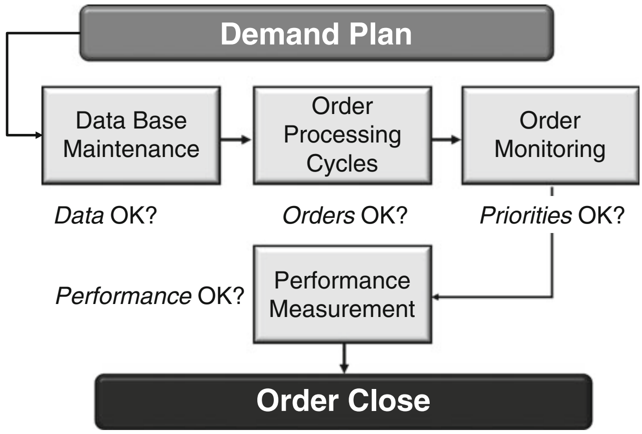


FIGURE 10.9 Order management process.

The third step in the order management process is monitoring order status. Once orders are entered into the open order file, customer service can monitor order ship dates, backorders, and inventory quantities so that order priorities are maintained. Once the order is shipped, order history online system displays and reports assist sales and service to track order delivery and inventory statuses. Order status information details such key data as order due date, quantity required, pricing, and quantity shipped for each line on the order. Besides providing a window into current order status, timely and complete information enables customer service personnel to closely monitor not only order priorities but the entire replenishment system and keep it up to date.

The final step in the order management process is monitoring performance metrics. Important order measurements include the number of lines and orders filled complete, number of shipments by customer due date, percentage of stock outs, total order cycle time, billing adjustments, administrative errors, and profit margins. While providing information on the order process itself, performance measurements also compile data on how well the entire supply channel is responding to customer requirements. The ongoing benefits of a "world-class" order processing system are the following:

- *Continuous decline in average order cycle lead times*. This is the span of time from the moment an order arrives until it delivered and accepted by the customer.
- *Improved customer relations*. Effective order processing provides customer service with critical information necessary to service the customer in as expeditious a manner as possible.
- *Increased order accuracy*. Online data validation and system record defaults not only improve the accuracy of order entry activities but also speed up the entire order processing cycle.
- *Decrease in operating costs*. With the ability to process orders quickly and accurately, order processing systems eliminate internal costs associated with order review and expediting. What is more, linking the entire distribution channel system eliminates costs associated with order processing redundancies, excess inventories, and unprofitable transportation.

- *Timely invoicing and accounting*. Effective order processing systems accelerate the transfer of accounts receivable, discounting, and other financial data resulting from order shipment. Improvements in order shipment accuracy decrease the occurrences of invoice errors and improve receivables collection.

10.3.3 The Order Management Cycle

As illustrated in Figure 10.10, order management consists of four phases [21]. The argument is that each phase usually requires the presence of specific customer quality and service elements if the sale is to be successfully executed.

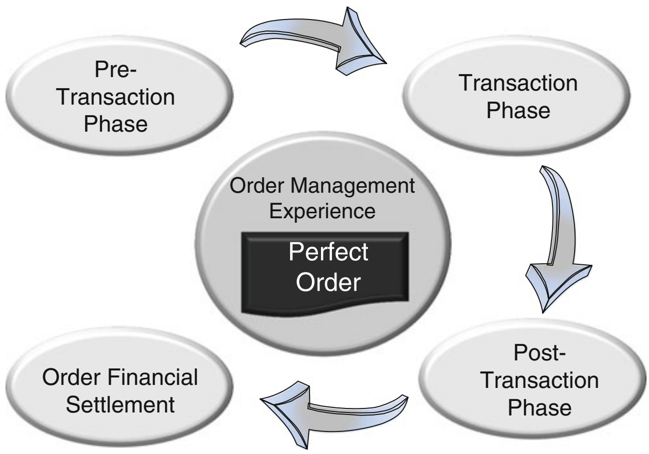


FIGURE 10.10 Subprocesses of a perfect order.

10.3.3.1 Pre-transaction Phase

The service dimensions in this phase are, for the most part, focused on setting customer expectations and formalizing the sales and operations support structures of the firm. Specific elements consist of the following:

- *Written customer service policy*. A clear and concise definition of customer service objectives provides a formalized approach to guide all customer service activities. The contents of the service policy should consist at a minimum of the service mission, detailed service standards, and a list of quantifiable performance measurements. The goal of the service policy is to clearly define customer expectations and serve as a benchmarking tool to measure ongoing service performance.
- *Service policy communication*. Once a detailed service policy is devised, it must be communicated to the customer. A formal service policy enables customers to shape the expectations they have as to the level of service performance. The service policy should also detail the proper channels to communicate with company services if specific performance standards are not being met.
- *Organization structure*. The goal of the service organization is to facilitate communication and cooperation between the customer and the firm's product management, sales, logistics, and financial functions. The identity of the management and staff of

the service organization must be communicated to the customer base, as well as the means by which they can be contacted.

- *Organizational flexibility*. The design of the service organization must be flexible enough to enable a quick and comprehensive response to customer problems and requests.
- *Management services*. The final *pre-transaction* element is the availability of supplier training and printed materials to assist customers in performing their own product problem-solving diagnostics. Education courses, training seminars, and training manuals are key components of management services. Functions in this area have been greatly expanded by the use of Internet marketing and service sites.

10.3.3.2 Transaction Elements

The service dimensions in this phase of the sales cycle focus on sales order execution. Specific elements consist of the following:

- *Stock out level*. The availability of products in the right quantity and at the right place is at the core of effective order management. Customer serviceability levels are the key performance measurement for this element. Serviceability is defined as the percentage of times customers' requirements are met without a stock out. Once a stock out does occur, actions, such as offering a suitable substitute or expediting, are also part of this service element.
- *Order information*. This service element focuses on the ability of order management to respond quickly and accurately to customer inquiries during order placement. Order information consists of such data elements as inventory status, customer credit, pricing, ease of order configuration, use of web-based and mobile apps, shipping and handling costs, delivery, and open order and backorder statuses.
- *Order cycle time*. The order cycle is defined as the time that transpires between the moment an order is placed until the date it is delivered. In reality, there are three distinct sub-cycles that must be completed during order management: order entry, order allocation and picking, and order shipment and delivery. Fast and accurate order cycle processing is essential to competitive advantage.
- *Expedite shipments*. Expedited shipments fall into two categories. The first is concerned with expediting through the order processing cycle those customer orders that are to receive special handling. Customers usually pay premium prices for expedited orders. When suppliers absorb expediting costs, it is absolutely essential that management not only review who is to receive this service but how future expediting can be eliminated. The second category of expediting occurs when a customer backorder occurs. Expediting in this instance encompasses swift resupply order action and premium delivery to the customer. Expediting incurs costs that directly impact corporate profitability and are symptomatic of deficiencies in inventory ordering and control, sales, and delivery functions.
- *Transshipments*. This service element refers to the transfer of inventory between stocking points in the distribution channel necessary to meet customer demand. While inventory inequalities occur over time in the supply chain network, planning tools like DRP should be used to eliminate this often costly alternative to stock out.

- *System accuracy*. Order processing inaccuracies, such as incorrect items, prices, quantities, shipping information, due dates, and billing, are costly to both the supply chain and the customer. Instances of order cycle inaccuracy should be recorded and used as data in performance measurement calculations.
- *Order convenience*. This element refers to the degree of ease by which customers place orders and have access to open order information. The Internet, mobile technology, and social media have revolutionized order management. Service attributes, such as 24 × 7 × 365 service, real-time information, on-line customer support, instantaneous availability of documentation, self-service, and Web-page personalization, enable today's Web-savvy customers to receive a truly unique, interactive buying experience.
- *Product substitution*. The ability to offer product substitutes has a dramatic impact on total inventory investment as well as the level of customer service. For example, by offering two substitutes for a given item, a company found that a previous customer service level of 70 % increased dramatically to 97 % with no additional inventory investment.

10.3.3.3 Post-transaction Elements

The service dimensions in the final area of the sales cycle are concerned with after-sale product support. Specific elements consist of the following:

- *Installation, warranty, alterations, repairs, and service parts*. These post-sales elements are value-added to the product and are part of the reason why customers choose to purchase from a specific firm. A company offering post-sales services must have the following conditions in place: assurance that the product will function as documented; demonstrated availability of service parts and support staff for advice or installation; full product documentation that explains product functioning, troubleshooting tips, and parts lists; and a product and services warranty administrative function that serves as a point of customer contact and contract tracking.
- *Product tracing*. Many products such as food, pharmaceuticals, medical supplies, and large-ticket items require lot and/or serial number tracing. The availability of such information enables companies to recall products due to defect, spoilage, or obsolescence, or to record historical information used in marketing and future product design.
- *Customer claims, complaints, and returns*. Factors concerning customer claims, complaints, and returns should be clearly defined in the written customer service policy. In the after-sale environment, policies regarding these and other customer issues must be rigorously followed if the firm's reliability, responsiveness, and credibility is to be maintained. Information arising from this element provides valuable data that is used for product redesign, marketing programs, shipment and delivery, and other channel functions.
- *Product replacement*. In some cases, products that are required but are not in stock or that must be repaired require the firm to offer a temporary replacement. Costs borne by the supplier are considered part of the warranty or of the presales arrangement.

10.3.3.4 Order Financial Settlement

The final phase in the order management cycle is financial settlement. Once the order is shipped, modern business systems will automatically generate an invoice (either paper, electronic, or direct debt) that is sent to the customer. The invoice displays such critical information as the payer address, discounts, early payment terms, total invoice amount, and due date. An important Web-based self-service customer inquiry is the accounts receivable (AR) status. The display enables customers to easily access information about their account, such as detailed order and account summary balances, payer analysis, statement of accounts, detailed payments, period analysis, payment pattern information, and AR aging.

10.3.4 The Perfect Order

In the past, companies sought to win and keep customers by compiling metrics that weighed order management and fulfillment performance against predetermined service targets. Sales, customer service, and logistics often based their performance on several independent measurements: fill rates were compared to expected fill-rate standards; on-time delivery was determined as a percentage of deliveries made on time relative to a pre-determined standard; customer returns and warranty claims were evaluated against acceptable returned goods targets, and so on. When the results of each of these separate measurements were combined, the company could assess how well they were providing acceptable customer service to the expected standard.

In today's highly competitive global marketplace, however, simply tracking order management and fulfillment functions to set standards provides the bare minimum in the quest to attract and retain loyal customers. Winning today's customer requires that companies shape their customer-facing functions around the concepts of zero-defects and six-sigma performance: in short, that they consistently deliver the *perfect order*.

There are many definitions of what constitutes a perfect order. For example, the SCOR framework defines it as "the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage." The definition in the *APICS Dictionary* takes on a marketing flavor: "An order in which the "seven Rs" are satisfied: the right product, the right quantity, the right condition, the right place, the right time, the right customer, the right cost." Proctor & Gamble defines the perfect order as "a product that arrives on time, complete (as ordered), and billed correctly." But while the execution of a perfect order is an easy concept to understand, it is difficult to achieve in practice. Managers are painfully aware of the typical failures that arise during the order and fulfillment process: incorrect quantities, wrong items, missed delivery dates, wrong destinations, incorrect documentation, damaged items, and a litany of other failures.

There are numerous hurdles, such as company culture, entrenched business processes, and technology complexities that managers must overcome in their search to eliminate order execution failures. Other barriers include:

- Managing a process that often spans supply channels and consists not only of products, but also of associated services, such as delivery and installation.
- Poor alignment of organizational structures driven by functional silo management styles.
- Limited employee abilities and change management skills that inhibit collaboration among all stakeholders.

- Insufficient technologies to support the process. Many companies and supply chains are characterized by a number of different ERP, fulfillment, and logistics systems that atomize the order management process and inhibit critical insight and decision-making.
- Lack of sufficient financial investment that shrinks funding and budget allocation necessary to fund adequate resources for a perfect order improvement program [22].

The effort and resource commitments to achieve the perfect order is formidable. High fill rates generally require supply chains to maintain high levels of inventories to meet all potential order variations. Supply chains must closely collaborate and have access to a common system providing order placement, order status, ability to change existing orders, efficient order return, timely order payment, and other activities. Supply chains must present a consistent brand experience that promotes a common look, feel, and personalization. Each supply channel node must be able to offer the right product or service that is published in a common product and services catalog. There must be consistent post-sales functions, such invoicing, returns, warranties, and service agreements, across the supply network. By tackling these and other challenges, supply chains can engineer order management and fulfillment functions that ensure customers get what they want when they want it with an accompanying unbeatable experience.

10.3.5 Aligning Order and Fulfillment Supply Channels

An increasingly important component in executing the perfect order is aligning all nodes in the supply network to provide an integrated view of the customer order. Historically, fulfillment was considered a "backoffice" function concerned with such activities as tele-marketing, customer help lines, warehousing and shipping, postponement processing, and disposition of returns. It was the role of fulfillment to navigate often poorly synchronized, inflexible supply chains and deliver products to the marketplace that met acceptable lead times and costs. Because fulfillment often lacked visibility to the movement of goods and information across the supply chain, lead times tended to elongate and inventory to accumulate to buffer against random events impacting channel process flow-through. Such discontinuities resulted in supply chains that lacked the integration and interoperability necessary to provide the level of operations efficiency and velocity required for the short delivery cycles, customized fulfillment capabilities, and personalization demanded by customers increasingly acclimated to the online, real-time capabilities of Internet and multi-channel trade.

Today's fulfillment systems must be designed to provide transparency of supply chain data and events simultaneously to all regions of the channel network, solving the critical issues of connectivity and visibility that have traditionally blocked effective fulfillment. Re-architecting the supply chain around demand management principles and technology enablers provides individual channel partners with the capability to

- Leverage information from beyond the "four walls" of the enterprise to generate truly integrated fulfillment capabilities that dismantle the barriers set by past information bottlenecks, redundant processes, and excess channel buffers.
- Improve inbound and outbound inventory visibility, thereby reducing excess inventory costs, potential obsolescence, and cycle times.

- Leverage demand sensing and demand shaping to assist supply chain entities to better manage demand volatility, improve demand planning processes, and create incentives that stimulate demand and optimize sales promotions to maximize growth and profitability across the supply chain.
- Expand outsourcing capabilities while enhancing the focus on internal core competencies.
- Gain a better view of performance within the business and through the fulfillment network.
- Engineer more fluid business relationships and accelerate information and product flows.
- Achieve high-velocity, tightly synchronized business processes agile enough to adapt to changing business conditions and objectives.
- Develop personalized service capabilities for customers.

To meet rising customer expectations of the perfect order, supply chains need to increase their on-time deliveries, improve the reliability and accuracy of their promises to customers, and effectively manage their commitments.

Achieving such a radical redefinition of fulfillment management requires whole supply chains to respond to three critical challenges. First, fulfillment in the "Internet Age" requires new types of relationships to meet the needs of today's increasingly Web-enabled customer. Critical attributes include more collaboration between network suppliers and customers; the effective utilization of outsourcing to ensure "best-of-breed" response to the unique service competencies of channel partners; and the establishment of "win-win" commercial arrangements that enhance the relationship between customers and fulfillment service providers. Market leadership will go to those supply chains capable of monitoring order progress, resolving problems, and modifying fulfillment processes as the business and supply chain evolve.

The second challenge focuses on an unbending dedication on the part of all supply chain constituents to continuous operations excellence. While technology interoperability and enablement has occupied much of the lime-light in recent fulfillment literature, it has become clear that a "back-to-basics" approach that emphasizes the development of new fulfillment networks and make/buy strategies and the implementation of agile and flexible channel facilities and processes is critical to engineering supply chains capable of responding effectively to today's fast-paced environment. Only those supply networks capable of quickly customizing the logistics network; integrating demand and supply planning; integrating product, information, and financial flows; sourcing strategically; leveraging postponement strategies; and establishing pan-supply chain performance metrics will be able to seize and sustain competitive fulfillment leadership in their markets.

Finally, competitive supply chain fulfillment depends on the deployment of new technologies and services. In the past, supply chains consisted of individualized, one dimensional service functions such as in-bound/outbound freight, carrier management, total cost control, operations outsourcing decisions, load planning, routing and scheduling, and execution of administrative services. Today, emerging supply chain networks, utilization of outsourcing strategies, and the continuous shortening of all cycle times have generated the need for new types of services, while technologies have enabled the exploration of new methods of contact with the customer and speedy delivery. For example, many companies are exploring the use of Web-based services, such as fulfillment exchanges and auctions, for such functions as freight and parcel carrier selection. Another area is the use of *infomediaries* who utilize Internet technologies to facilitate the flow of fulfillment information, such as shipment track-and-trace, real-time alert messaging, supply channel modeling, "what-if" simulation, and performance measurement tracking. Finally, in another area is found channel providers offering *flow management solutions* that enable Web-based control of such fulfillment functions as transaction management across multi-partner networks, expediting, and channel event management.

10.4 CUSTOMER SERVICE MANAGEMENT

Over the past number of years the purpose, scope, and mission of *customer service management* (CSM) has changed dramatically. In the past, customer service consisted in receiving and answering correspondence with customers who had questions or problems with products or services. Next came the *help desk* where, instead of writing, customers could talk by telephone directly to a service rep about their issues. By the 1990s CSM had evolved beyond just an 800 telephone number to encompass a wide field of customer care objectives and activities. CSM functions sought to deploy a range of multimedia tools to not only retrieve order and account status, but also to manage every component affecting the customer from complaints and product information to education, warranties, and upgrades.

Today, the capabilities of CSM are expanding into new dimensions with the advent of exciting new toolsets, such as social networking, cloud computing, speech recognition, and video, to join older technologies. Such applications provide customers with even more opportunities for control of service dimensions while enabling companies to integrate all avenues of customer interaction on a central platform. Self-service opens a new dimension of customer service at less cost while service databases improve knowledge of customer behavior that enable the delivery of customized sales and service one customer at a time.

10.4.1 Defining Customer Service Management

CSM is commonly described by the use of two expressions: *easy to do business with* and *sensitive to customer needs*. There are several valuable definitions available. The *APICS Dictionary* defines customer service as "The ability of a company to address the needs, inquiries, and requests from customers." In their classic study, LaLonde and Zinser [23] state that CSM is best understood when seen from three perspectives: as an *activity* consisting of order processing, proof of delivery, invoicing accuracy, timeliness of delivery, and others; as a set of *performance* related criteria focused on service and satisfaction metrics; and, finally, as a *corporate philosophy* concerned with imbedding CSM within the long-term strategies of the enterprise.

Another perspective on the meaning of CSM is found by viewing its fundamental elements. Perhaps the most concise list of service elements has been formulated by Zeithaml, et al. [24]. These elements are:

- *Tangibles*. This element refers to the *appearance* a firm's service functions project to the customer. Often the image a company wishes to communicate includes such tangibles as new facilities, state-of-the-art technology, highly qualified personnel, and the latest equipment. Tangibles are designed to give customers a sense of confidence and assurance that the products and services they are receiving are truly "world class."

- *Reliability.* Once a company publishes their commitment to a specific level of customer service, their ability to live up to that standard is the measurement of their reliability. Service leaders must continually perform the promised service dependably and accurately each and every time. Reliability of service permits supply chains to "lock-in" their customers who will gladly pay premium prices for delivered quality.
- *Responsiveness.* The ability of a supply chain to respond to customer needs quickly and concisely lets customers know that their time and costs are important. Whether rendering prompt presales service or a willingness to assist with product quality issues, a helpful attitude and timely service will always leave the customer with the sense of dealing with a winner.
- *Competence.* Customers need to feel assured that the supplier possesses the required skills and knowledge to assist them when product or support issues arise. Firms that support their products with superior services will always be leaders in their marketplaces.
- *Courtesy.* Many a future sale is won or lost based on the way the customer is treated in the presales and post-sales cycles. Companies who do not respond to their customers with politeness, respect, consideration, and professionalism are destined to lose them to competitors who do.
- *Credibility.* Service leaders base their success on high standards of honesty, trustworthiness, and believability. Customers purchase products from firms that live up to claims of the best quality possible at the lowest price.
- *Security.* The delivery of products and services must be accompanied by a sense of security on the part of the purchaser. Issues range from Internet transaction security to confidence about shared proprietary information. Security frees customers from doubts and provides "peace of mind" for the products and accompanying services they purchase.
- *Access.* This service element has several facets. Foremost, access is the degree of ease by which customers can purchase products or contact sales and service staffs. Access also refers to the availability of goods and services within a time limit generally accepted by the industry. Finally, access means the speed by which after-sales replacement parts and services are delivered to the customer.
- *Communication.* The availability of sales and services staff to respond quickly and intelligently to customer questions concerning products, services, account status, and the status of open orders is the primary tier of a firm's customer communication function. Other communication forms, such as printed literature, manuals, product and service news-letter updates, and advertising, form the second tier. Effective customer communication stands as a fundamental cornerstone for service leadership.
- *Understanding the Customer.* Unearthing and responding to the needs, desires, and expectations of the customer is the first element in effective sales and service. Firms that provide the products and services customers really want will always enjoy an edge over their competitors.

The above list of service dimensions is applicable to all types of businesses. Although specific service goals may vary by industry, the ten dimensions represent concise benchmarks by which supply chains can measure themselves.

10.4.2 Elements of Effective Service Management

According to Gopal and Cahill [25], there are nine critical steps in effective CSM (Figure 10.11).

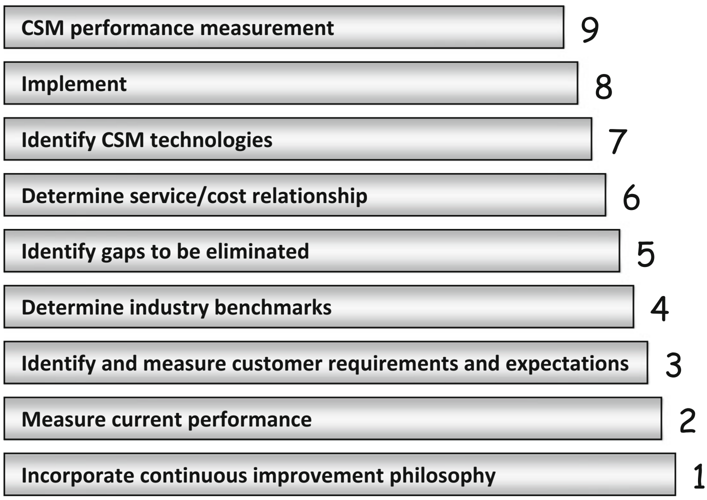


FIGURE 10.11 Elements of CSM.

Step 1—Establish and nurture a culture of continuous improvement

Customer service leaders are those organizations that espouse the concept of continuous incremental improvement at all levels in the organization. The ongoing ability to create value and deliver it to the customer is achieved by responsive "world-class" performers who are tireless in their examination of every aspect of channel operations in search of untapped sources of quality and customer satisfaction. Customer service value creation is strategic, systemic, and continuous. It is *strategic* because delivering quality to customers is at the very heart of supply chain strategy. It is *systemic* because the information, planning, and execution systems utilized by the organization must be aligned and continually refocused in the pursuit of customer value. Finally, it is *continuous* because the challenge of gaining and keeping customers in today's marketplace requires an unrelenting dedication to achieving continuous improvement in all levels of performance.

Following a continuous improvement philosophy means managing the supply chain by aligning and realigning operations with corporate objectives and goals; the institutionalization of shared values providing for quality, customer orientation, and the ongoing improvement of functional processes; problem solving at all levels; cross-functional operations; people empowerment; and two-way networked communications. In addition, a dedication to increasing service quality and value means enabling a continuous process for measuring customer perceptions of service quality, identifying service shortfalls, and responding to quality gaps with appropriate action to improve service metrics. Without this management cornerstone in place, supply chains will find it difficult to start on their path to customer service excellence.

Step 2—Measure current performance

Once a strategy of process improvement is in place, companies can move to measuring current service performance. Not only does this exercise provide management with a window into current service problems, it also clearly marks the path on the way to competitive service leadership. Measuring supply chain service effectiveness consists of two elements: determining customer expectations and needs and quantifying current service practices and measuring the variance between existing levels and marketplace expectations.

Step 3—Identify and measure customer requirements and expectations

In this step service management identifies the current level of service being offered to the customer. First, service management performs a thorough audit of those elements perceived by the customer as a requirement before and after the purchase. As illustrated in Figure 10.12, there are five general areas associated with the nature of customer requirements and expectations.

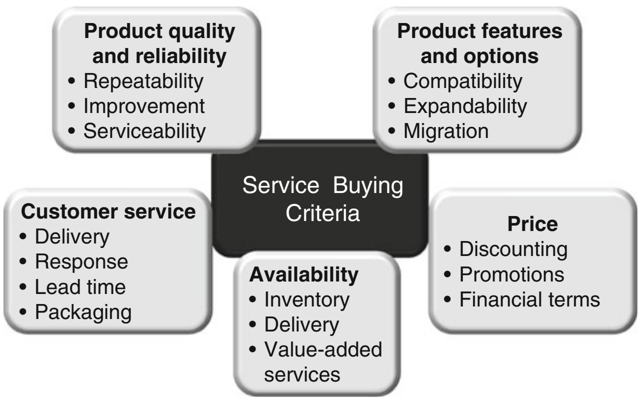


FIGURE 10.12 Customer buying criteria.

Perhaps the most important criteria from the customers' viewpoint is the combination of product quality, reliability, and features. Price, while an important element in the customer decision, is not necessarily the leading differentiator. Increasingly, customer pre-and post-sales services is a key factor in the buying decision. Finally, it can be argued that availability may sometimes trump the other four criteria. Product features, options, and price are tangible components of customer requirements. Quality and reliability are less tangible, but, nevertheless, are demonstrated through certification, publication of performance data, compliance testing, and customer testimonials. The level of customer service is perhaps the least tangible customer requirement, but, nonetheless, is often the most important in making or losing a sale.

A detailed audit of these five criteria provides customer service managers with answers to critical questions such as:

- What is the prevailing corporate culture regarding customer service excellence?
- How do business units (marketing, sales, finance, and logistics) perceive their role in providing customer service?
- How is customer service measured within each business unit?

- What are the performance standards and service objectives?
- What are the internal customer service performance measuring systems, and how are they integrated to provide a corporate viewpoint?
- What are the current performance metrics?
- How are these metrics used to increase service performance?

Answers to these questions arise by conducting an analysis of existing service performance data and through departmental interviews. Attributes, such as organizational structure, performance measurement systems, problem-solving techniques, perception of customer needs, level of direct customer contact, and plans for service improvements, will detail current service paradigms and interfaces with other functional departments.

Exercise 10.2 : Service Factor and Fill Rates for a Safety Stock Policy

A stock out occurs when customer demand for a product exceeds the available inventory. Preventing stock is perhaps the single most important task for service management. The planners at ABC Electronics want to ensure that a popular item is stocked out as little as possible. To solve this problem management has determined that the product should have a 98.5 % customer service level (CSL). After reviewing transaction history, the projected yearly sales of the product are 6,300 units. The standard replenishment lot size is 25 units. The current cost of the product is US$235 and ABC's carrying cost is 21 %. The formula to calculate the cost of the safety inventory is

$$(\text{Carrying cost} \times \text{unit cost}) \times \text{standard lot}/(1 - \text{CSL}) \times \text{average demand per year}$$

Using the planning detail identified above, the per unit cost of achieving the targeted service level at ABC is calculated as:

$$(21\,\% \times \text{US\$235}) \times 25/(1 - .985) \times 6{,}300 = \$13.06/\text{unit}$$

As inventory grows to support higher customer service levels, the cost of lost sales decreases. However, as customer service increases, the costs of carrying the accompanying safety inventory increases correspondingly. Service managers must be careful to perform a thorough cost-benefit trade-off analysis in making these decisions.

Step 4—Determine industry benchmarks

Step 3 is followed by executing a benchmarking analysis designed to determine customer perceptions of the services offered by competitors. The starting point is to identify and rank the relevant customer service attributes. A possible method is to create a survey of service factors divided into three major areas: *marketing* (price, sales support, product mix, terms of sale, and so on.), *service* (delivery performance, order turn around, fill rates, accuracy, and so on.), and *product* (quality, reliability, availability, documentation, and so on). In addition, firms could use several different forms of customer interview, such as telephone, intercept, opportunity, on site, and focus group. This discovery process should provide answers to the following questions:

1. Who are the firm's customers?
2. What service attributes are pivotal in meeting their needs?
3. What service activities are currently being performed to meet these needs?

Benchmarking is the central tool in this process. Benchmarking is defined in the *APICS Dictionary* as "Comparing a company's costs, products, and services to that of a company thought to have superior performance." The objectives of benchmarking are to determine standards of superior performance and best practices, understand and quantify performance gaps in key processes, and share knowledge of superior working practices. Benchmarking is a process of setting performance targets by investigating other organizations' operations practices to derive ideas that could contribute to performance improvement. Benchmarking requires gathering information concerning "best-in-class" performance found in other companies and then matching it to the performance of internal processes. The result of the exercise enables quality improvement teams to determine the strengths and weaknesses of their processes and to highlight areas for possible improvement. Benchmarking enables improvement teams to validate those processes which are *competitive* and those identify those needing *improvement*. In addition, benchmarking highlights where the company possesses *excess*, and perhaps unnecessarily, high levels of performance that are costing the company more than they are worth. Finally, benchmarking exposes those processes that require *urgent action*.

Applying benchmarking to process improvement is similar to using the plan-do-check-act (PDCA) quality management circle with the difference that it focuses on setting quantitative goals for continuous improvement. Benchmarking steps are:

1. *Planning*. Identify the processes to be benchmarked, the companies to be used in the comparison, the measures of performance, and the data to be collected.
2. *Analysis*. Once the comparison data is collected, determine the gap between the current performance and the benchmarked firms. Identify causes of significant gaps.
3. *Integration*. Establish process improvement goals and design improvement projects.
4. *Action*. Create the process improvement team and launch the improvement project based on plan-do-check-act (PDCA) or six sigma define-measure-analyze-improve-control (DMAIC) concepts and functions. Recalibrate benchmarks as improvements are made.

While there are different forms of benchmarking that can be deployed (such as competitive, process, and strategic), all forms are best applied in situations where a long-term program of continuous process improvement is pursued.

Step 5—Identify service gaps to be eliminated

The audits arising from steps 3 and 4 are used to develop a *services attribute matrix*. The matrix appears in Figure 10.13. The matrix permits service managers to rank each service attribute by its relative importance to the customer. The matrix has five zones. The service rank for each attribute is measured by determining the relative importance of the attribute to the customer and to the actual performance of the firm. By intersecting the lines, service managers can detail the strengths or weaknesses relative to customer expectations and the position of competitors. Once each service attribute is applied to the matrix, service management can begin the task of ranking each by level of importance. Attributes that illustrate a competitive vulnerability require high priority in the service strategy. Attributes, on the other hand, that indicate irrelevant superiority are probably causing unnecessary service costs and should be eliminated. Metrics that indicate that customer expectations (or competitive positioning), and the firm's corresponding performance intersect somewhere in the middle range, means that the service attribute is located in the grey zone. This zone indicates that the level of importance and performance are not of significant strategic importance.

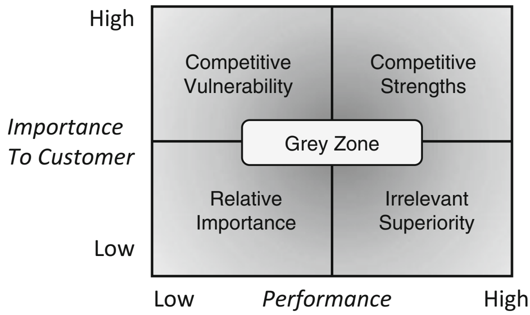


FIGURE 10.13 CSM attribute matrix.

Metrics illustrating performance *gaps* provide a clear understanding of the level of current performance as opposed to customer perceptions and expectations and to advantages enjoyed by industry leaders. Once these gaps are quantified, CSM can begin to redesign organizational and value structures, refocusing them on continuous incremental improvements in processes and operational performance. Zeithaml, et al. [26] have formulated a service quality model that enables service managers to identify gaps between customer expectations and actual service performance. The model, shown in Figure 10.14, identifies five gaps inhibiting "world-class" service delivery. Gaps 1–4 are shortfalls that occur within the services organization. Gap 5 is a service-quality shortfall as perceived by the customer. The gaps are described as follows:

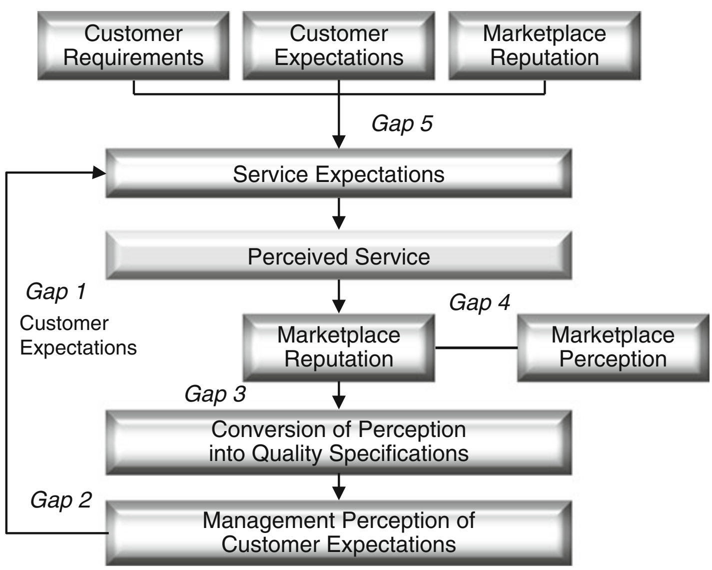


FIGURE 10.14 Service quality model.

Gap 1: Customer expectations and management perception. Perhaps the most fundamental service gap is the variance between what customers expect from products and services and what management thinks are customers' expectations. Normally, there is close congruence between expectations and perceptions. However, management might not always be completely aware of which service attributes constitute high priorities for customers. In addition, even when key attributes are identified, it might be difficult to quantify what exactly is the expected level of service. The *external audit* should provide service managers with a way of narrowing this gap by revealing accurate information about customer's expectations. As an illustration, a company may feel their customers buy because of low price, when, in reality, it is product delivery that is driving expectations.

Gap 2: Management perception and service-quality specification. Although service managers might correctly perceive customer expectations, a gap can occur when a firm experiences difficulty translating those expectations into service-quality metrics. These difficulties usual result in the adoption of superficial or ill-defined standards. Sometimes managers believe, because of the nature of the product and support, that it is simply impossible to set service levels that match customer expectations. The most frustrating form of service-quality gap occurs when there are clear service standards, but management is not committed to enforcing them. For example, a firm pledges timely field support for a product but does not hire sufficient staff to meet presales pledges, and then does nothing to remedy the service deficiency.

Gap 3: Service quality specifications and service delivery. Even when firms develop detailed quality-service standards and programs for creating a *customer-centric organization*, service leadership is not a certainty. A gap may exist and continue to widen because of poorly trained customer-contact personnel, ineffective service-support systems, insufficient capacity, and contradictory performance measurements. When service delivery quality falls short of the standard, the result has a direct impact on what customer can expect (Gap 5).

Gap 4: Service delivery and external communications. A fundamental component shaping customer expectations is service quality standards detailed in advertising media, promised by the sales force, and found in other communications. Take, for instance, a distributor that publishes a 24-h order turnaround time but lacks the information systems for effective inventory accuracy and fulfillment to meet that objective. When the customer is told and expects next-day delivery and does not get it, the gap begins to widen between what sales tells the customer and what logistics can deliver.

Gap 5: Perceived and expected service. The discrepancy between perceived and expected services is detailed in Gap 5. The content of this gap is gathered from the cumulative shortfalls found in each of the first four enterprise gaps. Determining this discrepancy is more than just totaling the metrics of Gaps 1–4; often the cumulative effect on customer perceptions of service delivery are greater than the sum of the parts. The source of customer service expectations is found in word-of-mouth communications, past experiences, social media, and customer requirements.

Metrics illuminating performance gaps provide the supply chain with a clear understanding of the level of current performance as opposed to customer expectations. Once these gaps are quantified, management can develop an effective services strategy that focuses the organization on continuous incremental improvements in processes and operational performance.

Step 6—Determining service/cost relationships

Before service organizations begin the process of closing service gaps, an analysis of *service/cost relationships* is performed. In this step, not only the actual cost of selling to and servicing the customer but also the incremental cost of reaching the next level of service is determined. Classically, it is assumed that as sales and market penetration increases, the cost to maintain optimum service levels also increases. As Figure 10.15 illustrates, companies often attempted to chart expected sales revenues and the cost of services and to calculate the optimum service level. The optimum service level at a minimum balances sales increases with cost increases. For example, consider the effect of higher sales on transportation. As sales increase, the costs for inbound, inter-plant, inter-distribution center, and outbound transportation will according increase. By combining the increased costs for facilities, carrying inventory, transportation, administration/overheads, information technology, and operations costs, service managers can compute the cost trade-offs between higher sales and higher costs.

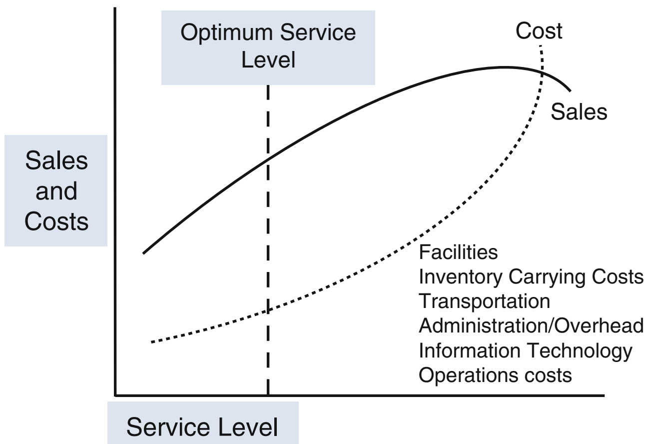


FIGURE 10.15 Charting the cost of service levels.

Exercise 10.3: Service Factor and Fill Rates for a Safety Stock Policy [27]

The service managers at ABC Electronics have been assigned the task of determining the trade-off cost of increasing the customer service level and fill rate and the effect on inventory cost for a top-selling item. Increasing service and fill levels will result in an increase of safety stock (and inventory cost). Currently, sales is experiencing, on average, a shortage of about 7 units during the replenishment cycle (2 week lead time) and the customer service level is at 96.5 %. Management would like to achieve a 99 % customer service rate and a decrease in replenishment cycle shortages. After item history review, customer service gathered the following information:

Average demand/units per week	1,500
Lead time/weeks	2
Mean demand during lead time/units	3,000
SD of demand per week	350
SD of demand during lead time	495
Replenishment lot size/units	5,000
Customer service percent	96.5 %
Unit cost	$50.00

The first step in the process is calculating the safety stock and reorder point.

1. Demand (D) during the lead time (L) = 1,500 units × 2 weeks = 3,000 units.
2. Safety stock = *CSL* safety factor × σL = *NORMSINV*(.965) × 495 = 896.9 units.
3. Reorder point = *DL* + *SS* = 3,000 + 896.9 = 3,896.9 units.
4. Safety stock cost = Unit cost × *SS* = US$50 × 896.9 units = US$44,842.50.

The next step is to calculate the fill rate by subtracting the replenishment cycle shortage from the replenishment order quantity and then dividing this value by the replenishment order quantity, or 5,000 units – 7 units/5,000 units = .9986. In other words, 99.86 % of demand is filled during the 3 week replenishment lead time.

If the target 99 % customer service rate is achieved, the safety inventory would have to be increased from 896.9 units to 1,151.5, or *NORMSINV*(.99) × 495 = 1,151.5 units. If this level of service was achieved, replenishment cycle shortages would drop to less than 2 or 1,151.5[1 – NORMDIST(1,151.5/495, 0, 1, 1)] + 495 NORMDIST(1,151.5/495, 0, 1, 0) = 1.68 shortages. However, to achieve this level will cost an extra US$12,731.67 (US $57,574.17 – US$44,842.50). Service managers would have to weigh the value of the trade-off of extra inventory cost to increase both fill rate and customer service levels.

When performing service-cost trade-off analyses, service managers must strive not to fall into the fatal attitude of "we win, the customer loses." Regrettably, many a service program devised from cost trade-offs has resulted in a justification for low expectations and performance. In reality, management techniques, such as lean improvement and enabling technologies, actually increase the velocity and flexibility of customer services while slashing costs imbedded in excess inventories, order management cycle times, and order shortages. The goal of service-cost trade-off analysis, therefore, is not to look for ways to optimize service costs at the expense of customer satisfaction but rather to rank and prioritize competitive service attributes and continuously refocus service resources to improve each service element. Service leaders seek continuous improvement in cost, quality, response time, and flexibility simultaneously.

Step 7—Identify CSM technologies

An important step in developing world-class CSM functions is selecting the optimal information technologies. Over the past few years, CSM has evolved from banks of service reps connected to the customer by phone and fax, to highly automated service centers. CSM leverages technologies to activate open dialogues with the customer that are *personalized*, in that they are capable of responding to individual customer concerns; *self-activating,* in that they provide applications for customers to self-service their questions; with *immediacy*, in that critical information is conveyed in real time; and *intimate,* in that customers truly feel suppliers are concerned about their needs and problems. When developing the technology element of the CSM strategy, today's service departments utilize the following toolsets:

- *Automatic call distribution* (ACD). This technology provides for the automatic routing of incoming customer calls to the proper service resources based on call content. ACD seeks to minimize service call wait and queues by automatically switching a call to an open resource, matching call content with service rep expertise, and even prioritizing the call by level of severity or service contract.
- *Interactive voice response* (IVR). This toolsets enables customers 24 × 7 × 365 service access by typing the appropriate keys on a telephone. The goal is to provide

access to service information or to qualify and route a call without human interaction. More advanced applications provide automated speech recognition whereby customers can verbally communicate their questions without cumbersome typing of keypad digits.

- *Internet call management*. The use of Web-based self-service has enabled customers to escape from the tedious entry of data characteristic of IVR systems. The advantage of Web-activated service is that customers enjoy a significant level of self-driven interaction with the service system. Also customers can access proactively a wide range of services ranging from order status tracking to new product introduction to on-line chat forums.
- *Service cyberagents, bots, and avatars*. While mostly futuristic, the use of intelligent agents capable of performing automated service tasks is expected to expand dramatically. The goal is to equip these tools with specific expertise, instructability, simplified reasoning, and the capability to work with other cyberagents in solving service questions.
- *Call center analytics*. Effective CSM requires a holistic view of the customer. While CRM analytics focus on tracking the marketing side of the customer, the capability to record and analyze the vast amount of service-related data from each customer is essential for CSM leadership. Analytical data assists in the selection of the appropriate CSM technologies, the overall corporate service strategy, and the level and type of individualized service provided to each customer.

The power of the customer and enhancements in technologies have transformed the traditional scope and mission of customer service. Until just recently, customer service was considered as purely a cost center and a drain on profitability. In contrast, today's customer service function is seen as absolutely critical in cementing customer loyalties and assuring maximum value.

Step 8—Implement the CSM strategy

In order to achieve superior customer service performance, the firm must do more than establish service goals and identify the service gaps. In step 8 of the CSM model, service managers develop and implement an effective service management strategy. Service leadership in the Internet Age means that companies be concerned with the success of all supply chain service processes and not just with internal success. Strategies must be architected that are in alignment not only with internal business goals and objectives but also with the goals of the entire supply chain. Perhaps the most effective customer service strategy is one that integrates and facilitates the four major groups (Figure 10.16) impacting the external and internal functions of the enterprise. These groups are the customer, the firm's shareholders, the employee, and the supplier channel.

The *customer* has by far the greatest impact on service strategy development. Servicing their requirements is why the supply chain exists; revenues from their purchases are the central growth variable; and their feedback is the only true voice guiding product and service direction. The customer side of implementing an effective service strategy focuses on the following key questions:

- *Customer/channel relationship*. What are the current levels of communications and expectations between the customer and the supply chain? Have customer product and service requirements been clearly communicated, and what mechanisms are in place

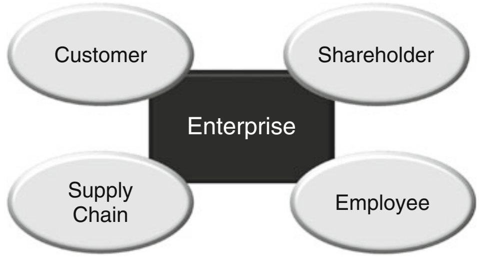


FIGURE 10.16 Supply chain service groups.

to ensure effective and timely feedback? Has the supply chain established a product and services value proposition that is fully compatible with network capabilities, limitations, and customer expectations?

- *Product strategy*. What is the product unit-cost strategy? Are channel partners to concentrate on low-margin or high full-stream cost or a mixed strategy? Is the product unique or is it interchangeable? Is the supply chain offering standard or customized products or a combination of both? What kind of packaging is used?
- *Services strategy*. What services are to accompany the product in the presales and post-sales cycles? What are the response and mean-time to resolution performance targets? What are the return, warranty, and field service policies?
- *Merchandising strategy*. How are products to be marketed to the customer? Is the focus to be on a direct sales force, catalogs, or other contact mediums? How are marketing tools such as promotions, deals, and special pricing to be communicated to the customer? Does demand have seasonality or trends, or is it stable for a given period of time? What are the parameters of the order processing function? Are computerized methods such as Internet, EDI, direct contact, telemarketing, social networking, mobile technologies or other forms to be used, and what are the service performance standards? What are the expected sales volumes per year, and is the supply chain focusing predominantly on long-term customer relationships or is it purely transaction based?
- *Delivery and order requirements*. What are the standards for order response times (hours, days, weeks)? What is the cost of a stock out? What are the limits on order quantities, and how are transportation systems to be used for delivery?
- *Material handling*. What are the handling and storage requirements of the product? Is the product a discrete unit, liquid, or handled in bulk?
- *Stocking requirements*. What should be the scope and structure of the distribution channel? Are products and services to be delivered from a central facility, clustered in specific geographical areas, or scattered to leverage logistics economies?

Right behind the customer, the firm's *shareholders* are also important in the formulation of the service strategy. In a very real sense, this group influences the vision and mission statement of each channel partner. Shareholder objectives must be in alignment with and supportive of the objectives set forth in the services strategy. For the most part, shareholders acknowledge their secondary role in the enterprise behind the customer. Conflict arises when this group begins to pursue goals antipodal to marketplace requirements. The solution is to respond to shareholders as if they were also customers. Instead of goods and services, shareholders require sufficient return on investment, evidence of continued progress and growth, and definition of marketplace expectations. In return, the enterprise can expect continued support for products and programs. The same operational strategies calling for continued incremental improvements in product and service quality need to be applied as well to the supplier-shareholder relationship.

"World-class" CSM also views the *employee* as a customer. In the traditional organization, divided by departmental budgets, narrow job descriptions, procedures, and performance measurements, the vision of the employee as a customer is lost. Not only are such organizations chronically out of alignment with the customer, but they ignore both the creative abilities and needs of the firm's *internal* customer. To begin with, employee satisfaction should be seen as an objective as important as customer satisfaction. This satisfaction is attained by streamlining work-flows and mandating internal performance measurements that support the firm's dedication to continuous improvement. Second, employee potential is enabled when management provides ongoing training and an atmosphere designed to promote self-empowerment. The company-employee relationship that emerges is defined on one side by management commitment and a clear enunciation of expectations and performance objectives; in turn, employees must be prepared to exercise and expand their skills and contribute to superior service quality through continuous learning. As work centered on narrow tasks and command and compliance management styles give way to multidimensional focused teams responsible for performing whole processes, the nature of work becomes more value-added, self-directing, and satisfying. In such an environment, success is measured by the extent to which the entire organization meets the needs and expectations of their internal as well as external customers.

The final component of the overall service strategy involves the level of service found between the firm and its *supplier chain*. The quality of products and services received from the supplier has a direct impact on a company's ability to respond to the needs and expectations of its customers. If supplier product and service functions contain unacceptable performance gaps, the firm cannot help but respond by passing on the excess costs, lack of quality, and poor service to its customers. On the other hand, a superior supplier enables the firm to jump-start and sustain continuous improvement initiatives that are then communicated to the customer. When viewed as the customer, companies should provide suppliers with a clear statement of product and service expectations; search to remove redundancies in material movement, delivery, and paperwork; and implement ongoing improvements designed to eliminate costs. On their part suppliers should provide a preview of new product development, participate in design, and open a window into new market opportunities and trends. Effective supplier partnerships provides a synergy whereby both parties enjoy a level of quality, performance, and continuous improvement unattainable by each working independently.

Step 9—CSM Performance Measurements

The last step in managing customer service is ongoing service performance measurement. Just reviewing the opinions and expectations of the customer once a year will hardly provide the kind of metrics necessary for effective service management: there must be flexible and comprehensive measurement tools in place that provide detailed information on an ongoing basis and that change as marketplace conditions change. Once the means to gauge service performance is formalized, the results are measured against standards and corrective action taken to eliminate variances.

Effective customer service measurement involves implementing programs that measure *both* internal and external metrics (Table 10.1) [28]. Three general areas of measurement are used: process measurements, product measurements, and satisfaction measurements. *Process measurements* are the most common measurements employed. Measurements, such as customer complaint statistics, billing adjustments, profit margins, productivity-to-cost ratios, order cycle time, timeliness, and others, provide metrics detailing the performance by which a product or service is delivered. *Product measurements* are concerned with how well a product or service conforms to design and quality specifications. Such metrics as failure rate, service frequency, design, packaging, ease of use, and attractiveness provide the core for this set of measurements. *Satisfaction measurements* utilize data directly from feedback concerning customers' perceptions of product quality and service. Analysis of complaints, focus groups, toll-free telephone lines, customer comment cards, social networking communities, and management visits are all geared toward gathering metrics relating to performance satisfaction. The collective goal of the three techniques is to ensure that the objectives embodied in the firm's customer value-creation strategies do, indeed, match the expectations of the customer base.

TABLE 10.1. CSM Performance Measurements

Measurement	Description
Order fill rate (by item)	Rate at which order lines are filled at point of sale
Order accuracy (by order)	Rate at which order items are accurately filled and delivered to the customer
On-time delivery	Rate at which orders are delivered to the customer at the committed time based on customer's expectations
Total order cycle time	Elapsed time from order receipt to product delivery based on customer's expectations
Response to emergency requirements	Time required to respond to and satisfy unplanned and unforeseen customer needs
Damaged goods	Level of damaged to delivered products during transit or installation
Inventory distance to customer	Geographical proximity of the supplier to the customer in time and distance driving speed of response and on-time delivery
Inventory availability	On-demand availability of inventory for immediate orders
Order completeness (line items and quantities)	Degree to which delivery to the customer satisfies order requirements of time and item quantity.
Customer access to inventory/order status	Ability of the customer to view supplier's inventory and/or order status
Response to customer complaints/issues	Quality and time response required to recover adequately from complaint to satisfaction
Packaging convenience	Function, features, information, and quantities of packaging needed for ease of shipment, receipt, storage, and use

Developing effective service performance measurements begins by identifying those *key service attributes* desired the most by the customer and are being offered by the competition.

The *service attribute matrix* discussed earlier is used to prioritize these attributes so that management attention is focused on service strengths and weaknesses. Although important, formal service metrics are not the sole source of measuring service performance. Informal feedback, face-to-face communications, and on-the-spot data collection all provide sources of meaningful customer opinion. Another key source of service-quality is information attained from customer complaints. In studies carried out by the United States Office of Consumer Affairs, it has been proven that the average business never hears from 96 % of those customers dissatisfied with the quality of the products and services they received. In addition, out of those customers who are unhappy, 90 % will simply stop buying from particular suppliers, never telling them the source of dissatisfaction. Such a high statistic means that the CSM function must not just wait for the customer to complain but take active steps from site visits to ongoing questionnaires to ascertain the level of customer satisfaction.

Finally, service performance must also be measured by the satisfaction of the *internal* customer. Such metrics as supplier on-time delivery and quality, the speed by which information and data moves through internal systems, the on-time completion of internal due dates, the elimination of useless procedural red tape, the level of employee proficiency for problem solving, asset utilization, and others must be constantly monitored and steps taken to eliminate performance shortfalls. A comprehensive service strategy creates a total quality service attitude that enables the entire supply chain to better sell their products and services, deliver them faster and cheaper, respond quicker to serious service-quality gaps, develop service systems that are responsive to customer needs, provide timely performance metrics, and attract and keep service-oriented professionals who are dedicated to excellence and ongoing improvement.

10.5 SUMMARY

The changes brought about by the globalization of the marketplace, the spread of Internet technologies, and requirements for high-quality products and value-added services have forced supply chains to reexamine their traditional attitudes toward customer service. In the past, market share was gained by expanding business capacities, introducing new products, and decreasing product cycle times. Today, the search for competitive advantage entails a broadening of this strategy to include a philosophy of continuous customer service improvement dedicated to increasing quality and productivity and the adoption of information tools that enable the firm to respond quickly to on-going changes in customer requirements. “World-class” performers are tireless in their examination of every aspect of their firm’s operations in search of untapped sources of quality and customer satisfaction. Activating such a vision means that the enterprise must constantly measure customer perceptions of service quality, identify service shortfalls, and respond to service gaps. Once these gaps are quantified, management can begin to redesign organizational and value structures, refocusing them on continuous incremental improvements in service performance. Service leaders see quality as one of the fundamental building blocks of market dominance, set levels of service that exceed their customer’s expectations and surpass the standards set by the competition, have an action-oriented attitude focused on teamwork and commitment to excellence, and are ceaseless in their endeavor to satisfy the customer at all costs.

Superior customer service also requires order promising functions that provide for the speedy and accurate transference of goods, services, and order information. Order management is the primary contact between customers and suppliers. It serves as the gateway into the way orders are placed and priced, how inventory is allocated and tracked to orders, and how goods and services are delivered to the customer. It can also be argued that the requirements of high velocity response driven by the Internet, mobile technologies, and social networking necessitate that the scope of order management be expanded to encompass not only the demand on individual enterprises, but also how that demand impacts the customer service capabilities of the entire supply chain.

The customer order management process begins with the maintenance of the database elements necessary for timely and accurate order processing. Accurate customer master, pricing, and inventory files are absolutely critical for the second step in the order management process: executing the sales order processing cycle. This cycle consists of three separate but integrated activities: order receipt and entry, inventory allocation and picking, and order shipment and invoicing. The third step in the customer order management is monitoring order status. The open order file provides customer service with a window into order ship dates, backorders, and inventory quantities so that order priorities can be maintained. Once the order has been shipped, computer displays and reporting assists customer service in tracking order delivery and quality-related issues. Finally, the last step in the order management process is defining and maintaining performance measurements.

The rise of Internet commerce has recently provided fresh challenges to customer service management. Today's Web-enabled applications offer companies radically new approaches to generate customer value participation, and collaboration; facilitate the sales process; enhance customer service capabilities; and architect highly integrated, customer-centric infrastructures. For customers, Internet-enabled applications provide radically simple, self-directed tools for browsing and locating suppliers and their products, as well as simplifying order entry and open-order inquiry. For suppliers, Web applications enable direct sales to the end-customer, thereby by-passing costly channel intermediaries. Further, because demand is placed in the system in real-time, suppliers have enhanced visibility to improve the effectiveness and use of resources. In the suite of CRM applications is found sales force automation tools, new forms of Internet-based marketing capabilities, and communications tools that deepen customer partnership management.

DISCUSSION QUESTIONS

1. This chapter refers to a “revolution” in customer management. What does this mean?
2. In the supply chain, there are multiple customers. Detail who these customers are?
3. Today’s customer has a different view of what provides value. How do you define this new sense of customer value?
4. How does a lifetime customer create value for the supply chain?
5. Define *customer experience management* (CEM).
6. Discuss the impact of Internet technologies on customer management.
7. What are the characteristics of customer relationship management (CRM)?
8. The objectives and operations of CRM and CEM have been compared to the two parts of the brain. Describe what this analogy refers to.
9. What are the five critical attributes of effective customer order management?
10. List and describe the 10 customer service attributes.

REFERENCES

1. Shaw, Arch W. 1915. *Some problems in market distribution*, 41–44. Cambridge: Harvard University Press.
2. This phrase was coined by Larry Seldin and Geoffrey Covin in their book *Angel customers and demon customers, 7*. New York: Portfolio, 2003.
3. All definitions from the *APICS Dictionary* used in this chapter are from the 14th edition, 2013.
4. For further discussion relating to channel systems see in Rangan, V. Kasturi. 2006. *Transforming your go-to-market strategy: The three disciplines of channel management*, 90–91. Boston: Harvard Business School Press; Ross, David Frederick. 2008. *The intimate supply chain: Leveraging the supply chain to manage the customer experience*, 1–22. Boca Raton: CRC Press; and Selland, Chris. 2004. Sell-side channel management. Aberdeen Group White Paper, September.
5. Peppers, Don, and Martha Rogers. 2005. *Return on customer: Creating maximum value from your scarcest resource*, 72. New York: Currency/Doubleday.
6. Authoritative discussions of the LCV metric can be found in Kotler, Philip, and Kevin Lane Keller. 2006. *Marketing management*, 12th ed, 148–152. Upper Saddle River: Prentice-Hall; Peppers and Rogers, 221–227, and Greenberg, Paul. 2004. *CRM at the speed of light: Essential customer strategies for the 21st century,* 3rd ed, 655–662. New York: McGraw Hill.
7. Kotler and Keller, 149.
8. Parts of this section have been adapted from Ross, *The intimate supply chain*, 11–21.
9. These points have been summarized from Gupta, Sunil, and Donald R. Lehmann. 2005. *Managing customers as investments: The strategic value of customers in the long run*, 115–121. Upper Saddle River: Wharton School Publishing.
10. Thompson, Bob. 2006. Customer experience management: Accelerating business performance. CRMguru.com White Paper, June, 2.
11. Womack, James P., and Daniel T. Jones. 2005. *Lean solutions: How companies and customers can create value and wealth together*, 9–17. New York: Free Press.
12. The role of chief customer officer has its own website and membership. The website address is www.chiefcustomerofficier.com (accessed February 2014). The definition is found on the website.
13. Greenberg, Paul. 2001. *CRM at the speed of light: Capturing and keeping customers in internet real time*, xviii. Berkley: McGraw-Hill. Greenberg also devotes 33 pages of his first chapter to detailing a variety of comprehensive definitions. In his 4th edition of *CRM at the speed of light* (New York: McGraw-Hill, 2010) Green defines CRM as “a philosophy and a business strategy supported by a system and a technology designed to improve human interactions in a business environment.”
14. Dyche, Jill. 2002. *The CRM handbook: A business guide to customer relationship management*, 4. Boston: Addison-Wesley.
15. Sawhney, Mohan, and Jeff Zabin. 2001. *The seven steps to nirvana: Strategic insights into e-business transformation*, 175–181. New York: McGraw-Hill have been most helpful in writing the above two paragraphs.
16. Rossi, Ben. CRM Will Be at the Heart of Digital Initiatives for Years to Come. http://www.information-age.com/industry/software/123457714/crm-will-be-heart-digital-initiatives-years-come-gartner#sthash.Uhi8GWJR.dpuf. Accessed February 2014.
17. Dyche, p. 85.
18. Greenberg, *CRM at light speed,* 3rd ed, pp. 52–64.
19. Editor. 2013. “In customer relationship management, you must adapt to stay relevant” *SupplyChainBrain* 17(1): 56. January/February.

20. Peerless Research Group. 2013. Aligning order and fulfillment channels. *White Paper*, June, 3. There were actually 13 issues identified. Figure 10.7 is an abstract of the top 6 issues.
21. The classic view of the order cycle is found in LaLonde, Bernard, and Paul H. Zinszer. 1976. *Customer service: Meaning and measurement,* 272–282. Chicago: National Council of Physical Distribution Management.
22. These barriers are cited in Wang, Ray. 2009. 20 steps to delivering the perfect order. *Forester White Paper,* March, 2–3.
23. LaLone and Zinszer, pp. 272–282.
24. Zeithaml, Valerie A., A. Parasuraman, and Leonard L. Berry. 1990. *Delivering quality service*, 20–23. New York: The Free Press and Zeithaml, Valerie A., A. Parasuraman, and Leonard L. Berry. 1985. A conceptual model of service quality and its implications for future research. *Journal of Marketing* Fall: 41–50.
25. Gopal, Christopher, and Gerard Cahill. 1992. *Logistics in manufacturing*, 127–162. Homewood: Business One Irwin.
26. Zeithaml, V.A., A. Parasuraman, and L.L. Berry, *Delivering quality service,* pp. 9–13.
27. This exercise is based on the example in Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operation*, 4th ed, 294–295. New York: Prentice Hall.
28. This list is based on the list in Gopal and Cahill, 143–145 and the SCOR® Reference Model.

11

Procurement and Supplier Management

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_11) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_11,

Without much argument, it can be said that the procurement function is an essential function found at the core of all organizations. The acquisition of materials, components, finished goods, service inventories, and support services is a fundamental activity found in all industries. Effectively designed and executed procurement processes provide several direct advantages. To begin with, procurement plays a fundamental role in actualizing business and operations planning objectives concerning production, supply chain delivery, flexibility, quality, and costs. Second, the sheer financial impact of procurement directly affects the financial stability and profitability of virtually every trading partner in the supply channel. Depending on the nature of the business, procurement costs alone range from 40 % to over 70 % of each sales dollar. Third, the efficiency of procurement has a direct influence on the capability of the business and the entire supply chain to respond effectively to marketplace demand. Because of its significant impact on revenues, costs, and operational efficiencies, procurement is a key enabler of supply chain strategy.

Finally, effective procurement requires the structuring of strong supply chain partnerships. With the rise of Internet-driven tools opening dramatically new vistas for sourcing, cost management, concurrent product development, quality, and delivery, the need for close, highly integrated relationships between buyers and suppliers has expanded concomitantly. In fact, the confluence of these trends has revolutionized past concepts and practices of supplier relationships and transformed it into a new science: *supplier relationship management* (SRM). In today's fast past environment, academics, consultants, and practitioners understand that while high quality and low cost are critical, it is the relationship that exists between buyer and seller that determines the real value-added component of procurement. The closer the demands of the customer and the capabilities of suppliers are synchronized, the more total costs decline, the more agile suppliers become to meet complex demands, and the faster inventory moves through the channel pipeline. In addition, the more integrated the supply chain, the more channel partners can truly fashion collaborative partnerships where core competencies are merged to generate a common competitive vision.

Chapter 11 focuses on the procurement and supplier management functions found in today's supply chain environment. The chapter begins by defining the role of the purchasing function, purchasing responsibilities, organizational structure, ongoing operational objectives, and requirements to successfully leverage supplier relationship management (SRM). After a detailed discussion of the steps necessary to architect effective procurement and SRM strategies, the chapter proceeds to outline the purchase order management process. The elements of the procurement process—assuring database accuracy, understanding the purchase order processing cycle, transportation decisions, receiving and order closeout, and status reporting activities—are then reviewed in detail. Next, the role of performance measurement in charting the effectiveness and efficiency of suppliers and of the purchasing function is discussed. The chapter concludes with an in depth analysis of the impact of e-business tools on purchasing. e-Sourcing, e-procurement, and types of e-marketplace B2B exchanges are in turn examined.

11.1 DEFINING THE PROCUREMENT FUNCTION

In the past, purchasing was regarded as a clerical or low-level management activity charged with the responsibility of sourcing and acquiring goods and services for other departments of the organization. The primary role of purchasing was to acquire the resources and services needed by the enterprise at the lowest possible price. Today, this concept of the purchasing function is obsolete. With its emphasis on total cost reduction and buyer-supplier relationship building, purchasing has become an important strategic function. This new focus is illustrated in the substitution of the term *procurement* for the traditional purchasing to emphasize its growing strategic role in the supply chain. Despite the distinction, the terms "purchasing" and "procurement" are often used interchangeably in today's business vocabulary.

11.1.1 Defining Purchasing

According to *The Purchasing Handbook*, purchasing is defined as

> the body of integrated activities that focuses on the purchasing of materials, supplies, and services needed to reach organizational goals. In a narrow sense, purchasing describes the process of buying; in a broader context, purchasing involves determining the need; selecting the supplier; arriving at the appropriate price, terms and conditions; issuing the contract or order; and following up to ensure delivery. [1]

There are several key concepts implied in this definition:

- *Purchasing is a business function*. The effective and efficient management of the acquisition of goods and services is a science and is the responsibility of professionals trained and certified in purchasing.
- *Purchasing is about the acquisition of goods and services*. Just about all departments in the organization purchase goods and services. Some of the purchases are consumed within the organization and are not for resale. Most of the materials purchased in the typical manufacturing organization, however, are used in production or the acquisition of finished goods ultimately ending with sale to the customer.
- *Purchasing is about developing close supplier relationships*. The objective of supplier management is the establishment of collaborative partnerships focused on information sharing, long-term commitment to quality, mutually shared benefits, and joint participation in product design and specification.
- *Purchasing is about the close review of purchasing and supplier performance*. A critical component of effective purchasing management is the measurement of purchase order and supplier performance. The goal is to maintain the highest levels of purchasing on-time delivery, product quality, low cost, and collaboration.

11.1.2 Categories of Purchasing

Broadly speaking, there are four types of purchasing: for consumption or conversion; for resale; for maintenance, repair, and operations functions (MRO); and for custom equipment and services.

- *Goods purchased for consumption or conversion*. Goods purchased in this category are the concern of industrial buyers and consist of raw materials, semi-finished, and finished components that are consumed or converted during the production process. These goods are rarely sold to customers. Raw materials include such items as petroleum, coal, wood, and various metals. Normally these products are purchased in bulk and by quality or grade. Components include subassemblies, assemblies, and information systems. Critical to this category are quality, cost and delivery objectives. Buyers are very active in all facets of the purchase process, including planning, researching, sourcing, pricing, order releasing, strategic planning, and supplier relationship building.

- *Goods purchased for resale*. Goods purchased in this category are classically the concern of distributors and retailers. Companies buying these types of goods act as intermediaries for the movement of inventory from the production source to another intermediary in the supply chain, a retailer, or the end-customer. Normally, purchasers in this area are not buying goods that require additional processing before being sold to the end-customer. In this category buyers determine what goods their customers want; search and buy these goods based on targeted levels of quality, delivery, quantity, and price; and sell them competitively based on price, quality, availability, and service.
- *Maintenance, Repair, and Operating* (MRO) *inventories and services*. Goods purchased in this category are used for general operating activities, repair, or services. Items in this category include general supplies, such as copy paper, pens, paper towels, and light bulbs; equipment repair parts; various forms of equipment; the contracting of services (equipment maintenance, education, cleaning services, and so on); and facility repair. Businesses using these types of goods include manufacturers, service businesses, institutions, utilities, and government. Purchasing this category of goods or service often requires a knowledgeable buyer, supplier search, detailed request for quotation, price negotiation, and a budget. Many of the goods purchased in this category are purchased only once or periodically.
- *Custom equipment and services*. Finally, purchasing is also responsible for the acquisition of specialty items and services. In this category are products that are specially designed or fabricated to meet specific needs. Custom-made machinery, storage and material handling equipment, and computerized information systems are some of the products in this category. Special services such as training, advertising, market research, and consulting services are also included. Because of their uniqueness and cost, purchasing usually begins with a requirements definition and proceeds through request for quote (RFQ) and a proposed budget that must be approved by company management before purchasing activities begin. Once approved, it is purchasing's responsibility to support and oversee project development, collaborate with the supplier to assist in specification definition and issue solution, serve as the intermediary between technical personnel and suppliers, and execute the actual purchase order process.

11.1.3 Purchasing Responsibilities

Before any meaningful discussion on purchasing begins, the responsibilities, objectives, and organizational structure of the purchasing function needs to be examined.

11.1.3.1 Responsibilities of Purchasing

While the buying of goods and services is its central function, the responsibilities of purchasing have been expanding over the past several decades [2]. These responsibilities have increased as product outsourcing, globalization, and supplier networking and collaboration have grown in importance. The functions of purchasing encompass a multitude of activities. These functions are arranged below, starting with activities of strategic importance and then progressing to those performed on a daily basis.

- *Supply chain management.* As today's supply chain becomes much more complex and time-sensitive, the purchase and delivery of goods and services has correspondingly become much more important and therefore of higher risk. Managing this risk requires purchasers to assume responsibility for the development and management of the business's total supply system. Purchasers expect to closely link purchasing capabilities with the plans and requirements of other departments within the firm as well as with the capacities of supply channel partners.
- *Materials management.* The purchasing function has long been responsible for activities associated with the receipt, transportation, scheduling and planning, and warehousing of purchased materials. In most organizations purchasing is folded into the materials management function. This enables materials management to closely integrate requirements for purchasing, planning, inventory control, and inbound transportation into a single, integrated department.
- *Sourcing.* This high value-added activity is concerned with matching purchasing requirements with sources of supply, ensuring continuity of supply, exploring alternative sources of supply, and validating supplier compliance to ensure goods and services meet or exceed buyer criteria for quality, delivery, quantity, and price. For the past decade, a critical component of sourcing has been reducing needless redundancies in the supplier base and increasing supplier collaborative partnering.
- *Value analysis.* This set of functions is concerned with increasing the value-added elements of the purchasing process. Value analysis consists of such components as price for quality received, financing, and delivery. An example is identifying less expensive goods and services used as substitutes at comparable quality and value.
- *Supplier development.* In today's environment, increasing collaboration with suppliers is a requirement for doing business. Pursuing capabilities that promote supplier partnering require buyers to be knowledgeable of supplier culture, capacities, resources, product lines, delivery, and information system interoperability. A key component in the strengthening of this partnership is the development of pricing, promotion, technology, information-sharing, and financial settlement agreements that network supplier and buyer and provide for a continuous "win-win" environment.
- *Internal integration.* Purchasing needs to be closely integrated with other enterprise business areas, such as marketing, sales, inventory planning, transportation, and quality management. By providing key information and streamlining the acquisition process, the purchasing function assists the enterprise to synchronize replenishment requirements with the overall capacities of the supply network. Buyers should also be members of product marketing, research, and engineering development teams if the proper inventory at the best quality, delivery, and cost is to be purchased.
- *Supplier scheduling.* One of the keys to effective purchasing is the development of a valid schedule of inventory replenishment. By sharing the schedule of demand from MRP, reorder point (ROP), and distribution requirements planning (DRP) techniques, purchasing provides detailed visibility of future company requirements to supply chain partners, who, in turn, can plan the necessary material and capacity resources to support their customer's replenishment schedules. In addition, the increased use of

purchasing portals and B2B marketplaces have dramatically expanded buyers' ability to search anywhere in the world for sources to meet product and service replenishment needs.

- *Contracting*. Critical functions in this area are the development and analysis of *request for quotation* (RFQ); negotiation when pricing, volume, length of contract time, or specific designs or specifications are significant issues; and supplier selection and monitoring of performance measurements.
- *Cost management*. A critical function of purchasing is the continuous search for ways to reduce administrative costs, purchase prices, and inventory carrying costs while increasing value. Improvement activities include purchase cost reduction programs, price change management programs, volume and "stockless" purchasing contracts, cash-flow forecasting, and strategic planning.
- *Purchasing and Receiving*. These purchasing responsibilities include every-day purchasing activities associated with order preparation, order entry, order transmission, status reporting, receiving, quantity checking and stock put away, invoice and discount review, and order closeout.
- *Performance measurement*. Monitoring the quality and delivery performance of suppliers is an integral part of supplier "benchmarking." The ability to measure performance is critical when evaluating the capabilities of competing suppliers and ensuring that costs, delivery, and collaborative targets are being attained.

11.1.4 Objectives of Purchasing

The simplest response to the question "What is the objective of purchasing?" is obtaining the right products or services, at the right time, in the right quantities, delivered to the right place, at the right price with perfect quality. As is imagined from such a comprehensive answer, the buyer is faced with the task of pursuing not just one but a multitude of objectives, some of which are contradictory. Buyers are continually faced with the dichotomies arising from the often conflicting objectives of pursuing simultaneously optimal quality, service, and price. Rarely will all three elements be obtainable from a single supplier. Often a buyer must select a supplier based on balancing all three of these cost elements or *total cost*.

Although total cost management is perhaps the most fundamental ongoing activity of purchasing, there are several other key objectives.

- *Providing an uninterrupted flow of materials and services*. The foremost goal of the purchasing function is to ensure that the company is not hindered by inventory and service shortages. Shortages cause production downtime, generate excess costs for expediting, interrupt the normal flow of product and cash through the channel, and strain relations with customers on one end of the supply pipeline and suppliers on the other end. Just buying inventory and other resources, however, is not enough. Purchasers must also continually search for methods of increasing the velocity of the flow of goods and services through the supply channel without accompanying increases in carrying and transportation costs.
- *Purchasing products competitively*. This objective requires purchasers to continuously search for sources of supply that provide the best combination of quality, price, and service relative to the enterprise's needs. Pursuing this objective means that buyers are

conversant with the market forces of demand and supply that regulate prices and product availability. In addition, this objective requires purchasers to understand the cost dynamics of their suppliers, and then to negotiate quality, price, and service arrangements that achieve optimum value.

- *Keeping inventory investment to a minimum.* Although the first priority of the supply chain is to have products available to meet any customer requirement, the cost of maintaining large inventories can negate sales profits. Effective inventory management requires that purchasing does its part in achieving a reasonable balance between stocking levels and the cost of carrying inventory. In addition, purchasing significantly assists improvement teams in their efforts to reduce inventory loss due to spoilage, obsolescence, deterioration, and theft.
- *Developing the supplier base.* Reliable, quality-oriented suppliers are important company resources. Purchasers must continually search for ways to enhance supplier relationships by developing mutually beneficial value-added service, quality, and training programs that promote supplier partnerships. In addition, buyers need to continually search for and evaluate new suppliers. Performance measurements and periodic evaluations ensure that suppliers are maintaining quality and customer service response objectives.
- *Provide consistent, quality purchased materials and services.* Purchasing today requires buyers to explore all possible avenues to ensure product and service quality. In the past, purchasers spent their time calculating the trade-off costs between a desired quality level and the cost of acquiring it. The result was often low prices with accompanying poor quality that caused expensive customer returns, product rework, and lost customer confidence. Today, purchasers must bargain for nothing short of total product quality while searching for methods to reduce costs. Quality is maintained by such activities as the communication and continuous review with suppliers of specifications and products needed for production or resale and close conformance to delivery standards. Many purchasing departments require their suppliers to pass and maintain specific quality certifications. "World-class" procurement requires both the enterprise and the entire supply channel to implement lean tools for the elimination of material and operational wastes and to increase the flexibility of material acquisition and service response, while reducing transportation and non-value-added functions.
- *Developing people resources and information tools for productivity optimization.* As today's purchasing organization grows ever leaner, the need for team-based management styles grows proportionately. The continuous development and training of personnel at all levels in the purchasing function results in the creation of a professional staff prepared to shoulder the responsibilities of decentralized decision making, continuous search for improvement, and the acquisition of the technical knowledge required of "world-class" purchasing. In addition, the implementation of information systems that automate clerical functions and provide timely inventory, order, and cost status also greatly assists in achieving objectives focused on improving productivity and reducing costs [3].

One purchasing objective growing in importance is expanding the scope of supplier *value-added services*. The goal of this set of activities is to reduce wastes in ordering and delivery, and facilitate the flow of goods and information through the supply channel. Three critical flows are identified:

- *Product flow*. Accelerating the physical movement of goods from the supply source to the point of consumption.
- *Information flow*. Reducing redundancy in the transmission of critical information up and down the channel, such as demand schedules, market data, inventory supply levels, warranty and product information, product specifications and application information, and post-sales support.
- *Service flow*. Increasing value-added services that improve productivity and eliminate costs such as Internet order placement, advanced shipping notices, order status tracking, electronic transfer of payables and receivables, bar coding, packaging, and delivery.

The continuous development of supplier-enabled value-added services is one of the most important objectives of the purchasing function.

11.1.5 The Purchasing Organization

The ability to execute the functions of purchasing requires the establishment of an effective purchasing organization. The structure of purchasing is determined by how it is utilized by the rest of the organization. Companies that consider purchasing of fundamental importance to the success of the business view purchasing as a strategic advantage and provide it with high-level decision-making power. Conversely, in those companies that perceive purchasing as purely a tactical activity, it is treated as an administrative function without much of a strategic impact on the business. The relative position of purchasing in an organization is also revealed by its level of interaction with other business functions. Purchasing management normally is closely involved with other enterprise departments and is an integral part of the operational strategies of each of these business areas.

11.1.5.1 Purchasing's Role in the Organization

Each business determines what role the purchasing function plays in the organization [4]. In general, the higher the level of the purchasing function in the corporate structure, the greater the role it plays in supporting strategic objectives. Organizations can choose from three possible models as illustrated on Figure 11.1.

- *Executive level*. In this organizational structure, the purchasing executive is elevated to the role of vice president, reporting directly to the company president. In such an organization, purchasing is considered as constituting a strategic advantage. This type of structure, for example, is found in a high tech company that must constantly innovate and change products. Purchasing in such an environment is under tremendous pressure to work closely with product development personnel and suppliers, and is responsible for sourcing new parts and reducing costs. Another example is a business that faces very high costs for materials and purchased components, and thus requires close management control. In such business environments, an effectively run purchasing department is essential to strategic success.
- *Director level*. In this organizational structure, the purchasing executive is on the director level, reporting to the vice president of manufacturing or operations. In such

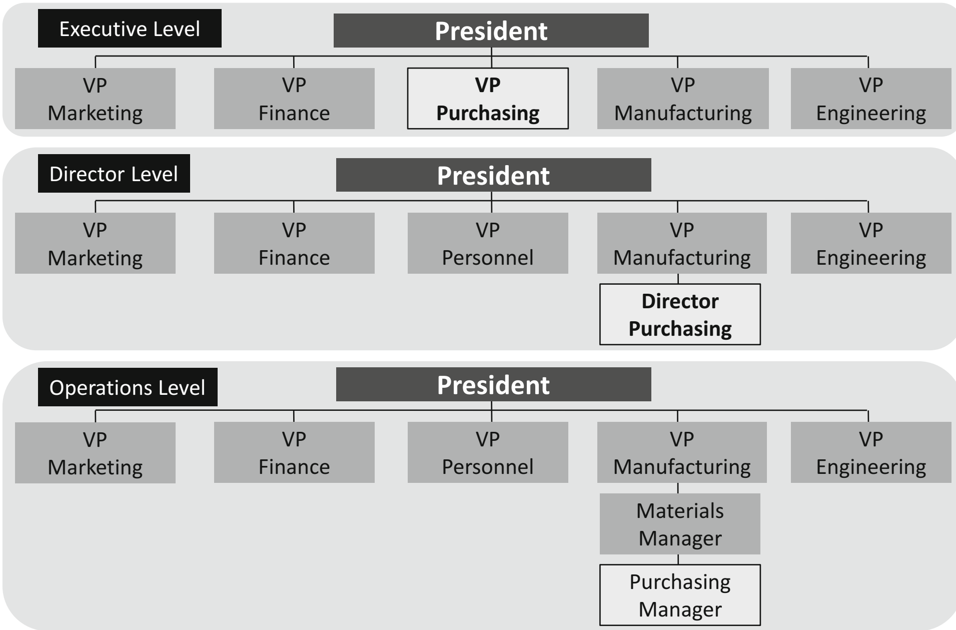


FIGURE 11.1 Purchasing place in the organization.

an organization, the purchasing function is considered of tactical importance. The purchasing department is normally large, with high volumes of activity, and staffed by trained and certified purchasing professionals. The purchasing function is fairly autonomous from materials management, planning, engineering and other departments. The purchasing strategy is part of the overall production and distribution strategy.

- *Operations level*. In this organizational structure the purchasing manager reports to the materials manager. Organizationally the purchasing function is considered as performing a clerical role, concerned with daily supplier sourcing, pricing, order release, and receiving. In such business environments, purchasing has only operational objectives and figures little in the formulation of corporate strategy.

Regardless of the level of its strategic role, purchasing is considered a central support function for the successful management of other company departmental functions. For example, purchasing assists engineering in the vital task of translating design materials and component specifications into actual sourcing and procurement requirements. Areas of cooperation include early supplier involvement in product design, establishment of quality levels, pricing, lot size calculations, and request for quote (RFQ) management. Other tasks include the sourcing and purchasing of equipment, materials, and services used for new product prototyping. Purchasing assists operations by ensuring the timely ordering and receipt of the materials and component inventories necessary to ensure smooth production flow through the manufacturing system. Purchasing planners must be capable of translating MRP outputs into actual purchase orders that satisfy lead times, reduce order expediting costs, and reduce shortages.

Purchasing assists marketing and sales by ensuring quality products are available so that customer orders are shipped on time and within budget. Purchasing is a party to the sales forecast and revenue projections. In a distribution environment, close cooperation between purchasing and sales is necessary to reduce sales-generated expediting, costly inbound shipments, and poor pricing. In a production environment purchasing is responsible for the efficient and timely support of operations to ensure production inventories are available. Purchasing supports finance by ensuring purchasing costs are within budget and support overall company profitability. On finance's side, prompt payment of accounts payable is a critical factor in the success of supplier relations.

11.1.5.2 The Purchasing Organization

Effective purchasing management requires an effective purchasing organization. The functions of the traditional purchasing department are divided into following five distinct activities.

1. *Management*. Managing the purchasing function involves a matrix of tasks and responsibilities. Foremost among these activities are developing and defining the content of operating procedures, developing the necessary planning and execution controls, and establishing the procedures for coordinating purchasing operations with other business functions.
2. *Buying*. The process of acquiring goods from suppliers involves such activities as defining procurement requirements, reviewing product specifications, supplier sourcing, performing value analysis, analyzing bids, negotiating, supplier selection, and purchase order release.
3. *Status Reporting and Expediting*. Follow-up of open orders is a fundamental function of purchasing. This involves activities such as supplier liaison, open order status tracking, supplier visits, and expediting late or emergency purchase orders.
4. *Research*. Often purchasing is required to investigate new avenues of supply or to buy products for special projects. Research activities include value analysis, economic and market studies, special cost analysis, sourcing, supplier certification, and systems research.
5. *Clerical*. Every purchasing department performs a number of clerical activities. These range from paperwork completion, filing, and purchasing database maintenance to purchase order release and price, receipt, quality tracking, and accounts payable preparation.

The objective in structuring an effective purchasing organization is to focus on those activities that add value to the purchasing process while eliminating those that add cost. For example, roles concerned with sourcing products and supplier development are value-added; expediting and clerical administrative activities, on the other hand, do not add value to the company and should be kept to the bare minimum, if not eliminated altogether. Classically, the structure of the purchasing function consists of four levels as illustrated in Figure 11.2.

On the first level of the organization is found the *purchasing manager*. Recently this role has been termed *chief procurement officer* (CPO). The scope of the CPO's responsibilities are determined by procurement's overall role in the organization [5]. Organizationally, it is the responsibility of this individual to align the goals of the department with the business plan, act as liaison to the other business departments in the firm, participate in the sales and operations planning (S&OP) meetings, formulate and review performance measurements, develop the purchasing staff, and perform all required management functions. Strategically,

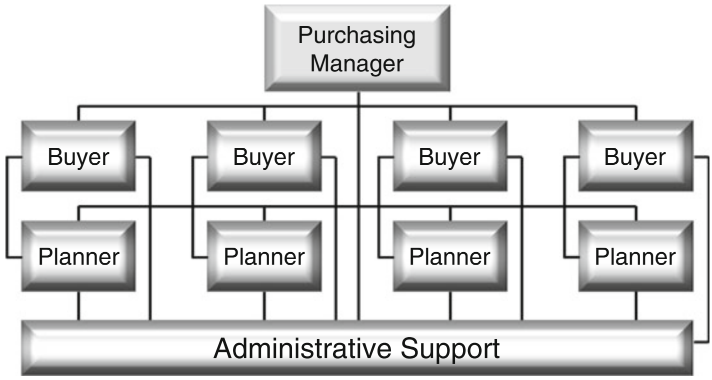


FIGURE 11.2 Standard purchasing organization.

the role of the CPO is to reduce risk, improve supplier communication, contribute to improving profit margins and working capital, improve suppler planning and forecasting, and improve supplier scorecard and performance measurement capabilities.

On the second level of the purchasing department structure are the *buyers*. The buyer's role consists of a number of tasks centered on the value-added work involved in building supplier relationships and achieving high value for the goods and services purchased by the organization. On the third level are the *purchasing planners,* who perform the tasks associated with the actual release and management of purchase orders. Most of these functions are considered non-value-added to the organization. On the final level of the purchasing department structure is *administrative support*, which assists the other three purchasing levels by performing clerical activities such as record keeping, paperwork, statistics, expediting, data entry, and record maintenance.

In today's purchasing environment, it is important that the roles of buyer and planner are separated. The *purchasing planners* normally are responsible for working with the requisition schedule arising from material requirements planning (MRP) or reorder point planning; reviewing the planning system exception messaging; communicating the buy plan to suppliers; launching and expediting purchase orders; managing order and transportation costs; and communicating problems to the buyer. Once orders are released, the planner is responsible for order follow-up and possible expediting, maintaining the accuracy of system planning and open order data, and communicating order status to other company departments.

In contrast, the buyer's role, shifts from a concern with paperwork and expediting (which belong to the planners) to a focus on a range of value-added functions supportive of the supplier relationship. The buyer assures the timely supply of quality goods and services achieved through intense supplier selection, negotiation, pricing agreements, value analysis, quality improvement, and alternate sourcing. The mechanics of the whole operation are determined by the requirements output from the planning systems supported by the supplier agreements determined in advance by the buyer and the supplier's sales force. Both buyer and planner are normally organized by commodity or supplier, assist in problem solving, attempt to integrate the supplier into the business, perform administrative duties, forecast and plan inventories, and report on problem issues. Table 11.1 provides a summation of the roles of buyers and planners in the modern purchasing department.

TABLE 11.1. Buyer/Planner Concept

Buyer role	Planner role
Negotiates supplier agreements	Communicates requirements schedule
Executes changes to supplier agreements	Manages inventory investment
Explores alternate sourcing	Manages MRP planning output
Performs value analysis	Analyzes excess/obsolete inventory
Negotiates quality agreements	Reviews receiving quality rejects
Develops long-term partnerships	Works daily with suppliers
Performs supplier selection	Plans new product introduction
Negotiates lead time reduction	Reduces order and transportation costs
Involved on a exception basis	Executes day-to-day buying
Problem solving	Problem solving
Forecasts and plans inventory	Forecasts and plans inventory

The purchasing organization is structured around three general approaches: commodity or function, project or product, and matrix. The *commodity* approach is the structure most commonly used by companies. In this model, the purchasing function is divided into spheres of buying responsibility such as production inventories; maintenance, repair, and operating (MRO) inventory and services; and capital and construction equipment. In addition, other non-buying functions, such as acquisition research, administrative support, and technical liaison, can be integrated into the model. The buyers and planners within each commodity group are responsible for all sourcing, negotiating, and purchase order releasing activities for that commodity area. The advantage of this method of organization is that dedicated members of the purchasing team are able to acquire specialized knowledge about products and suppliers, serve as the communication point for purchase order requisition, and execute acquisition activities while minimizing product and administrative costs.

For those firms whose products and services are focused on long-term projects, the purchasing function is organized around specific projects or programs. The goal of the purchasing group in such organizations is the acquisition of the required materials and services necessary to meet project requirements. The advantage of this form of organization is that certain buyers are linked to specific project segments, thereby ensuring that purchasing requirements are kept within budget targets and scheduled time frames are met. A *matrix* organization is a variation of the purchasing function organized around projects or a product line. In this structure, buyers are organized into project teams charged with the responsibility of meeting the acquisition needs of the entire project. Such an organizational structure streamlines the project purchasing process and eliminates possible redundancies.

11.1.5.3 Centralized Versus Decentralized Purchasing

Many enterprises today consist of multiple facilities that are geographically dispersed. A critical question for such companies is determining how to configure the purchasing function. Should purchasing be performed at a single centralized (normally the corporate) facility, or should it be decentralized and performed on the local facility level? A third option is possible: Hybrid solutions can occur with commodity-type products bought centrally and specialty products used locally and bought by facility-level planners. Historically, the choice between centralized and decentralized purchasing has moved back and forth. Today, according to a survey by APQC (2013), a majority of organizations participating (68 %) use a centralized structure. This finding points to the importance of processes in achieving efficiency and lower costs rather than channel purchasing structure [6].

Several factors drive the centralization/decentralization decision. These factors must be considered together because a decision cannot effectively be made by focusing on only one factor.

- *Business strategy*. For a business with facilities located in multiple geographical regions that competes by offering high customer service levels, a decentralized approach is more effective. In contrast, a firm that competes by offering low-cost, commodity-type products is more successful by centralizing purchasing to realize economies of scale in pricing, production, and product delivery.
- *Nature of products offered to the marketplace*. If an enterprise offers a wide range of products but segregates them by geographical region, a decentralized approach to purchasing is more effective. In contrast, if most or all of the products are carried by most or all of the facilities located in different geographical regions, then a centralized option is the best choice. Exceptions to this rule are driven by the nature of the products offered. For example, highly perishable and costly-to-transport products or the contracting of services will are likely sourced locally.
- *Total purchasing expenditures*. As the total value of purchasing increases, pursuit of total inbound transportation and carrying cost economies of scale dictate that purchasing functions be located centrally. If product lines carried at remote locations are different, then inbound costs would be cut by following a decentralized strategy.
- *Management philosophy*. There has been a long-standing debate regarding the choice of purchasing centralization versus decentralization. The decision to select an approach is influenced by customer service objectives, transportation costs, expertise of purchasing staffs, desired level of supplier partnership, and financial and performance targets.

Ultimately, the decision as to the degree of centralization is weighed by several advantages and disadvantages. The arguments favoring centralization center on buyer “clout” and economies of scale. By centralizing purchasing, buyers obtain larger discounts and cheaper inbound transportation; remove duplication in buying; better coordinate purchasing requirements through the application of computerized software; link purchasing strategies more closely to overall corporate strategies; more efficiently utilize scarce resources among competing facilities; and develop a specialized professional purchasing staff. In contrast, arguments favoring a decentralized purchasing option center on linking acquisition authority with those company branches responsible for inventory availability; increased responsiveness to the customer; greater speed in item replenishment; use and development of local sources; providing supplier visibility to special product features, services, or transportation needs; closer alignment of purchasing with local product development; and increased local ownership. In the final analysis, the decision to structure the purchasing function either one way or another is often not clear-cut, with some commodities, such as bulk items and widely used products being purchased by a centralized group, and specialized products and services acquired locally.

11.2 ANATOMY OF PURCHASING STRATEGY

The need to develop an effective enterprise procurement strategy is testament to the impact purchasing has on the business's competitive positioning. Companies that do not develop a comprehensive purchasing strategy risk interruption in the stream of supply due to poorly executed product and supplier planning and sourcing, misunderstood environmental or regulatory constraints, and uncertainty in price and delivery. From the outset, it is true that the best purchasing strategy is not necessarily the one that promises to optimize efficiencies or lowest total cost of ownership, but the one that supports the competitive objectives of the organization and, ultimately, the supply chain. Factors influencing purchasing strategy development are sophistication of the corporate planning process, degree of dependence of the enterprise on purchased products and services, top management's perception of the purchasing function, the availability of technology enablers, and state of the evolution of the purchasing function from being *transactional*- to *strategically*-based. A possible model to guide overall purchasing strategic development is illustrated in Figure 11.3.

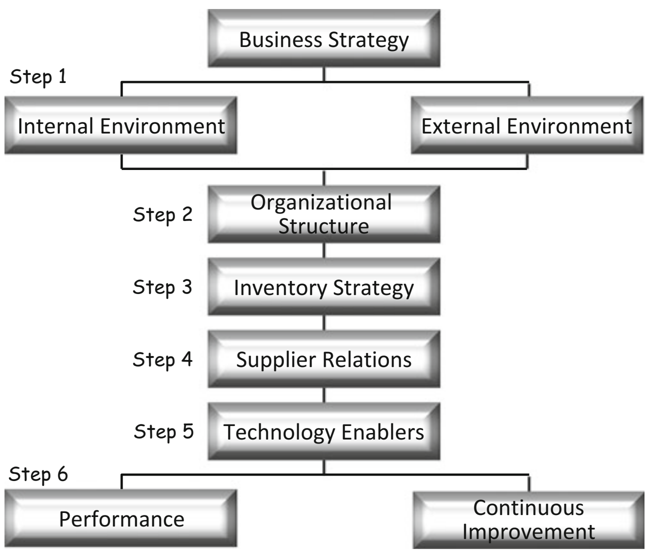


FIGURE 11.3 Purchasing strategy model.

Step 1: **Environmental Scanning**. The first step in the purchasing strategy development is matching the strategy with the dynamics found in the company and external marketplace environments. Internal factors include the stage of enterprise technological development and the nature of corporate culture and values, perception of supplier partnering, outsourcing initiatives, and purchasing organizational structure. External factors include mapping international sources of supply, technological communications capabilities, political and social issues, and government and environmental regulations. The objective of this step is to provide purchasing management with a complete understanding of how they are to support the business's and, by extension, the supply chain's competitive strategy.

Step 2: **Strategic Mapping**. The second step in the strategic purchasing model involves mapping the capabilities of the purchasing organization to meet corporate strategic objectives. Several activities are required. Purchasing strategists should start by reviewing purchasing's *organizational structure*. This step details the degree to which purchasing is centralized, the geography of the organizational matrix in which purchasing and sourcing responsibilities are assigned and actions are performed, how authority is delegated, the level of influence purchasing has in the business, and the structure of communication flows both within the purchasing organization and between purchasing and other business functions. In this step *employee capabilities* are also mapped. Detailed mapping determines the qualifications of purchasing professionals and their ability to execute the purchasing strategy, identification of missing skills, and needed training and certification programs designed to enhance purchasing personnel's skills and professionalism. Finally, the business's *current purchasing practices* are mapped. The goal of this activity is to reveal the content of such work elements as the sophistication of existing purchasing controls and technologies used in order management; purchasing's capability to perform strategic sourcing and value-add buyer activities; use of technology tools such as e-commerce and EDI; use of P-cards and supplier contracts; and development of statistics to record and analyze supplier performance.

Step 3: **Inventory Strategy**. Once the strategy governing purchasing's organization dynamics are defined, managers can move to step three: the *purchasing inventory strategy*. The first action is to conduct a *spend analysis*. The purpose of this activity is to thoroughly analyze all goods and services purchased across the enterprise in an effort to determine the actual spend levels and the degree of supplier fragmentation. The analysis documents how much is being spent by individual product and by product family. Finally, the analysis identifies how much is being purchased, by category, of goods and type of service from each supplier. The objective of the exercise is to unearth answers to questions such as what is being purchased, from whom, from where, and from what locations. An important part of the spend analysis is including what goods and services need to be acquired as a result of new product development. The goal is to quantify costs, purchasing staff effort, and requirements for new technologies. Finally, the spend analysis is used in drafting the purchasing budget for inventory. This plan is compiled through an analysis of historical spend data, new product development, plans stemming from long-range MRP planning, and so on.

Another important component of the inventory strategy is the *make/buy decision*. This component details how intensive is the firm's inventory backward integration strategy. What is to be purchased and what made in house is influenced by a number of factors such as delivery cycle time, current supplier performance, cost advantages, process/technical capabilities, patents and trade secrets, existing supplier contracts, and supplier production superiority. Conditions impacting make/buy decisions are detailed as such:

- *Degree of operational change*. If the firm decides to produce in-house, does it currently possess the equipment, personnel, and processing experience, so that only a small capital outlay for equipment and personnel is necessary? On the other hand, would a decision to produce the product line require the expenditure of significant capital to acquire the necessary equipment, facilities, and know-how?

- *Cost*. What is the difference in cost to make the selected items in-house or to purchase them from a supplier? Factors to consider are the cost of purchasing component items versus buying the finished products; increases in receiving and inspection costs if items are purchased; cost of purchasing production equipment and direct labor required to handle components and to perform production; and the size of incremental increases in warehouse overhead, managerial, inventory carrying, purchasing, and capital costs.
- *Production processing control*. If production is performed in-house, what information technologies are required to plan for component requirements? How is order release and WIP maintenance to be performed? What is to be the level of management control over operations, and does that expertise exist within the firm or must it be acquired from the outside?
- *Quality*. How is quality to be measured during and after production processing? What tools should be used and does the firm currently have such expertise? What would be the quality requirements of supplier-produced items and what type of inspection criteria would be necessary?
- *Risk management*. Does the outsourcing of specific items pose a competitive risk to the business? Risk is low when the business possesses the capabilities to produce purchased products and high when the firm surrenders control to a supply partner. In addition, does outsourcing risk the theft of a source of competitive advantage in that proprietary information can become public knowledge? Finally, what is the risk of supply disruption caused by supplier problems, the threat of governmental regulations, or natural disaster?

Another issue relating to procurement inventory strategy is ranking materials and services by their importance to the organization. This principle recognizes that purchasing is not subject to a one-size-fits all approach when it comes to procurement strategies, tactics, use of technologies, and application of resources. Two values are critical in the assessment. The first, *value*, relates to the level of importance the product/service has in ultimately servicing the customer. The greater the value, the more detailed the procurement strategy and the closer the control of the product/service. The other factor, *risk,* relates to the potential damage to competitive positioning caused by product stock out or quality failure. Simply put, as a product/service grows in importance, purchasers must exercise greater control to ensure availability and reliability. As illustrated in Figure 11.4, an effective way to ensure high value and low risk is to divide purchased products into the following four distinct quadrants [7]:

- *Generics*. Purchased items in this quadrant are characterized as of low strategic value and low cost to the organization. For the most part, products necessary for sales or production are not found in this quadrant. Administratively, the goal is to pursue very low cost methods of sourcing and ordering these items. Recently, the application of Internet-based trading exchanges has been applied to this area to take advantage of low cost procurement, auctions, and even barter. *Maintenance, repair, and operation* (MRO) products can be placed in this area.
- *Commodities*. Products in this quadrant are classified as possessing low acquisition cost, but are often important for the production of assemblies and finished goods. Because commodities are usually generic and are acquired from a wide variety of

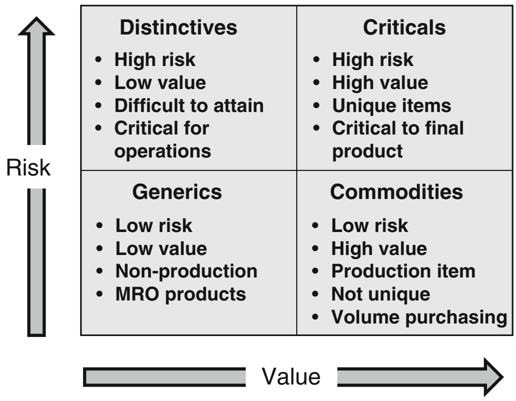


FIGURE 11.4 Purchasing classification matrix.

sources, they pose a low risk to purchasing strategies. While brand is usually not an important criterion, price is a distinguishing characteristic. Volume purchasing opportunities are important. These products are also increasingly being sourced through the Internet to attain low cost while ensuring timely delivery. Fasteners, packaging material, paints and lubricants, and transportation services that add direct value to finished goods are examples of commodities.

- *Distinctives.* Products in this quadrant are normally of high risk to competitive strategy, but are low in the value they provide to finished goods. While these products are not outwardly of critical importance to the form, fit, or function of the end item, they may be difficult to source, are subject to long lead times, or are low cost substitutes for very expensive components. Stock out of these items can stop production and require time-consuming rescheduling of the production floor. Sourcing and ordering distinctives are under the watchful eyes of buyers and planners and normally maintained by MRP planning.
- *Criticals.* In this quadrant are items that are of high risk and high value. When used in production, these components often provide competitive distinctiveness to the finished product and cannot be easily substituted for or omitted from the final product configuration. Buyers and planners are very involved in the management of these often unique components, where such values as build to exact specification, value analysis, high quality, cost management, collaborative design, and the building of very close supplier partnerships is absolutely critical.

The discussion of the four quadrants illustrates the importance of the purchasing inventory strategy. It suggests that purchasing managers must design multiple approaches to purchasing inventories based on the value and risk of the items to the organization.

Step 4: **Supplier Relations**. An essential component of an effective purchasing strategy is the development of meaningful supplier partnerships. The goal is to architect collaborative relationships that enable the operations of supply chain partners to be so closely integrated that they appear as a single, seamless supply engine to the customer. Instead of contact consisting solely of buyer-customer transaction-based interaction, an effective purchasing strategy is centered on growing close supplier relations where, for instance, the purchasing planner works directly with the suppliers' inventory planners to optimize product flows. Another example is integrating the supplier's product design and quality assurance departments with the buyer's product development team to remove excess costs, engage in continuous improvement efforts, exploit networking technologies, and assure close item conformance to buyer specifications. Achieving such relationships require procurement managers to work closely with suppliers to cultivate partnerships that foster the pursuit of common goals and reside on trust and mutual advantage.

Establishing supplier partnership programs consist of several steps. In the first, purchasing management determines the current levels of supplier relationships. This activity identifies partnership strengths and gaps. Gaps include a lack of shared goals for tactical purchase order and receiving performance as well as strategic issues such as linkage of supplier production processes and purchasing requirements, identification of out-of-bounds situations, development of continuous improvement programs, and the application of technology. Normally, purchasing management finds that buyers have close relations with their key suppliers while relations with secondary suppliers are purely transaction-based.

Once the levels of supplier relationships are documented, the next step is to determine actions to increase existing high-level supplier relationships while establishing strategies to strengthen relations with the remaining supplier base. This activity focuses on the enhancement of relationship-building such as identifying opportunities for collaboration on joint product design, education and training, computerized networking, and agreement on common performance measurements, such as on-time delivery and quality. Once the basic ground rules are defined, suppliers can use other devices to communicate purchasing expectations and enhance supplier partnerships. Evaluation and certification programs, for instance, enable buyers to assemble product quality databases and assurance metrics that provide documentation of supplier quality levels.

Another tool is the use of rating systems based on supplier performance. Activities center on evaluating and ranking suppliers by different award levels based on detailed criteria relating to on-going quality and delivery performance. All problems are formally stated and must include a follow-up process to document corrective action taken by the supplier. Finally, suppliers must agree to submit their quality management systems to buyer audit. The goal of the audit is to verify supplier conformance to production processes that meet the specifications and delivery needs of the purchaser. The output of the audit is a certification that processes are conforming to documented standards while permitting the purchasing audit team to recommend and oversee the necessary adjustments to guarantee future compliance. Audit standards, such as ISO9000, can be used as models for the audit.

An important step is determining the roles of company buyers and planners in managing supplier relationships. This step is concerned with actualizing an effective supplier management program that contains multiple levels of collaborative communication through business review meetings, supplier collaboration and team building, and supplier scheduling. A partnership communications structure that includes all three ensures that purchasers and suppliers will receive the necessary flows of information.

- *Business review meetings*. The goal of business reviews is to integrate the long-range business plans and supply chain requirements of buyer and supplier. Topics of discussion include supply process optimization, handling of new product introduction, short- and mid-term demand and capacity planning, flow of materials and information, expected standards of quality and delivery, inventory levels, and cash flow between partners. Discussion results enable the building of strategic consensus and joint ownership of channel processes and flows.
- *Supplier collaboration*. These meetings are mid-range planning events that should occur at least monthly. Collaboration meetings ensure purchasing planners and buyers are working directly with supplier counterparts to address issues such as production levels, required resources, capability-to-promise, inventory levels, obsolescence, concurrent quality/engineering projects, and the capabilities of the existing supply chain. In addition, the meetings should review methods to improve supply chain capabilities relating to ongoing performance metrics, special projects, plant up-grades/shutdowns, and future product/service projects.
- *Supplier scheduling*. Scheduling meetings involve the every-day interaction between buyers, planners, and supplier service representatives. The goal is to communicate buyer requirements and availability of supplier capacities to guide the sequencing of production and product delivery. The level of interoperability of channel ERP and supply chain management systems are of significant importance in sharing of up-to-the-minute statuses of priorities, production, and process issues, and the confirmation of actual order release, delivery, and quality schedules.

A partnership communications structure that includes all three of the above levels ensures that all purchasers and suppliers achieve the necessary flow of information. Together, purchasers and suppliers can determine the participants, frequency, the data to be shared, and the output formats to be used at each level.

Step 5: **Technology Enablers**. The modern purchasing organization has increasingly turned to information technology to assist in the development and realization of procurement strategies. Tools like the telephone, Fax, EDI, linkages between ERP systems, and recently, the Internet, have bridged traditional gaps in buyer-supplier relationships. For example, *supplier search* applications have simplified buyer search for the best suppliers and products on a global basis. Search features include a window into the availability of procurement information and documentation, quality assurance, and capability-to-buy at competitive prices. Another application, *order management access*, refers to how easily buyers can gain access to order management functions to place purchase orders and review open order statuses. *Service management availability* provides applications that assure buyers that they are receiving or have access to support capabilities such as communications, customer service help lines, documentation, and training.

The goal of SRM technologies is simple: how to increase connectivity with suppliers. In the past, this objective was achieved by deploying person-to-person communication. Recently, computerized tools like EDI were used to transmit critical procurement data. Today, purchasing functions are deploying Internet-based applications. The basic form is a self-service buyer portal where the supplier provides information on the company story and products and services it wants to share. More sophisticated connectivity is achieved with private trading networks or even direct links to the buyer. These connectivity technologies are available in a wide spectrum of options to support a range of supplier technology capabilities. Once connected, suppliers offer several electronic enablers for such activities as request for information and request for quotation (RFQ), order entry and self-service management, and planning functions. These buyer-to-supplier links permit review of supplier capability-to-promise, channel inventory availability, production schedules, and availability of real-time analytics and performance scoreboards that empower planners to make rapid decisions on bids, spot sourcing, and pricing, and to view performance statistics regarding contract compliance and quality targets.

Activities in developing the purchasing technology strategy include:

- *Determine level of current technologies.* This activity is concerned with assessing the level of competency possessed by the purchasing department to use current integrative technologies with suppliers. The goal is to identify existing strengths and weaknesses and to serve as a platform for increased training and education. A critical part of this activity is identifying any gaps in technology tools that are missing that could significantly enhance the execution of purchasing functions, such as supplier search, order management, and Internet options.
- *Explore technologies that link product development and supplier capabilities.* This activity centers on broadening buyer and supplier collaboration. Critical criteria include:
  - Development of supplier contracts focused on long-term quality and mutual benefits.
  - Collaborative sharing of information.
  - Real-time communication of designs and specifications.
  - Computerized networking for design and replenishment planning.
  - Mutual responsibility for total quality management.
- *Deploy technologies that enhance RFQ, order entry, service management, and planning functions.* This activity identifies technologies that facilitate and reduce the costs of purchasing functions. Technology applications include automation tools that simplify and standardize purchasing, use of Internet-based portals to extract and aggregate data from suppliers, public exchanges and auctions, and private and consortium exchanges.
- *Establish real-time analytics and scoreboards.* This activity seeks to use purchasing databases to establish the key performance indicators (KPIs) that reside at the foundation of an effective supplier strategy. These technology-based applications provide monitoring tools that provide for the detailed measurement and enforcement of agreements and performance targets, the extent of the integration of purchasing and supply chain processes, depth of process control enforcing standardization, enforcement of common processes across the supply chain, and the establishment of a single source of procurement-related data and intelligence.

The *objective* of this step is to determine the capability of the purchasing staff to use advanced technology networking tools to establish closer collaborative relationships with suppliers. An important part of this objective is to identify gaps in available purchasing-driven technologies that need to be addressed.

Step 6: **Performance and Continuous Improvement**. The final phase in the development of a comprehensive purchasing strategy is establishing procurement performance standards and an environment dedicated to continuous improvement. Fundamental to this phase is focusing the purchasing organization's attention on cultivating a "winning" attitude. This is accomplished by, first, communicating the value of continuous improvement initiatives and stimulating individual and team contribution. Next, purchasing management needs to establish clear performance benchmarks accompanied by a review mechanism designed to track progress and ensure that recognition is given for achieving performance. To respond to new challenges, the organization must be provided with necessary skills, such as training in statistical quality techniques, problem solving, value analysis, and team building. Finally, a dedication to continuous improvement means being able to effectively and consistently guide resource allocation to respond to new business opportunities and challenges.

The objective of this step is to leverage continuous improvement and performance measurement techniques to drive competitive advantage. As illustrated in Figure 11.5, this objective is realized by the following:

1. Purchasing and producing defect free products and materials: *Quality*
2. Managing the inherent disruptions in the supply chain: *Risk Management*
3. Reducing product, process, and channel costs: *Productive Improvement*
4. Achieving and maintaining technological superiority: *Technology*
5. Exploiting *time* to create competitive advantage: *Velocity*

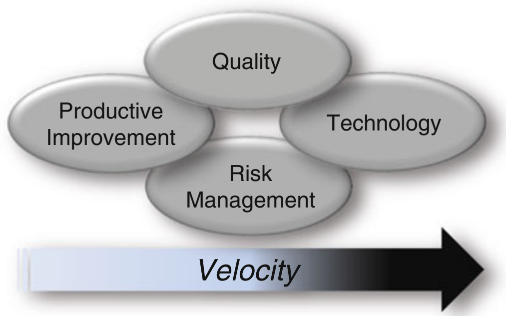


FIGURE 11.5 Purchasing's strategic goals.

An effective purchasing strategy aligns the goals and objectives of the purchasing function with the firm's overall competitive strategy. By implementing value-added philosophies that seek to remove redundancies and activate core capabilities, a comprehensive purchasing strategy can make a direct contribution to the marketplace effectiveness of the firm.

11.2.1 Role of Strategic Sourcing

The strategic management of purchasing is often termed *strategic sourcing*. In contrast to "tactical" sourcing (which is concerned with the day-to-day execution of purchasing activities), strategic sourcing is a process of evaluating, selecting, and aligning with suppliers or consortiums of suppliers to achieve the acquisition of high performance goods and services in support of an organization's strategic objectives. Strategic sourcing enables the purchasing organization to pursue the following objectives:

- *Establish close, collaborative relationships with key suppliers*. Strategic sourcing involves finding and building ongoing relationships with supply partners that account for the majority of an organization's purchasing spend. These suppliers provide goods and services that are critical in the production and delivery of the final product or service. Strategic sourcing enables buyers to grow supplier capabilities, improve processes, and introduce innovations such as the Internet and lean techniques.
- *Ensure reliable quality and delivery of materials*. Strategic sourcing seeks to increase the availability of high quality materials and components by working closely with suppliers' production and delivery processes. This objective is accomplished by a close analysis of spend patterns and construction of supplier profiles indicating volume, variety, and percentage of sales.
- *Reduce supply risk*. Strategic sourcing seeks to reduce risk in product and service supply arising from the actions of competitors or problems experienced by suppliers in production or delivery. Procurement risk management extends to countering possible disruptions in the supply chain caused by natural disasters and other non-business events.
- *Establish a smaller, more flexible, more responsive supplier base*. Strategic sourcing works best when buyers work with a small core of suppliers that are interested in developing deep, collaborative partnerships based not on price advantage or marketplace leverage, but rather on relationships that are mutually beneficial and provide each partner with a distinct competitive advantage. In addition, a smaller number of suppliers assists in streamlining the supply chain.
- *Closely integrate supplier input to product development and innovation*. Strategic sourcing seeks to establish an environment where suppliers provide critical core competencies that enable the buying organization to pursue product development and innovation far ahead of the competition.
- *Reduce external spending*. Strategic sourcing seeks the establishment of long-term contracts locking in price and transportation costs. It is also cross-functional, whereby the internal supply chain can buy jointly to reduce design and acquisition costs. A key consideration is reducing the total cost of ownership (TOC). Strategic sourcing looks beyond just the landed cost to determining the sum of all costs associated with every activity of the supply stream (carrying, customer satisfaction and quality, process change, and life cycle costs).
- *Use of targeted outsourcing*. A key requirement of procurement is assisting the entire organization to deepen and build differentiation capability. To enhance the focus on core competencies, buyers look to outsource non-core, non-critical functions to channel partners that have established strength in these functions.

- *Reduce transaction costs*. Strategic sourcing enables buyers to leverage computerized tools, such as automated request for quote (RFQ), request for proposal (RFP), and contract management, and the application of web-based processes, such as electronic auctioning and e-commerce, to facilitate supplier and product sourcing, order generation, follow-up, receiving, and payment.

Finally, strategic sourcing presents companies with the opportunity to clarify and communicate corporate goals and objectives. It is also a means to define and document what an organization's competencies are and what they should be. Non-value-add functions that waste critical time, resources, and require financial expenditure are identified and outsourced or eliminated. With these capabilities in hand, supplier sourcing assists organizations to be proactive to changes in the marketplace, understand ways to leverage suppliers' capabilities for lowest total cost solutions, and be better prepared for negotiation opportunities.

11.3 SUPPLIER RELATIONSHIP MANAGEMENT

In many ways, supplier relationship management (SRM) has the same objectives as customer relationships management (CRM), only in reverse. While CRM seeks to create long-term relationships that cement customers to the business's products and services, SRM enables buyers to lock in those suppliers that provide the business's critical components and finished goods. The depth of the SRM relationship depends on the nature of the interaction of the buyer with the supplier. Again, similar to CRM where not all customers are treated equally, the same holds for the buying experience: not all suppliers are created equal and are deserving of the same treatment.

11.3.1 Supplier Relationship Types

Purchasing's relationship with the supplier base is based on several factors including the choice of available suppliers, nature of the products and services required, price, volume, quality, and delivery. When the products are generic and are available from a wide array of suppliers, the buyer holds the power, interaction tends to be loose, intermittent, and based on the content of the last transaction. On the other hand, when buyers are restricted to a few suppliers who offer unique products, specialized services, distinct competencies, and necessary levels of quality, the supplier holds the power. In this type of environment, buyer-supplier interaction tend to be based on partnerships or collaborative/strategic alliances, is perceived as long-term, and is recognized as providing a level of synergy providing both parties with a high level of competitive advantage.

As illustrated in Figure 11.6, there are basically two types of supplier relationship–*tactical* and *strategic*. Tactical relationships are used to buy standardized (commodity) items based mostly on price that do not represent a competitive advantage. The relationship between buyer and supplier is very shallow or even non-existent. In contrast, buyer-supplier *collaborative relationships* are characterized by an alliance between two or more organizations that share a common operational, tactical, or business-level plan, participate in joint investments, and develop linked and common processes.

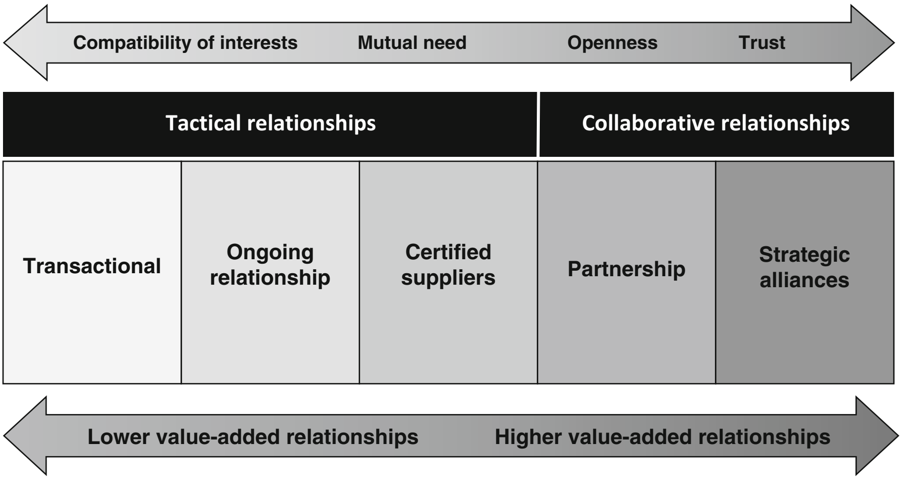


FIGURE 11.6 Range of supplier relationships.

Tactical and strategic supplier relationships are further broken down into the following five sub-types.

- *Transactional*. This level of relationship is characteristic of traditional purchasing. Purchasing buys products and services based on immediate need from a large number of possible suppliers. Since products and services are normally classified as commodities where brand is not an issue, purchasers often buy from competing vendors with the determining factor centered on price and product availability. Since the relationships are of low value, there is minimal to no investment by either side in building closer ties.
- *Ongoing relationship*. Buyers seek to build relationships with suppliers that provide a level of product and service value that, while not being unique, nevertheless are easy to do business with, have a certain synergy with the purchasing organization, or some other factor. Buyers and suppliers normally seek to solidify the relationship by negotiating medium-term contracts that seek to lock in price, quantity, delivery, or a suite of other values. Buyers often work with a specific customer rep who is responsible for negotiations, discounting, and transaction management.
- *Certified suppliers*. This type of supplier often bridges the boundary between tactical and collaborative relationships. Normally, the supplier commits to a certain certified level of quality and specification demanded by the buyer as the condition for doing business. This commitment can be informal or governed by a limited contract. Usually, the relationship is not exclusive and buyers are free to purchase from rival vendors. The products and services offered may also be standardized or contain increasing customization per the buyer's requirements.
- *Partnership type relations*. Supply partnerships seek to move beyond tactical buying and to engage buyer and supplier in meaningful collaborative relationships. In a supply partnership, buyer and supplier seek to coordinate their business plans with each other to gain mutual competitive advantage in terms of product development, operational integration and efficiencies, quality, speed to market, dependability, flexibility, cost, and risk sharing. The exact content of the relation is specified in a

long-term contract which normally contains a significant commitment to exclusivity. As the partnership grows over time, the relationship creates opportunities for increased understanding of each other's organizations and increased efficiencies through greater communication and value-added services.

- *Strategic alliances.* A strategic alliance is considered a long-term arrangement between buyer and seller that is driven more by agreements than by contracts. Strategic alliances entail common goals and long-term purchasing plans. It may include investment of money, personnel, and technology; sharing of future product plans; and joint investment in research and development. Strategic alliances can be formed at the business, product family, or part level. Information contact exists at many points throughout the organizations, and information flows unrestricted between buyer and supply organizations. The level of trust is high, and both parties are sincerely involved in fostering mutual success.

11.3.2 Advent of Supplier Relationship Management

While not all interactions between buyers and suppliers must or should evolve into partnerships or strategic alliances, buyers and suppliers are rapidly moving from the traditional approach to closer relationships using the SRM philosophy and set of tactical tools. The *APICS Dictionary* defines SRM as

> A comprehensive approach to managing an enterprise's interactions with the organizations that supply the goods and services the enterprise uses. The goal of SRM is to streamline and make more effective the processes between an enterprise and its suppliers [8].

SRM is about developing mutually beneficial relationships between buyer and seller. Historically, buyers treated suppliers with suspicion, focusing on short-term, transactional relationships. The growth of the SRM concept is a direct challenge to this lack of cooperation, partnership, and communication. Enhanced by Internet applications that draw buyers and suppliers together in "real-time," SRM can assume many forms based on the dynamics of the supply chain. SRM is found among allied industries, third-party logistics (3PL) organizations, and even competitors, and may exist for strategic or operational reasons. In all cases, however, SRM focuses first and foremost on changing organizational culture and transforming the way buyers and suppliers interact on a daily basis.

The SRM concept has evolved over time. As is illustrated in Table 11.2, supplier management has undergone dramatic modification and evolution. The adversarial nature of yesterday's purchasing arrangements have given way to the structuring of win-win relationships, a mutual commitment to sharing information and resources to achieve common objectives, and the creation of long-term partnerships meant to bind parties in good times and bad. Finally, collaborative partnership often means deconstructing traditional attitudes and practices concerning quality and reliability, delivery, price, responsiveness, trust, the sharing of research and development plans, and financial and business stability.

Today's focus on supplier partnerships has grown as a response to the following marketplace realities:

- *Increasing requirements for supply chain collaboration.* No company in today's marketplace can hope to survive without strong supplier partnerships. As businesses continue to divest themselves of non-core competencies and increasingly turn toward

TABLE 11.2. Traditional Purchasing Versus Supplier Relationships

Traditional approach	Supplier relationships
Adversarial relationships	Collaborative partnerships
Many competing suppliers	Small core of supply partners
Contracts focused on price	Contracts focused on long-term quality, collaboration, mutual benefit
Information is proprietary	Collaborative sharing of information
Evaluation of buy by bid	Evaluation by level of commitment to partnership
Supplier excluded from the design process	Real-time communication of designs and specifications
Process improvements are intermittent and unilateral	Commitment to continuous process improvement
Quality defects reside with the supplier	Mutual responsibility for total quality management
Clear boundaries of responsibilities	"Virtual" supply organizations

outsourcing, a deepening of partnering relationships and mutual dependencies is eagerly pursued in all industries as fundamental to continuous improvement strategies, total cost management, and competitive advantage.

- *Changing nature of the marketplace*. The dominance of the customer, shortening product life cycles, demands for configurable products, shrinking lead times, global competition, participative product design, and other issues have altered forever the nature of purchasing management and highlighted the importance of supply chain collaboration.
- *Changing business infrastructures*. Today's enterprise must possess business architectures characterized by extreme agility and scalability, while being customer-centric, collaborative, digitally-enabled, and capable of reliable, convenient, and fast-flow delivery. Although these attributes are normally focused on the sales-side of the business, they equally apply to the supply-side. The value chain can be compared to a coin: there is a customer-facing side and a supplier-facing side. The very existence of the functions driving customer demand axiomatically requires the replication of the same capabilities to drive supply.
- *Increased demand for cost control, quality, and innovation*. Buyers are now more than ever concerned about traditional purchasing values such as quality and reliability. Customers are no longer willing to do business with suppliers who not only cannot meet increasingly stringent product and delivery standards, but who also do not possess the capabilities to continuously unearth new product configurations and service management capabilities to provide them with the individualized products and services they require.
- *Increased demand for risk sharing*. True business partnerships mean that trust and risk sharing is a serious component in any collaborative relationship. Partnership agreements that provide for the equal sharing of risk (arising from the competition as well as supply chain disruptions) are essential for the management of new product development and controlling operations costs.
- *Enabling the power of Internet technologies*. The 'Internet age' has had a profound impact on purchasing, opening new and exciting doors providing supply chain

partners with the ability to closely integrate demand and replenishment in ways impossible only a few years ago. Applications such as supply chain management (SCM), point of sale (POS), and collaborative planning, forecasting, and replenishment (CPFR) enable supply networks to synchronize channel requirements, remove administrative costs, and cut costly lead times out of channel inventory management. In addition, Web-based tools have undercut the need for traditional purchasing functions, such as lengthy negotiations, requisitions, and paper-based purchase orders.

- *Focus on continuous improvement*. At the core of supplier management is a strong commitment to the joint pursuit of continuous improvement as a dynamic process. Whereas mutually profitable relations between trading partners might facilitate the achievement of common goals, only those companies pursuing closely integrated collaborative objectives can hope to continually streamline the development and guarantee the availability of superior products and services that consistently leapfrog the competition.

These marketplace realities are directly driving the two central challenges to SRM concepts and practices. The first challenge is encapsulated in the tremendous marketplace pressures calling for the continuous reduction of spend everywhere in the supply chain. The second challenge is searching for procurement practices and tools to simultaneously improve supplier relations and collaboration. SRM's response to these challenges is found in its ability to provide the information needed by purchasing departments to gain full transparency to spend; develop a comprehensive, accurate profile of the supplier base; reveal areas for cost consolidation; and identify opportunities for the optimal sourcing of materials, equipment, and services. At the same time, SRM provides the reporting and analysis tools to consolidate and prioritize suppliers based on quality, performance, and on-time delivery; ensure contract compliance and reduce maverick spending; certify the quality of purchased items; and ensure appropriate levels of supply. The end result is a procurement function capable of matching customer demand-side objectives with supplier performance.

11.3.3 Advantages of Supplier Relationship Management

Companies gain significant value through the application of SRM principles and practices. According to several global studies of buyers and their strategic suppliers [9], buy-side respondents reported realizing, on average, 40 % more value from those suppliers with whom they had collaborative relationships versus more traditional relationships. On their part, suppliers reported delivering 49 % more value to customers with whom they had collaborative relationships. Strategic alliances provide the following benefits:

- *Adds value to products*. Closer relationships with suppliers improves time-to-market, delivers products into the hands of customers more quickly, ensures quality, and increases customer satisfaction. This benefit is apparent during the product design stage where supplier involvement results in decreases in material costs, increases in purchased material quality, decreases in development time and cost, decreases in production costs, and increases in new product marketplace roll-out.
- *Enables strategic growth*. Closer relationships with suppliers enable organizations to combine resources to overcome barriers to marketplace entry and the capacity to search for and develop new opportunities. By partnering with suppliers, companies gain access to resources and skills necessary to make their businesses grow.

- *Increases market access*. Close supplier relationships lead to better advertising and increased access to new market channels. For example, an appliance component manufacturer that specializes in residential kitchen appliances might team with a manufacturer of kitchen appliances to gain access to new market segments.
- *Strengthens operations*. Building alliances between organizations results in lowering system costs and using resources more effectively. For example, a distributor negotiates with a lawn mower and snow blower supplier to warehouse inventories during winter and summer off-seasons.
- *Increases organizational expertise*. Partnering with a supplier that has expertise in a certain area makes it easier to implement new technologies while at the same time increases the knowledge and skills of the buyer's organization. SRM also enables the construction of governance structures and processes guiding how the purchasing organization is to manage buyer/supplier interactions across the lifecycle of the supplier relationship.
- *Builds organizational skills*. Strategic alliances provide an excellent opportunity for learning within the organization. Not only will organizations learn from each other, they will also learn more about themselves and become more adaptable.
- *Enhances financial strength*. Supplier partnerships assist in improving overall financial positions while sharing administrative costs. In addition, administrative costs may be reduced based on the expertise of one or both partners.
- *Enables easy supplier segmentation*. SRM enables buyers to quickly stratify the supplier base so that they can easily identify those suppliers which are most strategic to the organization
- *Provides for development of effective performance measurements*. SRM enables buyers and suppliers to establish performance measurements that increase both the overall value of the relationship as well as efficiency and cost reduction.

11.3.4 Implementing Supplier Relationship Management

Implementing SRM is a cross-functional, cross-organizational discipline that depends greatly on the ability of supply channel members to engage in change management. There are three critical attributes that need to be established at the outset. The first is a *commitment to change* on the part of buyers and suppliers. Regardless of the nature of the existing procurement environment, entering into collaborative relationships results in changes within each organization. Engaging suppliers early in implementation process ensures they are much more likely to understand buyers' expectations and their responsibilities as well as are more likely to exhibit genuine buy-in and commitment. The second attribute is *commitment to relationship*. This means that both buyer and seller believe that an ongoing relationship is so important as to warrant maximum effort to establish and maintain it. The final attribute is *commitment to communication*. Open and continuous communication regarding common objectives is essential to successful SRM relationships. Ideally, supply chain partners engage in a process of mutually deciding on the value of information, investigate it jointly, determine the course of action, and then measure its success.

11.3.4.1 SRM Implementation Steps

The successful implementation of SRM requires a detailed implementation plan and a detailed set of performance metrics. As illustrated in Figure 11.7, there are six steps in developing and implementing a successful SRM strategy.

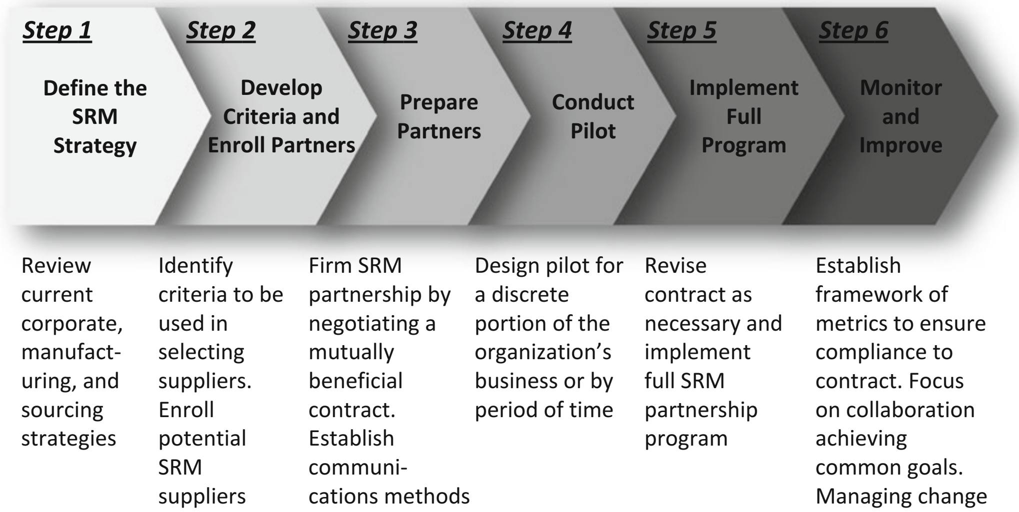


FIGURE 11.7 SRM implementation steps.

Step 1: Define the SRM strategy.

In this opening step, purchasing managers must review collectively the corporate, marketing, production, and distribution strategies of their organizations. Factors influencing the SRM strategy development are sophistication of the corporate planning process, degree of dependence of the enterprise on purchased products and services, top management's perception of the purchasing function, the availability of technology enablers, and state of the evolution of the purchasing function from being *transactional*- to *strategically*-based. Externally, procurement managers assess the level of power they can exert over suppliers, the amount of competition among suppliers, and the willingness of critical suppliers to engage in collaborative relationships.

Step 2: Develop criteria and enroll partners.

In this step, purchasing managers identify the criteria to be used in selecting suppliers for possible SRM strategic alliances. Criteria includes determining the profitability, growth, financial stability, and level of risk when dealing with possible suppliers. Additional considerations are levels of service, sophistication and compatibility with the supplier's processes, technology capability, supplier location, volume to be purchased, capacity available, innovativeness of the corporate culture, and quality levels. A high level of mutual trust is required, since information sharing has competitive implications. Finally, if buyers and suppliers do not share a common vision, the relationship will fail to reach a high level effectiveness. In the end, an offer of partnership goes to qualifying suppliers.

Step 3: Prepare suppliers.

In this step, a SRM management team, containing representatives from the buyer and the supplier, is created to negotiate and finalize the contractual agreement between the two parties and plan the transition to new operations. This step establishes the guidelines, processes, and protocols detailing how the relationship will operate, how conflict is resolved, and what is the communication methods to maintain the partnership. In addition, new systems and controls, which might require design and development of networking and communications infrastructure that are needed to support contract conformance may have to be established. Collaborative skills may require building both buyer and supplier abilities to resolve conflicts, solve problems jointly, and conduct difficult negotiations and conversations in a way that fosters increased commitment to the partnership.

Step 4: Conduct a pilot.

In this step, a purchasing pilot is designed for a discrete portion of the buyer's organization (such as buying for a geographical region) or defined by period length (such as one product life cycle). The object of the pilot is to test supplier performance to the contract, identify areas for possible revision, and ascertain supplier commitment to the relationship.

Step 5: Implement the full program.

In this step, the original SRM contract is revised to incorporate needed changes resulting from the pilot. Implementation plans include regular planning/pulse-taking/problem-solving sessions with suppliers to measure the effectiveness of the relationship and provide constructive feedback.

Step 6: Monitor and improve.

In this final step, buyers and suppliers develop and implement a set of performance metrics that ensure both sides are meeting the goals of the SRM contract and delivering the desired impact on the bottom line. An important part of this step is planning for the inevitable changes to the relationship that will come through time. Two aspects of change need to be managed. The first are incidental and inevitable changes in executives or reorganizations and shifts in the competitive or regulatory environment. Planning for these types of changes should be anticipated as natural to the course of business. The second type of change is positive change that is needed to improve the relationship. A focus on continuous improvement by both the buyer and the supplier is at the core of a successful SRM program. Rather than a static principle, SRM is a dynamic process by which the pursuit of collaborative objectives and continuous improvement result in the achievement of strategic and short-term common goals.

11.4 MANAGING THE SOURCING PROCESS

Whether governed by a SRM contract or transactional buying, the sourcing function is an essential part of procurement. Sourcing is defined as

> The body of activities focused on the purchase of materials, supplies, and services needed to reach the firm's strategic goals. In a narrow sense, sourcing describes the process of buying; in a

broader context, sourcing involves determining the need; selecting the supplier; arriving at the appropriate price, terms, and conditions; drafting the contract; and growing mutually beneficial supplier relationships over time.

When the definition is examined closely, four critical elements emerge. First, *sourcing is an integrated process*. Once a decision is made to source a good or service from an outside supplier, there are several steps the buyer needs to execute to ensure the end result of the purchase matches the company's objectives for cost, quality, and delivery. Second, *sourcing must support the business's strategic goals*. The focus of sourcing is on establishing supplier relationships that result in the delivery of goods and services that support the strategic goals of the business. Third *sourcing can be viewed narrowly*. Sourcing can be described narrowly as the *tactical* buying of goods and services. And finally, *sourcing can be viewed as a strategic activity* associated with a series of steps: determining the need; selecting the supplier; arriving at the appropriate price, terms, and conditions; drafting the contract; and growing long-term mutually beneficial supplier relationships.

Sourcing consists in the pursuit of several important objectives:

- *Establishing close, collaborative relationships with key suppliers*. Strategic sourcing, as opposed to traditional sourcing, involves finding and building ongoing relationships with supply partners that provide goods and services critical to the production and delivery of the final product or service that account for the majority of an organization's purchasing spend. Sourcing also enables buyers to grow supplier capabilities, improve processes, and introduce innovations such as the Internet and lean techniques.
- *Ensuring reliable quality and delivery of materials*. Effective sourcing seeks to increases the availability of high quality materials and components by working closely with suppliers' production and delivery processes. This objective is accomplished by a close analysis of spend patterns and construction of supplier profiles indicating historical performance regarding volume, variety, and percentage of sales.
- *Establishing a smaller, more flexible, more responsive supplier base*. Sourcing activities works best when buyers are able to work with a small core of suppliers that are interested in developing deep, collaborative partnerships based not on price advantage or marketplace leverage, but rather on relationships that are mutually beneficial and provide each with a distinct competitive advantage. In addition, a smaller number of suppliers assists in streamlining the supply chain.
- *Closely integrating supplier input to product development and innovation*. Strategic sourcing seeks to establish a collaborative and participative environment where suppliers provide critical core competencies enabling the buying organization to pursue product development and innovation far ahead of the competition.
- *Reducing external spending*. Effective sourcing seeks the establishment of long-term contracts with suppliers locking in price and transportation costs. It is also cross-functional, whereby company departments can buy jointly to reduce design and acquisition costs.
- *Reduce transaction costs*. Strategic sourcing enables buyers to leverage computerized tools that facilitate order generation, follow-up, receiving, and payment.

11.4.1 Sourcing Process Steps

Figure 11.8 illustrates a possible model detailing five sourcing process steps.

FIGURE 11.8 Sourcing process steps.

Step 1: **Make-or-Buy Decision**. The opening activity to be performed by procurement is to identify all items and services that the firm needs to make, sell, and service. Ultimately, the goal, with the assistance of marketing, engineering, production, and costing, is to determine which items are to be made in-house by the firm's production processes and which are to be outsourced to suppliers. When investigating the decision, the make-or-buy team must consider the following range of potential factors.

- *Low cost*. In recent decades, companies have decided to outsource the production of finished goods and assemblies to suppliers based on low cost. This factor is purely one of economics: either because of low labor costs, availability of materials and components, overall cost of doing business, availability of more modern and productive processes, presence of lower cost competitors, and others, companies have decided that shifting production to a supplier would enable them to maintain marketplace advantage.
- *Economies of scale*. Because of the availability of core competencies, better processing equipment, or access to raw materials and components, a supplier is able to produce products product faster, thereby increasing order fill rates, expanding the buyer's footprint into new markets, and increasing competitive advantage. This factor is often used by start-up companies that, after reaching a certain level of marketplace penetration, decide to outsource volume production to suppliers rather than expand equipment and hire personnel.
- *Risk reduction*. Transferring production to a supplier often reduces the risk of inventory shortages or overstocks. Because suppliers have the ability to aggregate demand for their products from many customers, they can spread inventory risks over the planning horizon. For example, a producer of cloth can aggregate the forecast demand

from many apparel customers for a base stock cloth into a single production order. By pooling the demand, the producer eliminates significant quantities of safety stock while possessing the inventory to absorb changes in customer schedules. The outsourcing supplier may also be able to react more rapidly to changes in customer demand, thereby decreasing the risk of stock out and lost marketplace share.

- *Increased availability of capital*. When a buy versus a make decision is made, procurement can shift part of the cost of maintaining equipment and labor to the outsourcing partner. This is particularly true when addition equipment or labor needs to be added to increase production volumes or expand competencies. The extra capital is then available for new product development, expanding critical processes producing the firm's best sellers, marketing and sales campaigns, new distribution channels, or debt reduction.
- *Refocus on core competencies*. A buy-decision for products and services for which the firm does not have a core competency assists in refocusing effort away from what the business does not do well to what gives it a special competitive advantage. Buying goods and services enables businesses to expand their marketplace reach without diluting core strengths.
- *Access to new technologies*. A crucial reason for the buy-decision is to tap into the investment and competencies in new production and networking technologies possessed by the supplier. Often the cost to acquire such technologies is prohibitive. This is especially important if the firm considers internal production tooling-up for a new product or service as containing considerable risk.
- *Accelerated product development cycle times*. Cycle times to move new products and services from conception to market can be accelerated by tapping into the unique processes, technologies, and skills of suppliers. Often companies will decide that purchasing development capabilities are far cheaper than building them in house.

In addition to these factors, the make-or-buy team must weigh the possible consequences of embarking on an outsourcing strategy. Perhaps the most important decision is determining if the firm will lose a core competency by outsourcing it to a supplier. Core competency questions centers on whether the item or service is integral to the production and/or quality of what makes the product unique to the company. Another decision centers on the possible loss of special knowledge or skills needed to product the product. Surrendering production competencies on essential items or processes in exchange for lower costs or enhanced focus shifts significant power to the supplier who could hold buyers hostage in future negotiations.

Exercise 11.1: Cost Avoidance Analysis

There are several methods of performing cost analysis to determine a make-or-buy decision. One method is cost avoidance analysis. This method calculates the benefit of outsourcing a product by determining those cost elements of production that cannot be totally outsourced or avoided. For example, even if a product is no longer to be made in house, some of the total overhead cost associated with the factory, labor, equipment, and so on, used to produce the product will remain, even if they are idle. This cost must be added to the purchasing cost to see if it is still profitable to outsource the product. The only way this cost could be totally avoided is if the factory totally eliminated all of the sources of factory overhead.

As an example, the cost data for a currently manufactured product is as follows:

Forecast/units	10,000
Purchase price proposal/unit	$4.50
Materials/components	$9,000
Direct labor	$12,000
Variable factory overhead	$5,000
Fixed factory overhead	$24,000
Total cost of goods	$50,000
Unit cost	$5.00

The total cost to make the forecast of 10,000 units for the year is US$50,000, or US$5.00 per unit. The buyer has received a quote from a supplier proposing to supply the 10,000 units for US$45,000, or US$4.50 per unit. Should this offer be accepted and the product outsourced?

To determine the answer, the buyer must calculate how much of the US$50,000 cost cannot be avoided. Obviously, 100 % of the materials and labor will be avoided. However, even though the part will no longer be made in house, the company still has to pay for the fixed and variable overhead it possesses. It is determined that 20 % of the variable and 25 % of the fixed overhead remains with the company and cannot be outsourced. To calculate the cost of these two elements, the buyer multiplies the products fixed and variable overheads by the remaining overheads. Next the buyer adds in the material and direct labor cost to arrive at the total cost avoided if the product is purchased. The total cost is calculated as follows:

Costs avoided if purchased	
Materials/components	$9,000
Direct labor	$12,000
Variable factory overhead	$4,000.0
Fixed factory overhead	$18,000.0
Total cost of goods	$43,000

Finally, the cost of purchasing the product is added to the production cost not avoided and compared to the total purchase cost. As illustrated below, purchasing the 10,000 units would result in an unfavorable cost-trade off.

Analysis	
Cost not avoided	$7,000
Plus cost to purchase	$45,000
Total cost to purchase	$52,000
Variance to purchase	$(2,000)

The make-or-buy team makes their decision on which items and services to buy and which are to remain in-house by comparing all criteria, from total cost of ownership (TCO) to the overall impact on the organization. In the end, the team must weigh the potential advantages against the risks associated with the loss of control over items, TCO expenditure, and acknowledging the loss of a degree of independence commensurate with the level of power held by the supplier. Sometimes the decision is a hybrid approach where some but not all items and services are outsourced. Determining the relative cost of full production or assembly of final components is a critical determinant. A brief comparison of considerations influencing the choice of make-or-buy for an item or service are summarized in Figure 11.9 [10]. Once the list of items and products to be purchased is finalized, the sourcing process then moves to the next step – *spend analysis*.

Considerations Favoring Make	Considerations Favoring Buy
Less expensive to produce item	Special supplier competencies and research capabilities
Desire to integrate plant operations	Less expensive to buy item
Productive use of excess plant capacity	Small-volume requirements
Maintain direct control over item and/or the production process	Constrained internal capacities
Guard proprietary design	Option to maintain a make-or-buy strategy
Lack of competent or cost-effective supplier	Reduction in inventory and managerial costs
Desire to maintain stable workforce in a period of declining sales	Desire to maintain stable workforce in a period of increasing sales

FIGURE 11.9 Considerations influencing the make-or-buy decision.

Step 2: **Spend Analysis**. An important step in the make-or-buy decision process is determining what was spent in the past to purchase goods and services. The goal is to chart what was exactly purchased over an extended period, such as a year, by such criteria as quantity, financial volume, and supplier. The output of this analysis will assist purchasers to identify what was the range and volume of commodities as well as strategic products and services that were purchased and who were the major suppliers. This data will assist purchasers to standardize purchased commodities, products and services; restructure contracts; execute aggregate buys across the organization; and create closer relationships with strategic suppliers.

Critical questions to ask during spend analysis are:

- *What products and services did the organization purchase by value and volume during the previous year?* Answering this question enables the organization to determine the total value of money spent on goods and services. This value is critical when calculating the cost of goods sold for the financial income statement. It also reveals which products and services were bought the most and by which parts of the business. Figure 11.10 provides an example of a spend analysis by commodity [11].
- *Which products and services are strategic and which are tactical buys?* Answering this question enables buyers to separate critical and non-critical products and suppliers by value and volume. It also assists them in identifying opportunities for negotiated cost reductions, supplier reduction, partnership building, and reengineering products and processes to utilize readily available standardized products and services.

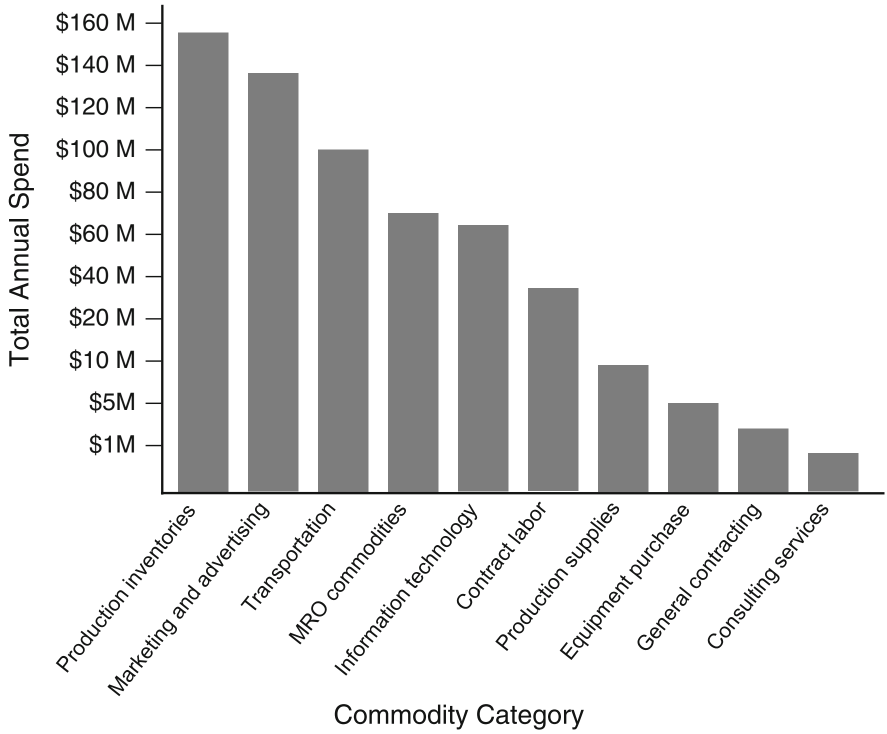


FIGURE 11.10 Chart of spend by commodity category.

An effective process to use is the purchasing classification matrix discussed previously (see Figure 11.4). The value of the matrix in spend analysis is to determine the potential risk in procuring an item from a supplier and the strategic value of the item to the firm.

- *Did the business receive full value for the products and services purchased?* Answering this question enables financial managers to certify the value of purchased goods necessary to meet accountability requirements specified by contract compliance and external bodies such as Sarbanes-Oxley Act (SOX) and the Securities and Exchange Commission (SEC).
- *Which suppliers received the majority of the firm's spend?* Answering this question enables buyers to determine by product, volume, and financial value the top suppliers to the organization. This analysis is critical in the development of supplier partnerships, supplier reduction, and contract renegotiation that is the centerpiece of the next step in the sourcing process. Figure 11.11 provides an example of a spend analysis by supplier.
- *What opportunities can be pursued for supplier reduction, combining purchases from across the enterprise, standardizing products, and leveraging market conditions?* Answering this question enables procurement to accurately ascertain how well suppliers met item requirements and specifications and to assess opportunities for improvement of procurement processes. Other options include finding opportunities to pursue aggregate product and service quantities buys, reduce the number of suppliers, determine opportunities for greater standardization, and leverage market conditions to attain better pricing.

Supplier	Product/Service Category	Annual Spend	Percent
Fourt Electronics	Electronic components	$ 425,775,550	37.38%
Camden Supply Co.	Cases and frames	358,624,125	31.49%
Gopal Transport	Shipping	125,874,359	11.05%
Chopra Tool & Die	Tooling	45,245,221	3.97%
Reliable Electric	Capacitors	41,258,326	3.62%
ABC Electronics	PCs	38,541,623	3.38%
Wynstar & Assoicates	General Contracting	28,750,236	2.52%
Gopal Transport	Packaging	28,541,234	2.51%
UPS	Parcel Shipping	25,451,321	2.23%
Energy & Utilities	Energy	11,548,884	1.01%
MicroSoft	Software	9,253,125	0.81%
DPC Research	Education	165,212	0.01%
Total Spend		$ 1,139,029,216	

FIGURE 11.11 Spend analysis by supplier, category, annual spend, and percent.

Once the spend analysis is completed, the make-or-buy team will need to assess the nature of past spend with the future procurement needs of the business. This information is assembled by researching the purchasing forecast provided by company departments. The team must also know what is occurring in the marketplace regarding key suppliers, available capacities, technology trends, price and cost data, technical requirements, environmental and regulatory issues, and other pertinent data. The goal of the research is to gather intelligence on business conditions and the ability of current and potentially new suppliers to effectively deliver needed products and services. Once the decision to buy has been made and the procurement team has determined such elements as volumes and pricing, the next step is to prepare the bids on the project. During the research component of the make-or-buy process, procurement should have also identified the suppliers to be approached. Prospective suppliers are identified through several sources such as supplier salespeople, catalogs, trade magazines, trade directories, and the Internet.

There are several different types of bids that can be drafted depending on the nature of the procurement requirement. In a *sealed bid,* proposals from prospective suppliers are "sealed." The buyer does not wish to publicly reveal any of the bids prior to a specific date in order to discourage suppliers from exercising leverage to unfair advantage. Sealed bids are used typically in government-related contracting. A *posted offer to buy* is normally used for government contracting. In this method the bid is posted in a public biding document or through the Internet. The goal is to ensure the bid is open to the general public. *Reverse auctions* became popular with the advent of Internet procurement. Normally, the reverse auction is an event whereby prospective or qualified suppliers have the opportunity to bid and rebid on a project with the objective of outbidding the competition and securing the contract. The contract may be awarded to multiple suppliers on a percentage basis, with the lowest bidder receiving the highest percent. A *request for information (RFI)* is used by buyers seeking to compile a list of suppliers or to prequalify suppliers. The RFI asks for such information as supplier financial viability, product lines, production capacities, purchasing management and collaborative technologies, and delivery capabilities.

Another type of bid is a *request for proposal (RFP)*. An RFP is generally used when the detailed product or service specification or the statement of work (SOW) has not been finalized. Among the questions asked are supplier qualifications and financial viability; response guidelines such as confidentiality, proposal preparation, terms of negotiation, proposal evaluation, and notification of award; and SOW steps, such as technical specifications, pricing and billing proposal, supplier quality program, and implementation plan. A *request for quotation (RFQ)* is normally used when the detail product or service specification or the statement of work (SOW) has been finalized. The goal is to obtain price, delivery, and other specific terms from prequalified suppliers. The results of RFQs are reviewed by the buying committee and a supplier is selected. As the bids are drafted, procurement moves to step 3, and begins the process of identifying the suppliers who are to receive the bids.

***Step 3:* Supplier Scoring, Assessment, and Selection**. There are several criteria used by procurement to research and qualify suppliers. The traditional method is to match potential suppliers to desirable attributes. Perhaps the most important factor in supplier selection is *quality*. This attribute refers to how closely the supplier's product matches the buyer's specification, life of the product, ease of repair, maintenance requirements, ease of use, and dependability. Another important attribute is *reliability*. This attribute measures the on-time delivery and performance history of a supplier. An important element is component reliability which affects the quality of the final product, warranty claims, and repeat sales. An attribute of significant importance today is *risk*. Low risk measures supply uncertainties, delivery lead time variations, and changes in pricing. The *capability* of a supplier is also essential in the selection process. This attribute considers the capacities of a supplier's production facilities, technical sophistication, management and organization abilities, and operating controls to meet buyer quantity and quality requirements. The *financial stability* of a supplier is another critical attribute buyers must consider in the selection process. Finally, suppliers might possess *desirable attributes*, such as special equipment, location, reputation, commitment to environmental sustainability and lean principles, technology, quality certification, and others.

Exercise 11.2: Supplier Rating and Scoring

Buyers at ABC Electronics are sourcing the P140-125 Capacitor. Three suppliers have responded to the request for proposal (RFP) with preliminary estimates. The buyers have created two matrixes to score the suppliers: one according to best *cost*, the second according to best *competitive values*. Next, the buyers have selected a series of attributes for both cost and competitive values. The buyers have also rated the importance of each set of attributes by using a percentage. Finally, based on the RFP feedback and other supplier information, the buyers have rated each supplier for each attribute using a numeric factor (1 = lowest, 5 = highest). The goal of the rating is to assess the expected performance of the suppliers on each dimension. By performing the estimate for each supplier and then combining the total, the overall performance of each supplier can be rated in terms of total cost and competitive factors. An example of the supplier rating and score method is detailed in the below spreadsheet (Figure 11.12).

Key: 1 - least favorable; 5 - most favorable

Cost attributes		Suppliers		
Decision Factor	**Rating**	**Ability Electric**	**D&R Supply**	**Alfa Electronics**
Price	65%	5	3	2
Inventory Cost	7%	1	3	4
Safety Cost	7%	1	3	4
Transportation Cost	21%	4	2	1
Total Cost Score	100%	4.23	2.79	2.07
Competitive attributes		**Suppliers**		
Decision Factor	**Rating**	**Ability Electric**	**D&R Supply**	**Alfa Electronics**
Tech Competence	19.0%	2	4	5
Reliability	8.0%	2	4	4
Delivery Frequency	3.0%	2	3	4
Flexibility	2.0%	1	3	5
Quality	24.0%	2	4	5
Pricing Terms	1.0%	5	3	1
Design Collaboration	25.0%	1	3	5
Supplier Viability	18.0%	5	4	3
Total Value Score	100%	2.3	3.69	4.49
Cum Scores		6.53	6.48	6.56

FIGURE 11.12 Supplier rating and scoring.

Another way to look at suppliers is to use the purchasing classification matrix (see Figure 11.4). For *generics*, buyers normally have a wide field of available suppliers. Selection criteria will focus on finding suppliers offering low price, volume and variety availability, speedy delivery, and the ability to automate the purchasing process. The buying team will also be searching for ways to streamline this category through item consolidation and reduction, elimination of small-volume spend, availability of auto-ordering systems, and others. Supplier selection is opportunistic and subject to change at any time. Suppliers of *distinctives* usually occupy a niche space due to the exclusive market position they occupy. Because of the unique products they supply, buyers will, after a competitive bid, seek to execute detailed service agreements that ensure continuity of supply. Normally, buyers engage in *sole sourcing* for this product type. Purchasing this class of item is normally transaction-based.

In many ways, *commodities* are similar to generics. There are usually a large number of equivalent suppliers, and criteria for supplier search is focused on low price, volume availability, high quality, and strong service. However, because of their importance, buyers will gravitate to preferred suppliers favorable to engaging in long-term contracts in exchange for volume business. An important factor is supplier willingness to continuously reduce the total cost of the contract through time. Buyer expectations of suppliers of *criticals* are very high. Buyers will seek suppliers eager to engage in close partnership governed by detailed long-term contracts. Suppliers will be selected on the basis of willingness and capability of supporting purchasing's overall strategy, continuously seeking to attain best-in-class status, and ready to improve value-added services. These suppliers are classified as strategic preferred suppliers. This type of arrangement is termed *single sourcing* because, while multiple suppliers are available, buyers choose to reduce the supplier base to a single supplier.

A final perspective in supplier selection is determining who has bargaining power. The issues centers on whether it is the supplier or the buyer has the greater leverage in establishing the terms and conditions of a purchase and who has competitive control over the relationship. For example, supplier bargaining power is greater when strategic products or services required are restricted to a small number of suppliers; the supplier has unique products or processes not easily substituted from other suppliers; the cost to switch to an alternate supplier is high; and availability of needed volumes is limited. On the other hand, buyer bargaining power is greater the product or service required is a commodity available from a wide variety of suppliers; the cost to switch to an alternative supplier is low; there are good substitutes available; a loyal buyer commands a large proportion of supplier total sales; and sellers eagerly seek to cement brand through close buyer relationships. When assembling the list of possible suppliers, buyers need to understand that the next step in the sourcing process – pricing, negotiating, and contracting – are heavily influenced by who holds procurement bargaining power [12].

***Step 4:* Pricing, Negotiation, and Contracting**. Once the sourcing decision has been made and RFQs and RFIs sent to qualifying suppliers, buyers begin the process of setting agreeable pricing, negotiating with suppliers, and selecting and contracting suppliers.

11.4.1.1 Pricing

The pricing decision contains three elements: price analysis, cost analysis, and total cost of ownership (TCO). The first, *price analysis* refers to reviewing purchase prices based on factors such as supplier comparisons, external benchmarks, and market forces. A price analysis usually involves examination of a supplier's price bid by comparing it with reasonable price benchmarks. Techniques include the following:

- Comparison with multiple, qualified bids attained independently from suppliers whereby the lowest offer does not enjoy an unfair advantage over the competition.
- Comparison of bids with prices set by law or regulation, catalog, or the current market.
- Comparison with historical quotes and prices for the same or similar product or service.
- Comparison with an independent cost estimate that is fair and reasonable.

In the second element of the pricing decision, *cost analysis,* buyers review and evaluate actual or anticipated costs necessary to make and deliver the desired product or service. This method is used mostly with non-standard items. During the analysis, each individual cost element (material, labor, overheads, tooling, logistics, administration, and so on) are totaled to attain a base cost. The goal is to establish the actual cost that will enable the buyer and seller to contract a fair and reasonable price. Methods include cost *markup pricing*. In this model the cost plus a markup percent to attain a desired profit is calculated. In *margin pricing* the buyer establishes a price that includes a predetermined profit margin. For example, if the current cost is US$25 and a 10 % margin is desired, the price is calculated by using the formula: cost/(1 – margin rate), or US$25/.9 = US$27.78. The final cost-based model is *rate-of-return pricing*. In this model, the desired profit is added to the estimated cost. For example, If the buyer wanted a 10 % rate of return on an investment of US$60,000, to make 2,000 units at a total cost of US$20 each, the price is calculated as unit cost + unit profit, or US$20 + ((10 % × US$60,000 units)/1,000 units) = US$26. A "break even" analysis can be used to indicate the point at which the volume produced and associated revenues equals total cost, and the profit is zero.

Exercise 11.3: Supplier Break-Even Analysis

A break-even analysis uses both the cost and revenue data for an item to identify the point where revenue equals cost, and the expected profit or loss at different production volumes. The method enables buyers to identify if a targeted purchase price provides producers a reasonable profit, simulates the impact of different volumes and prices, and assists the buyer to anticipate cost and price strategies during negotiations. For example, a buyer wants to perform a supplier break-even analysis on an item with a known supplier. The supplier's fixed overhead costs are US$3,000, and the variable costs per unit are US$6 to produce a lot of 900 units. The purchase price is US$10 per unit.

1. The *total cost* to the supplier is calculated as: overhead costs plus (unit cost × anticipated quantity), or US$3,000 + (900 units × US$6) = US$8,400.
2. The *unit cost* to the supplier is calculated as: total cost/anticipated quantity, or US $8,400/900 units = US$9.33.
3. The *break-even quantity* is calculated as: overhead cost/(purchase price – unit cost), or US$3,000/(US$10 – US$6) = 750 units.
4. The *break-even revenue* is calculated as: purchase price × break-even quantity, or US$10 × 750 units = US$7,500.
5. The supplier's *expected profit* is calculated as: ((purchase price × anticipated quantity) minus (unit cost × anticipated quantity)) minus overhead costs, or US $10 × 900 units – US$6 × 900 units – US$3,000 = US$600.

Figure 11.13 illustrates the mechanics of the method. The goal is to determine the break-even point where total revenues and total costs intersect.

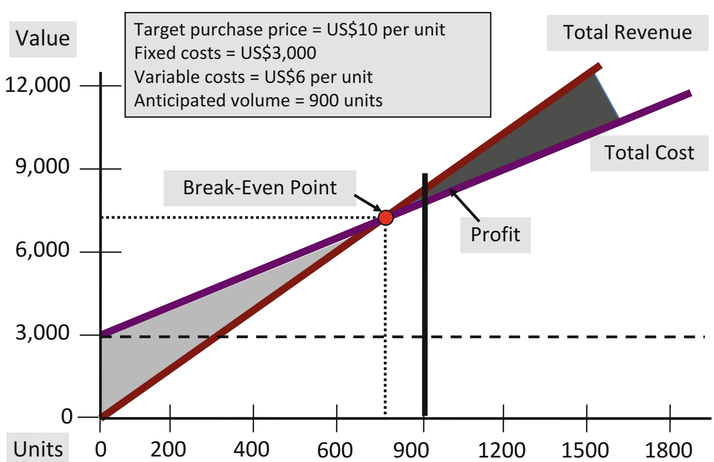


FIGURE 11.13 Supplier break-even analysis.

For an item that is produced in house, planners may want to determine the breakeven point for production and the supplier quote side-by-side. The idea is to see when the projected demand quantity is more economically made in house or outsourced.

Exercise 11.4: Production/Supplier Break-Even Analysis
The first step in the make or buy break-even analysis is to determine the production break-even quantity. Once calculated, the next step would be to work with potential suppliers to determine what it would cost to buy the same quantity. Performing the buy analysis requires that the supplier provide at least the purchase and fixed costs. After research, the following data was gathered:

Manufacturing	
Selling price/unit	$2.00
Production fixed costs	$25,000
Production variable costs/unit	$0.50

Purchasing - supplier A quote	
Purchase price/unit	$1.65
Fixed costs	$8,000

To find the break-even quantity, the planners would first set the costs of the two options equal to each other. The calculation is as follows:

1. Production fixed cost minus purchasing fixed cost of (US$25,000 – US$8,000 = US $17,000).
2. Purchase unit cost minus production unit cost or (US$1.65 – US$0.50 = US$1.15).
3. The break even quantity is determined by dividing the fixed cost by the unit cost or (US$17,000/US$1.15 = 14,783 (rounded)).

The results of the analysis indicate that if sales volumes are less than 14,783 units, it would be more economical to produce the product in house.

The final element of the pricing decision is *total cost analysis* or *total cost of ownership* (TCO). TCO is defined as “the present value of all costs associated with a product, service, or capital equipment that are incurred over its expected life [13].” The main insight provided by TCO is the understanding that the acquisition cost is often a very small portion of the total cost of ownership. This method requires buyers to identify and measure costs beyond just the unit cost. Typically these costs include several components. The first is the *purchase price* of the materials and components acquired from suppliers. The second component consists of the *acquisition costs*. This is the amount paid for delivery of purchased goods and services including sourcing, administration, freight, duties, and taxes. The next component is *product costs*. This contains the costs for planning, engineering, materials, scrap, downtime, opportunity costs, and technologies used in finished goods production. The fourth cost element is *landed cost,* which is the product cost plus the costs associated with carrying inventory, warehousing, transportation, product handling, customs, duties, environmental sustainability, and others. The final cost component of TCO is *end-of-life costs*. This is the cost incurred when a product or equipment is removed from service. These costs include salvage, obsolescence, disposal, clean-up, project termination, and recovery.

Buyers often attempt during pricing negotiation to reduce prices through discounting. There are five common forms of supplier discounts: trade promotion, quantity, volume, seasonal, and cash.

- *Trade promotion*. This form of discount is given to the buyer to compensate for performing various marketing functions for the seller. Normally, the discount applies to a promotion that has a definite expiration date. Trade discounts are usually set up as a series of individual discounts (e.g., 25 %, 10 %, and 5 %) and are termed *series discounts*. Generally, buyers want to get as close as possible to the producer versus dealing with downstream channel intermediaries who may only offer part of the original discount offered by the producer. This type of discount is common in the consumer packaged-goods industry.

- *Quantity discounts*. This form of discount results in price reductions based on the size of the order quantity and monetary value of the items purchased at one time or monetary value purchased over a set time. Quantity discounts are based on the unit cost reduction that results from economies of scale in production. Buyers should consider this type of discount for high volume repetitive purchases.
- *Volume discounts*. Also known as a *cumulative discount,* this form of discount is similar to a quantity discount in that it is based on cost reduction resulting from economies of scale in production. The difference is that a volume-based discount is based on the total quantity or monetary amount purchased over a given period.
- *Seasonal discounts*. This form of discount is based on the seasonal nature of goods or services. The buyer may be able to get a reduced price on the item by purchasing it when it is off-season.
- *Cash discounts*. This type of discount is determined by negotiations relating to the terms of buyer payment. Normally, a discount off the total value of the supplier invoice is granted for payment that occurs within a specific time frame. For example, the supplier will reduce the cost of the invoice by 2 % if the buyer will pay within 10 days of invoice receipt.

As RFQs and RFIs are received from prospective suppliers, buyers will begin the process of selecting candidates for products and services that are driven by price. Often buyers must choose between various prices and volumes for the same items coming from multiple interested suppliers. An effective method of selecting the most cost-effective supplier is to use the total annual cost of each suppliers' RFQs.

Exercise 11.5: Supplier Selection Comparison

ABC Electronics is looking to source a new capacitor and has received three bids in response to their request for quote to cover an anticipated weekly demand of 1,200 units. Supplier 1, who is local, is asking US$0.95 per unit for a lot size of 2,400 units and has a lead time of 3 weeks with a standard deviation of 1 week. Supplier 2 is asking US$0.98 for a lot size of 10,000 and has a lead time of 8 weeks with a standard deviation of 3 weeks. Supplier 3 is asking US$1.10 for a lot size of 3,600 and has a lead time of 5 weeks and a standard deviation of 2 weeks. Two transport companies handle the shipping. Associated Truck charges US$7.25 per 100 lbs. and Fast Forwarder charges US$5.50 per 100 lbs. with a minimum of 50,000 lbs. per order. Based on this data, select the best supplier for the capacitor based on cost.

The buyer begins by establishing the following table of the item's order information.

Item demand, cost, and transport data	
Weekly demand	1,200
Inventory carrying cost	22 %
Customer service level	97 %
Standard deviation (demand)	200
Order cost per order	$150.00
Item weight - lbs	6
Associated truck per 100 lbs	$7.25
Fast forwarder per 100 lbs, 50,000 lbs min	$5.50

Based on this information the buyer is able to calculate the following cost data for the three suppliers (Figure 11.14):

Supplier Data and Assessment	Supplier 1	Supplier 2	Supplier 3
Unit Cost	$ 0.95	$ 0.98	$ 1.10
Annual Material Cost	$ 59,280.00	$ 61,152.00	$ 68,640.00
Lot Size	2,400	10,000	3,600
Average Cycle Inventory	1,200	5,000	1,800
Annual Inventory Carrying Cost	$ 250.80	$ 1,078.00	$ 435.60
Lead time/weeks	3	9	5
Std Dev of Lead Time	1	3	2
Std Dev of Demand during Lead Time	1,249.00	2,163.33	1,754.99
Safety Inventory	2,349.11	4,068.78	3,300.78
Annual Cost of Safety Inventory	$ 490.96	$ 877.23	$ 798.79
Orders per Year	26.00	6.24	17.33
Annual Ordering Cost	$ 3,900.00	$ 936.00	$ 2,600.00
Order Weight/lbs	14,400	60,000	21,600
Order Transportation Cost	$ 174.00	$ 550.00	$ 261.00
Annual Transportation Cost	$ 4,524.00	$ 3,432.00	$ 4,524.00
Total Annual Cost	**$ 68,445.76**	**$ 67,475.23**	**$ 76,998.39**

FIGURE 11.14 Supplier cost analysis.

Supplier data	Calculation
Annual material cost	Weekly demand × 52 × supplier unit cost
Annual carrying cost	Avg. cycle inv. × supplier unit cost × inventory carrying cost
Std dev of demand during LT	SQRT (LT × std dev^2 + weekly demand^2 × std dev of LT)
Safety inventory	NORMSINV (customer service level) × std dev of demand LT
Orders per year	(weekly demand × 52)/lot size
Annual ordering cost	Orders per year × order cost per order
Order weight/lbs	Item weight × lot size
Order transportation cost	Transportation supplier cost × lot size/100
Annual transportation cost	Orders per year × order transportation cost
Total annual cost	Annual material cost + annual inventory carrying cost + annual cost of safety inventory + annual ordering cost + annual transportation cost

Based on cost, Supplier 2 offers the best price.

11.4.1.2 Negotiating

Determining the purchasing price is only part of the sourcing process. The final price is rarely a matter of simply analyzing costs and expected profits. When purchasing a commodity requires further definition of technical specifications, price, delivery time, and terms of sales; the products needed are not commodities; or the buyer is intent on establishing a collaborative relationship with the supplier, negotiating becomes a critical sourcing activity.

The *APICS Dictionary* defines negotiation as "the process by which a buyer and a supplier agree upon the conditions surrounding the purchase of an item." The process of deciding on a supplier and the price to be paid for goods and services often must meet several objectives before a contract is awarded.

An important objective beyond price is *quality*. To effectively manage this dimension, the buyer's product design team must be part of the negotiations. The team is responsible for knowing the exact specifications and tolerances for purchased materials and components. Discussion includes what cost and quality levels are needed. Another objective is achieving a *fair and reasonable price*. In most cases, agreement on a fair and reasonable price for the desired level of quality is the focus of the negotiation. Analysis tools, such as price, cost, and total cost analysis, are used in developing the final price. A further objective is *service level*. This objective refers to negotiations on such elements as lead times, transportation, and packaging. Similar to quality, service levels can be relaxed or traded-off. For example, price concessions might be made to implement lean techniques or establish a supplier-managed inventory program. Another objective is *control*. For critical items, buyers often negotiate prices to assure high levels of compliance to item specification. This is done through the use of special testing equipment, statistical process and quality control methods, use of highly trained workers, level of allowable supplier outsourcing, use of special processing equipment, and on-going status reporting.

In addition to the above, another negotiation objective is supplier *capacity/volume*. Negotiations surrounding this objective focus on limitations in a supplier's production or service levels as a result of forecasted changes in market conditions. Often buyers will trade higher prices for guaranteed amounts of supplier capacity. Another important objective is *length of contract*. Depending on market conditions or the cost volatility of the items to be purchased, buyers often will seek to lock-in favorable prices for a given time period. Hedging prices, however, can be a source of contention. Suppliers may not want a longer contract because of anticipated changes in production costs, or they may want a longer contract as assurance of the commitment of the buyer. The final objective of negotiation is establishing *continuing relations* with the supplier. In most cases, the negotiations should aspire to a win-win atmosphere. The goal is establishing a close relationship in which each side recognizes mutual long-term success as a central point of the negotiation.

Contracting. The last activity in step 4 of the sourcing process is *supplier contracting*. Supplier contracting is defined as an agreement between two or more authorized company representatives to deliver certain products or perform certain services in exchange for the purchase price. A contract can be oral or written and in effect for a single purchase or for the delivery of products or services over a period of time. Buyers and suppliers often formalize the outcome of the buy negotiation by drafting a contract that enables both parties to achieve tactical and strategic objectives. The goal of the contract is to manage and hedge risk in the supply relationship. Examples of purchasing contracts are presented below [14].

- *Purchase order (PO)*. The PO is the most common form of purchasing contract. The standard PO is used for recurring or repetitive purchases as well as one-time purchases. In addition to standard terms and conditions, the PO covers remedies, warranties, liabilities, rights of inspection and rejection, cancelation, and other clauses.

- *Requirements for unspecified delivery*. In this contract the buyer agrees to commit all the organization's yet-to-be-defined quantity and delivery requirements in exchange for a fixed price and/or lead time. Normally the buyer shares the forecasted requirements with the supplier during negotiations. This is also known as a "blanket" or "standing" order.
- *Specified quantity*. In this contract the buyer agrees to purchase a specific amount of product during a given time frame, but does not agree on the specific delivery dates. If the quantity is not totally purchased at the end of the contract period, the buyer must pay the supplier for the unpurchased quantity remaining per the contract.
- *Fixed price*. This is the most common type of contract in which prices are agreed to as a condition of the contract without regard to costs. There are several variations, including *firm fixed* (price cannot be changed), *incentive* (supplier's profit increases as costs decline or overall profit increases based on agreed upon targets), *economic price adjustment* (upward or downward scale based on costs or market), *price redetermination* (price temporarily fixed but may change over time), and *level-of-effort* (price based on the actual level of labor time and materials expended).
- *Cost-based*. In this form of contract, the supplier requires that the buyer provide a payment covering, at minimum, a certain level of cost. Variations of this model are cost plus an incentive fee, cost-sharing, cost of time and materials, and cost plus fixed fee. This method is used in government and large research and development projects in which capital investment is high and risk is great.
- *Buy-back*. In this form of contract, the supplier incentivizes the buyer to order more units by agreeing to buy back unsold goods at a negotiated price that is higher than salvage but lower than full price. Both parties hedge their risk.
- *Revenue and cost-sharing*. In a revenue sharing contract, the buyer agrees to share some of its sales revenue in exchange for a discounted price. In a cost-sharing contract, the buyer is willing to share a portion of production costs in exchange for a discounted price.

Once procurement contracting is concluded, buyers can start step 5 of the sourcing process and begin the task of purchase order release and management.

11.5 PURCHASE ORDER MANAGEMENT

Once sourcing activities have been completed, it is the responsibility of procurement management to convert the inventory replenishment needs of the organization into actual purchase orders. Replenishment requests can come from anywhere in the business. A request could originate with the receipt of a requisition for MRO equipment; a request for a one-time purchase of a special item for a customer; or it could be part of a computer generated requirements schedule where the firm's purchase orders for production inventories are mass generated. Effectively managing this execution phase of the purchasing management process requires several steps. To begin with, procurement must meticulously maintain the database elements necessary for effective and accurate purchase order release and control. Several key files must be continuously maintained such as the item master, the supplier master record, and the price master. In addition, to these *static* database files are *variable* database files, such as open requisitions, open purchase order (PO), and purchasing history. These files need to be 100 % accurate and up-to-date for the smooth flow of order creation and tracking.

In addition to database files, the procedures governing the PO processing cycle should be thoroughly documented. Essentially, there are five distinct stages required for successful purchase order processing: (1) order planning, (2) order entry and transmission, (3) transportation decision, (4) receiving, and (5) order closeout. Another important step in the purchasing management process is open order status tracking and performance reporting. At any time in the purchase order life cycle purchasing must be able to determine the status of every order and indicate each as open, received, or closed. The final step is the creation of effective procurement performance measurements. Detailed performance metrics provide the enterprise with the data necessary to chart the effectiveness and efficiency of the purchasing organization and highlight areas for improvement. Supplier performance measurement is concerned with ensuring that the goals, expectations, and agreements contracted between the buyer and the supplier are being fulfilled.

11.5.1 Purchase Processing Cycle

Essentially, there are five distinct activities required for successful purchase order processing. These activities can be respectively described as *order planning*, *order entry*, *transportation decision*, *PO receipt,* and *order closeout.* The purchase order processing cycle is illustrated in Figure 11.15.

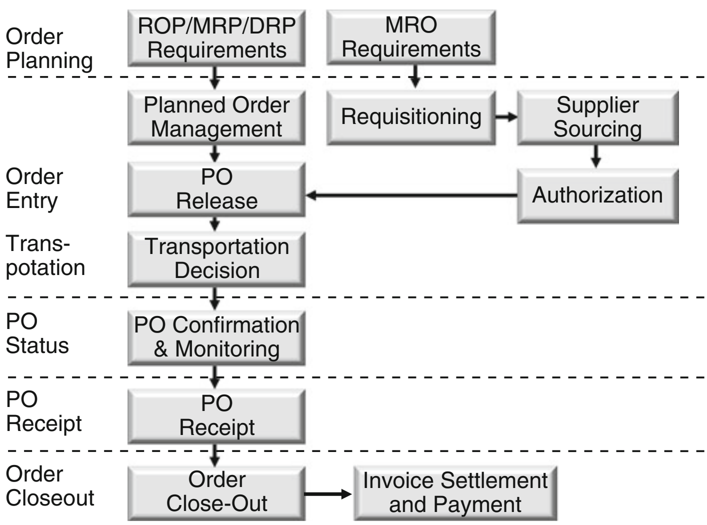


FIGURE 11.15 Purchase order cycle.

11.5.1.1 Order Planning

Two types of purchasing are planned during this stage. The first arises with requisitions for the purchase of general *maintenance, repair, and operating* (MRO) inventories and services. MRO requirements arise out of the everyday use of supporting products and services. MRO purchase orders are created on an "as-needed basis." In most organizations, MRO purchasing commences with the completion by the requestor of a manual or computerized *requisition order*. Once received by purchasing, requisitions must pass through several steps. Some MRO requests are complex, requiring a needs assessment, supplier sourcing, negotiating price and quantities criteria, authorization, and concluding with PO generation. For other MRO requests, many of these steps have already been resolved because of long-standing supplier partnerships or various forms of purchasing contract. In evaluating suppliers, purchasers will often use variables such as lead times; past record of on-time delivery; ability to expedite; convenience in ordering/communication; quality; availability of technical and training services; range of presales and post-sales value-added services; competitiveness of price, reputation, and past experience with suppliers; and availability of technology tools such as EDI and Web-based ordering.

Developing the plan for the purchase of production inventories and finished goods follows a different route than MRO procurement. As discussed in Chaps. 8 and 9, replenishment requirements for these types of product are normally identified by the firm's MRP, reorder point, DRP, and kanban systems. For the most part, issues relating to sourcing and pricing have already been determined, leaving the focus on selecting the necessary items, quantities, and required dates. Generally, buyers utilize three possible methods in developing the procurement plan:

- *Current requirements buying*. This is the most common method for purchase order release of production inventories. Based on a purchase schedule developed from planning tools such as MRP and order point, buyers will assemble a purchase order that balances lot quantities with cost elements such as quantity discounts, carrying costs, stock out costs, and ordering costs. This method is also used for repetitive MRO buying.
- *Forward buying*. This approach utilizes medium- to long-term inventory planning to purchase goods and services in excess of current requirements. Normally, buyer and supplier engage in some form of contract in which price, quantities, quality, and delivery are agreed upon. Some reasons why purchasers will use forward buying are to guard against possible price increases, attain economies of scale through quantity discounts and favorable transportation rates, guarantee supplier capacities, and guard against risks, such as supplier materials and capacity shortages and supply chain disruptions caused by labor disputes, adverse weather conditions, supplier financial problems, and other risks.
- *Speculative buying*. In this method of PO release, buyers purchase goods and services beyond current requirements. This practice is often called *hedge purchasing*. The usual reason for speculative buying is to lock in prices in anticipation of a price increase or an impending product shortage. A decision to use this technique, which entails high risk, requires the authorization of purchasing management and should support company objectives.

Another distinctive feature of this type of buying is that it is normally conducted by the inventory planners rather than the buyers. It is the responsibility of the inventory planners to review the planning system exception messaging, develop the purchasing schedule, firm the order with the supplier, and authorize delivery. Once orders have been released, the planner is responsible for maintaining the accuracy of system planning and open order data. If demand changes, the planning system will alert the planner to contact the supplier and alter quantities and due dates to keep priorities in balance. The buyer's role, on the other hand, shifts from a concern with paperwork and expediting to activating a range of value-add functions supportive of the supplier relationship. The buyer must assure the timely supply of quality goods and services achieved through close supplier selection, negotiation, pricing agreements, value analysis, quality improvement, and alternate sourcing. The mechanics of the whole operation are determined by the requirements output from the planning systems supported by the *supplier agreement* fleshed out in advance by the buyer and the supplier's sales force.

11.5.1.2 Purchase Order Entry

Once order planning activities are completed, the purchase order cycle moves to purchase order entry. Buyers have access to several different PO types. The criteria guiding their choice are the volume and value amount of the products or services to be purchased, availability of computerized technology, nature of the buy (one-time or continuous), and authority of the buyer. The most common type of PO is the *discrete purchase order*. This type of order is a one-time contract whereby the supplier promises to deliver specific products or services at a specified quantity, date, and price. Discrete purchase orders are best used for MRO needs, special products or components, and projects of limited duration. They are not appropriate for the purchase of high-volume, high-usage products, service contracts, or capital equipment.

Another form of purchase order is the *blanket order*. In this method, a purchase order containing a fixed quantity of units for specific items or a total value amount that extends over a period of time is negotiated between buyer and seller. When the quantity or value limit amount specified by the blanket order contract is reached, the order expires. Blanket orders work best when the quantity and/or value amount is known. This form of order is often used to purchase MRO items and services.

A third type of purchase order is the *requirements contract*. In this type of purchase order, the buyer commits to the supplier to purchase a fixed percentage of the company's requirements in exchange for quality, price, availability, and delivery considerations. Instead of a discrete quantity, the buyer normally will furnish the supplier a short-range rolling forecast of requirements, as well as authorizing the supplier to buy and build inventory for a specified number of forecasted periods. *Systems contracting* is another form of purchase order that resembles the *requirements contract*. It has often been called *stockless purchasing*. In this method, the inventory planning system (normally an ERP system) automatically generates purchase orders for items with replenishment requirements based on a schedule of requirements. Usually, direct electronic links are established between buyer and seller organizations through electronic data interchange (EDI), auto fax, or the Internet. The process is normally used with a blanket or contracted agreement or for low-value, high volume items, such as fasteners and lubricants. The ordering system enables buyers to place orders directly into a supplier's customer order system.

When goods or services are purchased in small amounts and at low cost, buyers can use *procurement cards (P-cards)*. In this method, authorized employees are presented with a purchasing card similar to a personal credit card. The card owner makes the buying decision, bypassing the purchasing department altogether. Perhaps the most exciting method of PO generation is the use of *Internet (B2B)*. In this method, buyers use Internet commerce capabilities to source, compare prices, submit requisitions, generate purchase orders, and transfer funds. Buyers can use such devices as buying exchanges, auctions, and online catalogs to locate and buy goods and services from anywhere on the globe. Another PO type is a *direct-ship purchase order*. Often customers wish to purchase specific products or large quantities the seller does not inventory. Instead of turning the order away, the products are ordered from an outside supplier, who, in turn, ships directly to the customer, bypassing normal in-house PO receiving, material handling, and shipping. Direct-ship purchasing only works if agreed to by the customer, and the supplier can be quickly notified of the order and can ship within a very short time frame. A final form of purchase order is the *service contract*. This type of order is used to purchase non-product services in response to a company requirement.

Today's purchasing systems provide sophisticated applications to streamline PO release. For MRO purchases, most computer systems provide functionality for easily converting the requisition into a PO. Similarly, most of today's ERP systems provide sophisticated "workbench" applications that facilitate mass planned order release directly into POs. In addition, these interactive computer screens provide buyers with the opportunity to examine the contents of the proposed order before actual release. The buyer/planner can analyze such elements as supplier lead times, proposed order quantity, available discounts, and shipping costs. These steps are particularly important for products to be replenished through a *discrete purchase order*. For repetitively purchased items, the system-generated requisitions provide the buyer/planner with a window into future requirements that can be negotiated into *systems contracts*.

11.5.1.3 Transportation Decision

The management of inbound freight for purchased goods has migrated from the purchase of a generic commodity to a complex decision involving a landscape of price and service options. As a result of deregulation legislation during the mid-1980s, buyers today recognize the need for closer integration of purchasing and transportation departments if they are to attain lower freight costs. In fact, some firms have combined the two functions into a single department. Regardless of the organizational structure, procurement has become acutely aware that many of the techniques used for supplier management should also be applied to the selection of transportation partners. Careful evaluation and selection, price analysis, aggressive negotiation, scope of value-added services offered, and a continuous search for cost reduction performed by knowledgeable personnel can effect substantial savings and improved services in the management of inbound freight. Purchasers can no longer simply specify "best way," "ship soon as possible," or leave it up to the supplier. Competitive purchasing requires buyers to work closely with their traffic management departments or utilize *third party service* (3PLs) providers.

The first transportation decision concerns the level of control buyers wish to retain over the goods in transit. If inbound freight is shipped *free-on-board* (*FOB) destination,* the supplier executes carrier search and payment and retains title to the goods and controls the shipment until it is physically received by the consignee. On the other hand, if the buyer wishes to retain control over the shipment, *FOB shipping point* is selected. Here, title to the goods is assumed by the buyer at the seller's shipping point. The buyer then must also perform the following transportation management steps (Figure 11.16):

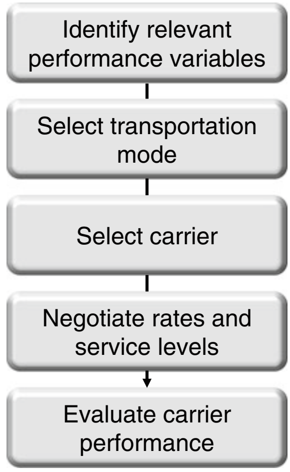


FIGURE 11.16 Transportation decision process.

Buyers must consider a number of performance characteristics when selecting the appropriate mode of inbound transportation. These characteristics must be matched with the type and quantity of product to be shipped, the capacities and capabilities of the transportation mode, and relevant cost issues. Six transport mode performance characteristics drive any transportation selection decision:

- *Completeness*. This characteristic refers to the ability of the transport mode to move inventory from one location to another *without* the use of other modes. The less material has to be handled, the lower the transport cost and the shorter the delivery time.
- *Dependability*. The degree of transport dependability is measured by the performance of a given mode in meeting anticipated on-time delivery. Dependability is critical in ensuring that planned inventory availability is delivered to schedule.
- *Capability*. Capability refers to the ability of a given transport mode to accommodate a specific load. Characteristics such as product type (liquid, solid, bulk, or package), load weight, and load dimensions are important in deciding on materials handling equipment and mode of transport.
- *Frequency*. This performance factor is a measure of the frequency a given transport mode can pick up and deliver goods. Generally, the shorter the transport interval, the greater the flexibility of the mode to respond to channel requirements.
- *Cost*. There are several costs in transportation. The most obvious is the rate paid to the carrier for use of the mode. Other costs are labor and material handling to load and unload the transport medium, occurrence of spoilage and damage, insurance to protect against possible loss, and in transit inventory carrying costs.
- *Speed*. Speed is the prime attribute of transportation. Speed enables the marketing utilities of *time* and *place*. Transportation speed is defined as the time required to move products from the source to a terminal, load the products onto the transport vehicle, traverse terminal points, and deliver the products to the receiving terminal.

The third step key transportation decision is selection of carriers. There are five modes of transportation: rail, motor, air carrier, water carrier, and pipeline. Once the buyer selects the mode best suited to move the purchase, the next step is selection of the carrier. There are essentially three categories of for-hire carriers operating in the United States: (1) *Common Carriers* must serve all buyers charging public rates for specific goods categories; (2) *Contract Carriers* move freight under a negotiated contract with a buyer; and (3) *Exempt Carriers* are free from regulations, such as rates, routes, and services, because of the type of products they transport and the nature of their operation. A fourth-type of carrier is not-for-hire private transportation owned by the purchaser.

The fourth transportation decision step is negotiating rates and determining service levels. Transportation cost decisions are influenced by modal factors such as delivery due date, cost, reliability, size, transit, and product type. The type of carrier also will determine pricing conditions. The final transportation decision is determining the performance metrics used to measure how well inbound transportation is meeting purchase receiving goals. Transportation performance is determined by measuring such metrics as on-time delivery, rates, coverage, transit, care and handling, and shipment tracing as established in the contract.

11.5.1.4 PO Confirmation and Monitoring

Once the PO has been completed it is transferred to the supplier either physically or electronically. In return, the buyer should receive confirmation of the order from the supplier. At this point in the PO process, the buyer is expected to continuously review order status. The open purchase order file is used to create a variety of reports, such as PO priority by supplier and due date, or PO status by product or order number. Priority reports are used as a follow-up tool assisting buyers to ensure POs are received on time without incurring costly expediting or possible material shortages. In addition, a report of open purchase orders can be used as a verification list for communicating with the supplier. Such a practice will ensure that the supplier's list of commitments matches the open purchase order list. Effective monitoring also assists buyers and planners in maintaining the schedule of open order priorities. The key element is ensuring PO scheduled receipt dates are met. Problems occur when demand and supply circumstances change after the purchase order has been released. The cancellation or postponement of a large customer order will require that the buyer/planner review the status of open purchase orders and perform required order action such as expediting, de-expediting, or even cancelling the PO. These action activities will ensure the schedule of open receipts in the firm's planning system is always accurate and up-to-date.

Finally, PO monitoring provides the detailed data necessary for purchasing planning and control. PO reporting takes two forms. The first provides a monthly or bi-monthly window on purchasing's impact on enterprise operations and future planning activities. The content of this report should consist of a summary of the general business climate, a list of specific price increases or decreases for major product lines or commodities, analysis of current lead times for major materials and suppliers, and finally a list of possible material shortages and purchasing's strategy to handle each shortage. The second type of PO report provides a monthly or quarterly summary of the state of the purchasing function and efforts to increase the company's profitability and competitive advantage. This report should consist of the following: a summary of quality, reliability, supplier, and cost improvements; operational statistics, such as number of employees, operating cost, dollar commitments against budget, and number of purchase orders issued during the period; a brief description of departmental efforts at continuous quality improvements and elimination of wastes; and a statement of future procurement projects and administrative activities.

11.5.1.5 Purchase Order Receipt, Inspection, and Order Close-Out

The culmination of the purchase order process is *receiving, inspection* and *order close-out*. Responsibilities of the receiving function are to receive, identify, perform general material inspection, and confirm that the products received from the supplier are what the buyer ordered. Effective receiving can have a significant impact on costs and operational efficiencies. Receiving errors will result in increased costs, inefficiencies in production and shipping, and widening gaps in customer confidence. Typical receiving activities are described as follows:

- *Unloading*. The first step in receiving is the unloading of the material from the carrier. Efficient unloading often requires working with carriers to schedule and sequence deliveries to prevent bottlenecks and maximize dock labor and equipment. Although most unloading is performed by manual handling, receivers can utilize material handling equipment, conveyors, or unitized loads that increase mechanization of the unloading process.
- *Shipment verification.*Receivers must verify the purchase receipt by referencing the freight bill and the original purchase order. An important check performed by receiving is verifying the scheduled receipt date indicated on the purchase order. If the receipt is deemed too early, the material should be returned back to the supplier, depending on company policy and the supplier contract. This practice can significantly assist companies eliminate unnecessary inventory carrying costs, stores congestion, and premature accounts payables. In case of external damage or incorrect materials, receivers normally will reject the receipt and reload it back on the carrier for return to the supplier.
- *Unpacking and damage inspection*. The receiver is responsible for three verifications. To begin with, the material received is checked against both the supplier's packing list and the original purchase order. Second, the quantity is checked in the same fashion. Finally, a general inspection is performed to determine if products are damaged, are the correct revision, and so on. If detailed inspection is required, the receipt would be moved to the inspection department for formal review and acceptance. While in inspection, products should not be allocatable to open orders until final disposition.
- *Unitize materials*. All received materials should be unitized to reduce material handling. For example, loose cartons are palletized on the receiving dock to enable the efficient use of forklifts and other equipment.
- *Hot list review*. Often newly received products are urgently needed for production or to fill customer backorders. By checking each receipt against a "hot list," personnel can speed the flow of materials through the receiving process to the production floor or the shipping dock.
- *Prepare receiving report*. Most companies utilize standard multi-copy receiving forms, computer entry, or bar code readers to record material receipts as well as quality, delivery, and other performance issues. The resulting documentation is sent to accounting, who uses the information to verify payables invoicing, inventory control for materials disposition, purchasing for supplier performance evaluation, and quality management for receipt inspection.
- *Delivery of materials*. Often receiving is responsible for transporting materials to the proper stores location or, in the case of non-stock items, directly to the requestor. Upon delivery of the materials, the recipient signs-off on the *receiving traveler*, thereby assuming full responsibility for the inventory.

Once receipt has been completed, the original order is reviewed for possible closeout. All lines received complete or with open balances should be so indicated on the order. Receivers and buyer/planners must be careful to review any unreceived lines and make judgments as to line and overall order status. Any open line balances, no matter how trivial, will remain as open replenishment orders in the supply system and will have to be rescheduled to ensure they do not fall past due. Effective receiving procedures will significantly reduce the acceptance of unordered inventories, inaccurate quantities, poor quality, and costly misidentification of materials. The PO is now marked for invoice settlement and payment.

11.6 SUPPLIER AND PROCUREMENT PERFORMANCE MEASUREMENT

The final step in the purchase order management process is performance measurement. Detailed performance metrics contain the necessary data to enable the purchasing function to chart the effectiveness and efficiency of the firm's overall purchasing effort and highlight areas for improvement. There are two dimensions to purchasing performance measurement: supplier and internal departmental performance. Supplier performance measurement is concerned with ensuring that the goals, expectations, and agreements contracted between the buyer and the supplier are being fulfilled. Performance scorecards and metrics provide suppliers with detailed goals that both the supplier and procurement can view on a daily, weekly, monthly, or other periodic basis. Regular evaluation of the purchasing function is needed to ensure that departmental activities are being optimized in the pursuit of value-added objectives. Permeating both areas is a commitment to continuous improvement. Successful companies consider continuous improvement as a way of life for suppliers, customers, and employees alike. Integrating purchasing performance measurement programs and continuous improvement objectives are fundamental building blocks of competitive advantage.

11.6.1 Supplier Performance Measurement

The first step in defining supplier performance measurements is to establish, with the supplier's participation, reasonable performance goals and then to implement a realistic time table for reaching them. The focus of this exercise is not to set up rigid metrics to be used as a punishment/reward tool; rather, the performance objectives represent an opportunity for buyer and supplier to establish common ground and develop a better understanding of each other's needs and capabilities.

Although quality, service (delivery), and price are normally the three supplier performance criteria used by most measurement systems, several others may be used. Selecting the proper measurements is a critical process and should be based on such elements as purchasing objectives, product characteristics, delivery requirements, and others. The following are the most commonly used metrics.

- *Quality*. By far, quality is normally considered the most important. There are several avenues buyers can take with their suppliers to ensure quality. Quality requirements can be stated directly on the purchase order or defined on a separate document negotiated between buyer and seller. Another technique is for buyers to educate and provide performance gathering tools to suppliers so they can attain the desired standards. Often this involves training suppliers on the use of specific *statistical process control* (SPC) techniques that enforce conformance to quality specification, narrowing of process and product variation, and identification of out-of-control processes. Examples of quality measurements include number of lots rejected by the number of lots received; dollar value of rejected items by the total dollar value of shipments; number of parts received by the number of parts rejected; and received parts per million defective.

- *Delivery*. As inventory planning systems increasingly focus on scheduled due date priorities, the requirements for on-time delivery increase. Industry leaders today permit the supplier to ship up to 2 days early, *no days late*. Furthermore, some firms actually require their suppliers to respond at a specific *time* of day, not just the day required. Possible delivery measurements include purchase order request date versus actual ship date, supplier promise date versus actual ship date, supplier promise date versus actual receipt date, and delivery within accepted windows. Another important measurement in this area is record of inbound freight cost reduction.
- *Price*. While critical, price has dropped in importance in rating suppliers. An appropriate measurement is to develop a *price index*. The goal of the index is to measure current price against a benchmark price for an extended period of time. Competing suppliers can then be analyzed by comparing their price indexes or by factoring in other performance criteria such as delivery and quality. This measurement is computed first by establishing for each item the price index as illustrated below:

Price criteria	Price element
Product price at the start of the year	$10.50
Product price at the end of the year	11.25
Price variance	$(0.75)
Annual product usage/units	5,000
Summed price at US$10.50	$52,500.00
Summed price at US$11.25	$56,250.00
Price index	1.07

The *price index* is calculated for each item purchased from a given supplier and a summed index derived. Competing suppliers can then be analyzed by comparing their price indexes or by calculating in other performance criteria, such as delivery and quality. Another measurement is how often the quoted PO price matches the invoice price.

- *Flexibility*. This metric measures how easily suppliers can accommodate changes in the purchase schedule, respond to an expedited order, or handle special requests.
- *Lead Time*. There are two possible measurements regarding lead time. The first is the percentage of times a supplier's delivery matched expected lead times. Although a useful metric that ensures arrival of products to sustain sales, this measurement is neutral. A far more important measurement is the percentage of lead time *reduction* for a given supplier. The use of this metric supports the philosophy of continuous improvement.

- *Quantity Received.* Suppliers may deliver on time but deliver in quantities that are more or less than specified on the purchase order. The best measurement for analyzing quantity receipt performance is to develop a range of tolerances (+/−) associated with rating points. For example, a 100 % delivered quantity rates 100 points, a +/− 5 % deviation rates 95 points, and so on. Using this method, the performance percentage would be calculated by dividing the sum of points earned by the sum of possible points.

Buyers could in turn easily use these metrics to create any variety of Pareto charts, scatter diagrams, histograms, and pie charts portraying short- to long-term supplier performance.

Exercise 11.6: Weighted Point Plan [15]

An effective method of combining various supplier performance measurements is the weighted point plan. This method is based on the supplier performance attributes identified by the buyer. It is termed a "weighted" performance plan because the buyer starts by weighting by a percentage how valuable the performance attribute is to the company. For example, on-time delivery might be weighted as 40, quality rejects as 20, and so on. Once weights have been assigned to the supplier, the buyer then specifies how supplier performance (expressed quantitatively) is determined. Finally, the weight and actual performance are multiplied to produce the performance value. (Example: $40 \times (1 - 0.08) = 36.8$.) These values are then summed to produce the overall rating. An example of a weighted point plan is detailed below. Note that the actual performance has been set to a percent of actual to expected performance. Once calculated, the performance value of a supplier can be rated against past performance or compared to other suppliers.

Performance attribute	Weight	Actual performance	Performance value
On-time delivery	40	8 %	36.80
Quality rejects	20	5 %	19.00
Current price to original price	5	2 %	4.90
Quoted lead time to actual lead time	5	6 %	4.70
Quantity received to ordered	15	15 %	12.75
Conformance to contract	15	9 %	13.65
	100	Overall performance	91.80

A common method to track supplier performance measurement is the balanced scorecard. The balanced scorecard provides a more objective view of supplier performance because it includes not only a financial perspective, but also customer, business process, and innovation and learning perspectives. In turn, each perspective contains the same four categories: goal, measurement, target, and actual performance. The scorecard enables procurement to communicate their strategies to suppliers, express detailed goals consistent with departmental measurements, and establish a collaborative approach with suppliers. For example, Figure 11.17 shows a compressed example of the balanced scorecard from the customer and financial perspectives.

Customer Perspective				Financial Perspective			
Goal	Measurement	Target	Actual	Goal	Measurement	Target	Actual
On-time delivery	% of orders delivered on time	99%	97%	Purchase order price reduction	% reduction of price on a yearly basis	95%	82%
Orders delivered complete	% of orders delivered delivered without shortages	99%	94%	Payables discounts offered	% of payables discounts taken	98%	97%
Order delivered with quality defects	% of orders failing inspection	99%	93%	Transportation cost reduction	% transportation cost reduction	97%	85%

FIGURE 11.17 Balanced Scorecard.

11.6.2 Purchasing Organization Performance Measurements

Besides charting supplier performance, it is critical that managers be able to document the efficiency and effectiveness of the purchase organization. Measuring and evaluating purchasing performance requires managers to determine the level of departmental compliance with purchasing objectives, development and updating of performance standards, use of control and reporting systems, results evaluation, and parameters governing the corrective action to be taken to counter deficiencies. The reasons for evaluating internal purchasing performance are to

1. Direct attention to critical departmental metrics so that performance continually improves while objectives are being met.
2. Improve purchasing department organizational structure, policies, and procedures.
3. Identify those areas where additional training and educational efforts may be required.
4. Provide data so that corrective action is taken where necessary.
5. Improve interrelations within purchasing, between purchasing and other business functions, and between purchasing and the firm's suppliers.
6. Evaluate departmental staffing requirements [16].

As a whole, the evaluation process focuses on the two critical measurements: *problem detection,* which illuminates organizational and process deficiencies, and *problem prevention,* which seeks to build fail-safe mechanisms into policies and procedures before the problems occurs.

Before performance measurements are developed, it is critical that managers understand that even the most precise quantitative methods may not provide the level of performance measurement their mathematical character would seem to indicate. Say, for example, that a manager wants to evaluate the pricing decisions of a buyer. Is the measurement to be calibrated versus a departmental or industry standard, and how valid is that standard? Does it reflect that products of lower quality and lower price are available? Does it reflect the potential cost reduction if the buyer had negotiated a detailed cost analysis negotiation with the supplier? Does it reflect economies of scale if the product had been purchased in a lot size? When establishing performance metrics, it is important to separate performance that is managed directly, such as departmental administrative efficiencies, from those that are dependent on ratios, cost levels versus current market levels, adherence to budgets, and others. Furthermore, it can be argued that the true meaning of purchasing measurements are not found in individual or departmental achievement, but rather how purchasing contributes to the enterprise's overall competitive advantage.

Internal performance measurement occurs on three levels: *departmental functional review, purchasing policy and procedural audits,* and *ongoing purchasing efficiency*. The first measurement consists of a broad appraisal of the purchasing function including policies, procedures, personnel, and interdepartmental relations. Because of its subjectivity, usually the review is performed by someone outside of the purchasing department, such as a private consulting firm or internal staff auditors. Effective reviews attempt to provide answers to such strategic questions as:

- What is the scope of the purchasing function? How important is it to the enterprise and how well is it integrated into the competitive strategy?
- Has the organizational structure, job descriptions, lines of communication, responsibility, and authority been clearly defined?
- What is the competency level of purchasing management? Are they qualified administrators, do they have sufficient company and industry experience, and are they knowledgeable about the markets and suppliers with whom they deal?
- What is the operational and industry competency of purchasing personnel? What opportunities are there for training? Are there adequate compensation plans, and is the employee turnover rate reasonable?
- Are there formal operating policies outlining purchasing responsibilities and authority and detailing sourcing research procedures, speculative purchasing guidelines, supplier relations, and quality issues?
- Are there formal operating procedures detailing purchase order execution; integration with other business functions; searching for, developing, and selecting suppliers; expediting; and performing receiving and material disposition?
- Are purchasing records being maintained in an accurate and timely fashion?
- What reports are necessary and how are they being presented to management?

In performing the *functional review*, the actual results are collected and compared with expected performance standards or benchmarked against other businesses or industries. Variances that emerge form the basis for the recommendations considered necessary to close the performance gaps.

The second level of internal purchasing performance, *purchasing policy and procedure audits*, measures the level of success purchasing has exhibited in achieving targeted objectives. Performed at least monthly, audits ascertain how well purchasing activities are meeting predetermined operational standards and provide a basis for corrective action to redirect purchasing activities that exhibit a wide variance from allowable performance tolerances. Dobler et al. [17] describe the possible criteria for evaluation at this level as follows:

- *Timing*. This measurement focuses on how well purchasing is supporting line operations. It includes metrics such as percentage of over-due orders and stock outs caused by late delivery, number of production stoppages caused by late delivery, actual versus budgeted expediting expense, and premium transportation costs paid.
- *Quantity and inventory investment*. In this category is found the percentage of stock outs and production stoppages caused by under-buying, actual supply service level compared to the performance target, actual inventory versus targeted inventory levels, value of dead stock, and a list of negotiated supplier stocking arrangements and estimated inventory savings.

- *Purchase price*. Key factors in this measurement are actual price performance charted against a standard; actual expenditure against a budget; price indexes compared to national commodity prices indexes such as the Producer Price Index; cost savings due to negotiation, cost analysis, volume buying, long-term contracting, supplier changes, and transportation cost reduction; and gains and losses from forward-buying activities.
- *Material quality*. Quality measurements consist of the percentage or number of orders quality teams reject, number of vendors who have achieved "certified supplier" status, cost savings generated by SPC, and other value analysis techniques achieved through joint ventures with suppliers.
- *Source reliability*. This category focuses on metrics relating to percentages of late delivery, rejected material, incorrect material, and split shipments. In addition, transportation measurements, such as transit times, percentage of damaged shipments, quality, and cost improvements, are part of this category.
- *Supplier relations*. Although this area is often difficult to quantify, surveys compiling data relating to supplier friendliness, helpful attitude, knowledge of buyer's product and service needs, ability to expedite, ethical standards, and others provide important measurements.
- *Internal coordination*. The ability to interact with other functional departments is critical to purchasing success. Measurements in this area deal with the degree of success characteristic of joint ventures, such as development of material standards with accounting, value analysis reviews with marketing and sales, and order quantities with material control.

In selecting these and other performance audit techniques, management must be careful to accentuate those that seek to uncover operational deficiencies and redundancies based on the nature of the business and the materials purchased.

The last level of internal purchasing performance measurement is designed to reveal the magnitude of purchasing *efficiency*. Measurement on this level requires weekly or at least monthly evaluation of day-to-day purchasing results. Although the following list is by no means exhaustive, it does provide the techniques used by most organizations [18].

- *Workload management*. This category contains a number of measurements associated with the ability of the purchasing function to handle such activities as timely purchase order issue, number of new long-term contracts executed, average number of dollars expended per purchase order, number of rush orders, and the number of changed orders.
- *Departmental operating costs*. In this category is found metrics such as departmental actual operating costs against budget per period, number of employees, and turnover ratio. It is important to note that these metrics by themselves mean very little. They are best used in conjunction with trends arising from other efficiency and effectiveness statistics that assist managers in charting the relationship of departmental costs to other business factors such as order quantity volume, product quality requirements, and total materials costs.
- *Personnel*. Measurements in this area are designed to detail the performance efficiency of purchasing personnel. Metrics employed focus around performance standards for clerical, repetitive work, and time utilization studies designed to pinpoint non-value-

added effort. There are a number of models available to assist managers in evaluating employees. The goal is to detail the strengths and weaknesses of each individual through job analysis, diagnostic evaluation of employee's knowledge of duties, goals, and functions, and employee involvement in training.

The implementation of concise performance measurements is critical to the control of the purchasing process. No matter how well purchasing planning and procurement activities have been executed, much of the results will largely be ineffectual without good performance controls. In developing performance metrics, managers must understand that there is no comprehensive formula, but rather each firm must develop measurements that, first, target those activities deemed necessary for ongoing organization efficiency and effectiveness, and second, are adaptive to changing circumstances. In addition, the cost of performance measurement should be weighed against the benefits. Finally, even the best set of performance measurements are no substitute for good management. Managers must effectively communicate the purpose of each measurement and use the entire program as a source to motivate and direct behavior and never to punish individuals.

11.7 IMPACT OF E-COMMERCE ON PROCUREMENT

When the second edition of *Distribution Planning* was published in 2004, the use of the Internet for procurement was just beginning to reach a critical mass [19]. Classically, purchasing was conducted through personal meetings, phone calls, faxes, and mail delivery. The introduction of Internet functionality has enabled procurement to escape the limitations of past methods of purchasing and take advantage of the tremendous opportunities to streamline operations, optimize costs, and communicate with potential suppliers located anywhere on the globe. Today, e-commerce has become mainstream. To begin with, as the need for collaboration on all aspects of business accelerates, so will information and transaction management be transferred from manual to digital. Second, as efforts to reduce costs and automate transaction processes are amplified, e-marketplaces will increasingly be seen as critical to achieving operational objectives. Lastly, e-commerce provides companies that were once considered rivals to jointly participate in the creation of e-marketplaces where they can as a group leverage their collective purchasing power and, in the process, increase efficiency across the entire supply chain.

11.7.1 The Array of B2B e-Commerce Functions

Figure 11.18 provides a visual of the array of today's B2B e-commerce functions. Understanding the B2B marketplace requires viewing it as composed of four separate, but integrated regions. The first region, the *procurement backbone*, is comprised of the traditional database and execution functions utilized by purchasing to generate orders, perform receiving and accounts payable, and record supplier statistics found in today's enterprise business systems. The second region, *e-services*, details the enhancement of traditional buyer functions, such as sourcing and supplier relationships, through the use of Web-enabled toolsets. The third region, *e-order processing,* contains the functions provided by the Internet that facilitate the purchasing order creation and transaction process. The final region, *e-technology services*, outlines the technical architecture that enables e-SRM front-end and backbone functions to be effectively applied to execute procurement strategies.

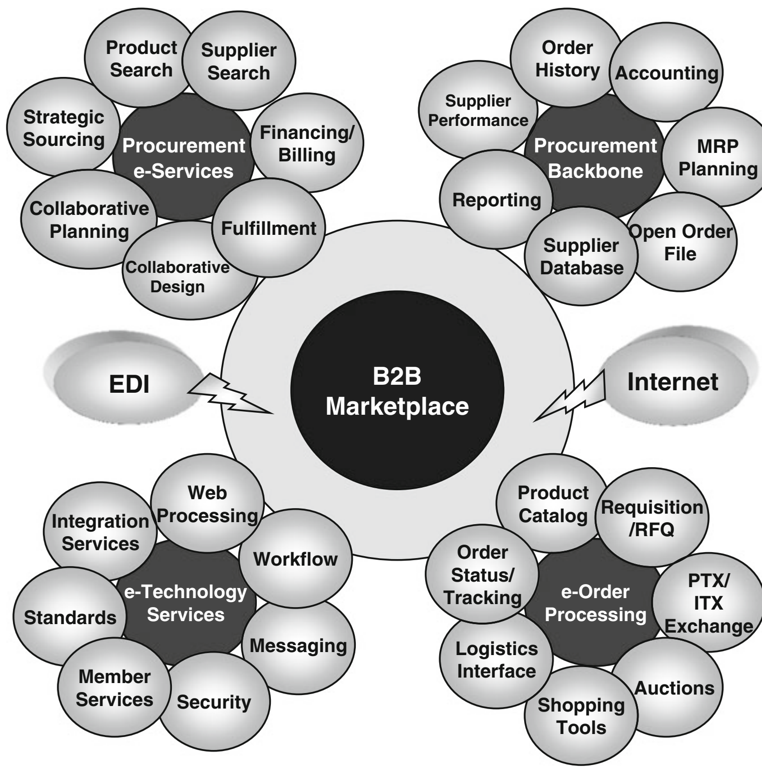


FIGURE 11.18 B2B e-commerce functions.

11.7.1.1 Procurement Backbone

In this region can be found the procurement functions associated with enterprise business systems such as ERP or supply chain management (SCM). The fundamental role of this region is to provide a repository for database information to guide purchasing decision making and operating processes. A major function of the procurement backbone is to provide a repository for *procurement history*. This information ranges from static records, such as past transactions, to dynamic information, such as open PO status and active supplier and sourcing files. The accuracy and completeness of this information serves as the foundation for all internal and networked procurement activities.

Another major function is *accounting*. Purchase order processes feeds directly into the firm's procurement backbone for order and price matching, invoice entry and payables, credit management, and any necessary financial reconciliation. A third major function is *purchasing planning*. Once total demand has been processed through the firm's MRP or reorder point system, the schedule of planned purchase orders is generated. Depending on the level of communication technologies and collaborative relationships, this schedule in turn is used to drive MRO and production inventory orders through the supply chain network. Finally, the procurement backbone provides buyers with tools for *performance measurement*. As receiving and payables history is compiled, companies have the capability to generate meaningful reporting and performance measurements indicating the value of their supplier relationships and the degree of success of continuous improvement initiatives.

11.7.1.2 Procurement e-Services

The Internet provides purchasers with fresh new avenues to transform the services traditionally used to execute procurement processes. In the past, purchasers were required to perform laborious and time-consuming searches for sources of new products and services. Today, Internet-based marketplaces provide a level of service features, such as online catalogs of products, sales promotions and special pricing, payment processing, and post-sales support, impossible in the past. Web-based technologies have made it possible for purchasing functions to significantly streamline these service features by utilizing the following B2B marketplace applications.

1. *Supplier search*. Historically, the supplier search process suffered from a high degree of fragmentation and discontinuous information flows. The normal process of locating suppliers, performing the mandatory round of RFQ negotiations, and securing contracts was slow-moving and often adversarial. Virtual B2B marketplaces, on the other hand, offer large communities of buyers and sellers an online, real-time channel to reach out to each other in an interactive mode that transcends barriers of time and space. In addition, buyers can explore new dynamic purchasing models, such as on-line auctions, for sourcing and spot buying.
2. *Product Search*. Instead of cumbersome paper-based catalogs and product registers, B2B services provide buyers access to a wide-range of online product and service catalogs that significantly enhance the sourcing effort. B2B marketplaces host electronic product search for all types of goods and services, including MRO and indirect materials, production, administrative, and capital goods. Effective Web-based applications enable e-marketplaces to centralize product and service content offerings, permit suppliers to host content on their own sites, and enable buyers to develop customized catalogs.
3. *Strategic Sourcing*. The challenge of B2B is to automate and optimize procurement functions, while at the same time improve strategic sourcing activities. The difference between the two is important. *e-Procurement* focuses on leveraging Web applications to reduce tactical costs and increase efficiencies and is primarily focused on non-strategic, indirect materials. In contrast, *e-sourcing* is focused on supplier sourcing, contracts and RFQs, and supplier partnership management driven by real-time Internet networking focused primarily on strategic production and distribution inventories. e-Sourcing is a systematic, cross-functional, and cross-enterprise process that seeks to optimize the performance of purchased goods and services through reductions in total cost, sourcing cycle time, and assets. It originates in the make/buy decision process and concludes with contracting and order generation.

e-Sourcing completely changes past concepts of sourcing by leveraging three categories of B2B applications. The first is the presence of *decision support tools* for creating an effective e-sourcing strategy. These tools include Web-based spend analysis, item rationalization, contract management, and supplier monitoring and improvement. The second B2B application category is *negotiation automation tools* streamlining access to supplier databases that reveal supplier capabilities and performance levels and cut the supplier RFQ search effort; *e-RFP* that provides for electronic request for proposals that link with bid analysis tools; and e-auctions that facilitate participation in auction events. The third B2B application category is *value-added services,* such as

- financial and billing services (payment cards, credit approval, corporate check payment, clearinghouse functions, and direct electronic billing)
- comparison shopping functions
- collaborative design and configuration management functions for complex, make-to-order production
- advertising, promotions, and dynamic pricing models based on market demand and availability
- transportation and logistics support to facilitate product fulfillment
- synchronized supply chain procurement planning
- establishment of marketplace performance benchmarks and key indicators

11.7.1.3 e-Order Processing

Perhaps the most common objective of Web-based B2B is to streamline the procurement process. Originally, the central focus of Web-based applications was on MRO and indirect inventories procurement. The reason was that these goods and services are normally highly standardized commodities, purchased in large volumes, evaluated normally on price alone, require minimal negotiation, and often are acquired through frequent spot purchases. In contrast, applying B2B tools to the purchase of production inventories is much more difficult. Procurement in this area oftentimes is subject to highly detailed design constraints and mainly applies to specialized vertical industry suppliers who provide products without sufficient breadth and volume of market demand. What is more, because of the specialized nature of the product/service, actual procurement is often preceded by a complex negotiation process and continued involvement in relationship-specific investments between trading parties.

Effective use of B2B functions requires companies to merge Internet-driven MRO and production inventories procurement under a common umbrella. This process enables buyers to capture B2B procurement advantages through economies of scale, more effective negotiations resulting in better pricing, and a deepening of communications and coordination with channel suppliers that translates into more efficient, collaborative buying. There are several functions characteristic of this form of e-marketplace.

- *Product catalog management*. The management of catalog content has been one of the most critical issues facing e-business from its very inception. The promise of “dynamic e-commerce,” defined as the exchange of goods and services via electronic markets where buyers have access to virtual storefronts to search for any product/service mix at the lowest cost, depends on the availability of catalogs containing “dynamic content” that always provides the most current pricing, product information, and product specifications.

- *Requisitioning.* B2B functions seek to facilitate the requisitioning process by integrating product/service catalogues hosted by exchange marketplaces, industry consortia, or third party aggregators located across the Internet into a single "virtual" catalogue available through on-line interfaces. Because MRO procurement usually involves highly standardized products and preferred vendors, integrating catalogs for MRO requisitioning is a fairly straightforward affair.

  On the other hand, developing similar sourcing references for production materials is much more complicated and requires the structuring of catalogs that present buyers with a range of possible suppliers and capabilities robust enough to permit them to perform the depth of value analysis and competitive comparison necessary to ensure alignment of purchasing decisions with strategic procurement targets. These catalogs must provide buyers with aggregate individual supplier statistics, such as specific contract pricing, service quality performance history, commitment to collaboration, and overall customer-care rating. When requirements fail to isolate a preferred supplier, the B2B toolset must support such features as browsing, keyword/parametric searching, collaborative filtering, product configuration, and other application functions. Finally, e-requisitioning applications must provide for online document interchange, supplier chat-rooms, open requisition status, and access to the latest budgeting and inventory information for transfer to the firm's ERP or SCM system backbones.
- *RFQ.* By transferring the labor-intensive process of managing bids to the Internet, buyers can significantly automate the RFQ process, thereby cutting costs and reducing cycle times. By opening up the bid to a form of real-time auction, buyers can greatly increase marketplace competition and solicit suppliers separated by geography and time to participate in the sourcing process. For indirect and MRO bids, the RFQ can simply be passed to the PO generation stage. For production materials or purchases subject to dynamic pricing, the buyer would initiate the RFQ process by either posting the RFQ in a public, on-line bulletin board for open bidding, or transmitting the RFQ to preferred suppliers by e-mail, fax, or private exchange. In addition to hosting bid boards, these exchanges enable companies to share buying experiences and exchange best-practice techniques.
- *Shopping agents.* While still in its infancy, the use of software shopping agents to perform the tasks of Internet browsing and initial gathering of and acting on basic information is expected to expand through time. Basically, shopping agents augment the work of buyers by performing searches of possible B2B marketplace sites to identify and match targeted products, pricing, quality, delivery, or other desired procurement attributes and execute transactions on behalf of the buyer. In the future, sophisticated buying tools will be able to interact with each other to locate appropriate products or services on the Web and negotiate price, availability, and delivery with a minimum of human interaction. For example, a company's shopping agent would store information related to minimum inventory levels, which suppliers are used to replenish those items, what level of quality is required for each item, acceptable price ranges, and shipping instructions. The shopping agent would interact with compatible software agents that reside in B2B exchanges, which track hundreds or even thousands of suppliers that have been screened relative to the company's buying criteria. Similar

to the computer-to-computer interchange that occurs with EDI, these intelligent shopping agents would automate much of the drudgery of today's buyer [20].

- *Auctions.* Used primarily as a means to buy and sell products whose value is difficult to determine or commodity in nature, Internet-based auctions enable buyers to expand beyond the domain of niche markets to reach potential sellers across geographic barriers and traditional industry lines. Almost any product, from airplane tickets to custom products, can be offered on an auction site. The use of auctions in procurement B2B is, for the most part, confined to non-production inventories.

  There are five types of e-auctions. The first type, *classical* or *forward auction,* consists of a single seller and multiple buyers who bid on a specific product or lot. The leading bid at the end of the allotted time wins the bid. This method is good for disposing of excess, aged, off-specification, or soon to be obsolete inventories. The second type, *reverse auction*, is the classical auction in reverse in which one buyer and multiple sellers drive the auction. This method is an alternative to the traditional RFQ method by which buyers solicit bids from the marketplace for one-time, high-value purchases. *Dutch auction* is the third type. This auction is characterized by one seller and multiple buyers, but with multiple homogeneous lots available. The lowest successful bid sets the price for the entire collection. This method is applied to products subject to supply shortages or dramatic demand fluctuations. The fourth type, *demand management auction,* differs from the previous models in two ways: there are multiple buyers and sellers, and the market maker plays an active role as the intermediary. This model is used for products that are perishable, characterized by variable or unpredictable demand, and whose prices are marked by extreme elasticity. The final type, *stock market model*, is characterized by multiple sellers and buyers, homogeneity of commodity, and mutual indifference as to the supplier or buyer. This type of auction is limited to true commodities and is normally found in private markets.
- *Purchase Order Generation and Tracking.* Once the order requisitioning or RFQ is approved, a PO is generated. POs are created using backbone functionality and are then transmitted to the supplier through a paper order or electronically via fax, EDI, or the Internet. In addition to serving as the instrument communicating the contract to purchase, the PO also provides valuable *internal* information. The PO record provides purchasing management with information regarding outstanding order data, budgeting, and performance reporting. The progress of the PO is then tracked and used to provide critical status information needed by production and distribution planners.
- *Logistics.* Today's B2B order management functions are significantly enhanced by the utilization of a variety of Web-based logistics services that can be integrated into the procurement process. Logistics partners have the capability to offer Internet enhanced services, such as inventory tracking, carrier selection, supplier management, shipment management, and freight bill management. In addition, logistics service providers can offer advanced functions, such as network planning, dynamic sourcing, and reverse logistics that integrate buyers with supplier e-fulfillment capabilities, dynamic strategies for cross-docking, in-transit merge hubs, postponed assembly, and commingling of loads to optimize shipments.

11.7.1.4 e-Technology Services

None of the components of procurement B2B are possible without the necessary supporting technology architecture. Over the past decade, interoperable protocols and the rise of cloud computing have enabled computer systems to share information across the supply chain network. Today's B2B applications require the following technology support services.

- *Web Processing*. The ability to drive B2B requires a technology focus on data access and transactions as well as optimizing business processes. While the efficient processing of e-commerce transactions stands at the center of the B2B marketplace, the applications should provide for effective and timely decision-making prior to the point when the actual transaction is being made. In addition, the supporting technology should be scalable to handle maximum transaction and data communications volumes. Companies engaged in B2B should have an IT structure equipped to perform load-balancing across multiple servers to ensure adequate performance and high availability of Web-accessed applications.
- *Security*. In today's global business environment ensuring information security is an important priority. Security services include components such as information boundary definition, authentication, authorization, encryption, validation keys, and logging of attempted security breaches. The goal is to protect individual files so that confidential information cannot be accessed without validation.
- *Member Services*. The quest to create Web-sites that are characterized by extreme usability, personalization, and customization is perhaps the "holy grail" of B2B procurement. Winning Web exchanges require marketers to ensure that customers have, first of all, an effective *personal experience*—did each customer's visit validate expectations and did they leave the Web-site with what they wanted, and second, an *emotional experience*—did each customer develop a positive perception of their interaction with the Web-site and do they wish to return for more in the future. Web-based toolsets assist in developing detailed user-profiles and analyzing user browser behavior and shopping preferences so that marketers can customize the customer's next visit to the site.
- *Content Search and Management*. The essence of e-business is the capability of buyers and sellers to utilize knowledge-bases, catalogs, text, graphics, and embedded files to access and transact a broad range of products, services, and information over the Web. Effective search requires engines that provide access either by *content* (product description, type, business application, classification or category, etc.) or by *parameter* (how the content is organized using hierarchies that, for example, provide drill-down through a search tree or fuzzy logic.) In any case, once content is defined, it should possess the following baseline functionalities: (1) the ability to provide optimal content distribution and content organization to searchers, (2) the ability to transform potentially vast amounts of data resources into a useable format for the searcher, (3) the ability of content/application/system managers to define and organize criteria and rules regarding what may be customized and what potential combinations are valid, and (4) the ability of the content management component to integrate directly with the procurement backbone.
- *Workflow*. Effective B2B enables the delineation of the parameters determining the dependencies that exist between a series of procurement process steps. For example,

what business rules govern the process a buyer must execute to move from requisition all the way through to actual purchase and payment? Workflow management provides the vehicle by which this path is mapped, the business rules that govern workflow decisions, and the workflow engine that receives the user's request and determines the next sequence of screen displays that will match both the process and the business rules definition.

11.7.2 Structure of the B2B e-Commerce Marketplace

Using B2B trading exchanges to automate and simplify the procurement process not only succeeds in sourcing the best products and services quicker, it also lowers the cost per transaction and increases market reach for both buyers and suppliers. B2B trading exchanges creates an electronic "space" where buyers and suppliers can optimize and coordinate strategies and transactions. e-Commerce B2B marketplaces belonging to three major types of exchanges. The first is an *independent trading exchange* (ITX) described as many-to-many marketplaces composed of buyers and sellers networked through an independent intermediary. ITXs are divided into three basic models.

- *Buyer-driven e-marketplaces* provide a simple B2B model to enable companies to facilitate internal procurement by linking, through Internet tools, divisions, partners, or companies to an internally maintained centralized online catalog assembled from a number of supplier catalogs that could be accessed through a portal linked directly to supplier websites. The catalog reflects volume-based pricing and rule-based agreements negotiated with suppliers. Requisitions are automatically routed for approval and orders are placed and tracked through the Web portal. Finally, the portal handles paperless invoicing or automatic payment upon receipt.
- *Vertical exchanges* provide Internet trading for a particular industry. These types of digital marketplaces act as hubs servicing a single industry. These exchanges work by aggregating a variety of industry-specific product/service catalogues into a single Internet site or to leverage online tools that distributors or brokers can use to tap into excess reservoirs of supplier materials and capacities and accelerate the matching of potential buyers and sellers.
- *Horizontal exchanges* facilitate e-business functions for products/services common across multiple industries and range from simple portals to sophisticated collaboration hubs. By providing a sort of virtual trading "hub" where multiple buyers and sellers are matched and conduct transactions, these Web sites enable manufacturers, distributors, buying groups, and service providers to develop shared marketplaces that deliver real-time, interactive commerce services through the Internet.

The second major type of trading exchange is a *private trading exchange* (PTX). A serious problem with an ITX is that it provided only simple buy-and-sell capabilities. Often what many companies really wanted from their B2B exchange is not only ease of doing business, but also one-to-one collaborative capabilities with network partners, total visibility throughout the supply chain, seamless integration of applications, and tight security. The answer is the creation of a private exchange. In this model an enterprise and its preferred suppliers are linked into a closed e-marketplace community with a single point of contact, coordination, and control. Often this type of e-marketplace is driven by a large market dominant company that seeks to facilitate transactions and cut costs while also cementing the loyalties of their own customers and suppliers. In addition, a PTX enables suppliers to avoiding ITX comparison shoppers as well as protect the product's unique value and brand. Because PTXs help build a sense of collaboration and trust among channel partners, they can extend a greater level of competitive advantage than can participants in an open exchange.

The final major type of trading exchange is a *consortia trading exchange* (CTX). A CTX can be defined as a *some-to-many* network consisting of a few powerful companies and their trading partners organized into a consortium. Historically, CTXs are formed by very large corporations in highly competitive industries such as automotive, utilities, airlines, high-tech, and chemicals. The goal of a CTX is simple: to combine purchasing power and supply chains in an effort to facilitate the exchange of a wide range of common products and services through the use of Web-based tools, such as aggregation and auction, between vertically-organized suppliers and a few large companies. A CTX offers control over membership, security, and, most importantly, the ability to build and maintain collaborative capabilities.

11.7.3 Benefits of B2B e-Commerce

Before the rise of B2B e-commerce, the purchasing management process was executed through time-honored techniques. Requirements were identified, suppliers contacted, prices negotiated, and orders transmitted the old fashioned way through personal meetings, phone calls, faxes, and mail delivery. With the application of the e-commerce tools, today's procurement function can source, collaborate, and transact with their suppliers using cutting-edge networking technologies to dramatically cut cost and time, utilize real-time data to communicate requirements, and make effective choices that result in real competitive breakthroughs. Companies using e-commerce procurement have realized the following benefits:

- *Increased market supply and demand visibility.* B2B e-marketplaces provide buyers with an ever-widening range of choices, an exchange point that enables the efficient matching of buyers and product/service mixes, and a larger market for suppliers.
- *Price benefits from increased competition.* Online buying and use of auctions can be used to increase price competition, thereby resulting in dramatically lower procurement costs for buyers.
- *Increased operational efficiencies.* B2B applications have the capability to increase the automation and efficiency of procurement processes through decreased cycle times for supplier sourcing, order processing and management, and buying functions.
- *Enhanced customer management.* e-Marketplaces assist suppliers to accumulate and utilize analytical tools that more sharply define customer segmentation and develop new product/service value packages that deepen and make more visible customer sales campaigns.
- *Improved supply chain collaboration.* Today's B2B toolsets enable buyers and sellers to structure enhanced avenues for collaboration for product life cycle management, marketing campaigns, cross-channel demand and supply planning, and logistics support.
- *Synchronized supply chain networks.* The ability of e-markets to drive the real-time interoperability of functions anywhere in the supply network focused on merging

information and providing for the execution of optimal choices provides supply partners with the capability to realize strategic and operations objectives. Among these can be included shorter cycle times for new product development and delivery, increased inventory turnover, lower WIP inventories, low-cost logistics, and others.

- *Efficient payment transfer*. e-Commerce greatly facilitates the collection of payment. Often, especially in retail sales, the payment for goods/services occurs at the moment of purchase either through credit card, P-card, or the use of a third party such as PayPal. Immediate payment can greatly increase the financial "float" of companies who can use the funds generated from customers for investment ahead of the 30- to 90-day window before they have to pay their suppliers.
- *Impact on cost*. e-Commerce has an enormous impact on an enterprise's infrastructure, inventory, facilities, and transportation capabilities. B2B models that utilize extensive backward and forward integration will find their technology infrastructures and call-center services dramatically increased, while experiencing decreases in inventory through improved supply channel cooperation, reduction in facilities costs by centralizing or outsourcing operations, and increases in direct or partner-based transportation. Transportation is eliminated altogether for digital businesses, such as NetFlix, Best Buy, and Microsoft, who can offer product delivery directly through Internet downloads.

11.8 SUMMARY

Effective procurement and supplier relationship management are fundamental building blocks for supply chain success in the twenty-first century. The management, planning, and execution of purchasing activities are the responsibility of the firm's procurement department. It is the job of this function to communicate effectively the company's inventory requirements to the right suppliers, execute efficient item and supplier sourcing, scheduling, contracting, negotiating, and partnership activities, as well as run the day-to-day functions of launching purchase orders, performing receiving functions, and analyzing procurement performance measurements. In performing these functions, the purchasing organization must be structured to leverage simultaneously continuous improvements in processes aimed at cost reduction and high customer service.

Integral to an effective purchasing function is the existence of a comprehensive purchasing strategy. Companies that do not develop a detailed purchasing strategy risk interruption in the stream of supply due to poorly executed strategic sourcing objectives, misunderstood environmental or regulatory constraints, and uncertainty in price and delivery. The purchasing strategy that emerges is not necessarily one that promises to optimize efficiency or least total cost but one that supports the needs of the enterprise and the competitive advantage sought by the entire supply chain.

Managing the tactical purchasing management process centers on the effective planning and control of the three cycles of PO management. The first cycle, *order preparation*, involves developing a buying plan that meets the needs of the firm, selecting and building collaborative suppliers, and negotiating the terms of purchase. The second cycle, *order entry*, entails choosing the appropriate purchase order type, order generation, and timely transmission of the order to the supplier. The final cycle focuses on product *receiving* and *order closeout*. Both during and after purchase order receipt, the purchasing function is responsible for open order status tracking and internal performance. The final step in the purchase order management process is performance measurement. There are two dimensions to effective purchasing performance measurement: *supplier performance* and *internal departmental performance*. In measuring and evaluating the purchasing function's performance, managers must review compliance to stated purchasing objectives, departmental professionalism, control and reporting systems, and commitments to continuous improvement. Integrating supplier and departmental performance objectives is a fundamental building block of competitive advantage.

With the advent of e-commerce marketplaces, the nature and traditional processes governing procurement have undergone dramatic change. Similar to what B2C e-commerce did for customer management, B2B e-commerce is permitting today's cutting edge purchasing departments to assemble a complete picture of their supply channel relationships, apply Web-based applications to cut cycle times and costs for sourcing and negotiating, and utilize real-time data to communicate requirements and make effective choices that offer real competitive advantage. Internet tools have enabled purchasers to develop revolutionary methods to drive sourcing, procurement, and value–added services that provide enhanced supplier collaboration and supply chain synchronization. In addition, the emergence of e-marketplace exchanges have provided a number of radically new models for the buying and selling of products and services.

DISCUSSION QUESTIONS

1. Describe the pros and cons of using centralized or decentralized purchasing strategies.
2. ABC Electronics purchases office supplies as well as complex subassemblies for its line of printers. As a buyer, what, if any, differences in sourcing strategy would you use to buy these two types of products?
3. Discuss the objectives of purchasing.
4. What impact does early purchasing and supplier involvement have on new product development?
5. What two major factors affect the make-or-buy decision?
6. Why has supplier relationships management (SRM) become so important?
7. When economic or market conditions are unstable, what methods of purchase order release will buyers pursue?
8. What main performance measurements can buyers use to validate the performance of their suppliers?
9. Describe the various purchasing methods available to buyers.
10. What are the objectives of strategic supplier sourcing?

PROBLEMS

1. The buyer at ABC wants to perform a break-even analysis on an item with a known supplier. The supplier's fixed overhead costs are US$3,000, and the variable costs per unit are US$6 to produce a lot of 900 units. The purchase price is US$10 per unit.
   (a) What is the total cost to the supplier?
   Answer: _________.
   (b) What is the unit cost to the supplier?
   Answer: _________.
   (c) What is the break-even quantity?
   Answer: ________.
   (d) What is the break-even revenue?
   Answer: ________.
   (e) What is the supplier's expected profit?
   Answer: ________.
2. Using the data detailed in question 1, if the buyer was targeting a purchase cost of US$8, what would be the break-even quantity?
3. The buyer at ABC Electronics wants to perform a break-even analysis on an item with a known supplier to formulate a new purchase price. The supplier's fixed overhead costs to produce a lot size of 3,000 units is US$4,200 and the variable cost is US$10.50 a unit.
   What is the *total cost* to the supplier for the lot size of 3,000 units?
4. Using the data in question 3, if the buyer was targeting a purchase cost of US$14.50 what would be the break-even quantity (rounded)?
5. Using the data in question 3, what would be the supplier's expected profit?

6. A *cost avoidance analysis* is a method that calculates the benefit of outsourcing a product by determining the cost elements of manufacturing that the buyer's plant cannot totally outsource or avoid. The buyer at ABC Electronics is engaged in a make-or-buy analysis and wants to use this method to view costs in helping to make a decision. The item in question has an annual forecast of 12,500 units. Based on feedback from costing, the following costs for the item have been determined if it was made in-house.

Costs	
Raw materials	US$10,000
Direct labor	US$14,500
Variable overhead	US$5,500
Fixed factory overhead	US$25,500

What will be the unit cost to ABC to make the item?

7. Based on the information in question 7, the buyer receives a quote of US$3.85 from a supplier to outsource the item. It has also been determined that outsourcing the item would result in a 35 % reduction in variable costs and a 38 % reduction in fixed overheads that ABC cannot avoid. What would be the total cost avoided if the item was purchased?
8. Based on the information in question 7, what would be the total cost difference between making the item in house or outsourcing it to the supplier?

CASE STUDY

Design engineering has created a new item that is to be reviewed by procurement as to whether it should be made or bought. Engineering, sourcing, and planning have determined the following values to assist in the cost (US$) analysis:

General Data
Estimated annual usage = 25,000 units
Inventory carrying cost = 22 %
Purchase ordering costs = 145.50
Direct overhead % = 50 %
Indirect overhead % = 50 %
Depreciation rate = 6,500 (absorbed 25,000 units)
Design rate = 25,000 (absorbed 25,000 units)

To determine the best option for the new item, the planners are required to calculate the cost first for the outsourcing option and then for the insourcing option. The source with the lowest cost will provide a significant criterion for the sourcing option.

Outsourcing Option

The planner began by determining the outsourcing option. After reviewing several suppliers, one was selected as the probable supplier. The planner received the following cost information to assist in the outsource cost estimate.

Purchase price = 14.25
Setup charge = .005
Shipping and handling = .18
General and Administration = .0963

Based on the information, assist the planner solve for the following purchasing costs:

1. Unit cost: ________.
2. EOQ lot size: ________.
3. Unit inventory carrying cost: __________.
4. Total unit cost: _______.
5. Total annual cost: __________.

Insourcing Option

After discussing the new item cost elements with design engineering, the planner complied the following internal production costs.

Direct costs (per unit):

Materials = .68 Labor = .60 Setup = .051 Overhead = 0.30

Indirect Costs (unit)

Labor = .10 General and Administration = 12.5

Based on the information, assist the planner solve for the following production costs:

1. Unit cost: ________.
2. EOQ lot size: _______.
3. Unit inventory carrying cost: _________.
4. Total unit cost: _________.
5. Total annual cost: ________.

Cost Summary

Assist the planner to summarize the costs associated with both options. Solve for the following costs:

1. Cost savings per unit: ______.
2. Total annual cost saving: _________.

Sourcing Option Selection

1. Based on the cost estimates, which source offers the better choice?
   ____
2. What other factors does the planner need to review before making the final decision?
   ____

REFERENCES

1. Williams, Alvin J., and Kathleen A. Dukes. 1993. The purchasing function. In *The purchasing handbook,* 5th ed. New York: McGraw-Hill.
2. These traditional responsibilities are abstracted from Monczka, Robert M. Managing the purchasing function. In *The distribution handbook*, 471–483 and Williams and Dukes, 7–8.
3. For further discussion see Leenders, Michael, Harold E. Fearon, and Wilbur B. England. 1989. *Purchasing and inventory management,* 9th ed, 24–27. Homewood: Richard D. Irwin; Heinritz, Stuart, Paul V. Farrell, Larry C. Giunipero, and Michael G Kolchin. 1991. *Purchasing: Principles and applications,* 8th ed, 10–25. Englewood Cliffs: Prentice Hall; and Dobler, Donald W., David N. Burt, and Lamar Lee. 1996. *Purchasing and materials management*, 6th ed, 41–45. New York: McGraw-Hill.
4. Dobler, et al., 114–115. See also Beckert, Norman C., L. Wayne Riley, and Keith Pratt. Purchasing organization. In *The purchasing handbook*, 29–66.
5. See the analysis in Schul, Herb. 2013. A more mission-critical role for procurement. *Supply Chain Management Review* 17(3): 34–35. May/June.
6. Partida, Becky. 2014. Looking beyond centralized and decentralized procurement. Supply Chain Management Review 18(2): 63–65. March/April.
7. These points have been adapted from Cavinato, Joseph, Quadrant technique: Key to effective acquisition and access. ARDC Spectrum, Report #11 (State College: Acquisition Research and Development Center) and Coyle, John J., Edward J. Bardi, and C. John Langley. 2009. *Supply chain management: A logistics perspective,* 8th ed, 562–565. Mason: South-Western.
8. All definitions from the *APICS Dictionary* used in this chapter are from the 14th edition, 2013.
9. Hughes, Jonathan, and Jessica Wadd. 2012. Getting the most out of SRM. *Supply Chain Management Review* 16(1): 3. January/February.
10. This list was adapted from Dobler et al., 194.
11. This figure was adapted from Monczka, Robert M., Robert B. Handfield, Larry C. Giunipero, and James L. Patterson. 2011. *Purchasing & supply chain management,* 5th ed, 199. Mason: South-Western.
12. See the discussion in Thompson, Arthur A., A. J. Strickland, and John E. Gamble. 2005. *Crafting and executing strategy: Text and readings*, 14th ed, 60–67. New York: McGraw-Hill Irwin.
13. This definition is from Monczka, et al., 408. Reference also the description on building an effective TCO model.
14. Reference Monczka, et al., 507–526 and Dobler, et al., 340–354 for a detailed analysis of purchasing contract models.
15. The weighted point plan is discussed in greater detail in Dobler, et al., 432–435.
16. Ackerman, Robert B. Evaluating purchasing performance. In *The purchasing handbook*, 316–317.
17. See the analysis in Dobler, et al., 676–684.
18. See the discussion in Ackerman, 324–325 and Dobler, et al., 604–606.
19. Parts of this section have been abstracted from Ross, David Frederick. 2011. *Introduction to e-supply chain management technologies,* 2nd ed, 262–287. Boca Raton: CRC Press.
20. For more discussion on shopping agents see Taylor, David, and Alyse D. Terhune. 2001. *Doing e-business: Strategies for thriving in an electronic marketplace*, 117–119. New York: John Wiley & Sons.

12

Warehouse Management

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_12) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_12,

Warehouse management in the twenty-first century provides manufacturers and distributors with unique avenues for competitive advantage. In the past, warehousing was looked upon as purely an operational business function charged with the task of storing production materials and finished goods. Someone once defined a warehouse as "inventory at zero velocity." The role of warehousing was to ensure that individual companies possessed sufficient stock and processing capacity to respond to anticipated customer requirements while acting as a buffer guarding against the "bullwhip effect" produced by uncertainties in supply and demand characteristic of linear supply chains. The operating philosophy was to search for the appropriate trade-offs between warehouse costs on the one hand and customer serviceability targets on the other.

In today's highly networked, global supply chains, this static perception of warehousing has become obsolete. When it is considered that warehousing now provides core value-added services, the need to reposition warehouse functions as fundamental strategic sources of competitive differentiation and marketplace leadership has grown. Instead of a lumbering giant accounting for the bulk of the firm's costs and labor requirements, the application of planning and execution technologies, automation, and supply chain management philosophies accentuating information flows, channel collaboration, and promoting quality and the elimination of wastes have drawn the warehouse function within the sphere of competitive strategy. Today's modern warehouse has evolved from being solely a place for storing inventory to dynamic fulfillment centers capable of responding to requirements for multi-channel and omni-channel fulfillment, postponement, and environmental sustainability. Today's warehouse is uniquely positioned to provide expanded services, such as repair and product postponement, and serves as a center for training certification and new product introductions. They represent an opportunity for customer interaction and leveraging the distributor's local presence.

12.1 DEFINING WAREHOUSE MANAGEMENT

The effective performance of warehousing activities is integral to the success of channel network supply and distribution functions. In many industries, product and market characteristics, such as the discontinuities caused by demand, seasonal peaks and valleys, and rapidly changing product life cycles, make it almost impossible to fully synchronize the acquisition of goods with actual demand, forcing companies to stockpile inventory in warehouses. While it can be argued that warehousing is a negative function, which accrues storage and transportation costs, many companies consider that the advantages of warehousing provide a level of marketplace value that exceeds the cost. As a result, for companies, such as grocery stores, catalog distributors, wholesalers, and large and small retailers from the corner drugstore to Wal-Mart, the storage of inventory and the ability to deliver it to the customer at the time, quantity, price, and place desired provides value-added differentiation and defines marketplace leadership. Warehousing is defined as

> the segment of an enterprise's logistics function responsible for the storage and handling of inventories beginning with supplier receipt and ending at the point of consumption. The management of this process includes the maintenance of accurate and timely information relating to inventory status, location, condition, and disbursement.

12.1.1 The Magnitude of Warehousing

A revealing way to view the impact of warehousing on individual businesses and the economy as a whole, is to consider relevant statistics. According to the Council of Supply Chain Management Professionals (CSCMP) *Annual State of Logistics* (2014), the cost of all U.S. warehousing in 2013 was $137 billion. This warehouse space was used to stock US$2.5 trillion of inventory. Accompanying carrying costs to house and administer this inventory was US$469 billion [1]. Other interesting statistics about the state of warehousing in the U.S. in 2013 was accumulated by Peerless Research Group [2]. The average total square footage of all warehouses in the average company network was 495,675. This space achieved around 8.0 inventory turns annually based on an average of 12,916 stock keeping units (SKUs). In terms of marketing channels served, 66 % was to wholesalers, 53 % to retailers, 30 % to e-commerce, and 15 % to others. Total capital expenditure for warehousing equipment and technology among all company sizes reached an average of US$1.2 billion.

According to Motorola's "2013 Warehouse Vision Survey" white paper [3], the outlook for growth of warehousing operations over the next 5 years is significant. Respondents reported the following figures:

- 35 % planned to increase the number of warehouses and distribution centers (DCs)
- 38 % planned to expand the size of warehouses and DCs
- the use of multimodal voice, scan, and screen guidance for order picking is expected to expand by a factor of almost 2.5
- 54 % plan on increasing order volumes and number of SKUs
- 70 % plan to have more automated processes
- 66 % plan to equip staff with more technology

The above statistics bear witness that the warehousing function is being seen less as simply a cost center and more as one of strategic importance. The movement from linear to complex, multi-node supply chains is at the heart of this change in perception and is being driven by greater marketplace volatility, constrained channel capacity, evolving regulations and environmental imperatives, major shifts in demographics and buying patterns, and increasingly demanding customer and supplier requirements. Instead of a cost center, channel network warehousing is now being perceived as a contributing driver of competitive differentiation and increasing profitability growth.

12.1.2 Warehousing Functions

Warehousing performs many roles. Warehouses are used to store production inventories inside a factory. Warehouses are used for finished goods storage in regional distribution centers that service downstream channel warehouses and local distribution points. Warehouses are used to store seasonal inventories to be used in future periods. Regardless of size, warehousing performs the following four basic activities: *materials handling, inventory storage, order management,* and *information transfer*.

12.1.2.1 Materials Handling

This primary function of warehousing consists of the following six major activities associated with the management of inventories.

- *Loading and unloading*. This function is the gateway activity in the warehouse management process. The major operations performed are inbound delivery scheduling, order receipt and acceptance, unloading and unitization, order audit, inspection, staging, load configuration, load checking, and transport loading. Outbound activities include picking and packing of customer orders, load scheduling, and customer delivery. Critical performance factors include ensuring labor productivity, equipment utilization, product quality, and unloading/loading efficiencies.
- *Movement of inventory from and to storage*. Goods may be moved multiple times from and to internal warehouse receiving, storage, reserve, and staging areas. Movement can occur between temporary locations, fixed locations, dynamic locations, and from reserve to forward picking locations. Often movement is accomplished with the use of various types of materials handling equipment.
- *Sorting*. In some stocking environments, warehousing sorts received merchandise and/or unitize it as a prelude to stock put-away. Often sorting requires activities such as grading, bulk-breaking, testing, and grouping. The object of sorting is reducing stock handling and the chance of location or picking error.
- *Postponement*. Often the warehouse function is responsible for final product differentiation. The activities associated with this function are component picking and staging, labor and machine allocation, order processing, labeling, and packaging. Postponement provides two essential values. In the first, finished good flexibility is increased by postponing the decision to produce the final product configuration until actual demand requirements are determined. A critical advantage is that the chance of stock out is reduced, while the amount of base inventory remains constant. Second, risk and total inventory investment are reduced by keeping the product as base stock with actual product differentiation not made until a sale is made. Disadvantages are that costs for postponement processing are incurred, and second, customers must be willing to absorb the extra lead time to complete final assembly processing prior to delivery.
- *Cross docking*. This function is similar to product mixing in that a *mixing warehouse* is used to consolidate deliveries (through bulk break, sorting, assembly, or packaging) from multiple sources into assortments. The major difference in a cross-docking warehouse is that instead of locating these assortments in a stockroom, they are moved directed to the shipping dock and sent out to the customer, by-passing any form of storage. The benefits of this function are reduced storage and material

handling costs, more effective use of docking facilities, shorter order fulfillment cycle times, and full truck load delivery.

- *Reverse Logistics*. In today's increasingly environmental-conscious world, the return of products, packaging, and waste materials back up the supply chain has grown in importance. The end point for the reverse flow of such products and materials is the warehouse. Once these goods arrive, the warehouse is responsible for performing several functions. To begin with, the warehouse is responsible for returns management, validating the receipt, and making the judgment as to disposition. One possibility is that the goods are assigned to be remanufactured or repaired. In such cases, the warehouse supports a repair depot complete with its own inventories, equipment, and technicians. Refurbished products are then remarketed and sold. Another activity is recycling returned goods with the object of tearing them down to salvage materials and components (precious metals, paper, plastics, and metals) that are reused or sold as is. Finally, for goods that cannot be reused, the warehouse would responsibly dispose of or engage further reverse logistics process flows.

12.1.2.2 Inventory Storage

Warehousing enables companies to pursue strategies focused on attaining the highest levels of customer responsiveness at the lowest inventory cost. The decision to store inventories may be the result of economies achieved by trading-off the cost of transportation against the cost of carrying inventories. This is particularly true of products that are purchased in bulk permitting purchasers to leverage quantity discounts and reducing inbound delivery costs. Another strategic reason to use warehouses is to assist the enterprise in balancing supply and demand over time. For example, warehousing is used by companies that distribute products subject to seasonality and uncertain demand. Stocked inventories ensure that customer order demands are met without the excessive costs resulting from replenishment expediting and lost sales. Again, for companies who purchase speculation inventories, storage enables price economies that more than offset the warehousing carrying costs. A third reason to warehouse inventories is to facilitate the production process. By having materials and components available, lead times to produce finished goods are drastically reduced. In another instance, food products, such as wine, cheese, and liquors, often need to be aged in extended warehouse storage for long periods of time. Inventories stocked in these warehouses are secured or bonded. This technique allows distributors to defer paying tax on the goods until actual sale. Finally, warehouse storage provides value to marketing and sales by ensuring that finished goods are available to satisfy place and delivery strategies.

Warehouse storage consists of the following functions:

- *Storing/Put-Away*. These cardinal function of warehousing consist in housing received inventory in the proper storage locations in preparation for demand order allocation and picking.
- *Stockpiling*. This function provides for the access to, and the protection, accuracy, and orderly stocking of products and materials. Stockpiling results from production overflows due to seasonal and demand variability or sales promotions and deals. The span of time inventory is held often determines the configuration and operations of the storage facility. Warehouses range from long-term, specialized storage, to medium-range storage of products subject to seasonal sales, to short-term general-purpose

merchandise storage for products subject to continuous demand, to temporary storage (as in a consolidation terminal).

- *Product rotation*. Some companies stock products that are subject to limited shelf life. A critical responsibility of warehousing is to ensure that first-in-first-out rotation of products, such as foodstuffs, pharmaceuticals, and chemicals, is properly managed to avoid spoilage and obsolescence.
- *Consolidation*. Often companies acquire products that are shipped *less-than-truckload* (LTL). A method of economically converting many small shipment into full carloads is to have products shipped to a local or regional consolidation center. At the consolidation warehouse, product are broken down, repackaged, or simply combined with other products that are transported in full truckloads to the deployment warehouse. Obviously, the savings achieved from more cost-effective shipping must be large enough to justify the cost of the consolidation warehouse.
- *Bulk breaking*. This function is the opposite of product consolidation. Often companies purchase goods in bulk quantities for pricing or inbound transportation cost purposes. These large quantity shipments are received into the warehouse where they are broken down and repackaged into smaller quantities that correspond to customer requirements. Bulk breaking is used most often when inbound transportation rates per unit exceed the customer delivery rates per unit, when distributors sell products in LTL quantities to meet customer demands, and when there is considerable transit distance between producer and distributor. Bulk breaking is a common activity found in terminal or deployment warehouses. The use of consolidation and bulk-break functions is illustrated in Figure 12.1

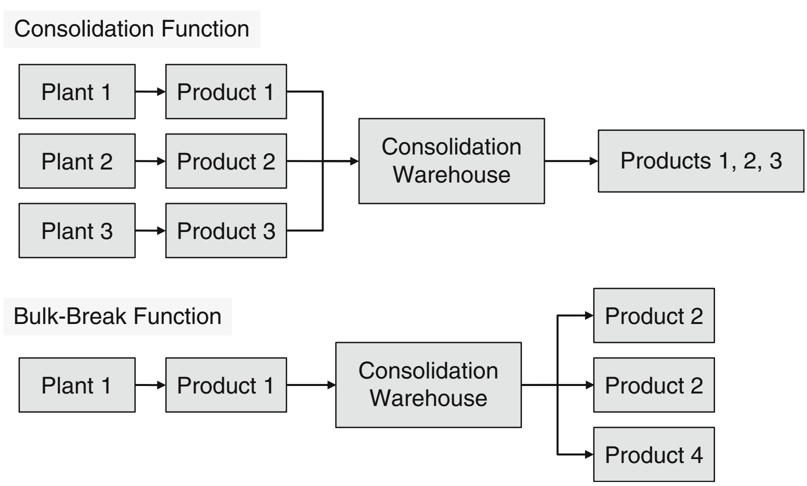


FIGURE 12.1 Consolidation and bulk-break functions.

- *Product mixing*. This function is used to produce or acquire a wide variety of products and then convert them into stocked assortments. When customers order these products they will request various types of goods that they wish to be assembled into a single order. Often these goods are purchased separately by the distributor from several different sources and then picked together to match the specific assortment desired by the customer. By creating large orders composed of heterogeneous products, the warehouse can also take advantage of creating full truckloads (TLs) that realize inbound and outbound transportation economies (Figure 12.2).

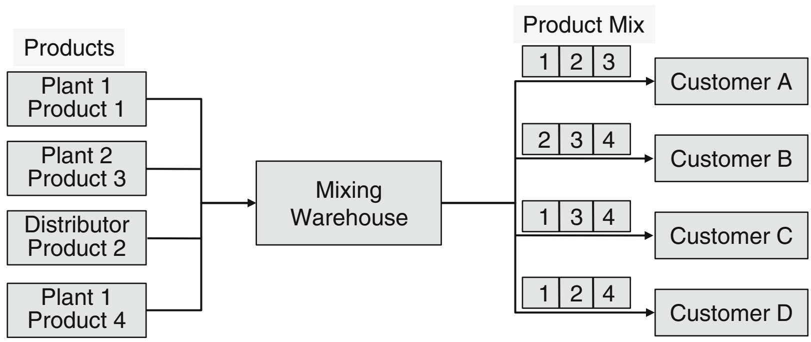


FIGURE 12.2 Product mixing function.

- *Spot stock.* This function is mostly employed by distributors faced with stocking finished goods subject to seasonality or limited quantities. The mechanics of the technique are characterized by the "spot" acquisition and storage of products to fulfill customer requirements during a particular marketing season or promotional period. For example, a bathing suit distributor may "spot" inventories in warehouses close to critical retail markets during the spring and early summer, and then, once the season is over, pull inventories back to a regional warehouse.
- *Production support.* In a production environment, warehousing takes on a dual role. It must not only perform finished goods warehousing to support customer sales, it must also provide raw material, component, and subassembly inventories consumed during the production process. Although lean and flow production strategies seek to remove a dependence on stores by having production inventories delivered directly to the processing line, long lead times and product lot sizes often force producers to maintain production warehouses.

The objective of warehouse storage is to maximize on customer service by improving product and location positioning. Success or failure is gauged by weighing the trade-off costs between storage and transportation.

12.1.2.3 Order Management

The third function of warehousing is to facilitate order management processes. Critical activities are the following:

- *Customer order picking.* This function consists in the picking of finished goods required to meet a customer order. For most companies, order picking is controlled through a *pick list* generated from the order detail. The major elements of a pick list are the order number, the required date, the items and quantities to be picked, and the picking location. The pick list serves the purpose of an inventory control turnaround document as well as an authorization to pick products for shipping. Because of the quality and accuracy required to satisfy customer expectations and the labor cost involved in handling small volumes of orders, order picking is a critical material handling function. To reduce the level of possible errors, order picking has increasingly been automated and made more flexible. Today's advanced warehouses are deploying such technologies as voice, scan, handheld, and wearable devices to facilitate and error-proof pick and fill activities.

- *Production order picking*. Companies that both produce and distribute their products normally use the warehousing function not only as a storage point for finished goods but also as a storage point for components and raw materials to be consumed by the production unit of the firm. In such environments, it is the responsibility of warehousing to receive, store, pick, and stage production inventories and deliver them to production based on the product bill of material.
- *Traffic management*. Warehousing is responsible for selecting the carriers to be used for outbound product shipment, subject to review from accounting and auditing. If the firm possesses a traffic management department, warehousing should work closely with it and be responsive to its policies and strategies. Over the past decade, warehousing and traffic management have been working closely with their carriers to reduce outbound transportation costs. Most of the major freight traffic in the U.S. is covered by master contracts negotiated with fine-tuned precision.
- *Shipping*. Shipping functions are normally performed by the warehouse staff. Shipping activities are divided into two components. The first, *shipment preparation*, is concerned with the performance of any necessary postponement activities and product staging at the outbound dock. Once orders are fully prepared, the second function, *shipping*, is performed. This function contains activities such as carrier scheduling, rate determination, loading transportation vehicles, and completing documentation such as bills of lading, packing lists, and shipment record maintenance.

12.1.2.4 Information Transfer

It is essential that information processed by the warehouse regarding everything from product receipt to shipment is recorded in a timely and accurate manner. Without accurate data, inventory quantities, storage space allocation, product location, and other activities would be virtually impossible to manage. Accurate information also enables other business functions, such as sales and production, to promise inventory and delivery to customers and to ensure sufficient materials and components are on hand to execute production schedules. Warehousing personnel must accurately perform the following three information transfer activities:

- *Transaction management*. The primary responsibility of warehouse personnel is the management of inventories. Depending on the degree of physical control required by the firm, each time inventory moves from one location to another, an inventory transaction describing the location from, location to, and quantity transacted must be performed. Sometimes the movement of inventory has both a *physical* and a *financial* effect. An example is a stock *adjustment* where inventory is transacted either to or from a physical location and to or from an inventory adjustment general ledger account number. The best way to ensure that inventory is managed effectively is to clearly define the transaction control points as inventory flows through the warehouse. In designing a company's inventory flow transaction system, the focus should be on thoroughness, simplicity, and timeliness. Most businesses use a computer system to facilitate inventory management and provide integration with other business functions.

- *Inventory balance accuracy*. Maintaining accurate inventory balance records is perhaps the most critical activity performed by warehouse personnel. Inaccurate inventories drain away profitability and inhibit effective performance. Inaccurate inventories make it difficult for investors and shareholders to correctly view reported profits. In addition, poor customer serviceability usually accompanies inaccurate inventories. Poor inventory control destroys the confidence of the firm to establish meaningful plans and performance measurements and to respond effectively to the competitive challenges of the marketplace. Accurate inventory balances are attained by implementing effective cycle counting, obsolete inventory reduction programs, and performance metrics.
- *Warehouse capacities*. In addition to maintaining accurate inventory status, warehouse personnel also provides information relating to warehouse capacities through the measurement of throughput levels and inventory turns. Equally as important, warehousing personnel needs to maintain accurate records regarding total and available storage space, equipment and manpower availability, and transportation requirements.

12.2 TYPES OF WAREHOUSE

There are several types of warehousing. Choosing the appropriate type of warehouse consists of a matrix of strategic, operational, financial, organizational, and legal decisions. The object is to select a type that provides the least total cost necessary to efficiently and effectively execute logistics functions while facilitating attainment of enterprise strategic performance targets. The optimal warehouse decision permits the firm to leverage inventory levels and transportation modes that effectively support marketing, sales, order processing, and inventory planning in the quest for competitive advantage. Factors influencing the selection of a warehouse type include the type of industry; supply chain goals; financial investment; product characteristics such as perishability, size, seasonality, intrinsic value, quantity, and potential for obsolescence; strength of the competition; and state of the general economy.

12.2.1 The Four Warehouse Types

There are four basic types of warehousing: private, public, contract, and in transit.

12.2.1.1 Private Warehousing

Private warehousing is differentiated by the fact that the property, facility, and accompanying storage and material handling equipment are owned and operated by the firm. This form of warehouse may be as small as a rack or a stockroom or as large as a network of complex warehouses separated by continents and consisting of hundreds of thousands of square feet of storage. Private warehousing possesses several advantages over other forms of warehousing. To begin with, private warehousing enables the firm to exercise a high level of direct control over warehouse operations. A significant measure of control is desirable when dealing with special types of products, such as pharmaceuticals or high-ticket goods, or when special handling or packaging is required. The ability to directly control warehouse operations is also critical when pursuing high levels of efficiency and performance. Another advantage is that private ownership is often less expensive than alternate types of warehousing. This is particularly true when business operations are characterized by high storage area utilization and high volume inventory transactions.

Private ownership of real estate, buildings, and equipment also provides the firm with certain tax advantages, especially as the costs are amortized over time. Private warehouses simplify communication. Critical information relating to such logistics elements as inventory stock status, receiving, customer orders, and shipping are available directly to the firm's management. In some cases, companies will convert unutilized warehouse space to other uses, such as support function expansion or value-added processing. In addition, space may be rented out to other businesses or used to realize public storage opportunities. Finally, the presence of facilities assists companies in projecting a public image to the community and customer base and conveying a sense of commitment and permanence.

Perhaps the most important disadvantage to privately owned warehousing is loss of flexibility. Because of its fixed size and cost, a private warehouse cannot expand and contract to meet changing marketplace needs, nor can it take advantage of possible strategic location options. A serious problem is the inability of the warehouse to adapt to changes in product storage due to building structural limitations such as height, position of supporting pillars, location of receiving and shipping docks and other physical characteristics. In addition, companies must carry the burden of fixed costs, risk of damage by fire or natural disaster, and exposure to labor disputes. Finally, companies may find that using contract and public warehousing enables them to reduce the capital invested in logistics assets and the presence of skilled operators and management teams while increasing facility flexibility.

12.2.1.2 Public Warehousing

Public warehousing is a permanent feature in the physical distribution strategies of many companies. In 2013 the public warehousing industry and associated terminal services represented about 45 % of total warehousing costs. The growing importance of public warehousing is traced to the changing nature of the marketplace. By offering a full range of services, public warehouses provide short- and long-term functions targeted at supporting the supply chain requirements of their customers. The key characteristic of public warehousing is that the facility, labor, and material handling equipment are owned by the warehouse company, which, in turn, contracts warehousing services for a month-to-month fee. The different types of public warehousing is classified as *general merchandise, refrigerated*, *special commodity*, *bonded*, and *household goods and furniture*.

In addition to providing rented storage space, public warehousing firms also perform operational activities, such as receiving, material handling, postponement, shipping, and loading operations on a unit-charge basis. Public warehouses normally specialize in handling certain types of products lines, such as hazardous materials, foodstuffs, and bulk storage. Public warehouses also target certain types of customers. Grocery stores, for example, require special warehousing services, such as cold storage and special handling equipment that facilitate product turnaround to minimize spoilage. Some public warehouses also provide clerical functions including EDI and Web-based order processing, product inspection, marking, tagging and inspection, transportation dispatching, traffic accounting, and prepayment of freight charges.

Companies use public warehousing for a variety of reasons. A significant advantage of public warehousing is that it requires no fixed capital investment. When using a public warehouse, all costs are variable in that they are directly proportional to the extent services are used. This factor may be highly advantageous to a firm attempting to conserve cash flow and capital rather than having to invest in private plant and equipment to solve a short-term, non-repetitive stocking and material handling problem. Another financial facet of using public warehousing is the elimination of the risk of plant facility and material handling equipment obsolescence. When it is considered that the normal facilities plan for a warehouse extends out for 20–40 years, the use of public warehousing assists planners manage and chart the course of marketplace trends and volumes before investing capital to expand their private warehouses. A final financial advantage is the ability of businesses to pursue heavy asset-consuming strategies while avoiding local taxes arising from property ownership. In addition, certain states do not charge taxes on inventories stored in public warehouses.

Public warehouses provide companies with the *flexibility* to respond quickly to short-term marketplace requirements without a corresponding rise in expenditure for fixed storage. Whether a small company or a large international enterprise, businesses in an expanding market are wise to utilize public warehousing while measuring whether the expansion is significant enough to justify the acquisition of proprietary facilities. In addition, the services offered by public warehousing enable smaller firms to target a national market and provide the same level of customer service available to much larger firms. The use of public warehousing to perform shipping and transportation activities provides significant cost savings. Many companies can bear consolidated freight rates but not the costs required to ship small quantities at premium rates. Often the savings in freight alone is sufficient to offset the total public warehousing cost. The public warehouse makes a profit by charging for warehousing and consolidation services and from the revenue generated by warehouse-owned transportation. Most public warehouses look to consolidate the deliveries of multiple customers on the same transportation equipment to take advantage of full truck load rates.

Public warehouses often provide a number of specialized material handling, storage, and shipping services more economically than a company-owned warehouse. The following are examples of such special services:

- Availability of material handling equipment such as cranes, lift trucks, conveyor systems, rail sidings, docking facilities, and personnel
- Special storage requirements such as sterilized and ultraclean rooms, barge and ship facilities, temperature controlled storage, and special bulk storage
- Broken-case order filling
- Office space rental for depositor's sales, customer service, marketing, accounting, and other business functional staffs
- Repackaging of products for shipment
- Bulk breaking
- Freight consolidation
- Invoicing for depositors

In addition to these services, public warehouses provide access to state-of-the-art technologies that are often beyond the capital investment or expertise of many organizations. Many public warehouses provide computerized tools such as EDI, RFID, Internet access, bar coding, and business system interface that can expand a firm's service functions without actually acquiring the equipment.

Beyond the availability of special services, public warehouses provide emergency storage space to assist companies accommodate abnormally large product quantities. Such quantities can arise from a number of sources, such as an opportunity purchase, an impending promotional sale, an unusual surge in customer sales, and seasonal demand. Public warehousing is an appropriate alternative in such situations, especially when the cost to acquire additional facilities, personnel, and equipment would be more than the cost of temporary storage. It also eliminates the costly practice of personnel hiring and layoff as the volume of business fluctuates.

There are a number of disadvantages to public warehousing. To begin with, lack of timely and accurate communication between the private and the public warehouse may hinder information transfer and create excess inventory and administrative costs. Second, the specialized services required by a company are not always available from a given public warehouse. This is particularly true of distributors who require regional or national services. Finally, firms may not always have access to public warehouse space and services. Availability and limitations in capacities do periodically occur, adversely affecting enterprise logistics and marketing strategies.

12.2.1.3 Contract Warehousing

Contract warehousing is a form of public warehousing. The key difference between the two types is the nature of the commitment made in the warehousing contract. For the most part, the public warehousing contract is for a short-term period with renewal on a month-to-month basis. In contrast, contract warehousing focuses on the creation of a long-term agreement that commits both parties for a period of time at least as long as is necessary to amortize mutual investment. The goal of the contract is to establish a form of guarantee on the part of the firm requiring the services that the level of business will remain constant over the life of the contract, and on the part of the public warehouse that the level of contracted services will be available throughout the contracted period. In addition to the normal benefits, contract warehousing provides both parties with the opportunity to explore new avenues for cost-cutting and continuous improvement in communications and services. For example, contract warehousing provides a gateway for improvements in warehouse planning, increased accuracy of receiving and shipping functions, development of specialized material handling, storage and transportation equipment, and the elimination of redundancies in transport, information, and administrative services.

In addition to long-term contracts, there are also a number of variations. Among these more specialized contracts are found the following:

- *Leased space*. This contract option provides the distributor with some of the benefits of both private and public warehousing. In this arrangement, the public warehouse guarantees either dedicated storage space in the facility isolated from other product/customer storage by fences or other types of barriers, or a guarantee of general space, but not dedicated, except as is specified by the lessee. The advantage to the lessee is that the contract space should cost less than comparable private space or, by guaranteeing a long-term contract, the expense of the lease is less than the cost of renting space from a public warehouse. The contract warehouse, on the other hand, benefits by being able to schedule space, equipment, and personnel, thereby optimizing the full capacity of the warehouse.

- *Leased equipment and personnel.* Normally used in conjunction with leased or dedicated space, businesses also contract equipment and personnel based on fixed rates per hour. Normally, the rate charges are higher, often three to five times higher, than comparable private costs. The reason for this premium price is the high overhead and indirect costs that are borne by the contract warehouse in having these services ready and available. The best contract for equipment and personnel is the one that provides mutual benefit to both parties.
- *Leased administrative services.* Many public warehouses offer clerical support for such activities as transaction recording; inventory management; order management, picking and shipping; financial settlement and freight rating; and customer service.

12.2.1.4 In Transit Warehousing

The final form of warehouse storage is *storage in transit*. This is a special kind of warehousing in which products are stored in the mode of transportation. For example, a company may elect to store product in the truck trailer or railcar (termed demurrage) in which it was delivered. The firm rents the storage container from the shipper. Inventory remains in this temporary warehouse until it is finally unloaded and received into normal storage. Again, depending on transit times, businesses may select a mode that substantially reduces the need to have space for stocked inventories by having them in transit. This alternative is particularly attractive to distributors dealing with commodity products that are shipped over long distances. A negative point is that inventories in transit are unavailable until they are received into a stocking warehouse.

Practically, manufacturers and distributors use a combination of private, public, and contract warehouses. When developing a strategy for warehousing, managers make their decisions based on two key factors. The first is how much warehouse space and services are required to meet the business plan. This is an aggregate, strategic decision that matches current warehouse capabilities with future requirements. If it is found that the business strategy requires greater capacity than the existing warehousing solution, managers must then focus on what is the optimal combination of private, public, and contract warehousing that best matches customer, product, and service requirements. This capability is increasingly becoming more important as product life cycles decline and multi-sourcing and omni-channel distribution and retailing grow in importance.

12.2.2 Specialized Warehouse Services

Cutting across the four types of warehousing are various specialized storage services. For the most part, these storage services are determined by product characteristics. Selecting the most appropriate service is the responsibility of a warehouse professional supported by planners from product management, engineering, accounting, sales, production, and traffic management. Their role is to first determine the most appropriate warehouse type, and then to ensure the selection provides the required warehouse service. There are several possible warehouse services.

- *Cold storage warehouse.* Often products must be kept at certain low temperatures to preserve freshness or prevent spoilage. This is particularly true of foodstuffs that are refrigerated or kept frozen. The cost of building, maintaining, and operating a cold storage warehouse is substantially higher than other forms of storage. These costs are a result of higher building materials costs, equipment, energy, premium pay for workers, insurance, and refrigerated transportation.

- *Temperature-controlled warehouse*. There are some products, such as fresh vegetables, fruit, liquids, and chemicals, that must be stored in warehouses whose temperature is somewhere in between cold storage and "dry" or ambient outside temperature. The temperature of such facilities range from 50° to 68° Fahrenheit (10–20 °C), and usually include some form of humidity controls. Such warehouses regulate the temperature through air conditioners, heaters, and humidity control equipment. As the facility, equipment, overhead, and labor cost is usually less, this type of warehousing is not as expensive as cold storage to operate.
- *Bonded warehouse*. Companies engaging in international trade often use a special type of warehouse that enables them to produce, transfer, and/or store products without having to pay excise taxes and duties. The regulations determining a bonded warehouse are defined by government agencies in the U.S. such as the Public Utilities Commission, the Alcohol and Beverage Control Commission, the Customs Services, and others. The most well-known form of bonding is associated with wines and spirits. By keeping these products in a bonded warehouse, a distributor may avoid paying the tax until products are transferred out of bond. The term "bonded" is often used loosely by public warehouses. Normally public warehouses do not insure their customer's inventories. Companies should insure inventories that are stored in public warehouses as if they were stored in private facilities. The extent of legal protection should always be stated by contract.
- *Records warehouse*. As the cost of office space spirals, firms are increasingly pursuing the more economical alternative of utilizing excess or dedicated warehouse space and personnel for the pickup, filing, storing, retrieving, and delivery of company records. Some public warehouses specialize in record storage, offering on-site pickup, retrieval, delivery of documents to and from their customers, and document destruction (shredding). The requirements for effective record storage are environmental (absence of dust, humidity, and excess heat), confidentiality and security, and the availability of technical equipment such as computerized storage, microfilming, reproduction, FAX, and cloud computing.
- *General merchandise warehouse*. This type of warehouse accounts for, by far, the largest percentage of all warehousing activities. It is defined as the storage of all goods except specialized or commodity products. This type of warehouse can be private or public, bonded or unbonded, and may or may not have customs and free-trade-zone privileges. Merchandise warehouses tend to specialize in certain classes of goods driven by storage and material handing factors. An example is grocery warehouses that employ certain types of transportation and storage facilities.
- *Commodity warehouse*. This type of storage specializes in commodity, bulk, or large products such as wood, agricultural goods, cloth, building materials, cotton, large appliances, and so on. Commodity warehouses are either public or private. Normally, commodity warehouses are located close to the source of production or extraction or are at the distribution end of the pipeline where they are close to the consumer. The central advantage of a commodity warehouse is the availability of specialized material handling equipment, such as conveyors, heavy lift trucks, containerization, highly

trained personnel, and other warehousing features, that enable them to achieve significant performance efficiencies. On the other hand, a negative characteristic of commodity warehousing, particularly in the agricultural industry, is their involvement with products dominated by seasonality which produces recurring cycles of boom and bust.

- *Foreign free-trade-zone warehouse.* This type of warehouse is used by enterprises engaged in international trade. In the U.S., these storage facilities reside legally outside of U.S. customs territory where they are exempt or have reduced customs duty liability. If the goods are re-exported, no customs duties are owed. In addition, free-trade-zone warehouses permit companies to buy and store goods in excess of permissible import quotas for resale in the next period. Besides the possible avoidance of duties altogether, this type of warehouse will improve cash flow by delaying taxes and duties until the goods are actually sold and shipped. Free-trade-zone warehouses are either private or public.
- *Mini-warehouse.* This type of warehouse is usually characterized by limitations in total space and the complete absence of warehousing services. They are simply intended as extra storage space, ranging from 20 to 200 ft^2. They are normally administered by an on-site caretaker, and often have a limited assortment of material handling equipment for rent. Besides their relative lack of expense, the prime advantage of mini-warehouses is their close proximity and convenience for renters. Distributors with overcapacity may turn their excess space into mini-warehouses.

12.3 DEVELOPING WAREHOUSE STRATEGIES

Warehousing is considered a critical cornerstone in the development of a company's business strategy. The sheer size of the physical assets and financial investment necessary to run warehousing functions requires firms to closely define the strategic role of warehousing in the organization. The warehousing function actually is "a business within a business," consisting of its own labor force, staff, financial accounting, management, and information system requirements that are different from other enterprise departments. Obviously, warehouse strategic planning involves more than just building a warehouse, setting up storage racks, purchasing some material handling equipment, and hiring staff. Nor is it a static, one-time activity. Instead, warehouse strategic planning is a continuous process that must be in alignment with overall organizational and customer service objectives.

12.3.1 Strategic Overview

Before the warehouse planning process begins, strategists must understand the objectives of other enterprise functions. Strategies associated with product, delivery, price, promotion, asset investment, and costs made by marketing, sales, production, procurement, and finance have a direct impact on the formulation of warehousing strategies. For example, if a new marketing strategy calls for offering customers a guaranteed 24-h order delivery cycle, warehouse management needs to explore the ability of the warehousing function to respond to this goal. If enterprise strategies are to be effectively executed, it is imperative that warehouse management be included as a full partner in the strategic planning process and that the warehousing plan be closely integrated with the enterprise's other functional business plans.

In addition to understanding their role in the company's strategic plan, warehouse planners must also be apprised of the tactical plans regarding the marketplace and the supplier base. Some of the questions posed to customers and suppliers that directly impact warehouse decisions are:

- What is the strategy for using private, public, and contract warehouses?
- What is the targeted level of warehouse utilization?
- How many warehouses should there be and what should be their type?
- Should warehouse decisions be based on customer or product strategies or a combination of both?
- What new operational or marketing strategies have been formulated that require changes in current warehousing practices?
- What new product lines are expected to be introduced and how will they affect warehousing and delivery?
- What changes to warehousing delivery and storage mechanisms, such as equipment and information technologies, are being planned?
- Are there any plans to open or close warehouses, and if so, in what locations?
- What plans are in place to streamline the existing supply chain warehousing operations?

By conducting a comprehensive survey of those customers and suppliers that account for the bulk of sales and procurement activities, warehouse planners can develop a reasonably accurate profile of the directions being pursued generally by both groups. The patterns and objectives that emerge will significantly assist in constructing warehousing strategies that aggressively address marketplace trends while maintaining support for the overall objectives of the enterprise.

Once a comprehensive understanding of the requirements is identified, warehouse planners are faced with a number of critical decisions that together constitute the core of the enterprise's warehouse strategy.

- *Location optimization.* This decision is concerned with establishing warehouses at geographic locations that maximize strategic goals. For example, large consumer products companies, like Wal-Mart or Sears, will establish distribution centers close to retail outlets to maximize inventory availability and reduce inbound transportation costs. Also, the locations should be flexible enough to be easily phased down or brought up online quickly as market conditions change.
- *Transportation cost.* Outbound transportation decisions are related to a warehouse's proximity to the customer. The more warehouses in the distribution channel, the more the cost of full truckload increases, the cost of less-than-truckload (LTL) delivery to the customer decreases, and the total cost of transportation decreases. However, as more warehouses are added, the marginal savings from transportation decreases.
- *Inventory carrying cost.* This decision is driven by ordering and carrying costs. As the number of warehouses increases, cycle and safety stocks increase across all warehouses.
- *Warehousing and handling costs.* If sales remains constant, adding warehouses results in an increase in facilities costs, while handling costs will decline at individual warehouses even though the total cost for handling remains constant for the system.

- *Network service capability*. As the number of warehouses increase, a company's ability to service the market increases. For example, a company found that 30 % of its market is reached in 1 day from one warehouse. A second warehouse would enable them to reach 70 % in 1 day, a third, 90 %, and so on.
- *Operational flexibility*. This decision relates to how fast a warehouse can adjust internal policies and procedures to meet marketplace changes. Private warehouses enable much greater flexibility, while public and contract warehouses are more difficult to change.
- *Industry synergies*. This decision relates to how well a warehouse location enables a firm to leverage the benefits of other companies serving the same industry. Companies can share transportation and public and contract warehousing opportunities to reduce costs.
- *Technology applications*. The use of computerized warehousing technologies will initially increase total operations costs, but result in cost savings and increased revenue opportunities in the long run.
- *Total system costs*. As a rule, when warehouses are added to the distribution network, total channel costs decrease and then start to rise. The reason is as more facilities are added to the network, the value from customer responsiveness increases. However, there comes a point when inventory and transportation costs counterweigh the benefits of increased supply chains. The goal is to identify the least-cost point where the total costs of the system is balanced with the number of warehouses as illustrated on Figure 12.3. An enterprise should have at least the number of facilities that minimize total logistics cost. Beyond this point, planners must be confident that additional facilities will eventually result in better responsiveness.

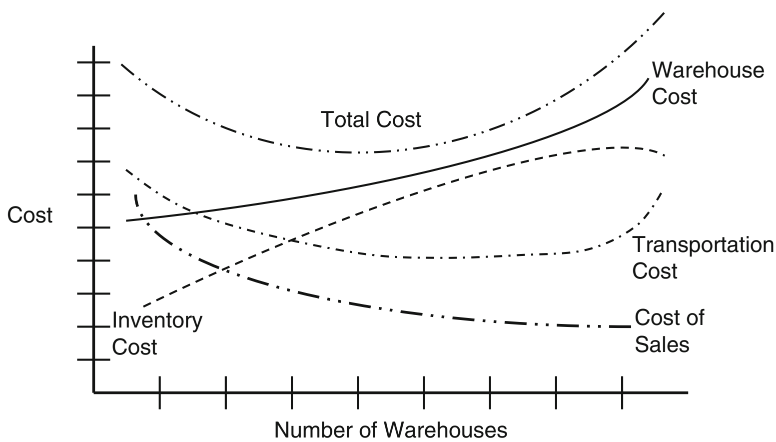


FIGURE 12.3 Total system cost.

12.3.2 Developing the Warehouse Strategic Plan

The warehouse strategic plan is directed at accomplishing two overall objectives. The first is to align the resources of the warehouse with the enterprise's long-term supply chain goals. A warehouse strategy cannot be developed in a vacuum but only has meaning in relation to and support of the strategies of the firm's other business functions. Examples of warehouse strategies are consolidating a national channel of satellite warehouses into a regional distribution center; building new storage facilities or acquiring new material handling equipment to meet rising demand; and determining the percentage of warehousing that should be owned and how much should be contracted from third parties. Second, an effective strategy forecasts future company warehouse requirements so that resources are acquired in time. Without such plans, the warehouse will be periodically subjected to executing costly ad-hoc solutions that are always detrimental to the overall health of the enterprise. A critical part of the strategy is the development of realistic contingency plans. Contingency planning attempts to provide solutions for possible circumstances beyond the control and estimates of strategic planners. Without a comprehensive contingency plan, the warehouse strategy risks being subjected to unanticipated problems for which there is no solution and which eventually render the warehouse strategy ineffectual.

As with other business strategies, the warehouse strategy should be expressed as a formal document detailing what goals are to be accomplished and how they are to be attained over a given planning period. Each of the stated goals should consist of:

1. a statement of business requirements
2. an inventory of existing warehousing assets
3. business justification for the acquisition of any new warehousing equipment
4. detailed description of new buildings, material handling equipment, information technologies, and operations, including diagrams and blue prints
5. required support resources
6. narrative of organizational changes/impacts
7. detailed implementation plan
8. project capitalization and expected ROI.

If possible, each goal should have a detailed implementation plan. Besides establishing project timelines and budgets, the plan should specify each activity, activity dependencies, and responsible roles. The plan should also include clear performance measurements that provide feedback to management indicating the relative success or failure of the warehouse organization in attaining stated objectives. Finally, an effective warehouse strategy should be bounded by a defined planning horizon. Most strategic plans are typically formulated in years, with a minimum of a quarterly review. A strategic due date gives meaning to detailed activities and provides the whole organization with a recognizable goal to guide their efforts.

An effective methodology for developing a warehouse strategy consists of the following seven steps [4]:

1. *Document existing warehouse operations*. This step consists of two separate elements. The first documents existing warehouse facilities, catalogs warehouse equipment and capacities, and establishes labor resources by department. The objective is to confirm the nature of these resources and accurately assess their capacities. The second part of this step involves performing an operations diagnostic, first on each resource and then on the general information and material flows in the entire warehouse. A complete business diagnostics will reveal areas where actual practice deviates from the established standard procedure.
2. *Determine and document the warehouse storage and throughput requirements over the specified planning horizon*. This step requires planners to forecast which products

and in what volumes are anticipated to be stocked in the warehouse over the planning horizon. In developing the estimate, planners must be specific as to the impact on existing material handling equipment and available storage space. Ideally, the product forecast should be in terms of unit weight and/or cube to assist in warehouse analysis.

3. *Identify and document deficiencies in existing warehouse operations*. One of the outputs from the operations diagnostics described in *Step 1* is documentation of areas of waste and redundancy that inhibit productivity. Once these processes are identified, a project is initiated to eliminate them. An operations diagnostics might also reveal that critical activities are being performed inefficiently due to a lack of equipment or labor resources. Once documented, warehouse management uses the findings as a basis for the acquisition of the necessary capacity.
4. *Identify and document alternative warehouse plans*. Once deficiencies in storage space, equipment, or labor are identified in *Step 3*, management must develop a plan that explores possible alternatives. One solution is to expand capacities by acquiring additional resources. Another is to explore using rented equipment, temporary help, or public storage facilities.
5. *Evaluate alternative warehouse plans*. Each alternative warehouse plan must undergo rigorous financial analysis. Key measurements are capitalization, cost/benefit justification, after-tax current asset evaluation, and return on investment. In addition to an economic analysis, the proposed plans must also be modeled against business, product, and marketplace objectives detailed in the business plan.
6. *Select the recommended solution*. Based on the results of the financial and business evaluation, the desired plan is selected. Plans consist of detailed descriptions of proposed warehouse storage, equipment, personnel, and operating standards objectives for the forthcoming planning horizon.
7. *Update the warehouse strategic plan*. Like all other business strategies, the warehouse strategy is not a static, but rather is a dynamic document that changes as the circumstances of the marketplace and the competition change. Because it is founded on aggregate forecasts of the future, the warehouse strategy will always require updating as more accurate information about products, customers, and competitors is revealed. As such, warehouse planners must meet at least yearly, preferably quarterly, to review the viability of the strategic plan and to weigh the impact of future requirements. An effective method of review is to include the warehouse planning team as a member of the sales and operations planning (S&OP) meetings discussed in Chapter 6.

The goal of the completed warehouse strategy is to communicate in clear and unequivocal terms the objectives to be pursued by the warehouse. Often the warehouse function is treated as if it was a variable resource that easily expands or contracts to meet shifting requirements arising from changes in the marketplace or product supply. In such an environment, warehouse managers, whose goals are not well defined, are condemned to an endless and non-productive game of attempting to please everyone in the enterprise. An effective way of broadcasting the warehouse strategy to the organization is to develop and publish a *warehouse charter*. The warehouse charter contains the following elements:

1. Clear statement of organizational and reporting structures
2. Performance metrics detailing targeted operating objectives

3. Authority to acquire capital equipment
4. Ability of management to hire, fire, and develop staff
5. Valid operating standards for all warehouse activities
6. Valid space utilization standards and performance measurements for products and storage facilities
7. Clear service standards and performance measurements for all warehouse functions

The warehouse charter is the document that ensures that warehouse objectives are in alignment with the firm's marketing, sales, procurement, traffic, and accounting strategies as well as with general supply chain objectives. The warehousing function is a unique part of the company, charged with the task of managing a complex set of inventory and delivery management activities all of which determine the degree of success of the plans formulated by upstream departments. The more the warehouse is managed to the objectives established in the warehouse strategy, the more dependable and efficient the warehouse is and the better it can respond to other business strategies. Conversely, as poor enterprise planning and communication increase knee-jerk reactions on the part of the warehouse, the less chance performance targets and efficiencies are achieved [5].

12.3.3 The Outsourcing Decision

One of the most critical decisions in warehouse strategy is determining the mix between private, public, and contract warehousing. In many ways this decision is reminiscent of the make-buy conundrum. Should the company spend the capital resources to have its own warehousing facilities and all the synergies and conveniences ownership provides, or should the firm outsource the function to cut costs and improve flexibility? Whether private or outsourced, either decision involves certain definite risks in handling a wide-range of issues, from the financial well-being of third party warehouses to how the organization will leverage the mix of private and outsourced services to grapple with the realities of satisfying customer demand. While there are some industry sectors, particularly in the e-business environment, that are "virtual" companies and exclusively use outsourced logistics services, most manufacturers and distributors to some extent maintain their own warehouses. The objective of these facilities is to ensure that the company has the capacity to provide inventories to cover normal production and customer demand. For the most part, full utilization of the typical private warehouse throughout the year is a remote possibility. According to Bowersox et al. [6], most warehouses will in fact be fully utilized only between 75 % and 85 % of the time. Thus 25 percent of the time or less most private warehouses possess additional capacity to handle all inventory requirements.

The problem occurs when certain peak periods require warehousing functions that exceed available private warehouse capacities. Such occasions could be driven by events such as product seasonality, new product introduction, promotions, temporary regional demand requirements, or planned plant shutdown. Solving this problem requires warehouse planners to devise a strategy that utilizes a combination of private, public, and contract facilities. For example, it may be decided that temporary warehousing should be contracted to provide coverage during a peak season. Or again, the strategy may be to utilize private warehouses as distribution hubs, with public or contract warehouses servicing regional requirements. Another strategy is to use private warehouses in locations where sales volumes are high, while using public and contract services in other markets if they are the least-cost option.

A company providing outsourced warehousing in today's distribution environment is normally termed a *logistics service providers* (LSP). In general, the role of a LSP is to provide for hire warehousing and transportation services to the marketplace. The use of LSPs is an important business strategy. According to the *2014 Third-Party Logistics Study* conducted by Capgemini, companies use LSPs extensively to perform transactional and operational activities. These include domestic and international transportation (81 % and 78 % respectively); warehousing and distribution center management (73 %); freight forwarding (62 %); and customs brokerage (57 %) [7]. Other important services used to a lesser extent are transportation leasing, small package delivery, cross-docking, product labeling and packaging, postponement and kitting, reverse logistics, freight bill auditing and payment, transportation planning, fleet management, customer order management and fulfillment, and customer service. In addition to these core functions, today's top LSPs have expanded their capabilities to embrace a variety of advanced technology services including EDI, bar coding, e-commerce order management, collaborative networking, and Web-based documentation management.

Companies can view the management of their logistics functions from either a strategic or an operations viewpoint. There are several choices companies can make regarding how much of transportation and warehousing are to be kept in house and how much is to be outsourced. The simplest arrangement is the *traditional logistics model*. In this model, internal company functions totally control logistics decisions and resources. Rarely does this strategy offer a practical solution. There are always special warehousing and transportation needs that periodically appear that require logistics outsourcing. However, when the use of an LSP occurs, it is concerned with the execution of one-time spot buys to solve temporary under capacities in internal warehousing or transportation capabilities.

The next level of LSP − *basic services* – is similar to the traditional model in that the company maintains control of logistics functions. The difference is the logistics team recognizes that as the company's logistics needs grow in complexity and scope, the need for logistics services beyond the company's competency will require the use of outside LSP partners beyond just intermittent spot buying. Logistics teams look to LSPs to provide important warehouse and transportation services such as cross-channel warehouse management or export. LSP use, however, is still opportunistic, with cost savings rather than partnership as the main driver.

The third type of LSP is a *3PL model*. In contrast to the first 2 models, which are focused strictly cost and immediate performance, companies pursuing a 3PL model are characterized by a partial surrender of logistics control to their service provider. While the internal logistics team still acts in the role of logistics integrator and retains control of channel design, 3PLs are given responsibility for managing entire portions of the supply chain. Normally, the company plays an active part in assisting the 3PL to assemble the logistics team, is responsible for enforcing 3PL adherence to the channel strategy, and oversees the execution of logistics functions.

The most robust type of LSP is a 4PL. In this model, the internal logistics team selects a service provider who assumes full responsibility for the company's logistics management. While the internal logistics team is still an active partner in the architecting and maintenance of both the logistics strategy and the community of service providers selected by the 4PL, full responsibility for the total logistics solution is given to the 4PL. The 4PL assumes ownership of channel design, spot logistics contracting, 3PL partner selection, and detail operations execution.

According to industry-wide research, the use of LSP services has increased dramatically over the past 20-years. While base logistics services are expected to be enhanced, LSP providers are expanding their offerings to encompass greater functionality in finance, inventory, technology, and data management. In the past, service buyers most frequently outsourced logistics activities that were transactional, operational, and repetitive, and less frequently those that are more strategic, customer-facing, and IT intensive. However, according to a 2014 study by Langley and Capgemini [8], service buyers are more receptive to outsourcing strategic services from LSPs. The fact of the matter is that the continuous squeeze on all elements of the supply cycle are simply pushed executives to explore LSP services to provide four key sources of logistics value.

- *Trust*. The goal of this value is to find a competent LSP partner that can relieve the company from the task of managing the supply channel.
- *Information*. The objective of this value is to leverage the technology capabilities of LSPs to provide a high level of logistics information accuracy, quality, and the timeliness for the operations they deliver.
- *Capital Utilization*. The reduction of fixed assets in the form of physical plant and equipment is a major source of LSP value. Less fixed expense is expected to be returned to the company in the form of better working capital.
- *Expense Control*. The overall reduction of logistics channel costs is by far the primary objective of using a LSP provider. Expanding customer service combined with lower logistics costs is seen by savvy CEOs as a critical path to survival.

12.4 WAREHOUSE MANAGEMENT PROCESS

The development of effective warehousing strategies enables supply chain planners to successfully execute warehouse management activities. For most companies, warehousing involves a number of functions ranging from product receipt to order shipment. Responding effectively to these and other functions is the objective of the warehouse management process. As illustrated in Figure 12.4, this process consists of four major activities that must be clearly defined if the warehouse is to work effectively and efficiently.

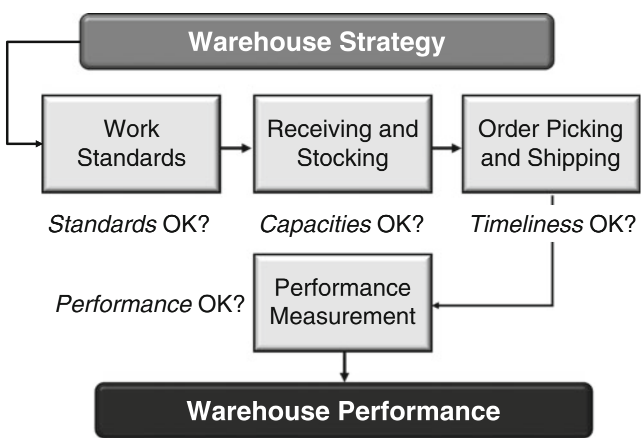


FIGURE 12.4 Warehouse management process.

12.4.1 Establishing Warehouse Standards

The first activity in the warehouse management process is determining the *work standards* for labor, equipment, and storage performance. Operational standards are the pillars of warehouse management and they enable the enterprise to chart in detail overall warehouse processing performance and productivity. Operations standards are classified into three broad categories, the sum of which constitutes the statement of warehouse capacity. *Efficiency* measures how well actual activities are performed against the standard times and costs assigned to perform them. For example, a picking standard is defined as the actual number of lines picked in an hour's time against how many lines should have been picked. *Utilization* attempts to measure how much of a warehouse resource was actually used to perform a task against the standard capacity that is available. Comparing the number of hours in a day a picking team actually has available against the number of attendance hours provides an example. The final operations standard is determining the *standard capacity* of each warehouse operation. This standard is calculated by combining the number of operators, number of shifts, standard available working hours, the utilization and the efficiency.

Exercise 12.1: Calculating Warehouse Standards

The warehouse operations team has been assigned the task of calculating several warehouse standards. The first task is computing the *efficiency* of the warehouse's bin picking area. The calculation is performed as follows:

I. Standard hours per bin picking with a six person crew

Standard available hours = 6 pickers × 7 h per day per picker = 42 h per day
Standard lines picked per hour per picker = 60 lines
Standard lines picked (per day) = 42 h × 60 lines = 2,520 lines

II. Demonstrated (actual) lines picked per day

2,520 lines picked in 39 h

III. Picking efficiency calculation (picking crew of 6)

$$E = \frac{Demonstrated\, hrs}{Available\, hrs} = \frac{42}{39} = 108\%$$

The second task of the team is to determine the *utilization* of the bin picking team.

I. Capacity available for bin picking team

Capacity = number of pickers × daily hours available
Capacity = 6 pickers × 7 h per day per picker = 42 h

II. Demonstrated (actual) daily hours used

Total hours used = 40 h

III. Picking utilization calculation (picking crew of 6)

$$U = \frac{Demonstrated\, hrs}{Available\, hrs} = \frac{40}{42} = 95\%$$

The final task of the team is to determine the *daily capacity* of the bin picking team

I. Data elements for bin picking crew of 6

Shifts = 2 shifts per day
Picking team = 6 pickers
Hours available = 7 h/per day per picker
Efficiency = 108 %
Utilization = 95 %

II. Bin picking team daily capacity

$C = 2 \times 6 \times 7 \times 95\ \% \times 108\ \% = 86$ h daily per bin picking team

Warehouse standards are defined using a number of methods. The first, *historical standards*, is a technique whereby a firm calculates an average time to perform activities by compiling actual time past work records for a designated period. Provided the data are available, this method is the fastest way to develop meaningful standards without in-depth technical knowledge. The disadvantage of this method is that it is based on how long a particular activity *actually took* versus *what it should have taken* to perform the work. If the warehouse has poor work habits, these subpar practices become the standard. Another method is to use *pre-determined standards* published by professional organizations like the U.S. Department of Defense or WERC. The procedure is as follows: divide work into essential elements of motion, apply predetermined time elements, factor in allowances (fatigue, interference, etc.), and calculate the time standard. This method enables standards to be quickly defined on the detail level with the minimum of observation time.

A third method consists in a firm performing its own time and work study analysis and determining standards based on the results. *Work sampling* develops standards by accepting the statistical outcome for a random sampling of work activities. The argument is that if a statistically correct number of random samples are taken, the results would hold the same weight as a detailed sample. The procedure for this method is to first determine the work element. Then a statistically correct number and frequency (the more observations the better the results) of sample observations are made. Finally, the results are used to determine the standard for the work performed. *Time study* is the most common technique used to determine warehouse time standards. This process uses detailed time and motion studies to establish process best practices. The steps are as follows: identify the increment of work; identify the motion routines needed to perform the work; establish the base time to perform the work using average or predetermined standards; factor in motion allowances and delays due to interruptions of work; establish the work standard.

The final method is to develop warehouse standards through the use of multiple *regression analysis*. This technique calculates a work standard by combining actual work content with the associated values affecting the activity. For example, the time required to pick a given quantity of a given item is not a straight equation but one that utilizes a weighting factor such as the item weight, number of cases, transport capacities, and other issues.

Operational and resource capacity standards are necessary for the smooth and efficient functioning of the warehouse. Effective standards enable the warehouse to execute the following critical functions:

- *Resource availability*. Warehouse standards provide managers with metrics detailing the capacities of labor, equipment, and facilities. These capacity standards form the basis for all subsequent warehouse planning.

- *Scheduling.* The ability to schedule warehouse resources is critical in actualizing performance targets. Effective scheduling begins by establishing the standard capacity resource profiles of the various operational and storage elements in the warehouse. Next, the resource requirements necessary to accomplish activities, such as receiving, stock put-away, picking, packing, and shipping, are determined. Once these elements are known, warehouse management then develops an everyday schedule designed to match resources with warehouse requirements. For example, if an order filler can pick 60 lines an hour and the projected load of lines to be picked for a 7 h day equals 4,200, the production manager must schedule ten pickers to be available. Schedules also assist warehouse managers plan for work backlog. By calculating the resources necessary to satisfy a backlog condition, a plan can be formulated to increase capacities by scheduling overtime, using part-time workers, or outsourcing alternatives. Comparable steps would be taken to handle capacity constraints caused by seasonality.
- *Problem identification.* The availability of detailed standards significantly assists warehouse managers improve productivity. Standards pinpoint efficiency and utilization problems in the warehouse and permit managers to redistribute resources to meet requirements. The real focus of problem identification is to seek out the source of why the problem is occurring in the first place, and then to eliminate it.
- *Continuous improvement.* Standards also form the basis for all quality programs targeted at continuous improvement. The goal is to remove all forms of waste in the process. Once standards are defined, management can decrease the standard by a given percentage and see where the bottleneck develops. The object then is to solve the bottleneck, revise the standard, and begin the process over again. Continuous improvement is the most effective way to reduce warehouse costs while maintaining the same level of service.
- *Costing.* The selling price of a product is generally defined as cost plus a percent margin over the cost. The cost, in turn, is broken down into the cost of product acquisition, direct labor associated with material movement, and fixed and variable overheads associated with a wide range of support operations and other burdened costs. When determining selling prices, it is critical that the firm know the exact content of operations cost. When the exact cost is uncertain, companies run the risk of retaining less profit than planned or missing opportunities to achieve price leadership opportunities in the marketplace.

12.4.2 Receiving and Stocking

Accountability for warehouse product storage and record accuracy begins when products are received and ends when products are shipped from the warehouse to the customer. *Receiving* is defined in the *APICS Dictionary* as

> The function encompassing the physical receipt of material, the inspection of the shipment for conformance with the purchase order (quantity and damage), the identification and delivery to destination, and the preparation of receiving reports.

The primary objectives of receiving are:

- Safe and efficient unloading of carriers
- Prompt and accurate processing of receipts
- Maintenance of accurate records detailing receiving activities
- Timely disbursement of receipts to stocking locations in preparation for picking and shipping.

To ensure receiving accuracy and the timely processing of necessary documentation, it is imperative that the receiving process be formalized. A conventional receiving flow is illustrated in Figure 12.5.

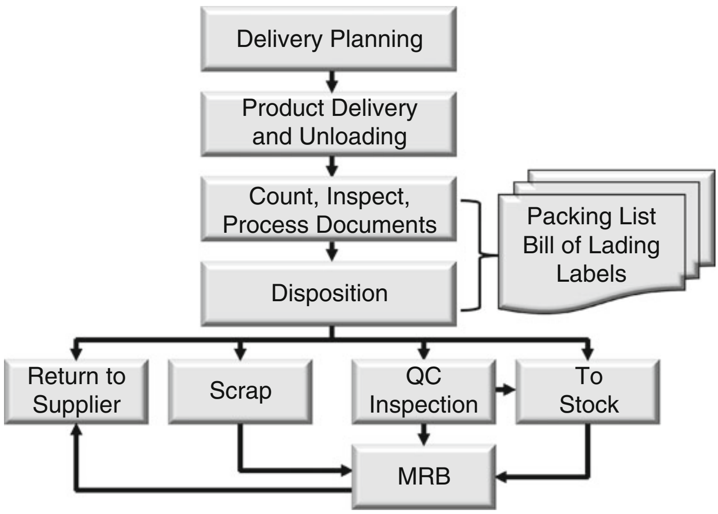


FIGURE 12.5 Receiving flow.

In the first step, *delivery planning,* it is receiving's responsibility to plan for the delivery by scheduling the arrival date and time, the type and quantity of material to be received, the availability of docking and material handling capacities, and the preparation of staging areas. The object of receiving planning is to prevent delivery bottlenecks and possible detention costs. In the next step, *product delivery and unloading,* the goods are unloaded from the carrier. Once unloaded, it is receiving's responsibility to *count the goods received, inspect for observable damage, and process documents*. In this process, the receipt is first verified against the original purchase order and receiving documentation (bill of lading, packing list, and so on). After a quick damage inspection is performed, the receipt is unpacked, sorted, counted, and the receipt authorized. Sometimes important activities such as labeling and unitization are also performed.

Following this step, receiving begins order *disposition* activities. A key activity is the posting of the receipt. For most companies, this activity is performed through a computer terminal that automatically marks the order as completed, posts the receipt to the warehouse, records quality control inspection data, and updates supplier performance statistics. Other posting information includes recording of early delivery, shortages, overages, and damaged goods. Often bar code reading equipment is utilized that significantly assists in item and quantity identification. Depending on the outcome of the receipt a number of different actions are possible. If the receipt is authorized for put away it can be moved directly to the stockroom. The receipt may be moved to the inspection department for rigorous review and certification. A portion or the entire receipt may be rejected and moved to a *material review board* (MRB) location for disposal or return to the supplier. Finally, the receipt is moved out of the receiving area, the inspection department, or MRB and staged for put away in main warehouse storage.

Once the receipt has exited the receiving process, it is the responsibility of warehouse stockkeepers to perform product put away. Once in stock, picking and put away personnel must maintain inventory accuracy, protect goods from damage and theft, and maintain orderliness of items in storage. The activities associated with warehouse stocking are

- *Receiving put away*. After receipt, warehouse stocking personnel are responsible for the timely and accurate placement of inventory into the warehouse locations (known as *slotting*) assigned during the receiving process. Included in this function is any pre-packing or kitting of products.
- *Product movement between locations*. Sometimes products must be relocated because of changes in stocking quantity, construction or phase-out of stocking areas, changes in material handling equipment, and others.
- *Location servicing*. Stocking personnel are responsible for ensuring that all stocking locations are clean and free of debris and for refilling forward picking bins and racks from reserve locations. Servicing also includes making sure inventory is housed in the optimal picking and storage locations.
- *Inventory balance count verification*. All warehouse personnel are responsible for accurate inventory counts. Validation of counts occurs when items are put away, moved to alternate locations, serviced, picked, cycle counted, and/or counted during the annual periodic physical inventory.
- *Transaction and move reporting*. Each time an item balance record needs to be adjusted or an item is relocated, it is the responsibility of warehouse personnel to quickly and accurately report the transaction.
- *Product staging for order picking*. For large, bulky items or large quantities of a product that are palletized or containerized, stocking personnel often will facilitate the order picking process by staging the required quantities. Included in this function is the process of consolidating orders that are picked from multiple places in the warehouse into a single customer order shipment.
- *Stock rotation and lot control*. Stocking personnel are responsible for the rotation of goods that have a fixed shelf life, are prone to spoilage, or must be lot controlled. The goal is to always have the oldest lots of a product staged in the location as the next to be picked.

12.4.3 Order Picking and Shipping

The third step in the warehouse management process is order picking and shipping.

12.4.3.1 Order Picking Functions

The picking of inventory to fill customer and production order requirements is perhaps the most important function of warehousing. It is the responsibility of the warehouse to fill orders within the smallest cycle time possible with perfect accuracy. For the most part, order picking is the most labor-intensive and expensive of all warehouse functions. Although automation has greatly assisted in shrinking direct labor content, order picking largely remains a manual activity, requiring significant planning, supervising, quality review, computerized support tools, and management direction. There are a variety of methods for order picking, and selection of one or multiple methods depends on a number of factors. The characteristics of the product being handled, total number of transactions, total number of orders, picks per order, quantity per pick, picks per SKU, total number of SKUs, value-added processing such as private labeling, and whether orders are handled by piece pick, case pick, or full-pallet loads are all factors affecting the eventual choice of an order picking method. Many times a combination of picking methods is needed to handle diverse product and order characteristics. The failure to effectively pick orders can have a dramatic effect on the whole enterprise. For example, it is estimated that the cost of an inaccurately filled customer order is $10–60, not to mention the potential of losing customers due to poor service. In addition, order processing and delivery that is not competitive places the firm at risk of losing business to more efficiently organized rivals.

Order picking is performed in three possible forms. In the first, *manual picking*, the picking is performed by teams that either walk or operate from a vehicle and pick inventory as determined by paper picking lists or computerized visual displays. The second type, *automated picking*, utilizes computer-controlled systems to retrieve inventory from each picking location, in the quantity and at the time specified to meet order demand. The third type of picking consists of a *combination of manual and automated picking* driven by the nature of demand, the product, and the availability of picking equipment. In addition, there are two order picking routing patterns. The first, *non-sequential,* is characterized by the fact that picking routes are completely random and determined by the arrangement of the order lines. This method is not recommended. The second, *sequential*, is characterized by the use of several sequencing methods that increase picker productivity, reduce picking time, and reduce picker fatigue by routing the picker level by level down a storage aisle, improve picking location density, and ensure fast-moving products are up front and close to shipping. Some sequential routing techniques are loop, horseshoe, Z, block, stitch, vertical or horizontal, and zone.

Regardless of the form of picking technique, most order-picking operations are governed by the following three factors:

- *Unit Load*. The unit governs picking times and equipment. The more product units are grouped, such as a picker to filling the order requirement by pulling a full pallet/container load from stock, the more efficient the pick. An example would be a refrigerator distributor who stocks each product one-per-pallet. This method of picking lends itself best to automated forms of picking.
- *Case Lot*. Often products are pulled to fill orders in full cases only. Case-lot quantities can be stored on a shelf or on a pallet, depending on the order point and replenishment quantities. Although this method can be automated, for the most part it requires manual picking.

- *Broken Case*. This condition is used by companies that allow picking quantities in less than full case-lot quantities. This method of picking is performed from a shelf, pallet, or other form of storage unit. This method is very difficult to automate and is almost exclusively a manual operation.

Due to variances in packaging, product characteristics, required quantities, space availability, and on-hand quantities, warehouses often use a hybrid of these methods.

In addition to the method, the way the picking order is controlled has an impact on warehouse operations. When *discrete order picking* is used, pickers fill all the open lines of an order before the next order is begun. Often this means that the filler passes through multiple storage zones to complete the order. The advantage of discrete order picking is that it maintains order integrity throughout the picking process, works well when the number of items to be picked is small, is simple to execute and easy to control, eliminates excess handling, provides fast customer service, facilitates quality auditing, and establishes direct fill responsibility. Disadvantages include the time required for the picker to traverse the entirety of the warehouse, increasing inefficiency as order size grows, and need of a large order filling staff.

In contrast, when *batch picking* is used, multiple orders are grouped into small batches. An order picker picks all orders within the batch in one pass using a consolidated pick list. Usually the picker uses a multi-tiered picking cart using a separate tote or carton on the cart for each order. Batch sizes usually run from 4 to 12 orders per batch depending on the average picks per order in that specific operation. In operations with low picks per order, batch picking greatly reduces travel time by allowing the picker to make additional picks while in the same area. The discrete identity of the order is then reassembled in the consolidation area and shipped to the customer or moved to the production line. Batch picking is also very common when working with automated material handling equipment such as carousels. The advantages to batch picking are that it reduces travel and fill times to pick individual products, permits volume picking from bulk storage, and improves supervision by concentrating order completion at the consolidation point. Disadvantages include double handling and sorting in the consolidation area, allocation of space and labor for the consolidation area, loss of order integrity until consolidation occurs, and difficulty in tracing primary accountability for order line items picked. Finally, in order to get maximum productivity in batch pick operations, orders must be accumulated in the system until there are enough similar picks to create the batches. This delay in processing may not be acceptable in same-day shipping environments.

A variation on the above methods is the use of *zone picking*. In this technique, picking is performed on products inventoried in specific storage zones. Orders are divided by zone with pick lists printed at the zone. Order fillers then pick the zone complete. Picked lines are then reassembled into orders in a consolidation area and shipped. There are three possible zone configurations:

- *Serial Zones*. In a fixed-zone picking route, order pickers follow a prescribed zone sequence. As an order is completed in one zone, it is conveyed to the successor zone by use of a cart or conveyor system.
- *Parallel Zones*. In a parallel-zone picking route, the filler picks from independent zones, located, for example, on either side of the picking aisle. Once the order is

completed, a consolidation point is used to reassemble the order for shipment or for movement to the production line.

- *Serial/Parallel Zones*. This arrangement permits the existence of a number of serial zones arranged in a parallel configuration.

The advantages of using zone picking techniques are that they establish good work standards, increase picking accuracy and productivity, reduce damage and errors, and increase shipping container utilization due to close picker familiarity with zone specific products. Disadvantages are that the techniques require high-volume picking, increase the requirement for management control, and inter-zone queues slow down other pickers. Zone picking is especially useful for distributors who normally pick products in family groups. It is particularly applicable to storage areas utilizing flow racks. A variation on zone and batch picking is *wave picking*. In this technique, all zones are picked at the same time and the items are later sorted and consolidated into individual orders/shipments. Wave picking is the quickest method (shortest cycle time) for picking multi-item orders but sorting and consolidation is more complex and time consuming. Storage systems with high total number of items and moderate to high picks per order may benefit from wave picking. Wave picking may be used to isolate orders by specific carriers, routes, or zones.

Often post-order-picking activities involve picking location replenishment. This function occurs when products are stored in fixed forward locations with floating reserves. Normally, each product in a forward location has some form of minimum quantity that, once triggered, alerts the replenishment planning system. Modern computer systems not only keep track of inventory levels but also generate a picker directing stock personnel to retrieve reserve product and move it to the assigned forward location. Replenishment activities include picking the required quantity of material from the reserve location on schedule, transporting it to the proper forward location, and positioning it in the pick location.

Warehouse management must take into consideration a number of key factors when designing a picking system. Is the warehouse arranged by fixed location, random storage, fixed forward locations resupplied by a reserve stored in bulk locations, or a combination of methods? A key factor is configuring the picking system to meet customer-quoted lead times. Another factor is the availability of picking equipment. New types of storage racks or bins, construction of mezzanines, picker vehicles, carrousels, conveyors, computer-controlled stacker cranes, and a host of other equipment impact picking system design. Successfully implementing a picking system requires warehouse managers to thoroughly research its impact on the organization, costs of equipment and labor, and creation of a detailed implementation program. In any case, a picking system must always be focused on cutting wastes in the process while improving picking accuracies.

12.4.3.2 Order Shipping Functions

Shipping is the process of preparing the delivery of finished goods to the customer. *Shipping* is defined as

> those activities performed to ensure the accurate and damage free packaging, marking, and weighing and loading of finished goods, raw materials, and components in response to customer order requirements in as cost effective and as expeditious a manner as possible.

The primary objectives of the shipping function are described as follows:

- Efficient receipt and handling of picked orders into a shipment.
- Prompt and accurate checking of order quantities and ship-to information.
- Efficient packaging/packing of orders in a manner that will prevent damage, reduce handling costs, and facilitate delivery.
- Selection of a carrier that will best deliver the order at the minimum cost.
- Development of an effective schedule of docking and loading facilities that eliminates outbound shipment bottlenecks and optimizes labor and equipment availabilities.
- Maintenance of shipping documentation that expedites order delivery and permits performance measurement.

As illustrated in Figure 12.6, the first step in the shipping flow is selecting and scheduling transportation. If a company-owned fleet is available, the delivery is coordinated by transportation management. If a common or private carrier is used, scheduling and rate negotiations will have to be discussed with the transport company. There are a multitude of types of carriers, ranging from couriers and taxicabs to logistics freight companies, the U.S. Postal Service, and United Parcel Service (UPS). In selecting carriers, key attributes, such as speed of delivery, scheduling flexibility, service consistency, security, reliability, electronic order tracing, and level of cooperation, are considered.

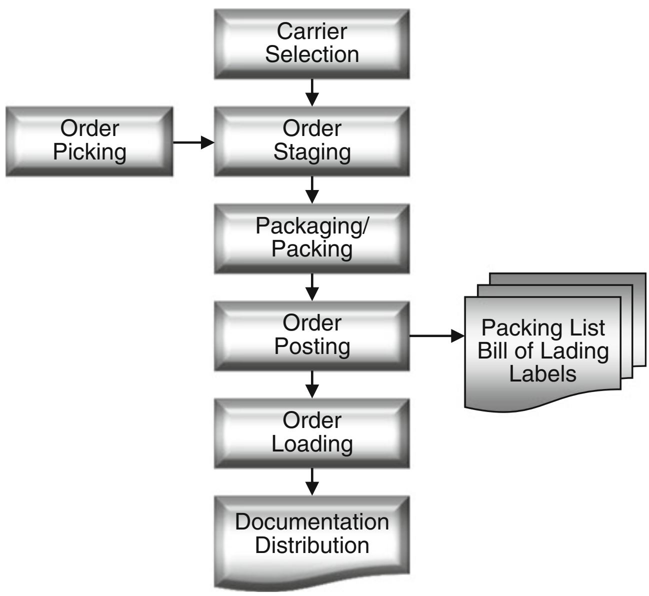


FIGURE 12.6 Shipping flow.

The second step is movement of the picked goods to a staging area where they are consolidated and packed. In step 3, orders have all required packaging, labeling, and any final postponement processing completed. At this point, information about the shipment is updated in the computer. A critical activity is the issue of item quantities out of finished goods inventory. Once these steps are completed, orders are then loaded on the carrier. Included in this step are the final order quality check; update of the shipment record;

preparation of the necessary packing lists, bills of lading, and documents specifying any special marking (bar codes and hazardous materials labels); customs documentation (as needed); loading; and sealing of the vehicle. Finally, shipping documentation is disbursed to the proper departments or entered into the computer for delivery follow-up, accounts receivable billing, and performance measurement.

During the past several years, receiving and shipping functions have been impacted by changes in equipment and management philosophies. The first of these changes occurred with the development of longer, wider trailers. Due to changes in federal regulations, permissible trailer width capacity increased from 96 to 102 in. and length from 45 to 48 ft. These new dimensions might require some warehouses to increase their delivery areas and storage yards. The growing use of lean and cross-docking has also reoriented warehousing away from a traditional concern with picking and storage and toward increased attention to facilitating receiving and shipping activities to achieve maximum product flow through. A third area is the implementation of computers, bar code scanners, radio frequency identification (RFID), wireless technologies, and vehicle tracking networks. These technology tools have driven improvements in document preparation, product identification, and work (labor and equipment) scheduling. The final trend changing receiving and shipping is the application of new unloading and loading equipment, such as dock levers, automatic unloading systems, mobile warehouse equipment, and conveyor systems. Equipment changes have resulted in increasing the flexibility of receiving and shipping departments to handle a wide variety of transportation loads and improving safety, product flow, and warehouse labor productivity.

12.4.4 Performance Measurement

The final step in the warehouse management process is establishing detailed performance measurements. Warehouse performance metrics have three objectives. First, they enable management to formulate a clear, quantitative statement of the performance standards to be achieved by the warehouse. These standards are then used as a benchmark guiding daily activity execution and continuous improvement. Second, they enable managers to chart how effectively warehouse activities are being performed to standard. Because the rest of the organization depends on the warehouse to execute receiving, storing, picking, and shipping functions that match published standards, performance measures demonstrate the degree to which the warehouse is responding to enterprise operational needs. Third, they assist managers and associates in pinpointing problems that inhibit productivity so that constructive steps are taken to eliminate the problem from reoccurring. Finally, performance measurements provide companies with a means to plan and control the significant variances experienced in warehouse operations. The randomness of customer demand, customer service commitments, rush shipments, postponement activities, equipment capacities, and a host of other factors disrupt normal throughput and require detailed planning and control if the warehouse is to maintain high productivities.

Performance measurement programs work best when designed as a closed-loop system. Actual work is reported against the performance method, and the input and output is analyzed. The results are then used to enable an improvement initiative, which then communicates directly into enhancements to work planning and scheduling. Whether a change in the standard has occurred or not, the standard needs to be communicated to warehouse employees as a guide to subsequent work activity. For a performance measurements system to function properly, it must be valid, accurate, complete, cost-effective, and timely. Without these components, the measurements system generates misleading data and causes managers to formulate false conclusions and execute invalid corrective actions.

There are essentially five warehouse performance measurements. The first, *throughput*, refers to the volume of product storage and retrieval transactions that are accomplished in a given unit of time. A particular performance measurement might be the percentage of received pallets that are put away in a day's time. If the standard is set at 98 %, then performance metrics are calculated by dividing the number of actual pallets put away against the standard. Other possible throughput measurements are deliveries unloaded, receipts checked in, orders picked, orders packed, and orders loaded. The next two metrics, *order filling* and *shipping accuracy* are determined by calculating the ratio of actual work outputs to standards. Order filling is based on a number of criteria such as lines filled without error, orders filled without error, and orders filled on time. Shipping accuracy is determined by comparing lines packed accurately, total orders packed completely, orders packed and shipped on time, and incidence of packing damage.

As opposed to the previous measurements, the third critical warehouse metric, *inventory record accuracy,* is more difficult to measure. Because of the sheer number of items to control and the size of the warehouse, ensuring inventory accuracy is a full-time role in many firms. The traditional approach is to take a *year-end physical inventory*. Except for the compilation of accounting information, however, this method has no value for ongoing inventory accuracy, and should be replaced by *cycle counting*. As detailed in Chapter 7, cycle counting methods not only are essential for maintaining record accuracy, but of more importance, they provide managers with a means of isolating the root cause of errors and devising the appropriate action to be taken to eliminate the error from reoccurring. In determining record accuracy, the following formula is used:

$$\text{Inventory accuracy} = \frac{Physical\,count - record\,balance}{Physical\,count}$$

Another measurement is to determine inventory accuracy based on a predetermined target. The formula for this method is

$$\text{Inventory accuracy} = \frac{\#\,of\,items\,at\,or\,exceeding\,target}{Total\,number\,of\,items}$$

The final warehouse performance measurement focuses on *storage utilization*. Many companies neglect to analyze storage space, assuming that plant and equipment are fixed assets and, therefore, the responsibility of accounting. However, metrics that assist managers to effectively utilize and evaluate storage is a critical part of overall warehouse performance. The first step in defining storage utilization is to define storage standards. This is done by noting the various types of storage in the warehouse, and then calculating the total capacity available by type and in total. A commonly used measurement unit is cubic feet. As an example, one storage type consists of shelf racks consisting of two levels each 4 ft high, 4 ft deep, and 8 ft long. The available cube of a single shelf in the rack is calculated as 128 ft^3

(4 ft × 4 ft × 8 ft). The available space of the entire rack is 256 ft^3. If there is 100 rack facings in the warehouse, the total space available in the facility is 25,600 ft^3.

The next step is to determine the storage requirements of every stocked product by calculating the cubic space required for one stocking unit of measure multiplied by the total inventory storage quantity. By matching inventory storage requirements to capacities, planners can determine the percentage of warehouse utilization. In addition, storage metrics assist managers to review existing procedures, material handling, and storage types with an eye toward optimizing the warehouse by developing new storage techniques as well as rearranging current designs.

The success of warehouse performance measurements depends on the same principles that characterize measurements in other enterprise functions. Effective warehouse measurements include the following principles:

1. *Simplicity*. Because performance metrics are really targeted at warehouse employees, they should be clear and easy to understand. Everyone should know why the measurements exist, how the measurements are calculated, what the results indicate, and what is their role in achieving performance targets.
2. *Goal oriented*. Performance measurements not only chart the performance of each individual warehouse department and the warehouse as a whole, they also clearly illustrate the goals and progress toward goals. This principle provides visual evidence for everyone in the warehouse on how well performance standards are being met. Figure 12.7 provides an example of a graph illustrating on-time delivery.

Category	Month (April) Avg.	12 Month Avg.	Year-to-Date
Orders Shipped	1,985	1,992	1,981
Avg. Lines per Order	3	4	4
Total Items per Order	5,955	7,968	7,924
Orders Shipped on Time	1,883	1,880	1,795
Performance	95%	94%	90.5%

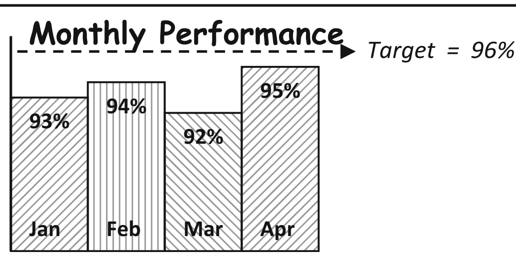


FIGURE 12.7 Warehouse performance reporting.

3. *Standards consistency*. Constant changes in measurements destroy standards integrity and renders performance goals meaningless. When too many modifications are made, warehouse associates may feel they are trying to hit a moving target that changes as the whims of management change. Such distrust negates the purpose for performance measurements.
4. *Punishment*. Performance measurements should *never* be used as a basis to discipline employees. Effective measurements depend on employee cooperation. When

measurements are used as a source of punishment, operators will find ways to report data that portrays the information as favorable when, in reality, performance is unfavorable.

5. *Continuous improvement.* The best performance measurements provide warehouse managers and associates with quantifiable information to assist in the development of plant, procedures, processes, and policies that lead to continuous elimination of wastes and impediments to productivity.

12.5 WAREHOUSE DESIGN AND LAYOUT

The size, design, layout, and selection of equipment for a warehouse is a complex process requiring detailed knowledge of the requirements of customer service; product stocking characteristics; material handling, receiving and loading technologies; transportation capacities and capabilities; and the availability of state-of-the-art storage and retrieval equipment. An effective warehouse design and layout is one in which the physical facilities, equipment, and labor is optimized and are in alignment with overall corporate and tactical strategies. If these elements are ranked, the first is a definition of warehouse strategic objectives; second, the proper equipment should be selected and operational parameters established; and, finally, the facility should be designed to satisfy operational goals while acknowledging the physical constraints of the equipment.

The process of determining the structure of a company warehouse system is concerned with two fundamental issues: what should be the size and where should the facility by located. As a norm, these two issues have an inverse relationship to each other: that is, as the number of warehouses in the channel grows, the size of each warehouse declines, and vice versa. The reason is that as the service market is segmented into spheres supplied from regional warehouses, the inventory carried in each, and hence the required size, will decline. However, as the number of warehouses increase in the channel, so does the level of total channel aggregate inventory. This occurs not only because each location needs to have sufficient inventory available to service customers, but each must also carry reserve stock to prevent shortages due to variances in interbranch resupply and excessive unplanned customer demand. Simply stated, the more unpredictable the demand, the larger the warehouse necessary to house cycle and reserve stocks.

There are a number of critical factors influencing warehouse size. Some of these are influenced by marketplace consideration, such as the desired customer service level, size of the market(s) to be served, number of products to be marketed, demand patterns, and strength of the competition. Other factors focus on storage elements, such as the size of products, availability and type of material handling systems, labor, stocking layout, and geographical access. Finally, other factors are concerned with productivity metrics, such as facility throughput rate and exploitation of economies of scale. Normally, warehouse planners use not just one, but a matrix of these and other factors in warehouse design. As a rule, larger warehouses are necessary when the size of the product is large (refrigerators, washing machines, furniture, etc.), a large number of SKUs are stocked, there is a high rate of warehouse throughput, the material handling equipment is large or complex (forklifts, cranes, automated put away and retrieval systems), and the building contains a large office area.

Perhaps the key factor in determining warehouse size is understanding the inventory and throughput requirements necessary to service the marketplace in which the proposed warehouse is to be located. Arriving at warehouse size is a complicated mathematical problem, involving knowledge of product requirements, the space/cube of each product, sales trends, building storage capacity, costs, and other factors. Simplistically, warehouse size is calculated by determining estimated sales by month and then compiling space requirements by converting units of inventory into required square footage of stocking space. Many firms also plan the use of public warehousing into the equation. When storage requirements fluctuate or cannot be known with precision, building a warehouse to meet maximum requirements usually results in underutilization of the warehouse during nonpeak periods. The most cost-effective plan is to use a combination of private warehousing to respond to normal demand and public warehousing or leased space during peak periods. Finally, the warehouse sizing exercise is not complete without figuring in the space requirements for receiving and shipping, dock requirements, buffer and staging areas, and necessary vehicle maneuvering allowances inside the stocking areas.

12.5.1 Warehouse Design and Layout Objectives

Regardless of its physical characteristics, a warehouse is nothing more than a materials handling system whose purpose is to facilitate the efficient and cost-effective movement of products through the channel network, ending in delivery to the customer. Analogous to the processing equipment necessary to produce products in a manufacturing company, materials handling systems are designed to meet the objectives pursued by the distribution strategy, and their capabilities and capacities determine the competitive boundaries available to each warehouse in the supply and distribution channel. Finally, the purpose of a warehouse determines design and layout. For example, a cross-docking warehouse looks and works different than a storage warehouse.

The objectives guiding effective warehouse design and layout are:

- *Space utilization.* A critical goal of warehouse design and layout is the efficient and cost-effective use of warehouse space. The existence of underutilized or poorly designed and maintained warehouse space is a significant financial waste.
- *Labor/equipment utilization.* Similar to the space within the warehouse, the efficient and cost-effective use of the labor and equipment to perform warehouse functions is an essential goal of warehouse design and layout. The physical building, labor, and materials handling equipment represent an enormous fixed expense that must be utilized efficiently and cost-effectively if the firm is to receive full value for its investment.
- *Optimal economical storage.* An effective warehouse design and layout plan provides the most economical storage of goods in relation to costs of equipment, use of space, potential damage to inventories, and managing warehouse personnel.
- *Good housekeeping.* An effective warehouse is one that is clean and orderly. Storage areas should be kept free of debris and forward picking areas regularly serviced. Good housekeeping prevents damage and facilitates the processes of item put-away and order picking.

- *Warehouse flexibility*. Although warehousing assets are usually fixed, they should be designed to allow personnel and materials handling equipment to be flexible enough to quickly respond to changes in the marketplace or to pursue an unplanned opportunity.
- *Warehouse scalability*. The amount of available warehouse space must be scalable to meet storage requirements. For example, if there is sizable fluctuation in warehouse storage needs over a period of time, designers may opt to size the warehouse and equipment to handle average storage and then to use rented space on a short-term basis to meet peak space requirements.

12.5.2 Sizing the Warehouse

Once it is decided that a new warehouse is to be constructed or acquired, planners must determine the size and capacity of the proposed facility. Size and capacity decisions have an enormous impact on the business: while the internal layout of the warehouse can be changed with relative ease, the physical size of the warehouse cannot be altered without great expense. An under-capacity warehouse result in higher materials handling costs, while an over-capacity warehouse will result in underutilized asset costs that will burden the logistics system.

Although it is common to think of *size* when planning the physical dimensions of a new warehouse, the real concern is how much the building will hold–its *capacity*. The two elements of design are definitely not the same. Size is normally expressed in physical dimensions. For example, the warehouse is 100 ft wide by 100 ft long. Capacity, on the other hand, refers to the amount of usable storage space that is available to hold inventory. When calculating capacity, warehouse planners need to add the height of the structure to its width and depth. The difference between size and capacity is then the difference between viewing the warehouse in terms of total square footage versus cubic footage.

The relationship between size and capacity is illustrated in Figure 12.8. The two warehouses have identical dimensions. However, because the height of the second structure is double that of the first, the capacity doubles. It should also be noted that the capacity calculation indicates the *total capacity* and not the *actual capacity* of the warehouse. The actual capacity is always less than the total capacity and is governed by the types of storage structures being used. For example, if a warehouse permits the erection of 25 ft high storage racks that covered 70 % of the stockable space, the actual storage capacity would be 175,000 ft^3 and not 250,000 ft^3.

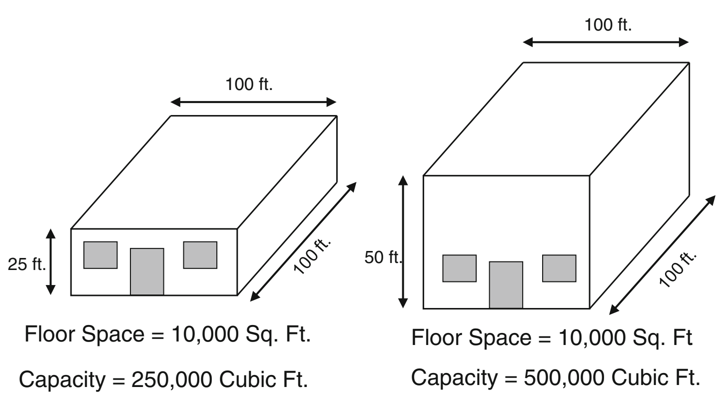


FIGURE 12.8 Computing warehouse size.

It is important to remember that increasing the height of the structure does not come without cost. The total warehouse cost is greater due to a stronger foundation, higher walls, more costly materials handling equipment to service the higher storage, taxes, and other operating costs. In any case, it is economically more feasible to build a warehouse that is higher versus one that has more square footage. Unless there is some problem with a taller building, higher storage is an important consideration during the warehouse design process.

Exercise 12.2: Calculating Warehouse Costs for an Estimated Warehouse Size [9] Warehouse designers often determine the size of a warehouse by first establishing a target warehouse size. Next, the ramifications of the estimate are tested against the demand and accompanying space requirements for a year's worth of aggregate inventory data. The goal is to first see how much of the forecasted demand will fit in the warehouse and how much will have to be outsourced, and then to see what the total cost will be for the target warehouse size.

Assembling the data for the review consists of several key values appearing in the below table. The monthly inventory turns are 3. Of the total warehouse space, only 50 % is available after pillars, racks, and other equipment is subtracted and only 70 % is to be utilized to anticipate variability in space requirements. The product size is a case measuring 2 ft^2 that can be stacked 16 ft high. Construction costs are US\$60 per square foot and are to be amortized over 20 years. Warehouse operating cost is US\$0.05 per case and annual fixed costs are US\$6 per square foot. A public warehouse used for outsourcing will rent space for US\$1 per case per month with a handling charge of US\$1.50 per case. This data is presented in the following table.

Inventory turns/month	3		
Remaining stocked inventory/cs	1		
Product stocking space per cs /cubic ft.	2.00	Height/ft/stacked	16
Operating cost/per cs	$0.05		
Rented space/month per cs	$1.00		
Rented handling charge/ per cs	$1.50		
Percent of total warehouse space available	50%		
Percent of warehouse space available utilized	70%		
Annual fixed cost/per sq ft	$6.00		

Warehouse size/sq. ft.	50,000
Amortization/yrs	20
Construction cost/sq. ft.	$60.00
Cost to build	$ 3,000,000
Amortized cost/annual	$150,000

The first step to be performed is calculating the space requirements for the estimated forecast. The monthly forecasted demand appears below.

Month	Warehouse demand, cs	Space Requirement, sq. ft.
January	280,000	33,333
February	320,000	38,095
March	390,000	46,429
April	430,000	51,190
May	450,000	53,571
June	530,000	63,095
July	450,000	53,571
August	390,000	46,429

(continued)

(continued)

Month	Warehouse demand, cs	Space Requirement, sq. ft.
September	360,000	42,857
October	310,000	36,905
November	290,000	34,524
December	260,000	30,952
Total	4,460,000	530,952

The formula to calculate the space requirements for each month is as follows:

(a) (remaining stocked inventory/inventory turns) times

(b) [product stocking size (per cs per cubic ft.)/stocking height] times

(c) [1 (warehouse doubled to account for aisles, etc.)/percent of warehouse space available] times

(d) (1/percent of warehouse space available utilized) times period demand

(e) or, $(1/3) \times (2/16) \times (1/50\ \%) \times (1/70\ \%) = 0.119 \times$ period demand $=$ space requirement, sq. ft. For January demand, $0.119 \times 280{,}000 = 33{,}333$ (rounded).

Next, a target warehouse size of 50,000 ft^2. is selected to be tested against the monthly space requirements. The results are displayed in Table 12.1.

TABLE 12.1. Simulated Warehouse Cost

Warehouse allocation (%)	Monthly fixed cost ($)	Monthly variable cost ($)	Public warehouse allocation (%)	Public monthly storage ($)	Monthly handling cost ($)	Total monthly cost ($)
100	37,500	14,000	0.00	–	–	51,500
100	37,500	16,000	0.00	–	–	53,500
100	37,500	19,500	0.00	–	–	57,000
97.67	37,500	21,000	2.33	3,333	15,000	76,833
93.33	37,500	21,000	6.67	10,000	45,000	113,500
79.25	37,500	21,000	20.75	36,667	165,000	260,167
93.33	37,500	21,000	6.67	10,000	45,000	113,500
100	37,500	19,500	0.00	–	–	57,000
100	37,500	18,000	0.00	–	–	55,500
100	37,500	15,500	0.00	–	–	53,000
100	37,500	14,500	0.00	–	–	52,000
100	37,500	13,000	0.00	–	–	50,500
	450,000	214,000		60,000	270,000	994,000

(a) *Warehouse allocation:* target warehouse/space requirements.

(b) *Monthly fixed cost:* [(annual fixed cost $\times$ warehouse size) + annual amortized cost]/ 12.

(c) *Monthly variable cost:* period demand $\times$ warehouse allocation (%) $\times$ operating cost per cs.

(d) *Public monthly storage cost:* [(period demand $\times$ public warehouse allocation)/turns] $\times$ monthly rented space cost per cs.

(e) *Public monthly handling cost:* period demand × public warehouse allocation × monthly rented handling charge per cs.
(f) *Total monthly cost:* monthly fixed cost + monthly variable cost + public monthly storage cost + public monthly handling cost
(g) *Total yearly cost* for 50,000 ft^2. warehouse = US$994,000.

12.5.3 Warehouse Layout

The actual arrangement of a warehouse can take several forms depending on the products the warehouse stocks, whether the facility performs production or is a distribution center, its service objectives, and its physical characteristics. A conventional warehouse model appears in Figure 12.9.

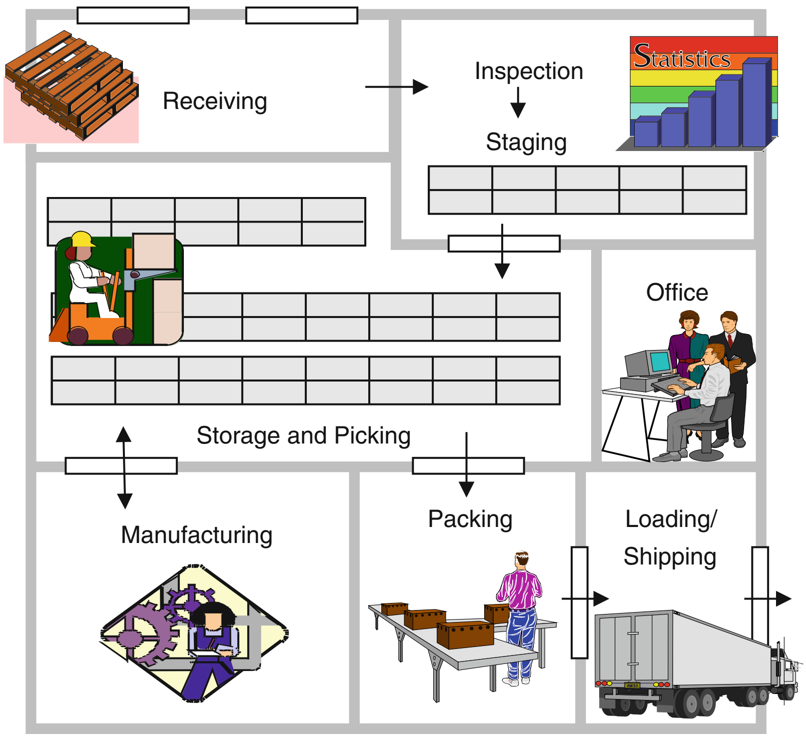


FIGURE 12.9 Conventional warehouse layout.

This layout is designed to simulate the movement of items from the point of receiving to the point of shipment and illustrates how the following functions are positioned in a warehouse:

- *Receiving*. This function is normally positioned close to the dock doors designated for incoming receipts. Receipts are validated, unpacked, appropriate documentation generated, and transaction update performed.
- *Inspection and staging*. Receipts are often moved first to an inspection location where they are quality certified and then palletized or containerized and prepared for storage in a staging area.

- *Storage and picking*. This area of the warehouse is dedicated to the storage of production and finished goods inventories.
- *Production*. For companies that perform production, storage and picking areas are located close to the production area. Once products are made, they move to finished goods storage.
- *Packing*. A demand order results in finished goods being picked and transferred to the packing area where items are packaged, labeled, and prepared for shipment.
- *Loading and shipping*. The packing area is located close to the loading and shipping area where demand orders are then sent to the customer.

The diagram illustrated in Figure 12.10 provides another example of a warehouse layout that contains a single type of storage, such as bins. This design is created for a distribution warehouse based on an ABC classification. Here, receiving and shipping utilize the same docking facilities with inventory storage locations stratified by usage. The fast-moving products are located closest to receiving and shipping, and slower-moving items progressively to the back of the warehouse.

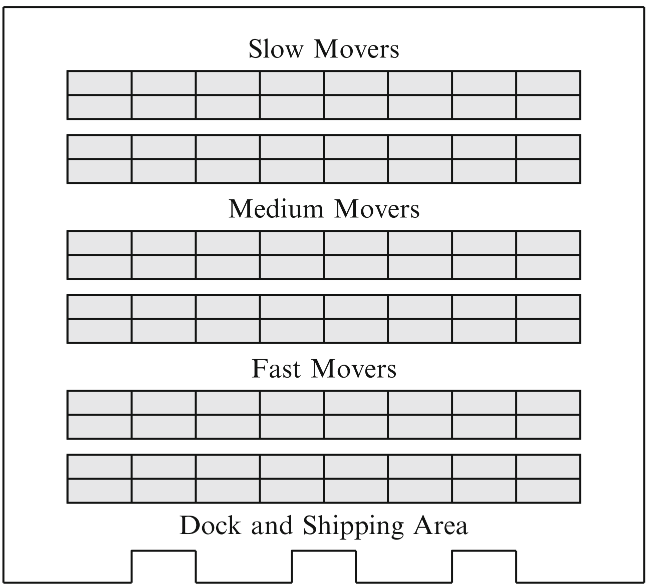


FIGURE 12.10 ABC storage layout.

Finally, Figure 12.11 portrays a layout of a warehouse that contains multiple types of storage. In this case, the warehouse is divided into receiving and shipping *zones* servicing small parts (bins and small racks), bulk parts (large racks and semi-automated storage and retrieval), and automated storage and retrieval (AS/RS) stocking areas. In selecting the general design of the warehouse, planners must be careful to utilize storage techniques that effectively leverage product and materials handling equipment and minimize labor and investment costs while facilitating product throughput and service targets.

Designing an effective warehouse layout is a multistep approach requiring detail knowledge of products, facility storage types and capacities, and customer service objectives.

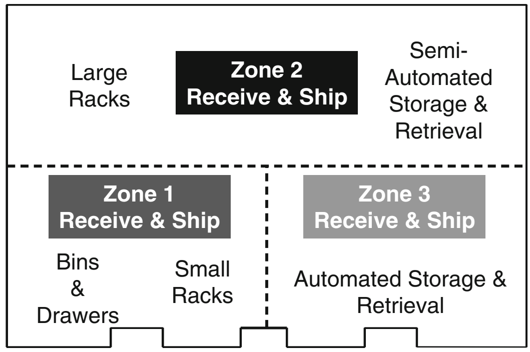


FIGURE 12.11 Mixed storage layout.

The actual storage area and the space necessary to perform related activities constitute, by far, the largest element in warehouse space allocation. A poorly structured plan results in a warehouse that is either too large or too small for normal operations. Too much space results in excess cost arising from underutilized land, construction, equipment, and energy. Too little space, on the other hand, results in a host of operational problems, such as excessive expediting, inaccessible products, damaged goods, poor housekeeping, and loss of productivity. In order to develop an optimum warehouse layout, the following steps should be performed:

1. *Establish a comprehensive warehouse planning process.* Determining an effective warehouse layout is a multitasked process that requires detailed project management. A successful project is one that is governed by a task schedule outlining milestones, due dates, responsible roles, and costs.
2. *Define layout objectives.* Although many managers may feel that the objectives of the warehouse are intuitive, it is best that objectives be precisely defined. Examples of such objectives are as follows:
   - Provide minimum cost warehousing while maintaining high customer service levels.
   - Improve space utilization by 25 % over last year's average without reducing operating efficiency.
   - Optimize space utilization in relation to the costs of equipment, space, and labor.
   - Make the warehouse a "showcase" of efficiency and good housekeeping.
3. *Define warehouse profiles.* In this step, planners detail the following requirements: (1) the products to be stored; (2) the storage size necessary to stock these products; (3) exact dimensions of the warehouse; (4) capacities of the storage area racks, pallets, bins, and so on; and, (5) capacities of planned material handling equipment.
4. *Generate a series of layout alternatives.* In this step, planners must "juggle" physical restrictions, such as the location of fixed objects like pillars and walls, the placement of receiving and shipping functions, storage areas and aisles necessary for equipment maneuverability, assignment of product storage requirements to stocking areas, stock put away and packing runs, and equipment storage areas. A critical part of this process is determining layout constraints. Besides column spacing and size, an

effective plan considers rack size and direction, the ceiling height, door and dock locations, building shape and land conditions, geographic area (climate), and local building codes.

5. *Layout evaluation*. Several configuration theories can be employed in determining the optimal warehouse layout. The use of *ABC Analysis* assists in pinpointing high-turnover items so that they are located close to receiving and shipping areas. Another theory states that items commonly received and/or shipped together should be stored together. In a similar vein, another theory states that items with similar characteristics, such as chemicals, heavy and oddly shaped items, items subject to shelf life, hazardous items, easily damaged items, and high-value items, should be stored together. Yet another suggests that heavy, bulky, hard-to-handle products should be stored close to their point of use in order to minimize costly material handling. Finally, the space utilization principle asserts that the total cube of available warehouse space should be accentuated while optimizing product accessibility and good housekeeping.
6. *Layout implementation*. Once the alternatives have been evaluated, a specific layout is chosen and implemented. At this point, project activities are structured around the tasks, schedules, and costs necessary for warehouse layout actualization.

Exercise 12.3: Calculating Warehouse Dimensions Based on Layout

A company is deciding on the size of a new warehouse. Initial estimates of inventory storage requirements and throughput indicate that the warehouse should be approximately 300 ft wide by 600 ft long or 180,000 ft^2 (S). The warehouse must be able to manage a monthly throughput of 120,000 cases of product at a cost of US$0.005 per foot per case moved. The cost to build is US$50 per sq. ft. to be amortized over 25 years. What should be the actual dimensions of the new warehouse and total cost per year?

The first step is to determine the annual warehouse size cost. The steps are as follows:

(a) Total warehouse perimeter: 2(300 ft) + 2(600 ft) = 1,800 ft
(b) Construction cost: US$50 × 180,000 ft^2 = US$9,000,000
(c) Annualized cost of construction: US$9,000,000/25 = US$360,000
(d) Cost per perimeter foot (k): US$360,000/1,800 = US$200
(e) Sum of the total cost per foot to move an item in and out of stock multiplied by the expected number of items to move per year (C): 0.005 × 120,000/12 = US$7,200.

To calculate the actual width (W) of the warehouse, the following formula is used:

$$W = \sqrt{\frac{C + 8k}{2C + 8k}}\sqrt{S}$$

or,

$$W = \sqrt{\frac{7{,}200 + 8(200)}{2(7{,}200) + 8(200)}}\sqrt{180{,}000} = 314.64ft.$$

To calculate the length (L), the following formula is used:

$$L = \frac{S}{W}$$

or,

$$L = \frac{180{,}000}{314.64} = 572.08 ft.$$

Finally, the total cost (TC) for this warehouse uses the following formula:

$$TC = 2\sqrt{\left[\left(\frac{1}{2}\right)C + 2k\right]\left[\left(\frac{1}{4}\right)C + 2k\right]\sqrt{S}}$$

or,

$$TC = 2\sqrt{\left[\left(\frac{1}{2}\right)7{,}200 + 2(200)\right]\left[\left(\frac{1}{4}\right)7{,}200 + 2(200)\right]\sqrt{180{,}000}} = US\$2{,}517{,}141.24$$

The following warehouse design and layout principles are used when designing a warehouse. The first principle is that warehouse planners *optimize the storage cube*. It is important for planners to utilize the vertical space in the warehouse, not just the horizontal space. Many companies do not utilize effectively the cubic capacity of their facilities. When planning cube utilization, designers need to assess the capacities of materials handling equipment which will be servicing and picking from each location area. The second principle is to *optimize equipment*. It is importance to select the appropriate materials handling equipment for warehouse configuration management. Appropriate equipment enables warehouse personnel to:

- more effectively utilize warehouse storage cubic capacities
- minimize the necessary aisle space
- reduce the amount of handling
- increase the velocity of product movement through the warehouse
- operate more cost effectively

The third principle is to *move goods in a straight line*. Moving goods in a straight line increases warehouse movement velocities. Eliminating obstructions or poorly positioned storage areas that decrease movement velocities reduces travel time and distance, increases stocking and picking efficiency, and decreases safety issues relating to too many turns and blind corners. Finally, the efficient warehouse layouts *minimize aisle space*. Minimizing aisle space enables warehouse designers to increase total storage capacities without increasing warehouse dimensions. Note in Figure 12.12 that the redesigned rack storage increases from five to eight aisles. The amount of aisle space depends on the types of materials handling and storage equipment a warehouse uses.

Exercise 12.4: Warehouse Handling Times Calculation

A critical factor in warehouse layout design is orienting the location of storage areas to match the volume of item activity. The goal of the process is to ensure that the items with the most activity incur the lowest internal materials handling and movement times. The most

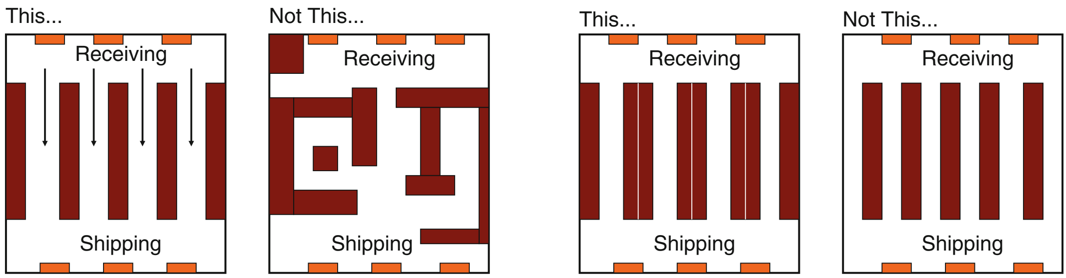


FIGURE 12.12 Warehouse principles.

efficient storage areas are those that enable items with the highest transaction volumes to be stored in a direct line and with the shortest possible move time from receiving to storage and from storage to the shipping dock. The reason why the location of item storage to the shipping area is so important involves a key dynamic in item storage management. When items are received, they are normally unloaded in large unitized loads. When items are shipped, however, they normally go out in much smaller unitized loads. The result is that efficient storage areas should be designed to recognize that there are fewer trips from the receiving dock to storage than there are from storage to the shipping dock. This dynamic is illustrated in Figure 12.13.

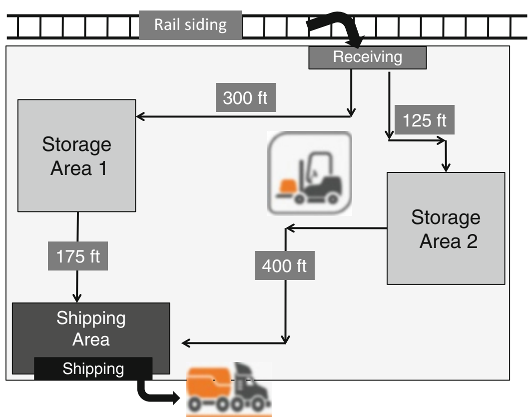


FIGURE 12.13 Warehouse layout and distances.

In the diagram, Storage Area 1 is 300 ft from the receiving dock and 175 ft from the shipping area. Storage Area 2 is a short 125 ft from the receiving dock but 400 ft from the shipping area. Since there are many more materials handling movements from each storage area to shipping than from receiving to each storage area, it is expected that Storage Area 1 provides the least overall transit times. This assumption is supported by the following spreadsheet.

Receiving	Storage area 1	Storage area 2	Variance/ft.
Distance from rail dock to storage/ft.	300	125	
Number of trips to unload 50,000 lb. car/ft.	50	50	
Total distance/ft.	15,000	6,250	8,750

Shipping	Storage area 1	Storage area 2	Variance/ft.
Distance from storage to shipping dock/ft.	175	400	
Number of trips to ship 50,000 lb.	125	125	
Total distance/ft.	21,875	50,000	28,125

Analysis	Storage area 1	Storage area 2	Variance/ft.
Total distance/ft	36,875	56,250	19,375
Total miles	7.0	10.7	3.7
Average speed/mph.	4	4	4
Total travel time per 50,000 lb. load/hrs.	1.7	2.7	0.9
Percent variance	**34.44 %**		

If an item with a lot size of 50,000 lb is received 50 times in a time period and it takes 125 movements to ship out the same 50,000 lb, Storage Area 1 has a significantly lower overall distance to travel to Storage Area 2. As such, the warehouse should stock all fast-moving items in Storage Area 1 and slow sellers in Storage Area 2. Warehouse management would have to perform similar calculations on all stocked items to ensure the lowest cost storage.

12.6 WAREHOUSE STORAGE EQUIPMENT

Materials handling is a sophisticated science incorporating advanced mathematical and modeling techniques. While these concepts are beyond the scope of this course, in practice warehouse managers can use several basic principles to guide them in designing effective storage and materials handling solutions [10].

- *Materials flow*. The creation of operation sequencing and equipment layout that optimizes materials flow through the warehouse.
- *Simplification*. Layouts that simplify materials handling by reducing, eliminating, or combining unnecessary movements and/or equipment.
- *Gravity*. The design of warehouse storage and materials handling solutions that use gravity to move material wherever practical.
- *Space utilization*. The design of storage systems that enable optimal use of both the building and the storage area cube.
- *Equipment analysis*. Selection of materials handling equipment that optimizes the velocity and ease of movement of products and materials stored in the warehouse.
- *Standardization*. The design of storage and materials handling systems that allow for the standardization of methods, as well as types and sizes of warehouse equipment.
- *Adaptability*. Requirement that warehouse storage and materials handling equipment be adaptable to the widest variety of tasks and applications.

In general, storage and materials handling solutions are designed so as to reduce as much as possible the distance materials are moved in a warehouse. The number of times a product is handled should be minimized. Fast-moving items are stored close to receiving and shipping areas. Once products are in motion they should stay in motion for as long as possible. The use of storage and mechanical or automated materials handling equipment should be based on appropriate volume and cost trade-offs to justify the investment.

12.6.1 Types of Storage Systems

At the heart of warehouse design is the selection of inventory storage equipment. The overriding factor depends on the nature of the items to be warehoused. Examples of item characteristics are the number of units to be stocked; throughput targets; weight, cubic volume, width, depth, stacking limitations; palletization; association with related products; packaging; dangerous and hazardous substances; temperature control; and shelf life. Just as important is the selection of the materials handling equipment to manage stock put away and order picking in the warehouse's storage areas. In this sense, the storage equipment and the materials handling equipment are planned together if warehouse objectives are to be realized.

A useful way to view storage types is to divide them into three general classes. In the first is found *large-item or large-volume product storage*. This type of storage system is used to handle products with large or irregular unit sizes or products with large inventory stocking quantities. Normally, the management of products in this type of storage area requires special manually-operated materials handling equipment capable of transporting heavy, over-sized, or large quantities of product. The second type of storage is *small-item or low-volume product storage*. This type of storage system is used to handle products characterized by small dimensions, small stocking quantities, low weight, or irregular transaction volumes. Normally, products in this type of storage are managed manually with standard materials handling equipment. The final type is *automated storage systems*. This type of storage is characterized by the use of semi- or fully automated storage equipment for put-away and picking. The products stored in these systems can be large or experience high volume transactions, or they can be small in size with small stocking quantities and irregular transaction volumes.

12.6.1.1 Large-Item or Large-Volume Storage

This type of storage is used to handle products with large unit sizes or that are stocked in very large quantities. Examples of equipment in this storage type include the following:

- *Open floor storage*. This type of storage is most applicable for items whose physical characteristics make it difficult for them to be easily stored on pallets or placed on racks. Another application is products whose stocked quantity and transaction volumes permit warehouse personnel to cost-effectively stack, service, and fill items directly from open floor storage areas. This type of space is a premium in a warehouse.
- *Pallet racks*. This type of storage is designed to facilitate the storage of multiple quantities of an item arranged on pallets. Normally, both the pallet and the storage structure dimensions are standardized. A key factor is determining the height of the full pallet and number of pallets to be used for an item. Storage and picking in this type of structure requires special pallet handling equipment. Advantages of pallets are ease of material handling in product put-away, ability to pick whole pallets, ease of inventory accuracy and control, and accessibility (Figure 12.14).

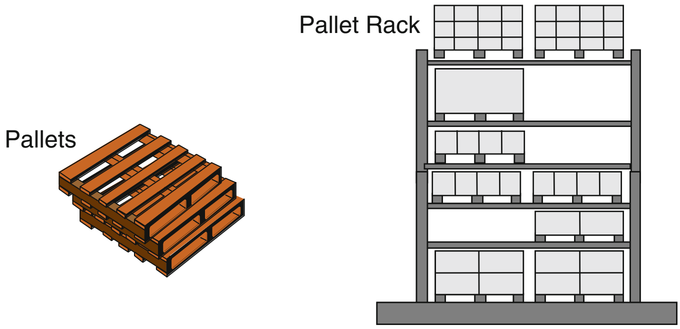


FIGURE 12.14 Pallets and pallet racks.

- *Drive-in/double-deep pallet racks.* Pallet racks can be designed to store two or more pallets deep, as well as multiple pallets high. Drive-in pallet racks are designed so that forklifts or other equipment can "drive in" to the racks between structure uprights and pallet support rails. Double-deep pallet racks require a special reach lift truck that has the capability to position pallets two to three levels deep. These types of storage provide maximum utilization of warehouse space by eliminating wasted aisle and vehicle maneuvering space (Figure 12.15).

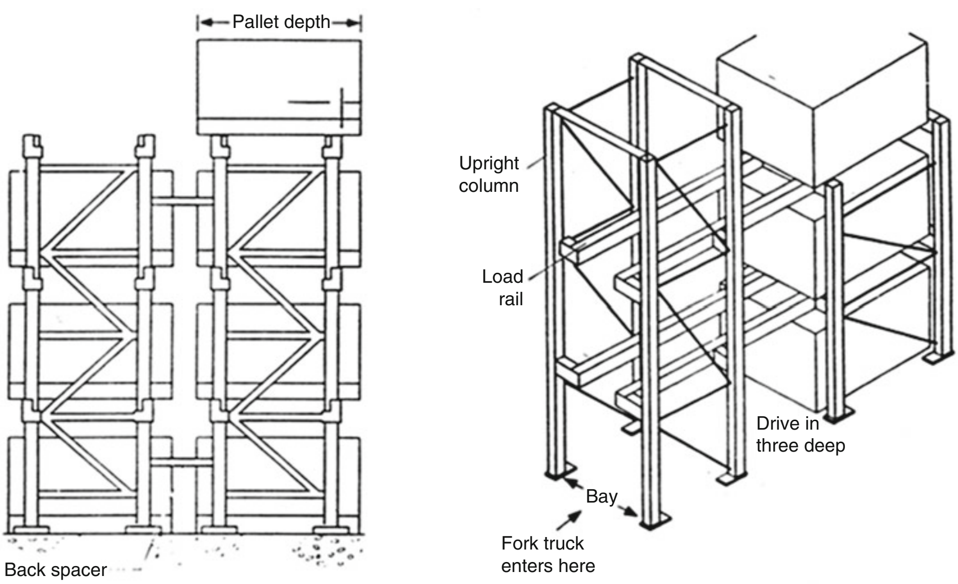


FIGURE 12.15 Drive-in/double deep racks.

- *Storage racks.* Often item stocking quantities are too small to warrant pallet storage but whose physical size disqualifies them for small-item storage systems. These items are best warehoused in storage racks. These racks consist of structure uprights, cross rails, shelving (usually wooden), and shelving cross rail supports. Normally, the storage shelf is standardized into several heights to accommodate product inventory requirements

- *Cantilever racks*. This type of storage rack is named for the leverage technique used to support the load-bearing arms. Cantilever racks normally consist of a row of single upright columns, spaced several feet apart, with arms extending from one or both sides of the upright to form supports for product storage. The columns rest on the warehouse floor, preventing the structure from toppling backward or forward, and horizontal and diagonal bracing between uprights prevents the structure from collapsing inside or out. Because of their long, unobstructed support, these types of racks are ideal for storing long metal rods, tubing, pipe, bar stock, wood poles, and other products of comparable shapes (Figure 12.16).

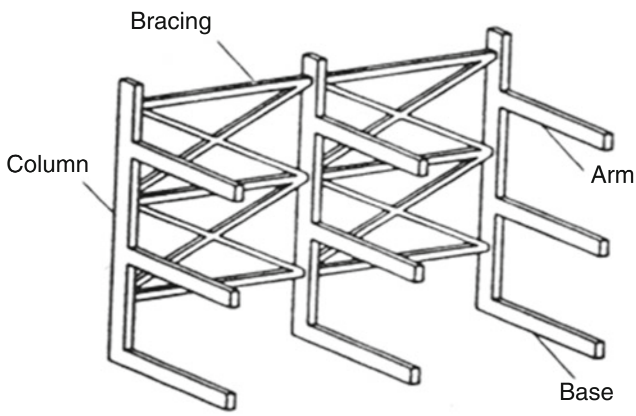


FIGURE 12.16 Cantilever rack.

- *Flow racks*. The single characteristic of this storage type is the use of conveyors positioned within a rack. By tilting up the back end of the shelf rollers, gravity draws individual products or pallets serviced from the rear forward so that they can be easily picked. Each flow run is dedicated to a single product. The advantages of flow racks over pallet and shelf racks are that they permit easy first in, first out (FIFO) inventory control, reduce the need for aisles, minimize handling by having one input and discharge point, and reduce damage and pilferage. Disadvantages are cost of structure materials, flexibility, and downtime due to equipment repair or failure (Figure 12.17).
- *Specialty racks*. Because of their shape characteristics, some items require specialized storage racking. One example is the use of tilted barrels staged in racks to store casters, metal ingots, and short metal rods. Another is special racks constructed to hold “D” handled shovels, rakes, and ladles.

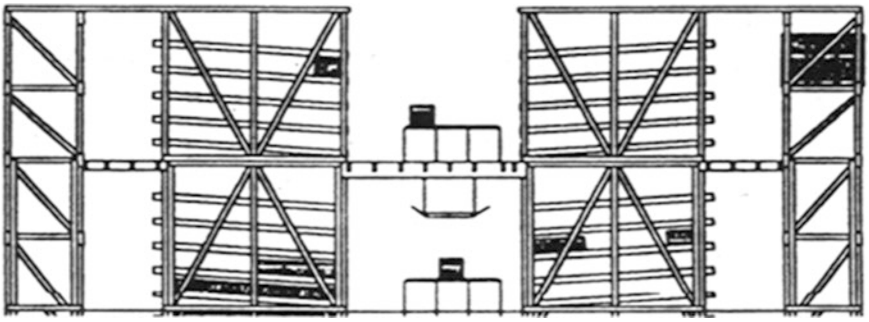


FIGURE 12.17 Flow rack.

12.6.1.2 Small-Item or Low-Volume Product Storage

This type of storage is used to warehouse items whose size and/or transaction volumes permit them to be warehoused in small-capacity storage equipment systems. Small-item storage systems are generally classified as belonging to two categories: static and dynamic. The difference between the two is how the storage system permits access to items. In *static systems,* stockkeepers and pickers must travel to stationary storage locations to service and retrieve inventory. Static systems are relatively inexpensive as compared to large-item or large-volume item storage or small-item automated systems. In fact, their lack of sophisticated automation and complexity often renders them the most efficient and economical type of storage when handling a wide range of items subject to low- to moderate-demand. *Dynamic systems*, such as carousels, bring the item to the picker. These systems are normally expensive to buy and maintain, and they require trained warehouse personnel.

Examples of equipment in this storage type include the following:

- *Bin shelving.* Bin shelving is perhaps the most basic type of static storage available. Normally, shelving structures are constructed of light-gauge cold-rolled steel and consist of a number of different types of posts or sides, shelving that is secured through bolts or special brackets, and optional steel backings. Bin shelving comes in standardized heights, widths, and depths. To maximize storage and ensure item stocking integrity, items are also stored in standardized bin boxes or metal dividers located on the shelf. Because of its flexibility, bin shelving is used to store a wide range of types and quantities of items. Other advantages are low equipment and maintenance costs and ease of erection, modification, and removal. Drawbacks center on space inefficiencies. Bin shelving makes poor use of vertical space between the ceiling and the top of the shelf facing, as well as wasted space on the shelf due to the size of the stored item. Possible solutions to more effectively utilize vertical warehouse space are to create mezzanines or high-rise shelving structures (Figure 12.18).
- *Modular storage drawers.* An alternative method to better utilize shelving space is to use compartmentalized drawers mounted in storage shelving or cabinets. As the size and quantity of items decreases, the use of shelving becomes less economical and modular storage drawers become more cost effective. By dividing the drawer space into small compartments, item storage requirements can be matched to the proper compartment, thereby increasing space utilization. Similar to shelving, modular storage drawers can also be stacked or mezzanined to utilize vertical warehouse space. The major disadvantage of this type of stocking is its relatively high-investment cost.

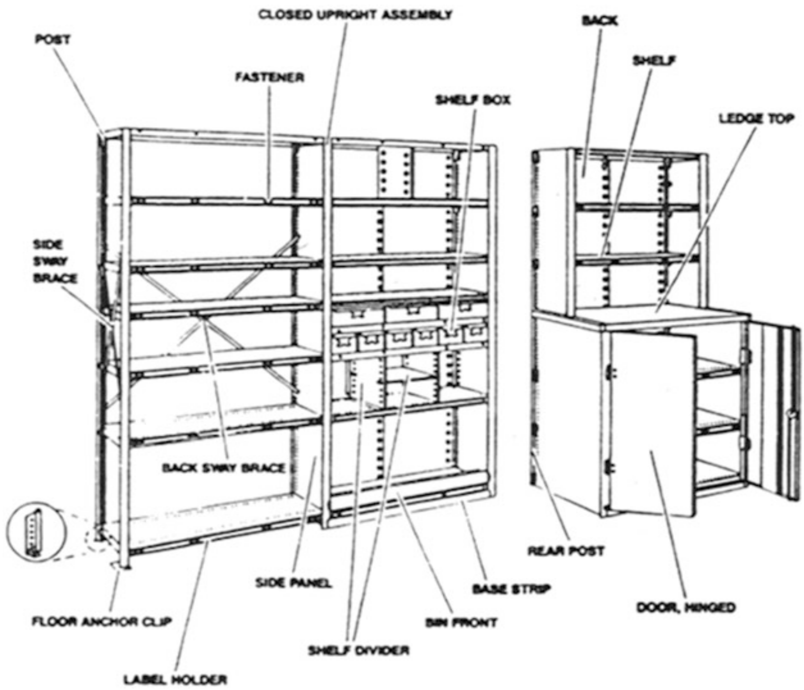


FIGURE 12.18 Small item shelving.

While static storage types have dominated the warehousing of both large-volume and small items, *dynamic storage systems* have been growing in popularity. Due to the declining costs of computerized systems and the application of automated storage/retrieval, dynamic systems have significantly increased their capabilities and have provided dramatic savings in labor and reductions in inventory levels. Dynamic system storage are broken down into the following four automated storage types:

- *Carousels*. This type of storage is defined as a series of modular, movable shelved or compartmentalized bin facings linked together by means of a motorized oval track. The basic concept is that inventory is brought to the stock person rather than the stock person moving to the bin. Carousels consist of two types: vertical and horizontal. *Vertical carousels* revolve on a vertical oval track and are either top-driven or bottom-driven. The benefit of a vertical carousel is utilization of vertical warehouse space. Drawbacks are limitations on widths, depths, and weights, and they normally cost more than horizontal carousels. In contrast, *horizontal carousels* revolve around a horizontal track. A motor, mounted in the center of the oval, moves the bins along the track. Horizontal carousels can be configured into a much greater variety of heights, widths, depths, and weight capacities than vertical types, and they can be used for many different warehouse storage applications. The most significant negative feature is waste of vertical warehouse space. Normally, an operator activates either type of carousel through manual, microprocessor, or computer controls, bringing the desired bin to the stocking and picking position. Benefits of using carousels are greater labor

FIGURE 12.19 Horizontal carousel.

utilization, increased throughput, improved control, improved space utilization, simplified inventory control and replenishment, and integration with other warehouse systems (Figure 12.19).

- *Movable aisle systems*. This type of storage is characterized by shelving cabinets or bins placed on movable carriages that either glide or roll on stationary tracks. The major advantage of movable-aisle systems is the elimination of aisle space between stocking rows. There are three types of movable-aisle systems determined by the type and weight of products stored. *Manual systems* are characterized by the ability of the operator to manually push rows to access items. The number of rows in this system are limited and stocked products are light weight. *Mechanically assisted systems* normally consist of gear systems that facilitate movement of the rows and are used for systems approaching 30 ft in length and for products of medium weight. Finally, *electric systems* utilize electric motors to move rows. This variation is most useful for controlling large racking systems and for heavy products.
- *Miniload automated storage and retrieval systems (AS/RS)*. Miniload AS/RS systems are defined as fully enclosed, automatic storage systems that bring small items and materials to an operator for picking, kitting, and so on, and automatically returns the material into the system. Similar to the much larger AS/RS systems discussed next, this type of small-item storage system depends on an automatic storage container insertion and extraction mechanism that traverses a stocking aisle vertically and horizontally. Miniload systems are controlled from keyboards or integrated with warehouse management systems. Benefits of this type of storage are floor space reduction, high stocking space cube utilization, increased throughput, reduced labor costs, increased security, and increased control of items (Figure 12.20).
- *Unit-load automated storage and retrieval systems (AS/RS)*. This type of storage is defined as the automation of the stockkeeping and picking functions associated with

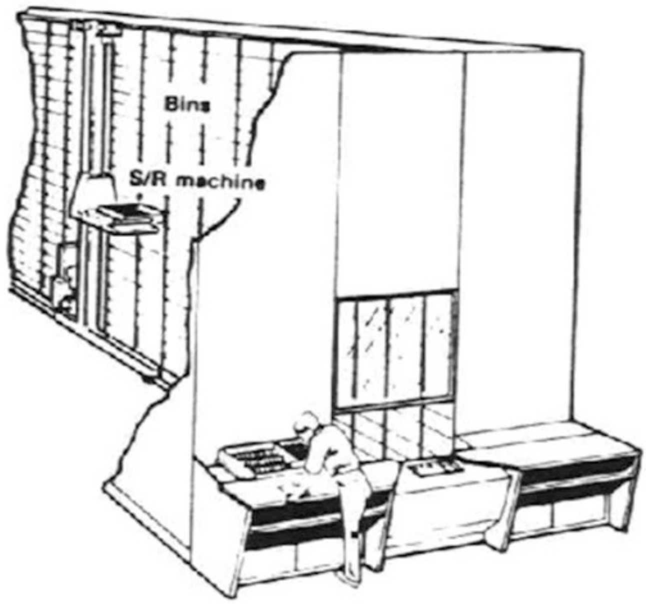


FIGURE 12.20 Miniload AS/RS system.

pallet or standard container loads. In designing unit-load AS/RS systems, the key is the size and storage cube of the material. Characteristically, an AS/RS system consists of two elements. The first is the rack structure that holds the pallets or containers. As a rule, free-standing or building-supported drive-through-type racks are used. Normally, the aisles separating each row in the rack cluster is only wide enough to permit the movement of the storage/retrieval vehicle. The second element of an AS/RS system is the *storage/retrieval vehicle*. Whereas the rack system provides the storage environment, the storage/retrieval vehicle provides the materials handling function of the AS/RS system. The machine must have the ability to perform vertical, horizontal, and shuttle subcycle (extension, pickup, and retraction) activities. Often termed a "crane," the vehicle resides on wheels and moves up and down each row in the rack cluster. Cranes can be dedicated to just one row or service a group of rows. For the most part, AS/RS cranes today are controlled through the use of computer systems that stockkeep and pick based on computer databases that are integrated with sales order, receiving, and inventory management systems. Finally, AS/RS systems are often accompanied by other forms of warehouse automation. Conveyor systems are used to transport product to and from storage clusters. Automated sizing and weighing stations can also be employed to ensure storage loads conform to weight and size requirements.

12.6.2 Stocking Inventory in Warehouse Locations [11]

The selection of warehouse storage types drives how inventory items are stored. The storage systems used depend on the type of inventory stored, targeted throughput, and equipment and picking requirements. There are several storage strategies that can be deployed. The first to consider are simple *basic systems* such as

- *Group functionally related items together*. In this method, items with similar functionality are stored together. For example, all hardware items are stored in the same area. The advantages of this method is ease of picking and familiarity of item location by warehouse personnel.
- *Group fast-moving items together*. In this method, high transaction items are stored close to receiving and shipping areas to minimize internal stocking and picking travel times. Slower moving items are located in storage zones farther back in the warehouse.
- *Group physically similar items together*. In this method, items are stored together based on their physical characteristics. Normally these items require special storage and material handling equipment. An example is using steel barrels to store casters or temperature controlled freezers to store food products.
- *Locate working stock and reserve separately*. Often used with palletized items that permit broken pack picking, this method enables a small quantity of items to be kept in a fixed picking location with larger quantities of reserve stored randomly in other locations.

There are several methods that are used to assign items to stocking locations. A popular method is *fixed location*. Fixed locations are advantageous when inventory stocking quantities and item unit sizes are small and readily identifiable by pickers and stockkeepers and where storage space is not at a premium. The advantages are ease of control, ease of record accuracy maintenance, and reduced safety stock. Since an item's storage space must be large enough to house its max stocking quantity (reorder point plus order quantity), a significant disadvantage is poor usage of the storage cube.

A second method is *random storage*. In this system, inventory is stored wherever there is space for it. Quantities of a single item are often stored in several locations at the same time. This system is best used for items that are stored and picked in full pallets. Random storage warehouses usually depend heavily on computerized locators systems to keep information current and accurate both as to the location of items, as well as available space. These systems also provide for computer-assisted location assignment to facilitate receipt put away. The advantage of random storage is location cube utilization and warehouse efficiency. The major disadvantage is that quantities of a single item are stored in very different locations in the warehouse making inventory control and picking functions difficult.

A third method is *point-of-use storage*. This system is used by manufacturers with lean production processes. Instead of inventory being issued from a storeroom, components and raw materials are stored at the production location. This method uses manual or computer system controls to record issues and suggest replenishment. It is an excellent method for managing "C" class items such as fasteners, paints, and lubricants where large quantities are issued to workstations and used as needed. Disadvantages of this method include difficulty in maintaining inventory control and stocking imbalances occurring at different workstations.

12.6.2.1 Cube Utilization

A critical component of warehouse capacity management is cube utilization and accessibility. Cube utilization is defined as the total volume of a warehouse available for item storage (both vertical and horizontal) minus the space allocated for offices, receiving docks, order picking and consolidation, and so on. There are several calculations that are performed to ensure the full available warehouse cube is being utilized. In the following examples, pallets are used as the focus of cube utilization. These techniques are easily portable to other stocking equipment.

Step 1: Number of pallets. The first step is calculating how many pallets are needed to store the maximum stock quantity of a given item. This step requires knowledge of an item's maximum quantity and how many are stacked on the warehouse's standard pallet. For example, if the maximum order quantity is 750 units, and 15 units are stored on a pallet, the warehouse must have space to store 50 pallets (750 units/15 units) plus any remaining balances.

Step 2: Pallet positions. The next step is to calculate the square and cubic feet needed to store the item's stocking quantity. The key factor is how high the pallets for an item are stacked in the storage location. Using the data from step 1, if the determination is made that pallets can be safely stocked 4 high, the number of pallet positions are calculated as 50 pallets/4 pallets = 13 (rounded) pallet positions.

Step 3: Pallet accessibility. The next step is to determine pallet accessibility. If only one item is stored at a location (such as a floor area), there is no problem with accessibility. If multiple items are stored in the same area, accessibility to items could pose a challenge. Stocking personnel must make sure that product is not blocked when items are put away.

Step 4: Cube utilization. All stocking equipment should be filled to the maximum cube capacity. Whether a small-items drawer or a pallet rack, stock should fill all available space while remaining accessible to picking and stock management. The two most important use-of-space factors are *aisle allowances* and *honeycombing*. Aisle allowance is the percentage of warehouse space occupied by aisles within a storage area. Honeycombing is the percentage of storage space lost because of ineffective use of the cube capacity of a storage area. Honeycombing occurs whenever a storage location is only partially filled with material and may occur horizontally and vertically (Figure 12.21). Allowances for aisles and honeycombing must be taken into consideration when planning warehouse layouts.

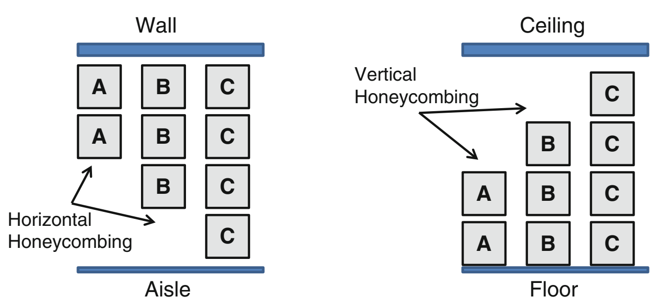


FIGURE 12.21 Pallet honeycombing.

Exercise 12.5: Cube Utilization and Accessibility

Determining cube utilization using aisle and honeycombing allowances, stocking equipment data, and item data is a multistep process. In the following exercise, a variety of important storage data using an item with a large stocking quantity stored on pallets in a bulk area of the warehouse are calculated.

Step 1: Basic data.

BASIC DATA	Height	Width	Depth	Square inches	Cubic inches
Item box size/inches	24	24	24	576	13,824
Pallet size/inches	6	48	48	2,304	
Max storage quantity	1,500				
Current on-hand balance	1,200				
Stocking units high per pallet/levels	3				
Pallets stacked	4				
Aisle allowance	10 %				
Honneycomb allowance	30 %				
Distance between pallets/inches	4				

Step 2: Pallet calculation:

- Case size, square feet: 576 in./144 in. = 4 ft^2
- Case size, cubic feet: 13,824/1,728 in. = 8 ft^3
- Cubic feet of one pallet of item: 2 ft wide × 2 ft long × 6 (3 levels) ft high = 96ft^3
- Cases per pallet: 96 ft^3/8 ft^3 (per case) = 12 cases per pallet
- Adjusted pallet height (allowances):

1. Height (6 ft + .5 ft pallet height) × width (4 ft + .33 ft distance separating pallets) × depth (4 ft) = 112.66 ft^3
2. Number of cases = 4 pallets high × 12 cases per pallet = 48 cases

Step 3: Allowance calculation for aisles and honeycombing:

- Aisles (1–10 %) × Honeycombing (1–30 %) × 48 cases = 30.24
- 112.66 /30.24 = 3.72575ft^3.
- Adjusted space/one pallet = [(width (48/12) + stocking units high (3/12)] + depth (48/12) = 17 ft^2.
- Adjusted storage allowance per case = 17 ft^2/[(1–10 %) × (1–30 %) × 48 cases] = 0.56217 ft^2

Step 4: Total storage cube required: 1,500 × 3.72575 = 5,588.64 ft^3

Step 5: Amount of linear storage space needed: 1,500 cases × 0.56217 ft^2 = 843.25 linear feet.

Step 6: Total number of pallet positions (max quantity): 1,500 cases/48 pallets = 31.25 positions.

Step 7: Max possible pallets stockable: 15,000 cases/12 cases per pallet = 125 pallets.

Step 8: Current pallets in stock: 1,200 cases/12 cases per pallet = 100 pallets

Step 9: Cube utilization: (100 pallets/125 pallets) × 100 pallets = 80 % utilization.

12.6.3 The Cross-Docking Warehouse

Cross-docking is defined as a method of moving items directly from the receiving dock to shipping without putting them into storage. Normally, cross-docking is used as a technique to combine inventory from many different suppliers into a specific assortment for a specific customer. It is also very applicable for bringing bulk loads into one central location, breaking them down into smaller quantities, and then sorting for delivery to a variety of destinations. Cross-docking warehouses normally are built differently than standard warehouses. After arrival, merchandise spends no longer than 24–48 h in the building, thus the amount of actual storage space is negligible. In addition, the number of inbound and outbound dock doors is dramatically increased in order to facilitate fast warehouse throughput. Perhaps the biggest difference is found in the center of the warehouse. Cross-docking warehouses use merge-in-transit equipment, such as conveyors, moving pallets, automated guided vehicles, and computerized tools such as bar codes, radio frequency (RF), and electronic data interchange (EDI) to link warehousing activities and the firm's warehouse management system (WMS) in order to facilitate the rapid case and pallet shuffling and light processing tasks required to make cross-docking feasible. Figure 12.22 illustrates a typical cross-docking warehouse.

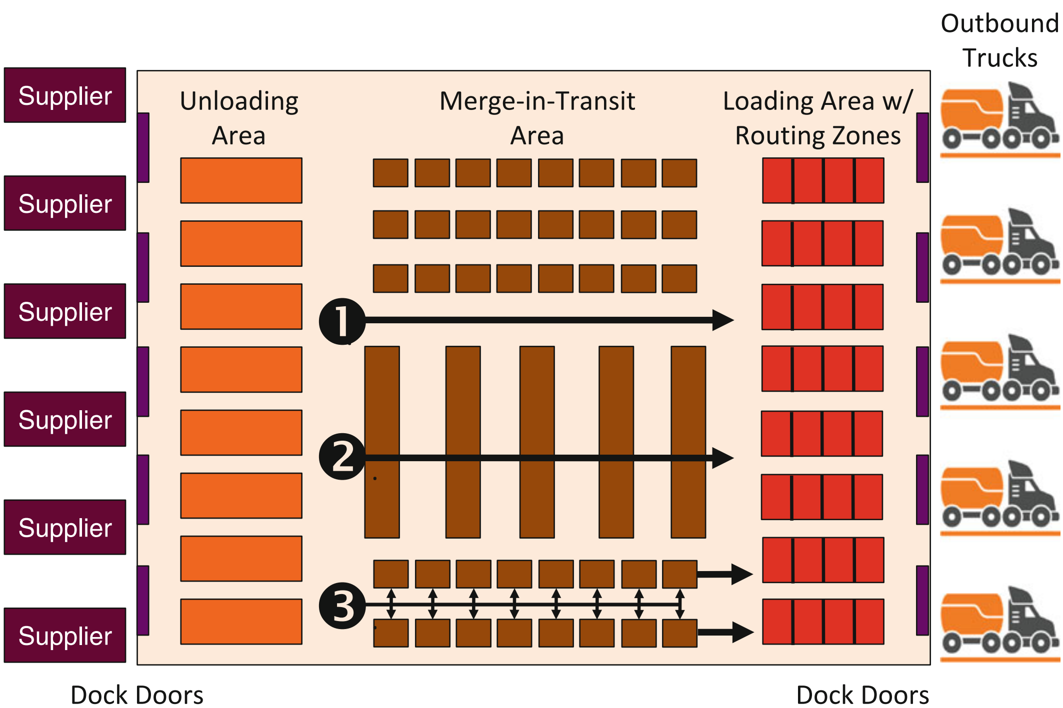


FIGURE 12.22 Cross-docking warehouse.

The cross-docking process begins with the receipt of the product and positioning in an unloading area for disposition. Three courses of action are possible as indicated in the visual with the numbered circles.

1. Arriving merchandise is moved directly across the warehouse to the loading area where it is first routed and then loaded on waiting vehicles bound for the next echelon in the distribution pipeline. Minimal to no changes to the receipt occur in this path.
2. Received loads are transported to processing areas for combination with other receipts, bulk-breaking, unitization into case or pallet loads, or other activities. Once completed, they are first routed and then loaded on waiting vehicles bound for the next destination.
3. Received loads are sent to tables where more labor-intensive work is performed. These activities include light assembly, kitting, relabeling, repackaging, and others. Once completed, these receipts are routed and sent to the customer.

Cross-docking warehouses provide distribution functions with several distinct advantages. To begin with, cross-docking streamlines and accelerates the velocity of the flow-through of product from the point of receiving to delivery to the customer. Because time-consuming receipt put away and picking are eliminated, inventory spends a minimal amount of time in the warehouse. Second, it reduces materials handling costs, carrying costs, inventory record keeping and management, and the activities associated with the physical storage of inventory. A big advantage is reduced warehousing costs achieved by the elimination of warehouse storage and material handling equipment. Finally, because there are minimal to no stocking areas, it enables companies to optimize warehouse, materials handling, and labor capacities.

Cross-docking does have some disadvantages. To begin with, it requires construction of nontraditional warehouse facilities. Because of its long and slender rectangular size, a cross-docking warehouse cannot be effectively converted to a storage warehouse. It requires expenditures for warehouse automation and information technologies. It requires close inbound and outbound transportation planning to ensure goods are quickly flowing from the receiving to the shipping dock with the minimum of waiting time. Finally, cross-docking requires close integration among warehouse management system (WMS) scheduling, floor processing capabilities, labor management systems, and automation equipment.

12.7 WAREHOUSE MATERIALS HANDLING EQUIPMENT

Efficient materials handling requires the effective use of different types of equipment including dock doors, forklifts, pallets, cranes, conveyors, and order-picking and stocking vehicles.

12.7.1 Dock Door Equipment

Materials handling begins at the warehouse dock door. Fundamental issues, such as number of doors, location, size, style, and security, must fit the expected product types and volumes to be received and shipped. Overall, dock door system selection is governed by the following principles:

- Position the warehouse and its docks on the site so as to facilitate truck access to and from the highway, maneuverability in the compound, and ease of docking.
- The loading dock dimensions should permit all intended vehicles to be loaded and unloaded quickly and safely.

- Select dock equipment that enables workers to load and unload trucks efficiently.
- Plan the staging area inside the loading dock so material flows efficiently to and from its in-warehouse destination.

The dock area can be designed using a staggered sawtooth layout, enclosed like a large garage, or flush with the outside wall of the warehouse. The typical dock door consists of a door seal (which protects against damage to the building and the door), bumpers (which extend from the wall and protect against damage to the dock or the trailer), and the dock leveler (a floor area on the edge of the dock that can be adjusted up or down to level the height of the trailer and the main warehouse floor) (Figure 12.23).

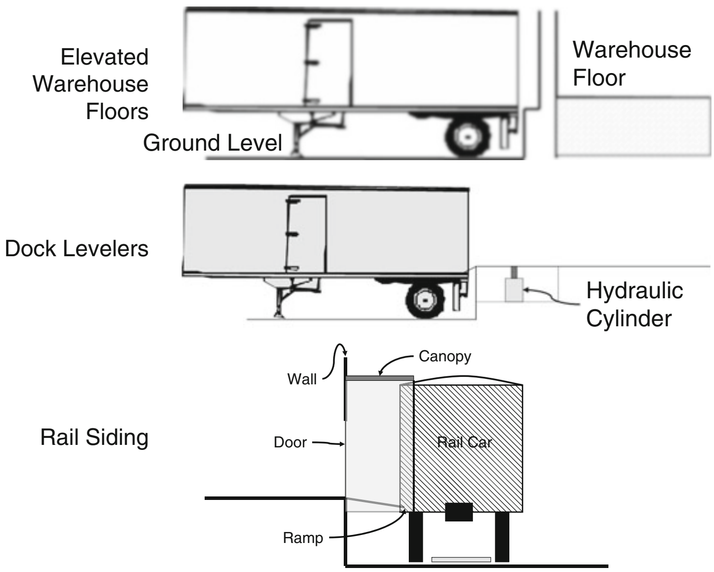


FIGURE 12.23 Dock door examples.

12.7.1.1 Forklifts

There are many models of *forklift* available for a variety of warehouse tasks, including loading and unloading trucks, item storage, and order picking. The great advantage of forklifts is their mobility to travel anywhere in the warehouse. While designed to work primarily with palletized items, special attachments enable it to work with large objects such as coils, rolls, crates, and containers. When selecting a forklift, consideration must be given to lift capacity, lifting height, power source (gasoline, battery, or propane), aisle space maneuverability, and speed (Figure 12.24).

12.7.1.2 Cranes

In addition to their use in the dock area, cranes are found everywhere in the warehouse. A crane is a type of machine, generally equipped with a hoist, wire ropes or chains, and sheaves that are used both to lift and lower materials and to move them horizontally. It is mainly used for lifting heavy items and transporting them to other storage locations. There are three basic types of crane: overhead, mobile, and fixed.

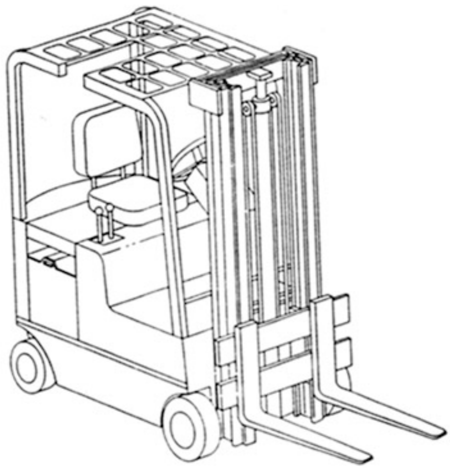


FIGURE 12.24 Standard dock forklift.

- *Overhead*. Also known as a *bridge crane*, this type of crane is characterized by a hook-and-line mechanism that runs along a horizontal beam supported by two parallel rails. It is often used in a long factory building and runs along the building's two elevated rails. Overhead cranes are constructed using either a single beam or a double beam and a hoist mechanism that does the lifting.
- *Mobile*. The most basic type of mobile crane consists of a truss or telescopic boom mounted on a mobile platform driven by a hoist mechanism that does the lifting. These types of crane are mobile because they can be mounted on trucks, railcars, movable platforms, or in automated storage/retrieval system (AS/RS) structures.
- *Fixed*. These types of cranes are characterized by the fact that they cannot be moved. A common type of fixed crane found in a warehouse is a *gantry crane*. This crane has a *hoist* in a fixed machinery house or on a *trolley* that runs horizontally along rails, usually fitted on a single beam (mono-girder) or two beams (twin-girder). The crane frame is supported on a gantry system with equalized beams and wheels that run on the gantry rail, usually perpendicular to the trolley travel direction. Another type is a *jib crane* where a horizontal member (jib or boom), supporting a movable hoist, is fixed to a wall or to a floor-mounted pillar (Figure 12.25).

12.7.1.3 Conveyors

This type of equipment can also be used anywhere in the warehouse. There are two basic forms of *conveyor*. *Gravity conveyors* are inclined, and goods use their own weight to move down through a fixed path on wheels or rollers. *Powered conveyors* use a motor to move goods up, down, or forward on a fixed path on belts, live rollers, or towlines. Products with irregular surfaces use *belt conveyors* where as heavy, regular items use *live-roller (automated) conveyors*. Advantages of conveyors are that they are automatic and can, therefore, significantly eliminate handling costs. Also, their size may save space since they operate in narrow aisles and on multiple levels. Companies can also utilize computerized devices, such as scanners, sorters, transfer diverters, and turntables, to move

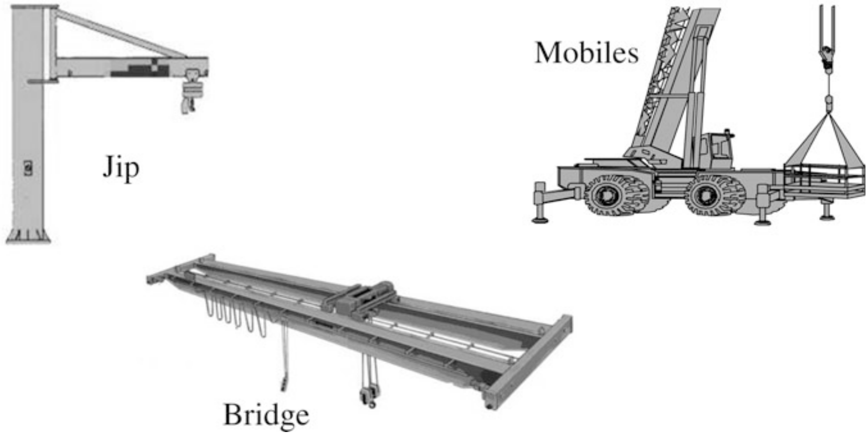


FIGURE 12.25 Types of dock crane.

and record item information on items moving by conveyors. Selection of a conveyor system greatly depends on the products to be conveyed, system requirements, and amount of capital investment available (Figure 12.26).

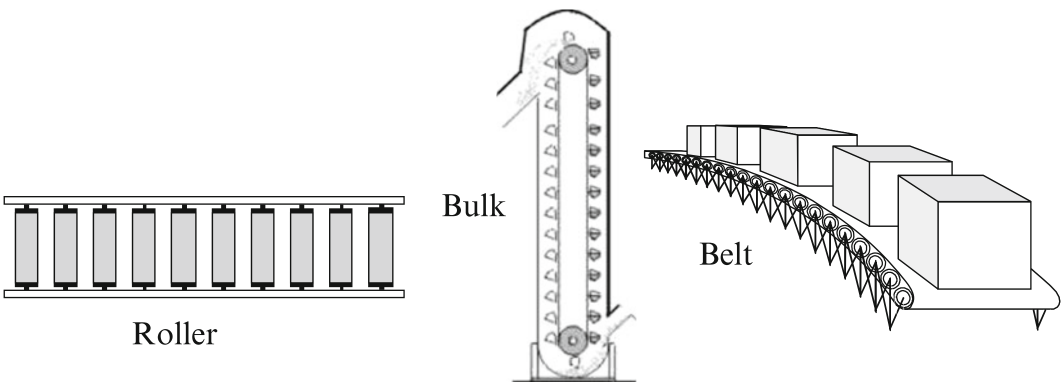


FIGURE 12.26 Types of conveyor.

12.7.2 Mobile Materials Handling Equipment

Once products are ready to be moved from the dock area to warehouse storage, there are various types of mobile materials handling equipment available. When selecting a vehicle, operators need to determine the desired load capacity, lift capabilities, travel and lift speed, maneuverability, and controls (manual or electronic).

12.7.2.1 Manual Lift Trucks

Equipment in this category is characterized as belonging to manually operated equipment that raises products from several inches to several feet off the ground. A popular type is called a "pallet jack." Pallet jacks normally are used to pick and move pallets of material.

Another version is a platform on wheels whereby the operator manually elevates products to the storage height (Figure 12.27).

FIGURE 12.27 Manual lift trucks.

12.7.2.2 Walkie Trucks

This type of equipment performs many of the same functions as a manual lift truck with the exception that the lift and vehicle movement are powered by on-board battery drive motors. There are many forms of *walkie vehicles* each with differing operational and physical configurations. In the first category are *low-lift walkies*. Whether they permit a rider or not, these vehicles have long or short forks normally used to transport pallets of heavy products short or long distances. They are normally cheaper than a forklift. Another category is *intermediate-lift walkie pallet trucks*. Similar to a forklift, the load carried by these trucks is counterbalanced by the chassis weight. The lift capabilities of these trucks are from 9 to 13 ft. They can handle single- and double-deep pallets, skids, and bins and can be equipped with rider truck attachments. A variation is a *walkie reach truck* which can extend or retract its load-engaging forks to pick up or stage a pallet (Figure 12.28).

FIGURE 12.28 Walkie trucks.

12.7.2.3 Reach Trucks

This type of vehicle is similar in function to a walkie reach truck with the exception that the operator rides in the stand-up position and performs all activities from inside the truck. Normally these vehicles are designed to work in narrow aisles. The truck design includes the counterweight base and cab for the operator, extendable mast, straddles (or "outriggers"), and forks. *Reach trucks* come in several varieties: *straddle*, where the forks do not extend; *reach*, where the forks extend as far as the length of the straddles; and *double deep*, where the forks have additional extension to permit storage of loads two pallets deep (Figure 12.29).

FIGURE 12.29 Reach trucks.

12.7.2.4 Turret or Side-Loader Trucks

Trucks in this category are used for pallet side-loading in very narrow aisles at heights of 10–42 ft. There are several variations. *Turret trucks* combine the characteristics of side-loading and fork (counterbalance) trucks. Designed with a long wheelbase for stability, the batteries and vehicle are at the rear to counterbalance load weight at high lift heights. The operator cab is stationary at the floor level ("man-down") or can be lifted along with the load ("man-up"). These trucks perform three basic operations: lifting load to a desired height; load rotation to left or right; and traverse, moving the load side to side during storage. *Side-loader trucks* are designed for special types of load handling such as pipe, bar stock, plate, sheets, and so on. These vehicles generally operate in electronically guided aisles. They can reach a storage height of 30–36 ft (Figure 12.30).

12.7.2.5 Order Picker

This type of vehicle provides a low-cost, very flexible method of general materials handling utility. Vehicles in this category are normally used for small quantity put-away, order picking, and shuttling loads through the warehouse. This truck is based on the same principle as a forklift, only in reverse. Instead of the counterbalance weight being behind the vehicle, the battery and main body is in front of the forks. Another distinction is that the rider

FIGURE 12.30 Turret or side-loader trucks.

operates the vehicle from a cab behind the main part of the vehicle. In addition, as the operator lifts the load, the cab and operator accompany the lift. This permits easy management of the load positioned on the forks (Figure 12.31).

FIGURE 12.31 Order picker.

12.7.2.6 Automated Guided Vehicle (AGV)

This type of vehicle is very different from vehicles previously discussed in that it does not have an operator but is, instead, routed through the warehouse by electronic guidance. AGV equipment typically is operated by optical, magnetic, or wireless guidance systems. Whether by a beam of light, an energized wire implanted in the warehouse floor, or high-frequency radio transmissions, vehicles automatically move through the warehouse or perform put-away and picking functions. There are various types of AGV. One type is a *tractor* which consists of a pull tractor to which wheeled flatbeds are attached for moving products. Another type is an *AGV pallet truck*. In this semiautomatic type, an operator picks up the pallet loads, but then the vehicle is preprogrammed to deliver the load to a certain destination for unloading. A *unit load AGV* enables automatic movement of a single or double-stacked load. *AGV fork vehicles* are unit load AGVs equipped with forks that can be lifted to heights of at least 12 ft. Both straddle and counterbalance models are available. The key advantage of this vehicle is its ability to handle palletized loads in different storage modes: floor, conveyors, and racks. When combined with automated storage and retrieval (AS/RS) systems, AGVs provide increased productivity and lower operating costs and are a critical component in today's automated warehouse (Figure 12.32).

FIGURE 12.32 Automated guided vehicle (AGV).

12.7.3 Packaging and Unitization

12.7.3.1 Packaging

Packaging serves many roles in the execution of efficient and cost-effective materials handling. Logistics operations are affected by packaging, from vehicle loading and warehouse picking to transportation vehicle and storage utilization. Packaging design, unitization, and information all have a significant effect on materials handling costs and efficiencies. Packaging serves four functions:

- *Protection*. Packaging reduces product damage. If damage did not exist, the cheapest possible packaging and mode of transportation could be used. In reality, damage is a significant issue. As a result, the nature of packaging is understood as determining the proper trade-off between the cost of increased packaging protection and the possibility of damage. The most important factors that typically dictate what type of packaging to use are:
  - the cost or value of the product
  - the product's susceptibility to damage
  - government regulations (hazardous goods, sustainability, and so on)

  The key point is to know damage costs and how each component of packaging is paying for itself.

- *Containment*. This function considers the selection of the optimal materials, construction, and structure of packaging. Packaging usually consists of at least three levels. The first level considers the product itself (for example, a box of bolts). Next, the individual boxes of bolts are stored in a larger box or case. Finally, the cases are assembled into a unit load, such as a pallet. The packaging should be constructed to inhibit package breakage or goods spoilage due to product weight, configuration, temperature, moisture, tampering, handling, light/darkness, and theft. An example is food packaging that has a high level of protection; tampering resistance; and special physical, chemical, or biological requirements. By supplying an undamaged and unblemished package, the producer guarantees that the details on the packaging correspond to the contents. Packaging is essential for branded goods, consumer protection, and product liability.
- *Information*. Packaging provides a wide array of information. Packaging conveys to the consumer details describing the contents and use of the product. Packaging contains important markings such as product codes, hazardous materials warnings, and others. Packaging information promotes the sales process and makes it more efficient. Promotional information placed on the packaging is intended to attract the potential purchasers' attention and to have a positive impact on the purchasing decision.
- *Utility*. Packaging facilitates the storage, movement, and picking of products in the distribution system. Packaging should be compatible with materials handling systems, such as palletization, shipping carton, containerization, and trailer dimensions. The less a product is moved, the less the potential for damage. Where handling is entirely or partially manual, packages should be easy to pick up and be of a suitably low mass. Heavy goods must be accommodated in packages that are well suited to mechanical handling. The loading and transport function places requirements upon the external shape of the package, the mass of the goods accommodated inside, and the convenient use of packaging aids.

12.7.3.2 Unitization

Unitization is an essential function of packaging. The *APICS Dictionary* defines product unitization as "the consolidation of several units into larger units for fewer handlings." Warehousing will pursue unitization for several reasons. A primary benefit is *lower handling costs*. In general, whenever a load of packaged product increases in quantity, size, and weight, the cost per unit handling becomes lower. Without exception, the handling of loose boxes is more time intensive than handling a unitized load. Unitization reduces the amount of labor hours saved in the put-away, movement, picking, and shipment of packaged goods. The end result is a quicker flow of goods throughout factories, warehouses, and cross-docking operations while utilizing fewer resources. Unitizing products, therefore, significantly reduces overall handling costs. Another benefit is *minimizing transit damage*. Unitized loads are less likely to suffer damage during movement through the warehouse than loose packages. Unitized loads should conform to materials handling equipment capabilities, thereby further lessening the chance of damage. The relation between total cost, damage cost, handling cost, and the cost of packaging is displayed in Figure 12.33.

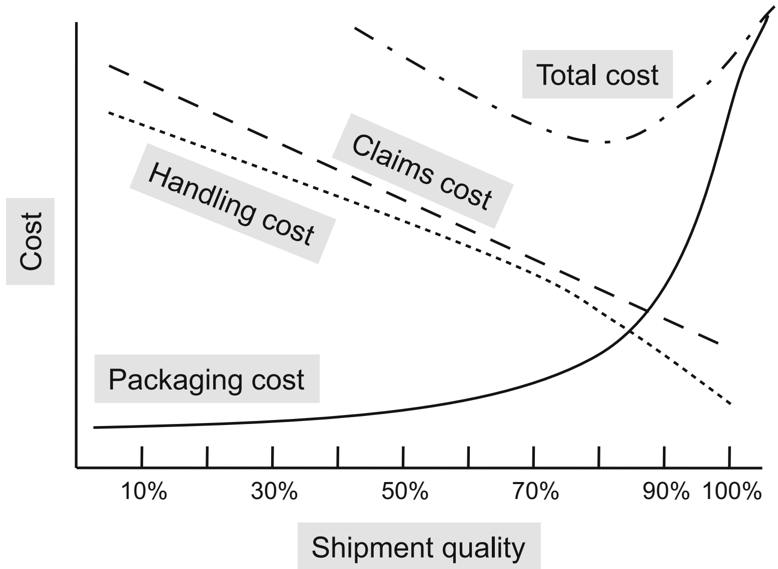


FIGURE 12.33 Relation between total cost and damage, handling, and packaging costs.

Another important benefit of unitization is *transportation savings*. Since unitized loads accelerate the speed at which goods are moved, materials handling vehicles spend less time at staging areas and moving inventory through the warehouse. This reduction in loading time provides valuable cost savings to the company that unitizes, as well as the customers receiving the unitized products. Unitization also promotes *security*. Unit loads reduce incidents of pilferage because packages from an enclosed load are difficult to remove. Moreover, unit loads are much easier to track than individually packaged products, making theft of goods more detectable. Unit loads also *increase inventory control*. Unitized products facilitate inventory control since unitized loads (as opposed to individual units) can be identified, counted, and managed more easily. In addition, lot number control is assisted by keeping the same lot units together. Finally unitization *increases customer service*. Unitization greatly improves picking of large quantity orders. In addition, customers appreciate unitizing because it allows them to unload their trailers and move goods through their warehousing systems more efficiently.

There are several principles guiding product unitization.

- The unit load size should fit all modes of materials handling equipment and transportation, such as trucks, railcars, and other containers.
- The unit load should be designed so that the largest quantity possible is handled.
- Unit load height should optimize the cube utilization of both warehouse space and transportation equipment.
- The unit load stacking pattern should maximize the stability of the load and minimize the risk of damage.
- The weight of the unit load must be in alignment with materials handling systems.
- Optimally, the packaging and unitization equipment (pallets, barrels, wire baskets, and so on) should be reusable, returnable, and recyclable once shipped to the customer.

Examples of package unitization are as follows:

- *Boxes, crates, and bundles*. This type involves stocking multiples of individual items/packages in master cartons, crates, or bundles. Examples are storing tissue boxes in master cartons of 12 each, placing screwdrivers into wooden crates of 24 each, and binding small diameter 8-ft long steel rods into bundles of 12 each.
- *Pallets*. This type involves stacking multiples of individual packages or cartons onto pallets. Key elements of palletization include use of standard pallets, full pallet cube utilization, use of stacking patterns that promote load stability, and weight considerations so as not to crush packages stored lower in the load. Pallet stability is enhanced through the use of shrink and stretch wrapping, banding, and stretch netting.
- *Barrels*. This type is used for products stored in powder or liquid form. Barrels can also be used for small, irregular items such as casters, metal spikes, and metal ingots.
- *Steel baskets*. This type is used for irregular, heavy products such as large wheel casters, small metal pipe, small metal plates, and so on. The advantage of this type of storage is the strength and portability of baskets.
- *Containers*. This type uses rigid, large containers of various sizes to store and transport master cartons and loose products. Containers can be general purpose (dry) or modified with heating or refrigeration units. They can be designed to open from the top or sides or adapted for intermodal transportation. Some advantages of containerization are security and protection of goods, reduced handling, reduced in-transit inventory, "through" or one bill of lading, recycled or returned capabilities, and outside and in-transit storage.

12.7.4 Warehouse Automation

One of the most important developments in warehousing today is the application of automation and computerized software and information-gathering devices to plan, control, monitor, and perform materials handling functions. The growth of automation in the warehouse is the result of the following drivers:

- Growing requirements for the application of lean thinking and practices to warehousing.
- The application and adoption of sustainable business practices in the warehouse focusing on reducing energy and environment costs.
- Requirements for increased horizontal integration between the warehouse and the information systems used by other enterprise business functions.
- Integration between warehouse management systems (WMS) and transportation management systems (TMS).
- Increased need to design multi-channel warehouses capable of fast-flow throughput and cost-reducing measures in the fulfillment of online order and web-based information.
- Effective scheduling, training, and management of warehouse labor through integration with labor management systems (LMS).

Effectively responding to these six challenges involves the increased utilization of technologies designed to enhance warehouse automation, deepening the planning and control of warehouse functions, and providing for integration with order management and transportation software applications. These imperatives are enhanced in today's warehouse for the following reasons:(1) declining costs of warehouse automation, (2) increasing costs of labor and associated overheads, (3) demand for much closer supply chain integration and collaboration, (4) value-added philosophies stressing continuous elimination of operational wastes and redundancies, and (5) requirements for shorter purchasing and customer service cycle times. While there are many possible directions that can be pursued in warehouse automation, two critical paths stand out. The first is the use of warehouse automation tools to reduce error, increase productivity, and speed supply chain flow-through. The second path is the implementation of software suites for integrated warehouse management, labor and task planning, automation of stock put-away and order picking, and use of bar coding, robotics, and radio frequency identification (RFID).

The different forms of warehouse automation are displayed in Figure 12.34.

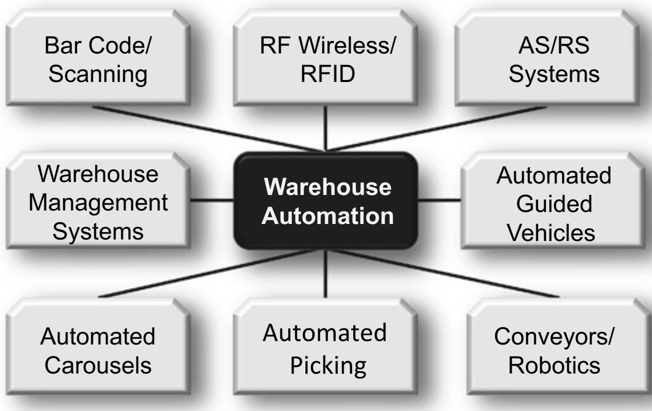


FIGURE 12.34 Components of warehouse automation.

These eight areas can be combined to form three distinct areas: materials handling flow-through facilitators, item identification, and warehouse management systems.

- *Materials handling flow-through.* This area of automation is the most visible in the modern warehouse. The overall goals of materials handling automation are to reduce materials handling, labor content, damage, and shrinkage; facilitate the flow-through of product; and integrate with other forms of warehouse automation. Applications consist of automated guided vehicles (AGVs), automated storage and retrieval systems (AS/RS), carousels, conveyors, and robotics. These systems work with warehouse control systems to drive order picking, stock put-away, inventory control, tracking item locations, storage bin utilization, stock rotation, and item movement through the warehouse. Robots can be programmed to perform a variety of functions from building and breaking down unit loads to managing picking and put-away functions in environments where it is difficult for humans to function. Finally, warehouse control systems can also pass demand orders to automated picking systems consisting of computer monitors, radio frequency (RF) terminals, pick-to-light, and voice-directed picking, and as well as to AS/RS systems, carousels, and robotic devices.

- *Item identification.* Automatic identification systems minimize or eliminate human operator involvement in the collection of information by using optical and radio technologies that input information directly into warehousing systems. The importance of automatic identification systems in modern warehousing is twofold: (1) it minimizes or eliminates the need for human activity in data collection, and (2) it significantly increases the accuracy and speed of data collection. Automatic identification systems generally fall into three main categories:
  - *Radio Frequency.* RF wireless handling uses standard mechanized materials handling equipment coordinated by warehouse control systems to provide operator directions and control in real-time. RFID provides the opportunity to use special tags capable of two-way communication between products and picking and lift truck put-away vehicles. RFID works with the warehouse control system to identify the exact location of inventory in the warehouse to facilitate inventory control and picking.
  - *Magnetic Readers.* This technique uses a magnetic film or strip on which is encoded information. By passing a sensing head over the strip, information is collected and passed back to the database.
  - *Optical systems.* Techniques in this category utilize light refracted from a printed pattern. Bar coding uses electronically driven automatic identification generated by moving a beam of light across a band consisting of a set of alternating opaque bars and white spaces. The following are examples of commercially available bar code readers: hand-held, moving beam readers, fixed-location, fixed-beam readers, fixed-location, moving-beam, and photodiode array (PDA) readers. An effective bar coding system is a significant assistance to warehouse operations. The advantages of bar coding are accuracy, speed, cost, reliability, simplicity, negligible space requirements, and ease of acceptance by employees.
- *Warehouse management systems.* As the complexity and speed of warehouse operations accelerates in today's business environment, many companies with distribution facilities are implementing computerized *warehouse management systems* (WMS). WMS software solutions were introduced over 20 years ago and today comprise a billion dollar market. Over that time period they have evolved from simple back office functions associated with inventory and shipping to today's robust systems. According to the *2013 Technology Usage Study*, 50 % of logistics operations are currently using some form of WMS while 44 % were anticipating acquiring a WMS in the near future. About 79 % of the respondents said that their ERP systems include a WMS module [12].

  Warehouse management systems provide a central information system for the control of the movement and storage of materials within a warehouse and the processing of associated transactions, including shipping, receiving, put-away, and picking. It involves the physical warehouse infrastructure; tracking systems; and the receipt, storage, and movement of goods to storage locations or to the final customer. The objective of a WMS is to optimize customer service while reducing warehouse costs. A WMS is easily linked to a firm's *enterprise resources planning* (ERP) system, as well as logistics transportation and supply chain process management solutions to provide companies with a totally integrated, real-time fulfillment system.

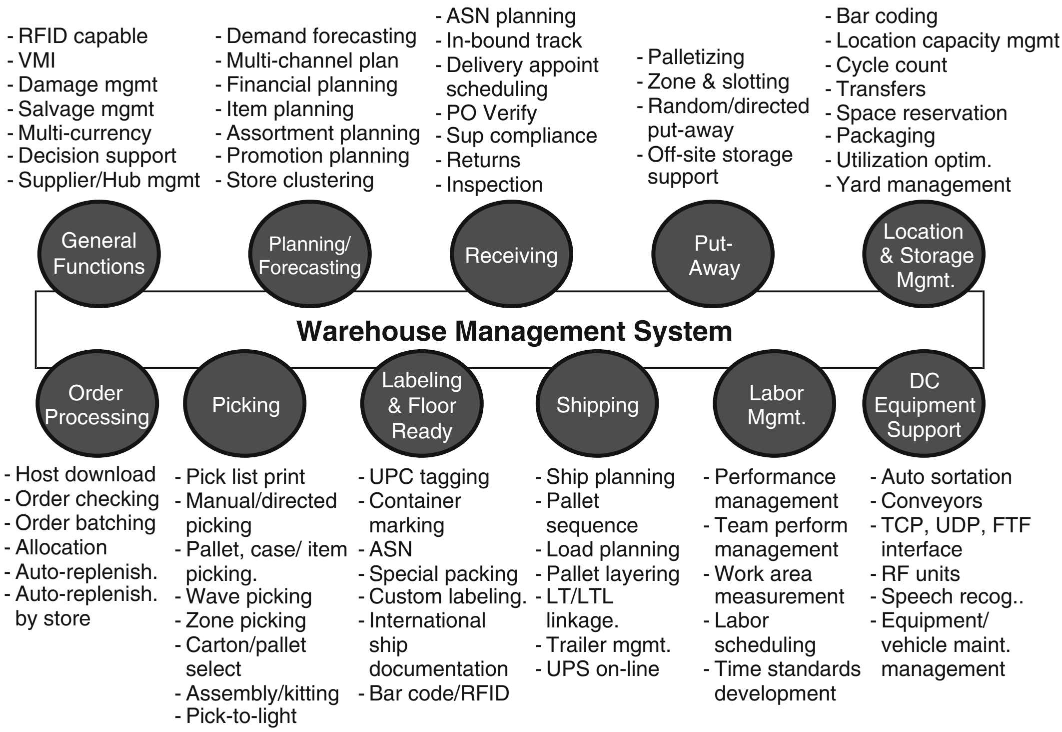


FIGURE 12.35 WMS application components.

As illustrated in Figure 12.35, the major WMS components consist of the following modules:

– *Receiving*. This module consists of several functions associated with supply order receiving. Often these applications are *electronic data interchange* (EDI) or Web-enabled. Key functions supported are in-bound order tracking, *advanced shipping notice* (ASN) planning, delivery scheduling, picking planning, order and packing slip verification, label printing, repacking, unitization, inspection, returns, and supplier audit.
– *Warehousing*. This module contains materials handling functions, such as cross-docking, put-away (slotting), location, and storage. Critical system functionality includes palletizing; containerization; packaging; zone and random storage location selection; off-site storage support; location capacity and utilization management; item bar coding, locator, serial, and lot control; quarantine management; cycle counting; yard management; and interbranch transfer. The goal of these functions is to improve the accuracy of inventory storage.
– *Order management*. WMS functions in this area focus on increasing customer service by automating picking and shipping functions, shrinking processing times, and improving service accuracy. Important functionality includes order allocation; checking and grouping/batching; auto-replenishment of picking locations; pick list

printing; FIFO, zone, and wave picking; product substitution; pallet layering; assembly and kitting; and scanning.

- *Labor management systems (LMS).* Labor constitutes an enormous percentage of warehouse costs. Unlike materials and equipment, warehouse labor productivity is difficult to gauge, control, and optimize. To solve this gap in cost and productivity information and control, some warehouses have implemented a *labor management system* (LMS). An LMS enables managers to collect information about warehouse labor activity that is then compared against historical information and established standards, such as order picking and inventory receipt put away. The information provides managers with data to monitor the productivity, identify the bottlenecks, and optimize labor both inside and outside of the warehouse, distribution center, and even the cab of a truck. In addition, an LMS enables managers to forecast workloads down to the job level, determine exactly how much time it takes to complete a specific task, and provide immediate operator performance.
- *Labeling and floor ready*. Today's WMS handles complex product labeling requirements such as UPC tagging, container marking, price mark tagging, custom label design/printing, international and customs documentation, bar code labels, and RFID tags.
- *Shipping and transportation*. WMS systems integrate shipping and transportation functions directly with the ERP backbone. Key functions are shipment and load planning, pallet scanning, full and less-than-truck-load and parcel post carrier linkage, trailer management, freight rating and shipping, traffic routing/scheduling, outbound appointment scheduling, transportation analysis, and in transit inventory tracking.
- *DC equipment support*. A critical WMS enabler is the capability to link warehouse equipment directly to the warehousing and business systems. Functions include *autosortation*, conveyors, RF units, speech recognition, picking/put away equipment, robots, and equipment/vehicle maintenance management.
- *Billing*. WMS applications also facilitate the management of receivables billing, time reporting, surcharges, and chargebacks.

There are several benefits gained by implementing a WMS system. By automating and linking warehouse functions, companies significantly increase warehouse productivity, efficiency, and accuracy. WMS applications reduce manual efforts expended on tracking locations and warehouse space recording, tracking item storage and balance accuracies, reducing stockkeeping and picking personnel, and improving order management accuracy and speed. In addition, a WMS helps in performance management through effective cycle counting, automated data collection, accountability, and simulation. Finally, WMS applications enable warehousing equipment to be truly automated by integrating it with business system purchasing, receiving, order management, and shipping and transportation databases.

Another warehouse management technology that is often implemented with a WMS is a *warehouse control system* (WCS). While the WMS has historically been used to manage inventory and oversee activities like receiving, picking, and put-away, when a warehouse installs complex materials handling equipment, such as ARS, pick-to-light, sorters, conveyers, and other systems, a WCS provides another layer of information technology to assist the WMS manage the materials handling subsystems to carry out the daily activities of put-away and picking and coordinate the equipment needed to move product out the door.

Recently, warehouse planners have turned to a newly developed application – the *warehouse execution system* (WES) – that replaces both the WMS and WCS. A WES both maintains the WMS concern with warehouse inventory records while driving the sophisticated automation systems normally controlled by a WCS. Most importantly, WES packages typically have built-in intelligence that enables them to take orders and construct a work-path flow, coordinating warehouse labor and material handling equipment in real-time to move products into and out of the facility.

While robots and other forms of warehouse automation are gaining ground, it is important that companies do not fall into the trap of automating for automation's sake. There are several strategies companies can follow to achieve effective ROI while avoiding "automation overkill." To begin with, automation should never be used to fix a poor process – it will only make the bad process happen faster and more frequently. Another strategy is to use a phase implementation approach that tackles processes capable of improvement while avoiding automating processes that show little benefit to justify the cost. Automating processes that shrink cycle times enables the warehouse to be more agile and responsive to unexpected change. Finally, automation should be viewed *strategically* and not just as a source of cost reduction and operational efficiency. Automation should always be undertaken to expand the business's competitive advantage and support the corporate strategy.

12.8 WAREHOUSE MANAGEMENT AND ENVIRONMENTAL SUSTAINABILITY

An increasingly important element of modern warehousing that combines facility design, storage equipment, and materials handling is the growing requirement that the warehouse not only be efficient but *environmentally sustainable*. Incorporating sustainability into warehouse design and functions has been shown to be a win-win proposition. A sustainable warehouse mitigates harmful effects to the environment, removes wastes and energy inefficiencies from operations, lowers operating costs, promotes worker safety, and secures the recognition, if not respect, of customers and the community.

As illustrated in Figure 12.36, environmental sustainability touches four main areas of warehouse design and operations. When it comes to warehouse *design and layout* the key driver of sustainability is energy savings. This driver takes several forms. One is the fact that the primary energy used in a warehouse is not the building, but the transportation that services the building. Relocating facilities closer to inbound ports, transportation hubs, and the customer significantly reduces emissions linked to the building. Inside the warehouse, more efficient lighting (which typically represents about 30 % of the energy used in a warehouse), high-volume, low-speed fans for cooling (resulting in a 12–50 % reduction in heating and cooling costs), and resource-use analysis through the metering of electricity, gas, water, and other utilities provide long-term improvements in sustainability.

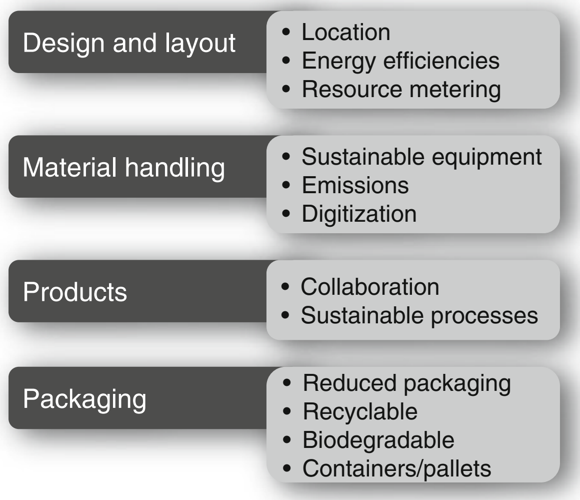


FIGURE 12.36 Components of warehouse sustainability.

The second area of warehouse sustainability, *materials handling*, is pursued by rearranging the location of storage equipment to reduce the movement of vehicles as they move from receiving docks to picking areas to shipping areas. Upgrading of transport equipment from gas-driven to electric vehicles, or the substitution of gravity conveyors and automated storage devices to replace vehicles decreases carbon emissions. Another initiative is reduction in paper picking lists, shipping documents, billing, and payment by deploying online digital reporting and scanning equipment. Finally, government regulations are forcing many warehouses to increase reverse logistics activities. As a whole, the warehouse success in executing green strategies is measured by its carbon dioxide emissions in tons per unit, volatile organic compounds in pounds per unit, and waste-to-landfill materials in pounds per unit. The third area, *products*, requires doing business with suppliers who produce certifiably environmentally sustainable products. For example, Wal-Mart is partnering with environmental nonprofits to select standards for organic cotton farming and production processes. By making a commitment to buy a specified quantity of each product certified as environmentally friendly, Wal-Mart gives its suppliers an incentive to develop and produce that product [13].

Finally, *packaging practices* are a prime source for environmental sustainability. Many companies today are focusing on efforts to reduce the impact on the environment associated with the disposal and recycling of the packaging used to manage their products. Among the most important environmental issues regarding packaging are:

- Over-packaging of products
- The consumption of natural resources, such as paper, to produce packaging
- The contribution packaging makes to the solid waste problem

These issues regarding packaging and the environment are reduced to three initiatives: *reduced packaging, reusable packaging*, and *returnable packaging*. Efforts to reduce packaging extend to such factors as weight, materials composition, and disposability. The goal is to reduce the amount of packaging and improve the ability of everyone to easily and effectively dispose of packaging in an environmentally-friendly way. Efforts aimed at reducing packaging through new materials and methods include the following: lighter materials, thin wall containers, recycled materials, packaging redesign, stretch film, bubble sheets, airbags, and others. Changes in packaging specifications could require changes to shipping methods, product handling systems, and product strength.

Instead of disposal, environmentally sound packaging allows reuse of the original packaging materials for other purposes. Examples include packing materials such as corrugated and bubble packs, wood, glass, food containers made of metals and glass, and reversible cartons for return shipments. Finally, returnable packaging has been in use for many years. Examples include returnable steel drums, metal containers, and pallets. Returnable packaging requires a close relationship and a willingness to cooperate between customers and suppliers. Companies can also employ a third-party agency that keeps track of the flow of packaging among supply channel members. A good example is the return of returnable pallets and containers. The auto industry uses many returnable racks and bins due to the high volumes of goods handled and the close relationships they have with their suppliers. Returnable packaging has a positive effect on both profits and the environment, but there are also associated costs:

- initial cost of containers
- in-transit inventory of containers
- return transportation costs
- storage costs of in-house containers
- repair, cleaning, and sorting

12.9 TODAY'S WAREHOUSE CHALLENGES

Over the past several decades the role of warehousing has evolved from a narrow functional concern with receiving, storage, picking, packing, and shipping to become strategic fulfillment centers capable of dynamic cross-docking, multi-channel fulfillment, "green" practices, application of advanced technologies, and operational agility to rapidly respond to any customer requirement. Today's warehouse professionals are confronted with a series of challenges that significantly change the way warehouses, distribution centers, and the entire supply chain operates. According to Motorola's *2013 Warehouse Vision Report* [14] these challenges are

- More and larger facilities demanding high-speed communications virtually everywhere on or off the floor.
- A virtual across-the-board customer demand for personalization is driving an increase in the number of SKUs leading to increased inventory visibility, accuracy, and efficiency needs.
- New government regulations requiring more accurate product tracking and tracing.
- The re-shoring movement is bringing manufacturing and other businesses closer to the customer, creating a need for more efficient and effective warehousing and labor management.

- The continuous rise in fuel costs has caused planners to plan the distances products are transported through the supply chain.
- Increased warehouse complexity requires the implementation of more automated processes and equipping warehouse personnel with more technology.
- Desire to consolidate and integrate warehouse information contained in ERP, WMS, yard management systems (YMS), and transportation management systems (TMS) to increase visibility and accuracy in every aspect of supply chain operations.
- Increasing use of advanced shipping notices (ASNs), GS1-compliant barcodes, and RFID tags for accurate, automated inbound/outbound shipment identification.
- The growth of omni-channel transactions creates the need for increased inventory control, flexibility, and faster, more accurate fulfillment.

Of all these challenges, two have the greatest impact on the future of warehousing. The first is the push for *same-day delivery*. The model has been set by online retailing giant Amazon.com who in 2012 decided to abandon its strategy of locating its fulfillment centers in low-cost, small-market cities in favor of locating in proximity to large U.S. population area like California, New York, Illinois, and New Jersey. By doing so, Amazon set the stage for offering same-day or next-day delivery to a major segment of the U.S. market. Brick-and-mortar retailers have responded by spearheading an omni-channel approach where warehouses are retooling to transition from large lot to small order fulfillment.

The second major challenge is increasing warehouse operations by keeping costs low and efficiencies high. Some of the solutions have already been touched on: relocation of warehouses to low cost areas that decrease annual costs of land, energy, construction costs, and operating costs (moving from northern California just over the border into Oregon can result in considerable construction and tax savings); reducing labor turnover and training times; reducing the volume and rate of customer returns; increasing automation in inbound/outbound handling; and linking business and warehouse information systems seamlessly together. Finally, the view of the warehouse must be changed in the corporate suite from being purely a cost center focused on eliminating inefficiencies and inaccuracies, to a powerful competitive asset that can drive profitable growth by bring products and services faster to the marketplace.

12.10 SUMMARY

Like other functions in the modern supply chain-focused enterprise, the goals and operating objectives of today's warehousing functions continue to undergo significant change. In the past, the role of the warehouse in the organization was purely operational and consisted of activities associated with receiving, storage, customer and production order picking, product sorting, traffic management, and postponement. The warehouse was perceived merely as a place where inventory was stockpiled, consolidated, sorted into kitted products, and shipped to the customer. In contrast to this view, today's warehouse is considered as a fundamental source of competitiveness differentiation and marketplace leadership. Through the use of such tools as the Internet, storage automation, and warehouse management systems (WMS) accentuating organizational integration, quality, and elimination of all forms of waste and impediments to service leadership, the development of a comprehensive warehouse strategy is an essential element of a successful supply chain strategy.

There are several types of warehousing companies can pursue. The choice of warehouse type is governed by how effectively it enables the execution of logistics functions and operating efficiencies while facilitating attainment of customer service performance targets. The optimal warehouse permits the enterprise to leverage inventory levels, operations, and transportation modes that effectively support marketing, sales, customer order processing, and inventory planning in the quest for competitive advantage. In addition, the warehouse system should promote the efficient management of warehouse activities centering on the receipt, storage, picking, and shipping of inventory.

In determining the size of the warehouse, managers must understand inventory and throughput requirements; balance the fixed and current costs associated with plant and equipment and the cost of transportation; and how the warehouse assists the organization in the attainment of strategic objectives. The design, layout, and selection of materials handling equipment for a warehouse is a complex process requiring a detailed knowledge of the requirements of customer service, product stocking characteristics, material handling, receiving and loading, movement capacities and capabilities, and the availability of automated storage and retrieval equipment. The most effective warehouse layout is the one where the physical facilities, equipment, and operational objectives are supportive of one another. The general objectives of the warehouse layout are to maximize warehouse space, labor, and equipment and to provide for good housekeeping and the ability to respond competitively to the needs of the customer.

The concept and practice of today's warehouse is undergoing significant change. Essential there are three challenges confronting warehousing. The first is the push for same-day delivery. With the continuing advance of e-commerce and powerful players such as Amazon.com, the distribution and retail segments of the supply chain are experiencing significant pressures to provide customers with access to a virtually unlimited reservoir of products delivered the same- or next-day. This competitive requirement is forcing companies to reexamine their idea of the warehouse and the tools and systems governing warehouse management. The second major trend is the growth of environmental sustainability which is slowly making its way into corporate mission statements and core values. "Green" goals and objectives are having a direct impact on where warehouses are located, what activities they perform, and how they operate. Finally, the overriding issue for warehouse managers is cost management and operating efficiencies. Much of the solution is transforming the role of the warehouse from a cost center to a driver of competitive advantage for the entire supply chain.

DISCUSSION QUESTIONS

1. Define the major activities of warehouse material handling.
2. What are the major benefits of private warehousing?
3. What are the basic objectives of warehousing?
4. What services does a third-party logistics provider (3PL) offer distributors?
5. What are the objectives of warehouse design and layout?
6. How does packaging assist materials handling?
7. Explain the difference between warehouse size and warehouse capacity.
8. In terms of inventory control, items can be stocked according to several methods. What are the basic methods of inventory storage used for record keeping, picking, and so on?
9. Name the decisions logistics managers must make when developing warehouse strategies.
10. What are the three "Ps" of effective warehouse inventory control?

PROBLEMS

1. If the width of a planned warehouse is 150 ft, the length is 250 ft, and the height is 60 ft, what would be the *size* of the warehouse?
2. If the width of a planned warehouse is 150 ft, the length is 250 ft, and the height is 60 ft, what would be the *capacity* of the warehouse?
3. The planner at ABC's warehouse has established the following data needed to calculate operations standards. Number of shifts: three 8-h shifts
   - Number of pickers available per shift: 10 pickers
   - Standard hours of work available each shift: 7 h
   - Standard number of lines picked per hour per picker: 60 lines

   Based on these data, what is the standard number of lines that can be picked each day?
4. The planner at ABC's warehouse has calculated the following data from warehouse transaction history:
   - Average number of lines actually picked per day: 5,200 lines
   - Standard number of lines that should be picked each day: 5,100 lines

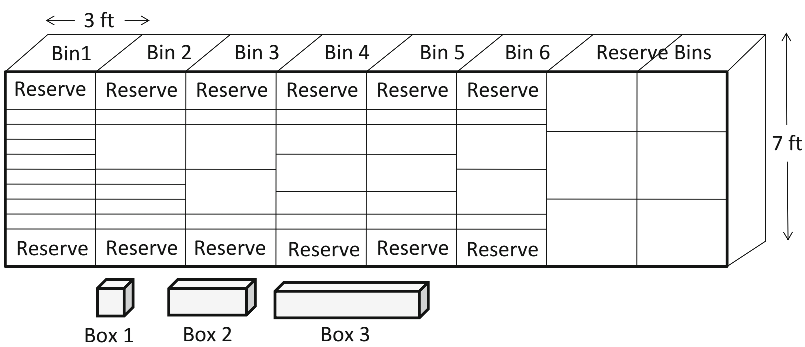
   What is the efficiency of the warehouse picking teams?
5. Using the base data from question 3, if the utilization is 85 % and the efficiency is 105 %, what is the daily picking capacity of the picking team?
6. A warehouse storage planner is trying to decide how much space a new product will need for storage. The storage racks in the warehouse are all standardized at 4-ft high, 8-ft wide, and 4-ft deep. The product's packaging dimensions are 2-ft^2. The order point for the item is 20 units and the replenishment order size is 44 units. How much cubic space should be allocated for the item's storage in one of the racks? How much of a shelf is used?
7. A warehouse storage planner is trying to decide how much space a new product with a large quantity will need for storage. Since the quantities are so large, the planner has selected the warehouse's pallet rack area as the appropriate storage area. The pallet racks in the warehouse are a standard 4-ft high (plus allowance of 6-in. for pallet height). The racks are wide enough to stage two pallets of 4-ft width side-by-side on a shelf. The product's packaging dimensions are 2-ft^2.

The order point for the item is 20 units and the order quantity is 48 units. If the demand is 16 units a week and the replenishment lead time is 1 week, how many pallets should the planner plan to stock in the warehouse?

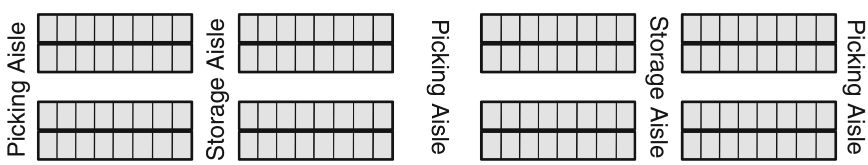
8. A company is deciding on the size of a new warehouse. Initial estimates of inventory storage requirements and throughput indicate that the warehouse should be approximately 200 ft wide by 500 ft long or 100,000 ft^2 (S). The monthly throughput is 90,000 cases of product at a cost of US $0.007 per foot per case moved. The cost to build is US$100 per sq. ft. to be amortized over 20 years. What should be the actual dimensions of the new warehouse and total cost per year?

CASE STUDY

Henry Bergson, the inventory manager at ABC Electronics, has been charged with solving a growing problem in the warehouse's small items bin area. The area contains four clusters of bins. Each cluster consists of 50 rows of bins, divided by a small inside aisle for picking and stockkeeping. As illustrated below, each row of bins consists of eight bins bolted together. Each bin is 7 ft tall and 3 ft wide. In each row, the first 6 bins are for picking and the last two for item overflow. The configuration of each bin consists of two forward reserve shelves at the top and bottom for product overflow. The arrangement of the picking shelves in the center of each bin is random. The shelves vary among three basic heights. Finally, depending on item size, product can be stored in one of three bin boxes or stored loose on a shelf. Seven box 1's fill a shelf; five box 2's fill a shelf; and three box 3's fill a shelf. Boxes can be used interchangeably on a shelf.



A modified view of the four clusters of bins is as follows:



The rows of bins have been positioned so that the reserve bins for each row are closest to the storage aisle and the picking bins (Bins 1–6) are closest to the picking aisles. Received inventories are dropped off by forklift or walkie in the storage aisle for the stock person for final put-away. All order picking is performed in the picking aisles. Since the items are small, pickers push a cart where the picked orders are placed. When the cart is full, it is brought to the packing area from the first sets of bin rows. All item stocking locations are fixed. Put-away and picking are performed at the assigned location.

Materials Handling and Picking Problems

Several serious problems have emerged over time with the bin area system.

1. *Inventory management*. All items had only one fixed location in the bin area. Originally, items were assigned a storage container based on their maximum stocking quantity determined as the order quantity plus the order point. If actual inventory exceeded this quantity, the remainder, after servicing the forward location, was placed in either of the bin's upper or lower reserve shelves. If these were filled, the extra material was moved to the last two bins in the row. Over time, the original space allocation for many items had become seriously out of date with the result that many items had too much or too little forward stock space allotted to them. For example, ABC stocked hundreds of very small items that poorly utilized Box #1 cube space. The allotted reserve space in many rows was filled to capacity. Stock was often lined up in the aisles by the dock-receiving team. Complaints were often heard that vehicles could not get down the storage aisles, and received items began to pile up at the front of each stocking aisle. With so much reserve, items were getting lost and picking shortages had become a chronic nuisance. Stock personnel was spending too much time searching for reserves and normal put-away and servicing was chronically behind, resulting in even more shortages. Often the bin area personnel was working overtime to catch up.
2. *Picking*. Besides the chronic shortages, picking had become a time-consuming task that perpetually exceeded the warehouse standard of 60 lines per hour per picker. In the beginning, items had been located in the bins by product family. Over time, however, items had been moved around so much that picking by product family had become impossible. Pickers were often traversing the entire bin area to complete their paper order packet of 60 lines. Another problem was the available room on the carts. Often the cart was filled before all 60 lines were completed. The picker had then to take the cart to the packing area, retrieve an empty cart, and complete the original order packet. Often the number of orders allotted by sales to be filled each day were being carried over to the next day or had to be filled using overtime hours. Since the business prided itself on next-day delivery, these picking problems had become management's number one issue.
3. As Henry's assistant, how would you help him tackle these problems? Be specific and offer reasonable advice.

REFERENCES

1. Wilson, Rosalyn. 2014. *25th annual state of logistics report: Ready for a new route*. Oakbrook: Council of Supply Chain Management Professionals, Visual 2.
2. Peerless Research Group. 2013. An evaluation of warehouse operations and trends. *Peerless Research Group*, November 2013.
3. Motorola. 2013. From cost center to growth center: Warehousing 2018. *Motorola White Paper*.
4. See the analysis in Tompkins, James A. 1988. The challenge of warehousing. In *The warehouse management handbook*, 6–14. New York: McGraw-Hill.
5. See the analysis in Jenkins, Creed H. 1990. *Complete guide to modern warehousing*, 34–48. Englewood Cliffs: Prentice-Hall.
6. Bowersox, Donald J., David J. Closs, M. Bixby Cooper, and John C. Bowersox. 2013. *Supply chain logistics management*, 4th ed, 237. New York: McGraw-Hill Irwin.
7. Langley, C. John, and Capgemini. 2014. Third-party logistics study. *Capgemini White Paper*, 12.
8. Ibid., 4–7.
9. This exercise is modeled after Ballou, Ronald H. 1999. *Business logistics management*, 4th ed, 440–443. Upper Saddle River: Prentice Hall.
10. These principles are referenced in Coyle, John J., C. John Langley, Brian J. Gibson, Robert A. Novack, and Edward J. Bardi. 2009. *Supply chain management: A logistics perspective*, 8th ed, 501. Mason: South-Western Centage Learning.
11. This section is based on Arnold, J.R. Tony, Stephen N. Chapman, and Lloyd M. Clive. 2011. *Introduction to materials management*, 7th ed, 265–266. Upper Saddle River: Prentice Hall–Pearson.
12. Logistics Management (LM). 13th technology usage study. *Logistics Management*.
13. Plambeck, Erica L. 2007. The greening of Wal-Mart's supply chain. *Supply Chain Management Review* 11(5): 18–25.
14. Motorola. 2013. 2013 warehouse vision report. *Motorola White Paper*.

13

Transportation Management

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_13) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_13,

When asked to provide a definition of distribution, both the public and professionals alike will most likely structure their response around two functions: *warehousing* and *transportation*. As was discussed in the previous chapter, warehousing is concerned with the storage and handling of inventories. Warehousing provides value by satisfying marketplace time and place utilities. Transportation, on the other hand, is associated with the movement of product from one node in the supply channel network to another. This ability to provide purposeful movement of goods in the supply chain is fundamental in assisting companies achieve time and place utilities. No matter how sophisticated the warehouse system, if a product is not available at the specific time and place it is wanted, the firm risks lost sales, faltering customer satisfaction, and increased costs resulting from order expediting. Transportation attempts to solve this problem by ensuring that product is moved as efficiently and cost-effectively as is possible from the point of origin to the point of consumption. Basically, transportation creates value by changing the location of inventory. In this sense, to conceive of a “world-class” supply chain without an efficient transportation system to support it is clearly an impossibility. Transportation’s ability to create place utility by ensuring that product is available at the time the customer wants it defines a fundamental pillar in the search for competitive advantage.

This chapter details the principles and functions of today’s transportation industry. The chapter begins with a discussion of the principles and statistical scope of transportation as well as the interaction of transportation with other enterprise functions. Following, the various legal forms, performance characteristics, modes, and types of transportation are examined in depth. The chapter then proceeds to outline the transportation management process, beginning with the determination of internal transportation costs and public carrier rate standards and concluding with a review of transportation performance measurements. Next, the critical challenges confronting today’s transportation industry are discussed. Included is a review of the state of today’s physical transportation infrastructure, impeding driver shortages, transportation environmental sustainability, transportation risk management, and the range of current transportation management technologies. The chapter concludes with a detailed review of the role and activities of today’s logistics service providers (LSPs) in the management of the transportation function.

13.1 DEFINING TRANSPORTATION MANAGEMENT

The capacities and capabilities of the transportation system determine the boundaries of the market system. The availability of inexpensive, efficient, and easily accessed transportation services activates several critical drivers of economic activity. To begin with, transportation enables companies to bridge the geographical gap between the place where products are produced and the point where they are consumed. It is virtually impossible in modern economies for companies to function without the ability of transportation to move products across the supply chain. Second, transportation provides for the growth of competition. The more mature the transportation system, the greater the ability of businesses to compete with other companies in distant markets on an equal footing. Third, the wider the product distribution and the greater the demand, the more producers can leverage economies of scale in production and channel transportation. Finally, the more efficient and the lower the cost of transportation, the lower the selling price. Because transportation costs to the producer are normally calculated into the price of products, as costs decline and delivery capabilities rise, producers and distributors normally pass on the savings to their customers in the form of lower prices, thereby increasing marketplace advantage. Transportation is defined in the *APICS Dictionary* [1] as "The function of planning, scheduling, and controlling activities related to mode, vendor, and movement of inventories into and out of an organization."

13.1.1 The Magnitude of Transportation

According to the Council of Supply Chain Management Professionals (CSCMP) *Annual State of Logistics* (2014) [2], the cost of all U.S. transportation in 2013 was $862 billion to move US$2.459 trillions of inventory. Transportation in 2013 accounted for 62 % of all logistics costs and 5.1 % of total gross domestic product (GDP) [Table 13.1]. When viewed from a micro level, just over 5 % of every dollar spent in the U.S. goes toward transportation.

TABLE 13.1. Transportation Factors

Year	Nominal GDP US$ trillion	Total U.S. logistics costs US$ billion	Transportation costs US$ billion	Transportation as a % of GDP	Transportation as a % of logistics
2000	10.29	1,018	594	5.8 %	58 %
2003	11.51	956	607	5.3 %	63 %
2006	13.86	1,338	809	5.8 %	60 %
2009	14.42	1,119	705	4.9 %	63 %
2011	15.53	1,310	821	5.3 %	63 %
2013	16.8	1,385	862	5.1 %	62 %

A more detailed breakdown of transportation costs for 2013 appears in Figure 13.1.

When compared to other international economies, total logistics cost in Europe are about 12 %. In developing economies, the share of GDP directed towards transportation is higher due to the fact that these countries have insufficient infrastructures [3].

Transportation Costs		US$ Billions
Motor Carriers		
• Truck – Intercity		453
• Truck - Local		204
	Subtotal	657
Other Carriers		
• Railroads		74
• Water (International 27, Domestic 7)		37
• Oil Pipelines		13
• Air (International 13, Domestic 20)		33
• Forwarders		38
	Subtotal	195
Shipper Related Costs		10

FIGURE 13.1 Transportation costs (2013).

Beyond the financial statistics, the sheer size of transportation just in the U.S. is considerable. According to the United States Department of Transportation Bureau of Transportation Statistics' (TBS) *Transportation Statistics Annual Report (2012)* [4], people and businesses are connected over 4.1 million miles of roads, nearly 139,000 miles of railroads, over 25,000 miles of navigable waterways, over 2.6 million miles of pipelines, and more than 5,000 public use airports. The estimated value of U.S. transportation assets in 2010 was over US$7 trillion. Public ownership, mostly highways, streets, airports, waterways, and transit facilities comprised one-half of total transportation assets. Private companies owned 31.6 % of transportation assets, including railroads, pipelines, trucks, planes and ships. Publically-owned motor vehicles accounted for the remaining 18.1 %. In addition, transportation accounted for

- over US$1 trillion in purchases and investments
- US$134 billion of public expenditure on operations and maintenance
- 11 million jobs in transportation-related industries
- more than US$8,000 average expenditures for each U.S. household.

In terms of volume and value, American manufacturers and related industries shipped nearly 11.7 billion tons of goods that were valued at more than US$13.6 trillion in 2012.

13.1.2 The Principles of Transportation

A conceptual understanding of transportation is best attained by a review of the basic principles constituting the transportation function. These principles are broken down into three fundamental concepts: *economy of scale, economy of distance,* and *cost of velocity*. The principle of economy of scale states that as the volume and weight of the load increases the cost of transport decreases. For example, the cost of full truckloads (TL) shipments costs less per pound than less-than-truckload (LTL) shipments. The economy exists because the fixed cost of the transportation asset is spread over the total load's weight. The principle of the economy of distance relates to the fact that transportation cost per unit of weight decreases as distance increases. Referred to as the *tapering principle*, the longer in distance a load travels the more the fixed expenses are spread over the distance, resulting in lower overall charges. Finally, the principle of cost of velocity states that as the speed of the movement of the load increases the cost of the transportation increases. Simply, as the velocity of the load increases, the cost of transportation services, such as equipment, fuels, handling, tracking, and loss of scale economies, dramatically increases [5].

These three foundation concepts are further elaborated into the following principles:

- *Continuous flow.* One of the prime objectives of transportation is to provide for the uninterrupted flow of products from the producer through the distribution network and concluding at the point of consumption. In pursuing this objective, transportation continually seeks to increase in-transit velocities by minimizing material handling, using modal transport, and optimizing routing and delivery while reducing cost of service.
- *Optimize unit of cargo.* Optimizing transportation capabilities requires that cargos optimize transportation capacities. This principle ensures that transporters are utilizing the best choice of vehicles, material handling equipment, and labor that provide the best service for the price.
- *Maximum vehicle unit.* As the size of the shipping load grows larger, the capacity of the transport vehicle utilized grows accordingly. Splitting a large load into smaller loads because of limitations in vehicle capacity results in increased costs and loss of efficiency. This principle is based on two assumptions: (1) The operating costs of the vehicle do not increase in proportion to load size, and (2) service costs, such as material handling, routing and dispatching, and shipment documentation, remain unchanged regardless of load size.
- *Adaptation of vehicle unit to volume and nature of traffic.* Shippers continually search for techniques to match vehicle transport characteristics and capacities with the transit environment. This principle requires that transportation vehicle size, weight, storage capacity, and speed be optimized to permit as free as possible the shipment flow through the traffic medium. For example, the development of equipment such as two-level rack carriers for automobiles is targeted at optimizing transport that minimizes costs and facilitates transit through the highway system.
- *Standardization.* Although specialized vehicles are often necessary to meet the shipping requirements of certain goods, the existence of standardized truck trailers, railcars, cargo ships, and air containers offer economical methods to transport products. Because of their general availability, capacity to handle a wide variety of products, and ability to be utilized for backhaul, standardized vehicles often provide lowest cost transport. This principle also applies to the standardization of docking facilities, material handling equipment, and methods of operation.
- *Compatibility of unit-load equipment.* This principle emphasizes that material handling equipment placed in transport vehicles and containers should readily fit and maximize cube space. In addition, equipment should be positioned so as to minimize damage to cargo and reduce load shift during transport.
- *Minimization of deadweight to total weight.* The cost of fuel when transporting products is directly derived by combining the weight of the load (payload) and the weight (deadweight) of the vehicle, containers, and material handling equipment.

Normally, the larger the transportation vehicle, the more favorable the ratio of payload to total weight. The use of lightweight materials and vehicle design assists transporters decrease the deadweight of containers and transport vehicles.

- *Maximum utilization of capital, equipment, and personnel.* Transport vehicle design, routing and scheduling, and operational practices significantly affects the utilization of transport resources. Utilization in transport refers to the percentage of time equipment and personnel are in use. The objective of transportation management is to reduce utilization imbalances caused by seasonality, the lack of operational practices such as backhaul, and poor scheduling of vehicle loading and unloading.

A thorough understanding of these principles is essential in developing transportation strategies. The object is to establish transportation selection guidelines that maximize on transportation economies while minimizing premium carrier modes.

13.1.3 Transportation Services

The role of transportation is to offer supply channel participants a variety of services. In general, these services are grouped into two main areas: *load transport* and *product storage*. Load transport services are concerned with the movement of product from an origin location to a geographical receiving point. During this process, the goal is to enhance the value of the product by positioning it in a more advantageous marketing location while minimizing the transit inventory costs, expenditures for transportation and labor assets, and impact on environmental factors such as air pollution, energy consumption, and congestion. In general transport services are described as follows:

- *Freight services.* The obvious function performed by transportation is the movement of goods through the supply network. These services are performed by company-owned equipment or through the use of a third party provider. Among the transport services available are direct delivery from origin to the customer, the use of air transport for next day delivery, third party ground delivery within a certain shipment radius, delivery of items requiring special storage such as refrigeration or perishability, freight service for heavy and/or bulky items, LTL/parcel post delivery of small/light items, and global package delivery by air or by freight.
- *Terminal Services.* Whether performed in house or by a third party carrier, transportation terminals provide several critical services. The most obvious is the pickup and delivery of products from and to channel warehouses. Another critical service involves the performance of value-added processing functions. Services include *consolidation* of many small shipments into full vehicle/container shipments that will optimize transportation costs. Another service is *bulk break* whereby large stocked quantities are broken down by customer order into smaller deliveries. A third is *shipment service* where normally a third-party provides freight-handling services and performs billing, routing, and other clerical functions. A final terminal service is product and ownership *interchange*.
- *Loading and unloading.* When transit is performed by a third party carrier, responsibility for the loading and unloading of transport vehicles varies by type of shipment. For example, when parcel post is used, the carrier normally performs the function. For TL shipments, the shipper is required to load and the receiver is required to unload the vehicle. Also, the carrier may perform these services for a charge. The receiver is

permitted a specified amount of time (normally one or two days) to unload the vehicle. After that grace period, the carrier normally will charge a fee (termed *demurrage* in rail transport or *detention* in motor transport) per storage vehicle for each day the equipment remains at the receiving location.

- *Value-added services*. Transportation also provides a number of value-added services beyond material handling and transport. Included are electronic tracking of shipments from pickup to delivery; availability of label imaging systems, such as UPC or Bar Code; delivery confirmation, management and control of inbound customer transportation charges; expediting of shipments to rush delivery; and line-haul services that permit shippers to change a shipment's destination (*reconsignment/diversion*) or to perform some function that physically changes product characteristics (*transit privilege*).
- *Documentation*. Transportation is normally responsible for the processing, control, and transmission of all shipping documentation. Documentation consists of domestic documents, such as the *bill of lading*, *freight bills, F.O.B. terms of sale*, and *claims,* and international documents, such as *sales contracts, terms of sale,* and *export documents.*
- *Transportation rates.* In most organizations the transportation function is responsible for negotiating shipping rates when third party transport carriers are contracted. Several factors are used in the determination of services rates. The process begins with the calculation of the actual cost of the needed services. This cost acts as the base price to be used in carrier selection. Next, planners factor in additional prices due to the nature of the product to be transported. Based on the principle of *value of service,* as the value of products increases, so do the transportation charges. Besides the value of the product, the amount of distance to be transported needs to be considered. Normally, the greater the distance the product is moved, the greater the transportation rate. This increase in cost due to distance, however, is not directly proportional. Because of the *tapering rate principle*, the rate structure declines due to the fact that the greater the distance, the more carriers can spread costs, such as handling and shipping monitoring, over a greater mileage base. Finally, the calculation of the full price must consider the weight. For the most part, the price of transport declines as the weight and volume increases.

The second major area of transportation services is *product storage*. While the role of transportation is to move products from destination to delivery point, often transporters must perform temporary in-transit storage functions. The following types of storage are found:

- *Transport mode*. A common type of in-transit storage is to temporarily store products in their mode of shipment, such as trailers, containers, or tank cars. While the cost of this type of storage is high and is normally used to span a very short period, it can be profitably deployed when the cost is lower than the cost of unloading, warehousing, and reloading transport vehicles.
- *In-transit storage*. A variation of in-transit storage is to select a transportation method that would take longer than a more direct mode to reach its destination. The objective of this delaying option is to use the transportation mode as a sort of rolling storage facility to solve space shortage problems at the receiver's warehouse.

- *Diversion and reconsignment*. Often companies postpone shipment receipt by changing the shipment's destination and/or consignee while in transit. *Diversion* permits the shipper to divert a shipment from its original destination to an alternative destination while in route. *Reconsignment* provides a similar capability by allowing designation of an alternative destination after it has reached its original destination, but before it has been delivered to its original consignee.

The services transportation renders to the organization are a critical and often overlooked component of competitive strategy. Effective transportation requires a thorough understanding of such functions as pricing, use of third party carriers for terminal services such as loading and unloading, consolidation, bulk break, handling transportation regulations governing domestic and international transport, and the selection of in-transit storage. An in-depth knowledge of transportation services and principles is fundamental to the effective cost management and optimization of the logistics system.

13.1.4 Transportation Participants [6]

Transportation is a core function of logistics management. Instead of a narrow discipline, transportation policy and practice involves not only the immediate shippers and carriers who are involved on a daily basis, but society in general. There are six participants involved in transportation. An introduction to transportation management is incomplete without a review of the role of each participant.

- *Consignor (shipper)*. The transportation process begins with the need for a company to move goods from its warehouse to other channel warehouses, distributors, or the customer. The goal of the shipper is to have goods moved as expeditiously as possible, without damage or loss, in as short a delivery time as possible. This process could be performed by a company-owned fleet or by contracting with a for-hire carrier.
- *Carriers and agents*. Carriers perform the actual movement of goods. The goal of carriers is to receive the highest rate possible for services while minimizing labor, fuel, and vehicle costs needed to execute the shipment. There are a variety of agents. Some purchase transportation services from primary carriers which they in turn sell to their customers. Other agents facilitate carrier and shipper matching.
- *Consignee (receiver)*. This participant is the receiver of the goods. Like the shipper, consignees want transportation that is low cost, reliable, and capable of delivery in the shortest time possible. (If a for-hire transportation company is used, they sometimes will assume temporary ownership of the goods until they are finally delivered to the end consignee.)
- *Transportation technology services*. The Internet has enabled transportation participants to leverage several new services. The most immediate benefit is that all transportation participants can share real-time information about transportation operations. In addition, the Internet enables the creation of two types of Web-based marketplaces. The first enables buyers to use the Internet to shop for carriers with available capacity to match freight requirements. The second is the establishment of buying exchanges for the purchase of fuel, equipment, service parts, and so on for transportation vehicle operations and maintenance.

- *Government*. Historically, all governments have had a deep interest and involvement in transportation. Governments understand the importance of effective and efficient transportation as a critical driver of social and economic growth. In the United States, that concern was at first manifested in the form of strict regulation and oversight of transportation. Starting in the 1970s, legislative deregulation increasingly moved the country's transportation industry to greater competition and operations freedoms.
- *Public*. The last participant in the transportation industry is the public. In general, the public expects and depends on accessible transportation, affordable and competitive rates, security, safety, and recently, a commitment to environmental sustainability.

13.1.5 Relationship of Transportation to Other Business Functions

Although some may argue that warehousing is the pivotal logistics function, a warehouse cannot remain functional for long without transportation. It is transportation's role to deliver products to the warehouse from supply points in the distribution channel. Whereas warehousing may rightfully be called the "heart" of the supply chain function, transportation forms the veins and arteries through which logistics pumps products and value-added services from one channel member to another.

The transportation and handling of inventories provides other business functions with essential information concerning products, marketing place and time utilities, and transit costs and capabilities necessary for effective supply chain planning and operations execution. Some of these functions interact directly with transportation; others interact indirectly. The relationship between transportation and other business functions is described as follows:

- *Strategic planning*. As enterprises design and improve their product and service value portfolios, the capabilities and costs associated with the transportation network serve as key inputs to business decisions. Whether it is expanding their geographical footprint or acquiring new companies, corporate strategists must consider how leveraging transportation can optimize their proposed supply networks. The availability of flexible and cost-effective transportation is a key component in validating the links between production and distribution channel nodes and the end-customer required by the business strategy.
- *Traffic management*. Many businesses have a traffic management department responsible for monitoring the selection and scheduling of the transportation modes necessary to move products through the channel pipeline. Figure 13.2 examines the different responsibilities of the modern traffic manager. The role of this function is to coordinate directly with shipping and indirectly with sales and marketing, and to ensure the business has access to adequate, cost-effective transportation that provides the delivery capabilities expected by the customer. Detailed responsibilities include freight classification, rate negotiation, equipment scheduling, shipping documentation, tracing and expediting shipments, claims for damaged goods, and auditing of freight bills. If the firm possesses its own transportation fleet, traffic management must be able to select the optimal mix of private and public transport services.
- *Warehouse management*. The effective scheduling of product receiving and shipping is fundamental to the smooth flow of both warehousing and transportation. For example, without effective delivery scheduling, vehicles arrive haphazardly and

FIGURE 13.2 Administrative functions of the traffic manager.

often in bunches. The result is that vehicles have to wait their turn to be loaded and unloaded, costing the company or the for-hire carrier dearly in lost productivity. In addition, inadequate scheduling forces the warehouse to staff excess labor and material handling resources than would be unnecessary if the work flow was evened out. Finally, poor scheduling causes the warehouse to digest uneven flows of material that require overflow staging areas and costly overtime. Effective transportation scheduling more evenly matches delivery arrivals and shipping departures with the capacities of receiving personnel and materials handling equipment, and removes inbound and outbound delivery bottlenecks that cause uneven flows of material through the channel network.

- *Purchasing*. Purchasing decisions have a direct impact on transportation. The physical attributes, quantity, and volume of purchased products require purchasers and transportation to work together to ensure that the cost, availability, and adequacy of transport vehicles is sufficient. In addition, purchasing positively influences supplier on-time delivery that facilitates receiving activities. Areas of cooperation include the following:
  - Working with suppliers to determine the most efficient material handling methods for inbound products. Options include containerizing, unitizing, or palletizing goods that will minimize damage, optimize carrier capacities, and speed shipment and receiving.
  - Selecting the best transport equipment that keeps costs low and reduces transit time.
  - Selecting the best transportation mode option that results in the lowest landed cost.
  - Scheduling the timing and location of product deliveries with suppliers.
- *Customer service*. Customer service delivery policy has a significant effect on outbound transportation. When customers place orders, the price of the shipping and expected delivery is as important as the product price. Service reps need access to negotiated shipping rates and lead times to not only provide key information, but also

to assist them in the selection of the appropriate delivery service level and cost that meets customers' requirements. Today's technology-enabled customer is demanding the ability to leverage Web-based applications and mobile devices that allow for self-service visibility to delivery status, as well as accurate freight cost information for their orders.

- *Product pricing*. The transportation decision has a direct bearing on product pricing. Because transportation is a significant component of the total purchase price, transportation expense must be factored along with other direct and overhead costs when determining product selling prices. Generally, the importance of transportation in price determination grows as transportation's share of product costs increases. Transportation costs are as high as 50 % or more of the selling price of bulk commodities such as coal or wood and may be less that 1 % for small-volume hard goods.
- *Channel network locations*. As was pointed out in Chapter 12, deciding where to locate new channel warehouses is a complex affair, requiring detailed analysis. Among the key factors in the planning process is determining the adequacy of transportation infrastructure and the cost and availability of third party for-hire companies. For example, if a distributor depends heavily on railroads for product delivery, any decision concerning the location of a new warehouse is influenced by its proximity to rail transport.
- *Inventory planning*. Transportation has an important effect on inventory planning. Part of the lead time for purchased parts is composed of the supplier delivery time. The shorter the lead time, the smaller the lot sizes and the less the cost of carrying cycle inventories. Another important area is the accuracy of in-transit inventory information. Regardless of whether statistical replenishment, material requirements planning (MRP), or distribution requirements planning (DRP) techniques are used, accurate information relating to inbound quantities and delivery dates is essential for effective inventory planning and order promising.

13.1.6 Transportation Performance Characteristics

There are a number of performance characteristics that shippers consider when selecting the appropriate mode of transportation. These characteristics are matched with the type and quantity of product to be shipped, the capacities and capabilities of the transportation mode, and relevant cost issues. There are six transport mode performance characteristics (Figure 13.3) driving any transportation selection decision.

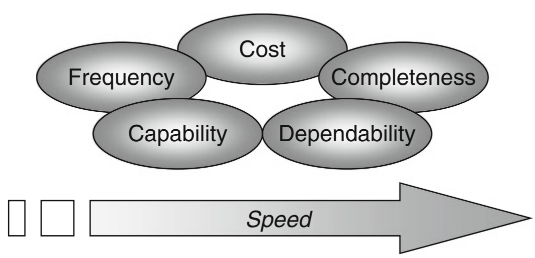


FIGURE 13.3 Performance characteristics of transportation.

The first performance characteristic is *speed*. The ability to transport products from one point in the supply chain to another as quickly as possible is, by far, the fundamental performance characteristic of transportation. Speed enables the marketing utilities of *time* and *place*. Transportation speed is defined as the time required to load products onto the transport vehicle at the shipping terminal, traverse distance and intermediate terminal points, and deliver the products to the receiving terminal. Another important characteristic is *completeness*. This performance characteristic refers to the ability of the transport mode to move inventory from one location to another *without* the use of other modes. This is critical because the less material is handled between the point of origin and the point of destination, the lower the transport cost and the short the delivery time. For example, if material is shipped by rail and the company does not have a rail siding, a second mode, most likely motor carrier, would receive the load from the rail carrier, and then transport it to the company where it is unloaded again for final receipt.

The third performance characteristic is *dependability*. The degree of transport dependability is measured by the performance of a given mode in meeting anticipated on-time delivery. Dependability is critical to ensure that inventory availability to meet *place* utility is realized to schedule. Poor dependability adds cost in the form of excess inventories and poor customer service. The next characteristic is *capability*. Capability refers to the ability of a given transport mode to accommodate a specific shipment load. The driving factor is the nature of the product. Characteristics such as product type (liquid, solid, bulk, or package), load weight, and load dimensions are considered when deciding on the necessary capabilities of material handling equipment and mode of transport. For example, when moving liquids, tank cars and pipelines are the most appropriate methods of transport.

The fifth characteristic is *frequency*. This performance factor is a measure of how often a transport mode picks up and delivers goods. Generally, the shorter the transport interval, the greater the flexibility of the mode to respond to channel requirements. More frequent transport also decreases the required modal size and the magnitude of the inventory to be transported. The final performance characteristic is *cost*. Although marketing *time* and *place* utilities are critical elements of transport mode selection, the cost the shipper must pay for the transport service is equally important to the survival and competitiveness of the supply channel. There are several costs in transportation. The most obvious cost is the rate paid to the carrier for use of the mode itself. Other indirect costs are labor and material handling to load and unload the transport medium, occurrence of spoilage and damage, insurance to protect against possible loss, and in-transit inventory carrying costs.

13.2 TYPES OF TRANSPORTATION

There are several different modes of transportation available to traffic management. Choosing the appropriate type of transportation consists of a number of marketing, product, warehouse location, customer service, and financial decisions. The goal is to develop operational methods that consistently provide for the selection of the best transport carrier system that efficiently and effectively executes transportation requirements while simultaneously facilitating the attainment of customer service performance targets. Factors influencing transportation selection include the type of distribution environment to be serviced; supply chain strategic goals; required delivery lead time; financial capacities;

product characteristics (size, perishability, seasonality, potential for obsolescence, theft, and intrinsic value); order quantity size; geographic size of the channel network; carrier-type availability; and strength of the competition.

13.2.1 Forms of Transportation

Before transportation modes are discussed, it is necessary to review how the various types of transportation are owned and operated. As a result of the Interstate Commerce Commission (ICC) Termination Act of 1995, essentially five basic types of carrier emerged: common, regulated, contract, exempt, and private. The first four types characterize more or less for-hire freight companies and are subject to various federal, state, and local statutes and regulations. In contrast, the fifth type, private carrier, consists of company-owned equipment that is used to transport company products and supplies through proprietary channel networks. The following is a brief review of the five types of transportation:

- *Common Carriers.* A common carrier provides transport services to the general public according to a published rates schedule. Although, common carriers no longer have to file their rates with the Department of Transportation, they are still, nevertheless, the most heavily regulated of the five types of carrier. The purpose of this level of control is to protect the shipping public and ensure cost effective service within reasonable limits. In order to operate legally, common carriers must be granted authority from the appropriate federal regulatory agency. Normally, this authority also defines the type of product or commodity that can be carried and the geographical area or terminal points to be served. As part of their legal obligation, common carriers must service all comers, provide rates, classifications, rules, or practices as requested by the shipper, provide service to all points prescribed in their certificates of authority, and deliver products within a reasonable time even if the shipment is not profitable.
- *Regulated Carriers.* This class of carrier provides basically the same functions as a common carrier, but with a few exceptions. They have the same responsibility to provide safe and adequate service, but without the requirement to serve all comers. In addition, while regulated carriers have basically the same immunity from government regulation as other carrier types, they must provide rates to shippers on request and they have the ability to collectively establish rates without antitrust prosecution. A benefit of employing regulated carriers is that they can be held liable for damages to transported goods. The extent of the liability, however, is limited through the use of tariff rules and released value rates.
- *Contract Carriers.* Similar to common carriers, contract carriers are regulated by the federal government and are authorized to transport certain types of products in certain geographical areas. Contract carriers are not required to offer their services to the general public, but, instead, provide transport services for a negotiated price to selected customers defined by contractual agreement. Normally, contract carrier rates are less than common carrier rates for two reasons:
    1. Contract carriers select customers that wish to transport products that optimize the capacities and capabilities of their vehicle and material handling equipment.
    2. Because customers provide contract carriers with defined contracts that specify product transit and delivery schedules, they can plan better and budget for equipment resources.

- *Exempt Carriers*. This type of for-hire carrier differs from common and contract carriers in that it is not regulated with respect to routes, areas served, and rates. The exempt status is determined by the type of product transported and the nature of the operation. Examples include a variety of land and water carriers that transport commodities such as agricultural products, livestock, poultry, newspapers, and other specialized products. Probably the most important class of carrier belonging to this type is delivery and cartage firms that operate in a local municipality or "commercial zone" surrounding a municipality. Although exempt carriers charge lower rates than common or contract carriers, limitations on the kinds of products that are exempt render their use inappropriate for the transport of most industrial products.
- *Private Carriers*. This final type of carrier is distinguished by the fact that it is wholly owned or leased by a firm and is incidental to the company's main line of business. Private carriers are not subject to federal government regulation regarding costs or scope of service. After the passage of the Motor Carrier Act in 1980, permission was granted to companies with private fleets to transport products for wholly owned subsidiaries or backhaul loads from nonaffiliated companies. The decision to acquire a private transport fleet or use for-hire types of transportation must be carefully made. Wholly-owned transport provides companies with a significant level of control and flexibility to respond directly to customer and internal channel requirements. On the other hand, since deregulation, many for-hire carriers offer services that are more cost and operationally effective than private fleets.

In addition to these types of carriers, new forms of transport services have grown dramatically since deregulation. These companies purchase transport services from primary carriers, which they in turn sell to their customers by providing services for handling small packages, consolidation and bulk breaking, and local pickup and delivery. These *transportation agencies* can be described as follows:

- *Freight Forwarders*. A freight forwarder, as defined by law, provides the general public with transportation services and, in the ordinary course of business, assembles and consolidates, or provides for assembly and consolidation of, shipments at origin and provides for break bulk and distribution of shipments at the delivery destination. In addition, freight forwarders assume responsibility for the transportation of a shipment, incur liability for loss or damage to cargo, and must use, for any part of the cartage, a carrier subject to the jurisdiction of Department of Transportation (DOT). Companies that handle domestic U.S. freight must be registered with the U.S. Department of Transportation's Federal Motor Carrier Safety Administration. International ocean freight forwarders arranging for shipments to and from the U.S. must be licensed by the Federal Maritime Commission as Ocean Transportation Intermediaries.
- *Parcel Post*. Companies engaged in this type of transport focus on the rapid shipment of small (weight and volume) goods and are designed for general public use. Parcel post shippers use all transportation modes except for pipelines and can consist of bus, motor, or air cartage. The U.S. Post Office, Federal Express, and United Parcel Service are examples of companies in this group. The main advantage of using small-package carriers is *speed of delivery*, especially for emergency situation. The high cost, however, generally prohibits use of this mode for low-value, high-density commodities.

- *Shippers' Associations*. This group is composed of nonprofit shippers' cooperatives whose primary function is freight consolidation. These associations consolidate smaller shipments from members, search for carriers, and execute low-rate shipment the savings from which are passed back to association members.
- *Shippers' Agents*. This group is composed of transportation brokers who provide ramp-to-ramp transit from railroads and motor vehicles at origin and destination using truckers as needed under a single bill of lading. They do not provide transport requiring consolidation or bulk-breaking functions. Shippers' agents are exempt from government regulation.
- *Brokers*. The broker is a third-party agent who is neither a shipper nor a carrier but rather an intermediary that arranges a match between the shipper's transportation need and a carrier from a pool of carriers they represent. To operate as a freight broker, a business or individual must obtain a license from the Federal Motor Carrier Safety Administration (FMCSA). Freight brokers are also expected to carry insurance to protect both their business clients and their customers from loss. In many areas, freight brokers are required to carry surety bonds as well. Since deregulation, the use of brokers has dramatically increased. In addition, brokers are generally not liable for cargo loss and damage. Issues regarding brokers' assistance in pursuing damaged goods claims, rate negotiation, billing, and tracing are normally determined during the contracting process.

When selecting from the above list of transportation carriers, the actual distinctions are slight. The real issues revolve around operating restrictions, financial commitment, and operating flexibility. The dramatic changes brought about by deregulation have lifted the historically tight restrictions on the way carriers operate and the way they are used. Still, there are several critical elements, such as service requirements, type of product, pricing, and level of carrier commitment that must be reviewed during selection.

13.3 MODES OF TRANSPORTATION

There are essentially five *modes* of transportation that are available to move goods through the supply channel. These five modes are as follows: *motor, railroad, water, pipeline, and air transport*. Each provides the supply chain with certain advantages and each has its own particular limitations. In addition, certain combinations, or *intermodal*, variations are possible. These include railroad-motor, motor-water, motor-air, and rail-water.

13.3.1 Motor Transport

Motor transport is by far the most popular mode of transportation. In 2012 motor transport moved roughly eight billion tons of goods valued at US$10 trillion or about 77 % of value and freight reported. As of 2013, the trucking industry employed over 6.9 million people. The characteristic feature of this mode is that transit occurs on the nation's highway network over which different types of carriers operate a variety of motorized vehicles capable of carrying a wide range of loads. Unlike railroads, which own and maintain tracks, line equipment, and structures, the motor industry has the ability to move products freely over four million miles of roads in the U.S. alone. It is estimated that the U.S. interstate highway system carries more than one-fifth of the total motor transport each year. As such, motor carrier capital investment is normally confined to transport equipment, terminals, and related repair and storage facilities. As of 2011, over ten million trucks traversed the nation's highways. The Federal Motor Carrier Safety Administration (FMCSA), established January 1, 2000, regulates the trucking industry in the United States [7].

The growth of motor transportation is traced to several factors. To begin with, the speed, flexibility, and relative cost of motor transport are more in alignment with today's strategies aimed at high customer service and quick response. Unlike the other modes of transportation, motor carriers provide supply-point-to-delivery-point service. Accessibility is a key attribute of motor transport. There are virtually no locations that are off limits to motor carriers. They do not require ports, switching yards, or large terminals. Furthermore, equipment versatility permits companies to ship almost any weight or quantity easily and cost effectively. Motor carriers also provide faster service than railroads and can successful compete with air transport for short hauls. Finally, product loss and damage ratios for motor carriers are substantially less than for most rail shipments.

The cost structure of the motor industry is highly direct-cost intensive. Although the fixed costs for trucks, trailer rigs, and material handling equipment are significant, variable costs involved in labor, taxes and tolls for use of public highways, terminal expenses, fuel, licenses, and insurance account for 80–90 % of total motor transport costs. Of these costs, labor accounts for about 60 % of each cost dollar. Generally speaking, about $0.97 cents of every operating dollar is consumed by operating expenses, with the balance going to cover interest costs and return to investors. As a result, the motor industry cannot operate for very long with rates below costs.

Traditionally, motor transportation vehicles are divided into two categories: *intercity over-the-road vehicles* and *specialized short-haul vehicles*. The former category generates the majority of all motor transport revenues. Equipment-wise, intercity freight carriers are usually characterized by the familiar tractor-trailer rig, but it also can consist of special equipment to haul products such as automobiles, liquids, tandem or double bottoms, refrigerated products, and large storage containers. Specialized short-haul equipment is normally much smaller in volume capacity and more flexible in order to handle a wider variety of products than intercity equipment. This category of motor transport is used for pick-up and delivery of products over short distances (up to a maximum of 20–30 miles). Automobiles, vans, trucks, and short tractor-trailer rigs are examples of short-haul equipment.

The motor industry is comprised of private fleet and for-hire operations. As previously discussed, private fleets are owned by the company that is operating the vehicles. The National Private Truck Council estimates that the US$300 billion motor market is driven by over 135,000 private fleets used by primarily by manufacturers and retailers operating the in U.S. In fact, three out of every four Class 4 through Class 8 trucks on U.S. roads are from private fleets, operated by such household names as PepsiCo, Coca-Cola, Sysco, U.S. Foods, and Halliburton. According to a benchmarking survey by the National Private Truck Council (NPTC), private fleets captured a 78 % share of all outbound movements in 2013, up 10 % from 2012. In addition to outbound, private fleets are gaining the market share of inbound freight—40 % in 2013, up from 31 % in 2011. In the meantime, the top 500 private fleets have grown their vehicle count by 50 % over the past 10 years, according to the NPTC survey [8]. As of 2014, Wal-mart operated the largest private fleet in the U.S. consisting of

7,400 drivers, 6,121 tractors, 54,540 dry van trailers, 5,631 reefer trailers delivering to 124 distribution centers with over 713 million miles driven in 2010, and 4 million total store deliveries per year [9].

For-hire trucking companies provide transportation services for other companies. In 2008, there were approximately 725,000 motor carriers registered with the U.S. Department of Transportation employing over 4.7 million drivers, deliverymen, and couriers. Less than full truck-load (LTL) carrier leaders in 2013 were Fed Ex Freight with revenues of US$5.9 billion, Con-way freight (US$3.4 billion), YEC Freight (US$3.1 billion), UPS (US$2.3 billion), and Old Dominion Freight Line (US$2.1 billion). Full truck load transportation leaders (TL) were Swift Transportation with 2013 revenues of US$3 billion, Schneider National (US2.3 billion), Werner Enterprises (US$1.7 billion), and J.B. Hunt Transportation Services (US$1.6 billion) [10]. The three general types of for-hire carriers include the following:

- *Truckload carriers (TL)*. This type of third party service provider (3PL), transports large shipments per full trailer that exceed 15,000 lb or use the full cubic capacity of a trailer. TL carriers provide direct service, picking up the load at the point of origin and delivering it directly to the destination without stopping at freight-handling terminals.
- *Less-than-truckload (LTL) carriers*. This type of 3PL provides transport of multiple shipments ranging from 150 lb up to 15,000 lb in each trailer.
- *Small package carriers*. This type of 3PL transports loads up to 150 lb and moves multiple shipments on a single vehicle. United Parcel Service (UPS) and FedEx Ground are the two largest small package ground carriers in the country.

Over the past several years, truck transport has encountered a number of serious challenges. According to a report (2013) produced by the American Transportation Research Institute [11], there are ten important issues confronting today's trucking industry. These issues are broken down into two major areas: regulatory and operational. At the top of the regulatory issues are *hours-of-service* (HOS); *compliance, safety, and accountability* (CSA); *electronic logging device* (ELD) mandate; and truck parking (for mandatory 30 min break after 8 h of driving). The HOS regulation (enacted July 1, 2013), which establishes driving hour limits, was identified as the most contentious. The top operational issues identified are the growing driver shortage, state of the U.S. economy, driver retention, fuel supply and prices, infrastructure and congestion, and driver health and wellness. In summary, the trucking industry is facing a severe problem with increasing demand, while capacity is declining.

13.3.2 Railroad Transport

Historically, transportation in the U.S. was dominated by the *railroad*. From the mid-nineteenth century to the conclusion of World War II, the continental U.S. was linked by a network of rails that provided for the economic and speedy transport of goods and passengers. Today, while motor transport accounts for the bulk of transportation revenues, railroads surpass all other modes in terms of shipping tonnage, accounting for over 35 % of the ton-miles shipped in the United States. This leadership is due primarily to rail's ability to transport large volumes of freight over long distances at low prices (the price per ton-mile in 2012 was $0.3961). In 2012, railroads carried over 1.5 trillion ton-miles of freight (non-commuter) over a track network totaling 162,306 miles at a cost of US$72 billion.

For the most part, railroad usage had been declining since the end of World War II, when rail accounted for about two-thirds of the ton-mile traffic. The growth of motor transport has generally absorbed a good deal of the small haulage while water and pipeline carriers have been eroding away the shipment of bulk commodities [12]. In 2013, however, rail transport exhibited a strong resiliency as ton-miles rose above 1.7 trillion and overall rail traffic was up 9.2 % over the previous year [13].

Although there are around 567 railroads in the U.S. (2012), there are only seven Class I railroads (defined as companies with revenues in excess of US$290 million). As of 2012, the rail transport industry employed over 176,000 people [14]. The reason for the limited number of rail carriers is explained by the nature of the industry. One of the most visible characteristic of rail transport is the enormous investment in fixed assets consisting of track and accompanying rolling stock, terminals, miscellaneous facilities, and administrative and management support. Unlike motor transport that uses the public highway system, rail must maintain its own transport structure. Because of this very large *fixed* expense, the costs associated with rights-of-way (tunnels and bridges), equipment maintenance, interest, depreciation, taxation, and other costs must be absorbed by the carrier. Unlike other modes of transportation, whose life cycles are considerably shorter, the cost of rail maintenance and physical plant remains fairly stable over the life of the equipment and has a minimal impact on transport rates. This means that railroads can take significant advantage of economies of scale. The average freight train hauls a load of 2,500 t and pulls an average of 71.5 cars. Over the past 10 years, the trend has been greater load per rail car, greater average daily car mileage, and faster trains. Simply stated, as the volume of freight increases, the total cost of transport decreases on a per-unit basis.

Rail transport is primarily used for the long-distance transport of low-value manufactured goods and raw materials. Commodities transported include coal, oil, chemicals, farm products, minerals, food, timber, and other basic materials. Because of their size and weight, these products are normally shipped in large quantities to gain transportation efficiencies. Compared to water transport, which is also well adapted to heavy loads, rail carriers have the edge in accessibility to land-based destinations and points of origin. Rail also is impervious to bad weather conditions. Rail also offers shippers considerable safety with a minimum of risk. Finally, rail is not constrained by weight and volume restrictions and is readily available in the U.S. Offering a wide variety of car types, such as boxcars, tankers, gondolas, hoppers, covered hoppers, flatcars, and other specialty car types, rail provides a considerable degree of flexible service. In 2012 the total number of freight cars in service for all U.S. rail companies was 1,283,225.

Although the most significant advantage enjoyed by rail carriers is that they can transport larger volumes of goods over great distances at a cost generally less than other transport modes, there are some distinct disadvantages. To begin with, rail compares unfavorably to motor cartage when it comes to transit time and frequency of service. Rail transport is relatively slow. Trains run on specific timetable schedules dictating departure and arrival, are required to stop at numerous locations, expend time to couple and decouple cars in a switching yard, and are subject to restrictions on speed. In addition, rail provides terminal-to-terminal service rather than stocking point-to-point service as does motor transit. Unless the shipper has a railroad siding, product must be unloaded and reloaded using other transit modes before it arrives at the final stocking point.

Finally, rail carriers have not been able to guarantee the same general equipment availability as motor carriers. Part of the problem is that the proper storage car may not be physically present at the shipment location when needed. In order to overcome poor utilization or have rolling stock lost in the cross-country rail network, the rail industry has turning to a number of advancements in yard management systems. Such developments as computerized routing and scheduling; railcar identification systems; development of specialized cars; upgrading of equipment, roadbeds, and terminals; and nonstop shipments between metropolitan areas enable the rail industry not only to hold its own but to enjoy the opportunity for growth in the twenty-first century.

13.3.3 Air Transport

Outside of pipelines, air carriers account for the smallest proportion of ton-mile traffic. In 2012 air transport revenues for U.S. domestic carriers amounted to $33 billion and accounted for only 4 % of all transportation revenues. In 2011 air transported 12.1 billion ton-miles and employed 458,000 workers. Although the industry grew during the late 1990s, recessions, airline bankruptcies, terrorist attacks, the skyrocketing cost of fuel and other factors in the first two decades of the twenty-first century dramatically hurt air transport. For example, air carrier growth declined from 34.4 % during the period 1990–2000 to just 7.5 % between 2000 and 2010. Overall ton miles declined 14.5 billion revenue ton miles in 2001 to 12.1 billion in 2011; the number of air carriers dropped from 87 to 76 in the same period. It has been estimated that altogether the industry lost from 3 to 5 years of growth. Returning to positive growth will require air cargo companies to successfully meet new security and safety provisions, increased customer expectations, and internal pressures to be profitable and competitive [15].

For most airlines, providing freight transport is incidental to carrying passengers which is treated on a space-available basis. In 2002, of the 1.6 billion tons of cargo shipped by air, 1.4 billion tons was carried by cargo airlines and 200.8 million tons was carried by passenger airlines. The air carrier industry, furthermore, is highly concentrated into a small number of carriers that account for nearly 90 % of the industry's revenues. While passenger airlines dominate, freight service companies, like UPS, Airborne, Federal Express, and Emery have their own fleets dedicated solely to transporting freight. These carriers transport approximately 50 % of all domestic air transport freight.

Air transport equipment costs are associated with the aircraft and supporting ground equipment and labor. For the most part, these variable costs are high, accounting for over 80 % of every airline expense dollar. Support equipment is used mostly for transporting people, freight, baggage, and fuels to and from the aircraft. Although the military does possess special aircraft used exclusively for freight and troop transport, commercial aircraft, even those used only for freight, is designed around the passenger business. In addition, the standard cargo bays in most aircraft are suitable only for freight that is not subject to special requirements, such as refrigeration, gases and flammable liquids, and dry-bulk storage.

The use of air transport provides shippers with some significant advantages. The most obvious is the speed of service. Aircraft can deliver goods in a fraction of the time required by the other four modes of transportation. In addition, air carriers generally offer excellent frequency and reliability of service, particularly to major metropolitan areas. Air carriers are most profitably used under the following circumstances:

1. Speedy transportation of high-value, low-weight products that need to traverse long distances.
2. Emergency transport of critical repair parts.
3. Emergency transport of products from stocking point-to-stocking point in the supply channel to prevent loss of sales.
4. Emergency shipments of components over long distances necessary to eliminate interruptions in production processes.
5. Speedy transport of perishables and seasonal products, such as exotic flowers, foodstuffs, and fashion apparel, over long distances.

The foremost disadvantage of air transport is the high cost of service in comparison to the other four transport modes. In addition, the limited cargo capacities of aircraft make it unsuitable for most classes of product. Finally, like rail transport, air carriers function terminal-to-terminal rather than stocking point-to-stocking point. This means that product must be unloaded from the aircraft and then reloaded onto motor transport which then delivers the cargo to the receiving company. Another significant drawback is weather. While modern day navigation equipment enables air carriers to cut back on disruptions to service caused by minor weather problems, of the five transport methods air transport is the most susceptible to weather conditions.

13.3.4 Water Transport

Historically, water transportation was the earliest form of mass transportation in North America. Although during the colonial and early republic period there were a few common carriers that transported goods by ferries, stagecoaches, and wagon lines, the almost nonexistent state of the nation's roads made water transport the only economical means of moving products from place to place until the arrival of the railroad starting in the 1840s. The most important forms of water transport were the trans-Atlantic trade, rivers, lakes, and bays, and the canal systems that were begun in the 1820s and 1830s. Then as now, water transport is particularly suited to the movement of large, heavy, low-value-per-unit goods that are unloaded and loaded efficiently by mechanical means. Water transport lends itself particularly well to commodity-type products, such as coal, iron ore, grains, building materials, and fuels, which do not require quick delivery and are not particularly subject to shipping theft or damage.

In 2011, total U.S. waterborne trade amounted to over 2.1 billion metric tons. Foreign trade accounted for 62.5 % of the total (1,343.1 million metric tons) and domestic trade accounted for the remaining 37.5 % (805.5 million metric tons). The industry as a whole employed roughly 71,500 seafarers of which about 33,700 were employed in water transport and the remaining 37,800 employed in other sectors.

Water transport is divided into two major categories: *domestic* and *international*. U.S. domestic water carriers, in turn, consist of three major areas. The first, *internal water transport*, consists of the various inland rivers and canals crisscrossing the nation. In 2011 the domestic maritime industry moved 500 million ton-miles of goods worth US$279 billion, representing about 4.7 % of the tonnage and 1.7 % of all freight shipments. Inland water transport represents about 19 % of all U.S. water trade. This category consists of approximately 26,000 miles of waterway, the heaviest utilized being the rivers and canals associated with the Mississippi Basin which in 2011 accounted for 269 million ton-miles of cargo. About 54 % of the inland waterway traffic moves in this river system.

The second water transportation category, the *Great Lakes System*, comprises some 95,000 mile^2 of natural waterways, with a coastline of 8,300 miles. About 10 % of the total of the nation's inland waterway traffic in tons (49,000 tons-miles in 2011) navigates on the Great Lakes. In addition, continuing improvements to Great Lakes facilities has provided access to the Atlantic Ocean and connection with the Mississippi River system through canals. *Coastal* and *inter-costal transport* is the third category of water transport. Comprised of the many rivers, canals, bays, inlets, and channels that are connected to the Atlantic and Pacific oceans and the Gulf of Mexico, coastal transport accounts for the remaining 36 % of domestic water transport. Companies in this trade belong to one of four modes: private, contract, regulated, or exempt. As of year-end 2011, over 38,700 privately-owned vessels were available for operating in the U.S. foreign and domestic trades [16].

There are several types of vessels found in domestic water transport. The large ships used on the Great Lakes are *lakers*. While similar to ocean-going vessels, their long, low profiles render them unseaworthy in the face of weather conditions characteristic of ocean waters. In contrast, on the inland water systems, barges propelled by towboats are the most common equipment. There are primarily three types of barge. *Open-hopper barges* carry dry bulk cargoes such as coal, sand, gravel, and limestone. *Covered dry cargo barges* primarily transport grains. Finally, *tank barges* provide sealed storage environments for transporting petroleum, liquids, or gases. Because of their shallow draft and ability to be linked together as a single unit or *tow*, barges are ideal for navigating the shallow depths of rivers and canals.

The second major category is *international water transportation*. This mode is by far the most popular international shipping method and accounts for over 80 % of all U.S. maritime freight, three-fourths of total U.S. trade tonnage, and 46.9 % of trade value. In 2010, U.S. ports handled 27 million twenty-foot equivalent units (TEUs) of containerized cargo. U.S. companies utilize water to transport almost any product across the globe, but, for the most part, this mode is used primarily for low weight-to-value commodities such as petroleum, minerals, dry bulk items, and commodities that are easily containerized. The type of equipment used is governed by the commodity carried and the category of waterway to be navigated. On the world's oceans, large sea-going vessels are used. These ships are specifically designed to transport various types of bulk cargos and are described as *bulk carriers* used for ores, grains, and metals; *tankers* used for petroleum and natural gas; *containers* used for packaged commodities and food-stuffs (constituting about 18.1 % of total U.S. waterborne trade); *roll-on-roll-off* (RO-RO) used for automobiles and motor transport; and *ocean-going barges* used to carry a wide-variety of products that are pulled by tugs over short ocean voyages to places like Puerto Rico and the Hawaiian islands.

The major disadvantages to water transport relates to capacity, transportation lead time, trade imbalances, and rising fuel costs. The dramatic increase in global trade since the year 2000 has stretched port capacities and required massive infrastructure upgrades. Another disadvantage is the relative slowness of water transport as compared to other transport modes, dependence on water terminals and ports, and low frequency of movement. Fuel costs in 2011 accounted for roughly 32 % of every dollar spent on water transport. Advantages possessed by water transport are that of all the transport modes with the exception, perhaps, of pipelines, it is the least expensive and is the most capable. Virtually anything can be shipped by water, especially bulk-type products. For example, a single barge tow comprised of 15 barges each with a capacity of 1,500 t, is the equivalent of 2.25, 100-car train units or 900 large semi-truck rigs.

13.3.5 Pipelines

Compared to the other modes, pipelines are one of the oldest forms of transportation. Perhaps the most unique feature of pipelines is their physical plant. Consisting of pipes, pumping stations, storage tanks, input and dispersal facilities, and land, pipeline transport is fixed in place and not dependent on roads or rails and is barely visible to the public at large. As pipelines have no vehicles, maintenance and investment are minimal and no backhaul problem exists. In addition, the pipeline industry is highly automated. The movement of product within the pipeline system can be controlled from pumping stations hundreds of miles away, where computers are used to schedule and monitor operations. Pipelines are very capital-intensive. In 1977, it was estimated that $21 billion had been invested in the pipeline industry. In the late 1980s, it was estimated that it would cost about $70 billion to replace the existing pipeline system. That cost would be dramatically much higher today. In 2013, pipeline industry costs were about US$13 billion. Approximately 182,135 miles of oil and other hazardous liquid pipelines are in place in the U.S. There are also 324,606 miles of natural gas gathering and transmission, and about 1.5 million miles of natural gas distribution pipelines. These pipelines are operated by approximately 2,434 entities. Pipelines provide the most economical form of transportation with the lowest cost per ton mile of any mode.

The use of pipeline transport is governed by the types of products that are carried by this mode. There are three basic types of products that use pipelines: oil, natural gas, and slurry. In transporting these products, pipelines are mounted above or buried beneath the ground. Petroleum products, crude oil, kerosene, water, chemicals, and natural gas are excellent products for pipeline transport. In the oil industry for example, pipelines are used to gather crude oil from the field, which flows to the refinery. Product lines then distribute the finished goods from refineries to consuming centers. Another important type of pipeline product is slurry. Often, solid products are ground and added to water for pipeline transport. For instance, coal is reduced to a powdered state, combined with water, transported via pipeline, and converted back into a solid at the receiving point by removing the water component. By far, the predominant users of pipelines are the oil and natural gas industries, with slurry products constituting a very small percentage.

Advantages associated with the use of pipeline transport are significant for liquefied types of products. Pipelines provide an extremely high level of service dependability at a relatively low cost. Pipelines can move large volumes of product, are not labor-intensive, are easily monitored through automated computer control, are almost free of the chance of loss or damage to product due to leaks or breaks, and are relatively impervious to climatic conditions. On the negative side, pipelines are extremely limited to the products they can transport, have no geographical flexibility, are comparatively slow in speed, and require the use of other transport modes as product moves closer to ultimate consumers or retail outlets.

13.3.6 Transportation Mode Summary

Each of the five transport modes has specific performance characteristic strengths and weaknesses. When making transportation decisions, managers must consider speed, completeness, dependability, capability, frequency, and cost associated with the performance characteristic of each transport mode. Table 13.2 ranks the performance characteristic of each of the five modes of transportation according to these criteria.

TABLE 13.2. Transportation Mode Characteristics

Attribute	Motor	Rail	Air	Water	Pipeline
Speed/transit time	Fast	Slow	Very fast	Slow	Slow
Cost	High	Low	Very high	Low	Low
Accessibility	Very high	High	Limited	Poor	Very poor
Reliability of service	Very high	High	Variable	Moderate	Very high
Safety	Poor	Moderate	Very high	High	Very high
Security	Poor	High	Very high	Moderate	Very high
Bulk transport	Moderate	Very high	Very poor	Very high	Poor
Small package delivery	High	Poor	Very high	Poor	Poor
Intermodal capability	Very high	Very high	High	Very high	Poor

13.3.7 Intermodal Transportation

One of the most debated topics in the field of transportation is the proper allocation of freight traffic among the five transport modes. The issue revolves around the supposition that shippers do not always use the most appropriate carrier mode to transport products and that too much or too little traffic is being carrier by one mode, resulting in loss of efficiencies and possible injuries to the environment. One of the methods to combat possible inequalities in transport mode use is the application of *intermodal* methods. The basis of intermodal forms of transportation resides in the development of systems that integrate or combine various elements of the five modes of transportation. For the most part, intermodal transportation consists of variations in the following two methods: *truck trailer on a rail flatcar* (TOFC) and *container on a rail flatcar* (COFC). Some carriers (CSX, Maersk Sealand, and FedEx) have multimodal capabilities, allowing them to utilize the most efficient and economical combination of intermodal transportation for their customers.

13.3.7.1 TOFC

The basis of intermodalism in transport is how to facilitate the transfer of unitized loads from one form of transport to another. TOFC, often called the *piggyback system*, is a method by which a truck trailer load is transferred in transit from the truck carrier to another transit mode without unloading and reloading product. An example is the use of a motor tractor and trailer for local pick up. When the route is completed, the tractor-trailer is then loaded intact onto a rail flatbed, which then executes a long-distance haul. Upon arrival, the rig is unloaded and motor transport would proceed to carry out delivery to the end-use customer. In this TOFC example the low-cost advantages of long-haul rail transport is combined with the flexibility and convenience of the motor carrier. There are several forms of TOFC systems. Piggyback methods are used between motor carrier and rail, between motor carrier and transoceanic vessels or barge (*fishyback*), motor carrier and container, and motor carrier, container, and air (*birdyback*).

13.3.7.2 COFC

The transfer of containers from one mode of transport to another is a key component of intermodal transportation. A container system is characterized by the storage of products in a box or similar form of container. Normally, container size is standardized to facilitate loading and unloading across several transportation modes. In addition to ease of movement, containers also inhibit theft and decrease the possibility of damage. Operationally, COFC methods function similarly to TOFC methods. Procedurally, the container(s) are first loaded onto motor flatbed trailers at the shipping point. After what is usually a short haul, the containers are then unloaded onto flatbed railcars, waterway carriers, or special air cargo planes for delivery. Upon arrival, the containers are loaded back onto motor carriers for customer delivery.

A variation on the intermodal forms of transport discussed above is the use of an innovative intermodal vehicle called a *railroader* or a *trailertrain*. A railroader is a special form of vehicle that combines motor and rail transport in a single piece of equipment. The railroader resembles a conventional motor trailer that has been specially equipped with both road tires and railroad track wheels that are rotated as necessary. When the vehicle is used as a railcar, the road tires are retracted and the vehicle rides directly on the steel rail wheels. The advantage of a railroader is savings in time and handling costs to mount conventional semi-truck systems onto railcars. The disadvantage is obviously the excess weight and added costs caused by hauling the steel wheels when the trailer is on the highway.

The use of intermodal methods of transportation promises great benefits to shippers. To begin with, intermodalism facilitates *global trade*. The capacity and efficiency of ocean transport, combined with container, motor, and rail transport, enables goods and materials to be rapidly transported to their destinations across global space and time efficiently and at the lowest cost making international trade economically and marketplace-wise possible. In 2011 intermodal accounted for 21 % of revenue for all major U.S. railroads. Exports and imports accounted for 55 % of U.S. rail intermodal traffic. Secondly, intermodalism provides *greater accessibility by linking the individual modes*. It provides better and more flexible services as well as wider area coverage at lower rates to move products from such combinations as ship to rail to motor, motor to rail to domestic river transport, and others. Finally, intermodal provides for *overall cost efficiency without sacrificing service quality or accessibility*. By combining the optimum transportation modes to fit the transportation task, it offers shippers the ability to tailor a transportation package for each system that maximizes transport efficiencies. In the end, intermodal poses as a viable contender to improve supply chain performance. It is also likely to grow as services continue to broaden and improve, while the major railroads commit larger amounts of capital dollars to improving infrastructure and service [17].

13.4 TRANSPORTATION MANAGEMENT FUNCTIONS

The effective day-to-day management of transportation activities is absolutely necessary for the smooth functioning of the supply chain. It is the responsibility of the transportation function to perform such tasks as the selection of proper carriers, monitoring and executing inbound and outbound logistics activities, pricing, scheduling, and transport routing. The every-day functions of transportation management are illustrated in Figure 13.4.

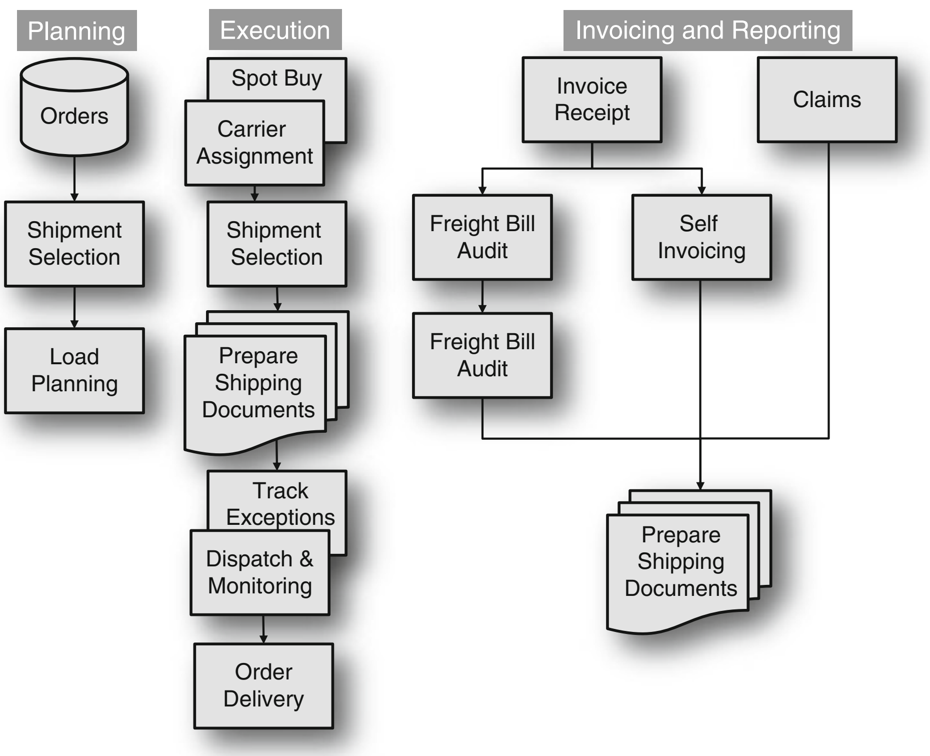


FIGURE 13.4 Transportation management activities.

In planning and executing these functions, transportation planners are concerned with such questions as:

- How will customer service objectives influence carrier selection and cost?
- If the firm possesses its own transportation equipment, what is the mix of shipping carried privately and contracted out to public companies?
- What is the cost in labor, equipment, and maintenance to run the private carrier fleet, and is it cost-effective?
- What transportation capacities are required to handle expected customer demands?
- How much will transportation cost to support current and projected levels of inbound and outbound shipping costs?
- Does transportation possess a formal process for public carrier selection?

- Are there formal procedures in place to ensure transportation is receiving the best freight rates possible?
- Should the company use a freight rating service?
- Can the transportation function benefit by the implementation of software support tools?
- What are the performance measurements to ensure that transportation is achieving optimal efficiency and productivity?

Whether it is the development of the enterprise's transportation strategy or the daily requirement to service customers and purchase from suppliers, responses to the above questions require effective understanding of transportation economics and carrier pricing. Driving all transportation decisions are seven possible factors that are used as the foundation of all transportation planning activities. Failure to understand the below principles results in excess costs and poor utilization of transportation capabilities.

- *Distance*. The distance products travel from point of origin to the destination has a critical impact on the transportation decision. Because of the *tapering principle*, the longer the distance the more the fixed and variable costs of transport can be spread out over the total trip. Since more distance is covered with the same fuel and labor and there are less stops, the cost decreases.
- *Volume*. Economies of scale are gained in this factor from the fact that transport cost per unit of weight decreases as volume increases. Leveraging distance and weight factors drive planners to seek to gather full truck load shipments, especially as the distance grows longer, during shipment planning.
- *Density*. This factor attempts to utilize weight and space considerations when planning for transportation. Weight and volume are important because transportation pricing is usually determined by weight, such as hundredweight (CWT). Since it is volume rather than weight that is the constraint, as product weight increases, products are generally assessed a lesser cost per unit of weight. Higher density products have a minimum impact on price because variable costs are not greatly impacted and remain relatively unchanged as weight increases. In contrast, once a transport vehicle's *volume* is filled, it cannot take on more goods regardless of the actual weight of the cargo.
- *Stowability*. This factor relates to the actual volume cube of the product to be shipped and whether it optimizes standard transport vehicle capacities. Simply, size and storage restrictions for some products, such as heavy wheel products, steel rods, and trash cans, significantly increase transport costs due to use of specialized vehicles or inability to optimize vehicle shipping volumes.
- *Handling*. The loading, unloading, and storage of some products may require shipping planners to utilize costly handling or equipment.
- *Liability*. Many products require shippers to plan for special modes of transport because of product perishability or damage prevention, the use of insurance to guard against damage or theft, or the use of containers or special marking and handling to ensure transport safety. These types of considerations will increase transportation costs.

- *Vehicle profitability*. Perhaps one of the oldest problems in transportation management is vehicle return. Often when products are transported to a destination, the return trip is made without any cargo, or *dead-head*. This condition is purely a waste of assets and variable costs which are simply added to the original shipment price. Such a condition occurs when there are imbalances in the direction of transport. The optimal condition is to have a balanced transport environment where once a load is delivered the transport vehicle can pick up another load, or *back-haul*, to the point of origin.

13.4.1 The Role of Transportation Administration

The role of transportation administration is to apply these principles to execute effectively and efficiently the functions relating to the planning and execution of transportation activities. The fundamental responsibility of transportation administration is to perform the *daily functions* of transportation operations (Figure 13.4). These daily functions are broken down into three major areas: *shipment planning* (order selection, carrier pricing, loading, and pick-up sequencing at the dock area); *execution* (modal and carrier selection, managing shipping documents, shipment tracking, monitoring, and delivery); and *invoicing and reporting* (freight bill audit, claims, and performance). Once orders are selected for shipment, it is transportation's responsibility to perform *load management*. Because load planning directly impacts transportation efficiency, traffic managers strive to match future shipment requirements with the necessary transportation equipment. Using automation tools, such as a *transportation management system* (TMS), provides traffic managers with visibility into future load demand so that processes linked to carrier search and price/rate negotiation can occur in advance. Once the load is determined, then next step is *equipment scheduling*. Activities in this area are concerned with the effective management of the facility's loading and unloading docks and the flow of traffic in the yard. Scheduling functions are associated with vehicle arrival and departure times so as to prevent wasteful bottlenecks and dock activity imbalances.

As the loading process begins, a critical task is shipment *documentation.* Transportation administration is responsible for generating bills of lading, freight bills, and shipment manifests that define the nature, quantity, and cost of the load being shipped. As the shipment leaves the loading dock, transportation is expected to perform delivery *tracing and expediting*. Transportation administration is also responsible for informing the consignee of the expected delivery, tracing the progress of the shipment, expediting the order, and tracking lost or late shipments. At the end of the delivery process, transportation is responsible for *freight bill auditing and claims management*. Transportation administration is responsible for auditing the accuracy of the freight bill and managing claims due to shipment loss or damage and any overcharge/undercharge on the amount billed. Finally, transportation administration executes all activities furthering *logistical integration.* Transportation plays a critical role as the liaison between shipment information and the logistics needs of the rest of the organization. Traffic managers provide timely information regarding transportation availability, timing, and costs to assist other departments in the execution of daily shipment requirements. It is also transportation administration's responsibility to assist in the development of the company's logistics plan.

13.4.1.1 Transportation Management Process

Against the backdrop of the seven transportation operating principles detailed above, there are several fundamental steps that constitute the transportation management process. As illustrated on Figure 13.5, the transportation management process is driven by the overall logistics plan. The logistics plan defines transportation's role in achieving the three objectives of logistics: cost reduction, capital reduction, and increased service.

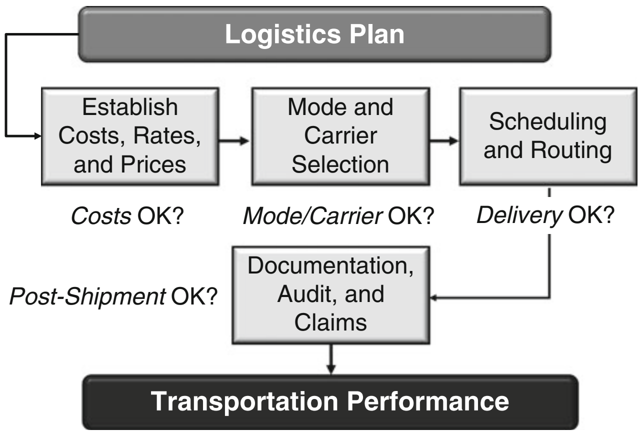


FIGURE 13.5 Transportation management process.

The first step in the transportation management process is determining whether the established costs, rates, and prices are *OK* and are in support of the logistics plan. The management of transportation costs involves determining the various types of costs of operating a transportation fleet. These costs are classified as fixed, variable, joint, and common; *rates* are published prices for shipments; and *pricing* is based on a cost plus a charge determined by prevailing market forces.

The choice of transport mode and carrier is the second step in the transportation management process. The goal is to determine whether the transport mode and carrier selection decisions being made are *OK* by weighing them against the objective of achieving the lowest possible transport cost for the maximum service. When selecting modes and carriers, transportation management must address specific shipping issues relating to special shipping needs, the rates and services offered by competing carriers, and the probability of shipment loss, damage, or delivery delay.

The third step in the transportation management process is scheduling and routing. The goal is to validate whether shipment deliveries and service performance are *OK*. *Vehicle scheduling* is the selection of which customer orders are to be delivered by a single vehicle. *Vehicle routing* establishes the sequence in which selected customer orders are to be delivered during the delivery route.

The final step in the transportation management process is to ensure that post-shipment functions are effectively performed and the necessary documentation, shipment charges, carrier payment, and claims management are *OK* and match company guidelines. The result of the transportation management process is the daily shipment plan. The shipment plan drives order shipment selection, postponement processing, private fleet and carrier routing and scheduling, vehicle loading and shipment, and post-shipment processes.

13.4.1.2 Establish Costs, Rates, and Prices

As is illustrated in Figure 13.5, establishing costs, rates, and prices for shipments is the first step in the transportation management process.

Transportation Cost. Regardless of the transportation mode and ownership (whether a private fleet or a for-hire carrier), companies bear several types of cost. Transportation management must understand these costs and ensure that the average revenue generated by the transportation selection covers at least the average total cost. There are four types of cost associated with transportation carriage. The first type is *fixed costs*. This type of cost arises with the ownership of transportation assets. Examples are motor vehicles and trailers, terminals, ports, pipelines, docking systems, rights-of-way, information systems, taxes, rents and loan interests, and materials handling equipment. The fixed costs of ownership are not directly influenced by shipment volume. In the short term, expenses associated with fixed assets must be covered by revenue contributions above variable costs on a per shipment basis (often termed the transportation *marginal cost*).

Variable cost constitute the second type of transportation cost. This type of cost arises when transportation equipment and/or services are used to make a shipment. Variable cost is significantly affected by shipment volume. Examples of variable cost are fuel, labor, and vehicle maintenance. These expenses are generally determined as a cost per mile or per unit of weight. The variable cost of operations represents the minimum amount a carrier must charge to pay operating expenses. The third type of transportation cost is *joint costs*. These are costs shared by the shipper and carrier to perform a certain transport service. An example is backhaul. When a carrier agrees to transport a shipment, there is an implicit decision to incur a joint cost for the backhaul. Either the original shipper shares in the backhaul cost or another shipper must be found to pay for the cost of the backhaul. The final type of transportation cost is *common costs*. These are costs for equipment such as terminals, rights-of-way, and management expenses that are spread proportionally over all shippers using the service. Normally, these costs are allocated based on the level of activity an individual shipper generates during the shipment process.

Transportation costs are based on two components: the *volume* of the shipment and the *distance* the shipment travels from point of origin to the destination. The relation of shipment volume and distance and transport equipment fixed and variable cost is illustrated in Figure 13.6.

Based on Figure 13.6, several factors relating to transportation cost can be determined.

- The fixed cost of transportation equipment does not vary by shipment volume and distance.
- The variable costs of transportation equipment varies significantly by shipment volume and distance. This is to be expected because cost elements such as fuels and drivers' times are a function of distance (time).
- The total cost of transportation grows as the volume and distance increase.
- The average cost per transportation unit will decline as the volume and distance increases.

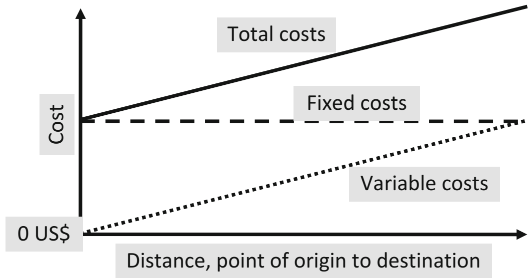


FIGURE 13.6 Transportation cost - distance.

The relation of costs to volume and distance are illustrated in the following example:

ABC Motor Transports, Inc., operates a fleet of trucks and 40-ft trailers that travel from Chicago to Cleveland and Detroit. The fixed cost for the fleet per year has averaged US $8,500,000. ABC determined that the average variable cost between Chicago and Cleveland and Detroit is US$350 per truck load. For the past 12 months, ABC has performed 110,000 shipments. To illustrate the annual costs the following spreadsheet is displayed (Table 13.3):

TABLE 13.3. Volume and Cost

Truck and trailer costs	US$
Fixed cost/year	$8,500,000
Variable cost/truck and trailer	$350
Shipments	
Number of schipments	110,000
Total variable cost	$38,500,000
Total cost	$47,000,000
Average cost per truck and trailer	$427.27

The total cost is calculated by multiplying the average variable cost times the number of shipments and then adding the answer to the annual fixed costs. The average cost per truck load is calculated by dividing the total cost by the number of annual shipments.

The above costing example explores the concept of transportation costing from an aggregate viewpoint. To view transportation cost from a more detailed vantage point, it is necessary to describe the four basic cost components of transportation: *line haul, pickup and delivery, terminal handling*, and *billing and collecting*. The four components apply to all transportation modes.

- *Line haul*. Whether it is a motor trailer, container, railcar or other vehicle, the carrier (private or for-hire) incurs both fixed and variable costs. While the asset costs are fixed and incurred regardless of whether the vehicle is used or not, the carrier must calculate the variable costs per shipment. These costs, as previously shown, vary with the distance traveled, not the weight carried. When operating the vehicle, the carrier incurs basically the same costs to move shipments whether the vehicle is full or empty. The only difference is the added cost caused by the distance traveled.

- *Pickup and delivery*. These costs are charged by the carrier each time a shipment is picked up and delivered. The focus of these costs is a function of the *time* a vehicle spends in pickup and delivery activities. An important part of these costs is the amount of time vehicles are idle during the delivery. This cost is lowered by using standardized shipments that facilitate loading and unloading and consolidating orders so that pickup and delivery is performed in as few trips as possible. Another method to cut costs is to use detailed scheduling of delivery and pickup times.
- *Terminal handling*. Terminals are temporary consolidation points positioned in between pickup and final delivery. Each time that a vehicle uses a terminal, extra costs are incurred for unloading, sorting, consolidation into new loads, reloading, and shipment to the next delivery point in the channel network. The more individual shipments in the vehicle are delivered to different destinations, the more consignors can expect to pay. Terminal-handling costs are reduced by placing fewer orders in the shipment while still shipping full truckloads.
- *Billing and collecting*. Each time a shipment is made, the appropriate documentation and invoicing must be generated by the carrier. Billing, auditing, and collecting costs are reduced by consolidating shipments and reducing the pickup and delivery frequency during the transportation route.

Exercise 13.1: Detailed Transportation Cost

The traffic manager at ABC Electronics needs to ship 30,000 lb of a popular TV from the main warehouse in Chicago to ABC's regional warehouse in Los Angeles (2,000 miles away). The traffic manager is using a contract carrier to perform the shipment. The load must also make a stop at ABC's cross-docking warehouse in Kansas City before completing the route where the product will undergo relabeling to reflect California product data. The traffic manager is interested in calculating the cost per hundred weight (cwt). To assist in the calculation of the cost, the traffic manager has compiled the following information:

- Transportation line-haul cost is US$3.5 per mile in the carrier's 40-ft trailer.
- The pickup and delivery cost is US$125.00 per shipment.
- The fuel charge for the trip is US$900.
- The terminal cost is US$225.00 per shipment.
- The billing and collections is .5 % of the total cost.

The traffic manager is interested in two costs. The first is the total line-haul cost of the proposed shipment of 30,000 lb. This value varies with (1) the cost per mile, and (2) the distance moved. The second cost is the cost per hundredweight (cwt) of the shipment. This values varies with (1) the cost per mile, (2) the distance moved, and (3) the weight moved. The cwt cost is calculated by first determining the line-haul cost and then dividing the result by the weight.

(a) *Line-haul cost*: [(Distance miles × line-haul cost) + (terminal stops × terminal handling costs) + pickup and delivery costs + Fuel costs] × billing and collections = (2,000 × US$3.50) + (1 × US$250) + US$125 + US$900 = US $8,275 × 0.5 % = US$8,316.38.

(b) *Cost per hundred weight (cwt.)* = Total line-haul cost/(Load weight/100) = US $8,316.38/(30,000/100) = US$27.72.

The transportation planner can now use this cost to compare with prices of other carriers when making a carrier selection.

Regardless of the transportation mode, shippers can take proactive steps to better control their transportation costs – steps that can transform a shipper's transportation operation and improve their carrier relationships. Six steps have been identified [18]. The first is mode and lane optimization. *Mode optimization* means putting the right-sized shipment in the right-sized mode. *Line optimization* means leveraging the most attractive rates on certain geographical lanes. A transportation management system (TMS) can greatly assist in this effort. The second step is to improve carrier relations by reducing expediting and other restrictions of shipment flow. Third, sharing shipment forecasts allows carriers to plan their work schedules rather than having to respond to emergency situations and unknown volumes. Fourth, searching for rate reductions by eliminating expedite shipments and drafting multi-year rate contracts. The fifth step is minimizing pickup and delivery times. An LTL driver and truck, for example, is estimated at US$100 an hour. Finally, costs are contained by improved packaging and crating that reduces freight claims, speeds handling, and improves shipment density.

Transportation Rates and Prices. When contracting with for-hire carriers, transportation departments are concerned with rates and prices. Determining the price for a shipment would be a simple affair if there was a single table of prices by ton-mile, charging consignors a fee to move each ton of product each mile. In reality, carriers must take into consideration a variety of factors before a price is determined. Carrier pricing is a sophisticated affair in which the charge for services must be fair and reasonable for both sides. Historically, carriers used published rates as the basis for shipment pricing. The term *rate* is a vestige of a time when transportation rates were government regulated. A rate is the lawful charge found in a rate tariff book indicating the payment for a given transportation service. Tariffs published by a company is termed an *individual tariff* and those set by a rate bureau used in common by many carriers is referred to as *bureau tariffs.*

Before deregulation, the tariffs charged by public carriers were established by rate bureaus composed of carrier representatives. Shippers would appear before these bureaus and petition for lower rates on specific commodities or transit routes. Although rate bureaus still exist, since deregulation during the period 1978 and 1996, most rates are the result of direct negotiation between the shipper and the carrier. Although each public carrier publishes transport rates, few shippers pay them. Instead, through a series of negotiations, a discount off the rate is agreed on which then serves as the actual price.

In general, rate structures are related to *volume, distance*, and *demand* [19]. Volume rates reflect pricing based on size of the shipment. Because high volumes are transported at lower rates, large loads are considered as justification for quoting a shipper special rates. There are several forms of rates based on distance. A *uniform rate* describes a single transport rate for all shipments regardless of the origin–destination. An example is the U.S. first-class postage. Other distance rate types include *proportional rates* (rates based on a published rate structure and the proportion of service cost to ship)*, tapering rates* (based on the principle that as the distance grows rates will increase but at a decreasing rate), and *blanket rates* (single rates that cover a wide area at the origin, destination, or both). Finally, *demand-related* rates are based not so much on established rates or distance traveled, but the state of available carrier capacities, importance to the shipper, and availability of alternative transportation services.

Each of the three general rates structures have specific rate models. A *class rate* is determined by first classifying the product being shipped and then specifying the price based on a preestablished freight tariff classifications. For motor freight, carriers can use the *National Motor Freight Classification,* while rail classifications are published in the *Uniform Freight Classification.* A key responsibility of the transportation department is to negotiate the lowest rate by being familiar with these tables. Once the classification is identified, the rate is determined. The rate charge per hundred weight (cwt) is based on the distance between shipment origin and the intended destination detailed in the tariff table subject to minimum charges and any surcharges. Another rate model is a *commodity rate.* This is a simple rate, published without reference to classification, used by carriers operating over a fixed route (such as a rail carrier or pipeline). This rate type is often used to move specified bulk items set by the carrier.

An *exception rate* is a special modification to the national classification offered by an individual carrier. Normally this special rate is created to attract shippers in a specific geographical area, origin/destination, or commodity justified by either competitive or high-volume loads. Examples include an *aggregate tender rate* used when a shipper agrees to use a carrier for multiple shipments in exchange for a special rate or a *limited service rate* where the shipper performs selected services normally performed by the carrier in exchange for a discount. Finally, there are several *special rates and services* provided by carriers. These rates are based on special services, such as the use of just one carrier (*local rate*) or multiple carriers (*joint rate*); *transit service* (shipment can be stopped at an intermediate point); *diversion and reconsignment* (ability to change route or destination while in transit); *demurrage* or *detention* (using rail or motor transportation equipment for temporary in transit storage); *split delivery* (when portions of a shipment are to be delivered to different destinations), and *environmental services* (when refrigeration, heating, and ventilation is needed).

Finally, transportation cost are determined by using several *pricing* models. In this method, charges are based on a cost plus a charge determined by prevailing market forces. Pricing centers on two approaches: the cost incurred by the carrier to provide the service and the value of service perceived by the consignor. There are two common pricing models. In *cost-of-service,* the variable or marginal cost of providing the transportation service plus a profit margin is used as the basis when setting prices. For the most part, the profit margin is simply what the "market will bear" and is expressed as a percentage of the cost of the service. This type of pricing is most commonly used for low-value goods or in highly competitive situations. In the second model, *value-of-service*, charges are based on the value of the shipment as perceived by the consignor. For example, high-valued products are assessed high prices, and low-value commodities are assessed low prices. The rationale is that high-value products are more expensive to ship and generally involve more risk for the carrier. The actual prices charged are subject to market competition and reflect the value and cost of the service.

Another pricing method is *combination*. In this method, transport charges are set at a mid-point between the cost-of-service minimum and the value-of-service maximum. For the most part, traffic managers must be aware of the current range of prices being charged by carriers and negotiate shipment prices that reflect market competition. In the *net-rate* model, carriers simplify pricing to fit an individual consignor's circumstances and needs.

Specifically, traditional elements, such as rates, costs, margins, and discounts, are collapsed into an all-inclusive price. The advantage of this method is that it significantly reduces the cost of the pricing process, carrier billing and administration, and customer payment. It also makes it easier for customers to compare rates and generate savings in shipment costs.

Terms of Sale. A critical factor in transportation purchasing is determining the point at which title to the goods is transferred from seller to buyer. The time and place of title transfer is critical because it determines control over mode and carrier selection, transportation rate negotiation, and risk. Terms of sale in the U.S. are broken into domestic terms and international terms. Domestic terms are detailed below (Table 13.4):

TABLE 13.4. U.S. Terms of Sale

Group	Term	Description
E	Ex Works (EXW)	The importer agrees to take possession of the shipment at the point of origin and to bear all of the cost and risk of transporting the goods to the destination
F	Free Carrier (FCA)	The exporter incurrs the cost of delivering the shipment to the carrier designated by the importer. FCA is normally used with intermodal transport
	Free Alongside Ship (FAS)	Same as above, but is used for water transport only. Risk is transferred when goods are delivered alongside the ship. Importer pays cost of loading
	Free On Board (FOB)	Same as above, but is used for water transport only. Risk is transferred when goods cross the ship's rail. Exporter pays for loading
C	Cost of Freight (CFR)	Shipment contracts that obligate the exporter to obtain and pay for shipment. CFR is used for shipments by water only. Risk passes to importer at ship's rail
	Carriage Paid To (CPT)	Same as above, but is applied to any transport mode. Risk passes to importer when shipment delivered to the main carrier
	Cost, Insurance, Freight (CIF)	Same as above, plus exporter pays for the cost of insurance. Risk of damage is the same as that for CFR and CPT
	Carriage and Insurance Paid To (CIP)	Same as above, but importer bears the risk of loss or damage
D	Delivered at Terminal (DAT)	Seller delivers goods to a named place of destination. The seller bears all risks involved in bringing the goods to and unloading them at the place of destination
	Delivered at Place (DAP)	Seller delivers goods at the buyer's disposal arriving for unloading at the named destination. Seller bears all risks involved in bringing the goods to the named place
	Delivered Duty Paid (DDP)	Same as above, plus exporter is responsible for clearing the goods for import and paying the customs duties

Note: international terms of sales are covered in Chapter 14

Issues related to domestic terms are as follows:

- *Ownership transfer*. This issue is concerned with the determination of when ownership and title of the shipment passes from the seller to the buyer. If the goods are shipped *Free on Board* (*FOB*) *seller's location (origin)*, the buyer automatically acquires title at the moment the shipment is delivered to the carrier. If the goods are shipped *FOB buyer's location (destination)*, title is transferred when the carrier delivers the goods to the buyer.
- *Responsibility for carrier payment*. In general, the seller pays the carrier for goods sold under FOB *destination*, while the buyer pays the carrier under FOB *origin* terms. Options to use *Freight Prepaid* or *Freight Collect* should be specified on the FOB terms.
- *Responsibility for freight claims*. Normally, the seller is responsible for claims for goods sold under *FOB destination*, while the buyer is responsible under *FOB origin* terms.
- *Coordination of freight movement*. Both consignors and carriers want to use FOB to negotiate lower freight rates and control the level of service. Some buyers, who integrate closely the flow of inbound and outbound freight, often want to combine shipment volumes as a leverage to gain lower rates with carriers. It is also possible to retain carrier capacity or improve access to equipment by generating continuous movement of shipments.

Purchasers must be cognizant of the ramifications of each method because of legal complications over such things as damage, loss, or breach of contract. There are several variations of the FOB terms of sale detailed in the following table (Table 13.5):

TABLE 13.5. U.S. Terms of Sale

Free on Board (FOB) terms	Goods owner	Selects & pays carrier	Bears freight cost
FOB origin			
Freight collect	Buyer	Buyer	Buyer
Freight prepaid	Buyer	Seller	Seller
Freight prepaid & charged back	Buyer	Seller	Seller
FOB destination			
Freight collect	Seller	Buyer	Buyer
Freight prepaid	Seller	Seller	Seller
Freight collect & allowed	Seller	Buyer	Seller

13.4.1.3 Mode and Carrier Selection

The choice of transportation mode and carrier is the second step in the transportation management process. The goal of the process is to achieve the lowest possible transit cost for the maximum service. In addition, when selecting a mode and a carrier, transportation management must address specific shipping issues relating to all required special shipping needs; the rates and services offered by competing carriers; and the probability of loss, damage, or delivery delay. Although the everyday selection of modes and carriers does not necessitate significant and time-consuming analysis, the relative advantages and disadvantages of the various modes and carriers normally employed must be constantly reviewed as conditions change or exceptions arise.

Transportation Mode Selection

- This step answers the question "How will shipment be transported from the point of origin to the destination?" As detailed above, there are five modes that can be chosen: motor, railroad, water, pipeline, and air, plus the availability of intermodal. Each mode has inherent service and cost advantages and disadvantages. Actual selection of a modal option requires consideration of the following transportation attributes:
- *Accessibility*. This attribute considers the ability of a transport mode to reach origin and destination points and provide service over the specified route. The geographical limits of a mode's capabilities, infrastructure, and governmental regulatory agencies affect mode selection. For example, air, rail, water, and pipeline face limitations due to infrastructure. Motor cannot transport shipment across continents separated by water. Intermodal can assist in lessening these limitations by combining modes.
- *Capacity*. This attribute considers how closely the capacity of the transport mode matches the size and nature of the shipment. Some modes, such as rail and water, are optimal for bulk shipments, while motor and air are best used for small shipments. Pipelines are limited by the nature of the product being transported.
- *Transit time*. This attribute is defined as the total elapsed time that it takes to transport a shipment from origin to destination. Air transport is very fast, but loses some of its velocity as pickup and delivery must be handled by intermodal. Motor is relatively fast and can provide door-to-door service. Rail, water, and pipeline are slow and require intermodal assistance.
- *Reliability*. This attribute refers to the consistency of delivery time provided by a transport mode. The more reliable a mode, the easier it is for companies to plan supply chain activities. Motor and air are the most reliable while rail and water are challenged by capacity and congestion.
- *Safety*. This attribute refers to how safely products are transported without damage, theft, or misplacement due to poor freight-handling techniques, poor ride quality, and accidents. Air and motor carriage have the best reputation for safety while water and rail expose shipments to movement and weather-related handling problems.
- *Cost*. This attribute refers to the rate for transporting the shipment plus any additional service fees. The key element in cost is product value. For example, products that are low value and shipped in bulk use an inexpensive modal choice. In general, rail, water, and pipeline have a very low-cost per ton-mile, but have slow speed. Air and motor carriage are high-cost modes used for expensive or time-constrained items with fast delivery and high safety.

Choosing from among the five modes requires consideration of multiple issues. The following table highlights the critical issues associated with each modes (Table 13.6).

Other factors impact the selection of transport mode. For example, the nature of the products (size, value, and transportability) may eliminate some of the transport modes. Another factor is shipment characteristics (size, route, and required speed). In additional, the inability to use intermodal transportation also limit modal selection.

TABLE 13.6. Comparison of Modal Capabilities [20]

Mode	Strengths	Limitations	Primary role	Product attributes	Example products
Truck	Accessible Fast & versatile Customer service	Limited capacity High cost	Move smaller shipments in local, regional, and national market	High value Finished goods Low volume	Food Clothing Electronics Furniture
Rail	High capacity Low cost	Accessibility Inconsistent service Damage rates	Move large shipments of domestic freight long distances	Low value Raw materials High volume	Coal/coke Lumber/paper Grain Chemicals
Air	Speed Load protection Flexibility	Accessibility High cost Limited capacity	Move urgent shipments of freight and smaller shipments of international freight	High value Finished goods Low volume Time sensitive	Computer Periodicals Pharma products B2C deliveries
Water	High capacity Low cost International capabilities	Slow Accessibility	Move large domestic shipments via rivers, canals and large shipments of international freight	Low values Raw materials Bulk commodities Containerized goods	Crude oil Ores/minerals Farm products Clothing Electronics Toys
Pipeline	In-transit storage Efficiency Low cost	Slow Accessibility	Move large volumes of domestic freight long distances	Low values Liquid commodities Not time sensitive	Crude oil Petroleum Gasoline Natural gas

Exercise 13.2: Choosing a Transportation Mode [21]

The traffic planner at ABC Electronics has been offered a buying opportunity by a customer to increase ABC's sales and margins on an important item in exchange for a shorter delivery time. Currently, the customer is buying 1,200 cases per order. ABC's cost per case is US $200 and the margin per case is 12 %. Orders are presently shipped using ABC Freight at a cost of US$2.50 a case and takes 9 days in transit. To reduce delivery days, the customer is incenting ABC by offering to increase the case order by 5 % for every day ABC can trim off the delivery time. The planner has contacted three alternative freight companies to gather information. The results are portrayed in the following base table of price and delivery times:

Modes	Rate/per case ($)	Delivery/days	Cases
ABC freight	2.50	9	1,200
XYZ freight	3.75	6	1,380
Advanced freight	5.50	4	1,500
Able freight	7.25	2	1,620

Based on the information, the planner then applied the incentive values and has compiled the following data (Table 13.7).

TABLE 13.7. Choosing a Transportation Mode

Modes	Rates/per case ($)	Delivery/ days	Cases	Gross Profit ($)	Transportation cost ($)	Net profit ($)
ABC Freight	2.50	9	1,200	28,800.00	3,000.00	25,800.00
XYZ Freight	3.75	6	1,380	33,120.00	5,175.00	27,945.00
Advanced Freight	5.50	4	1,500	36,000.00	8,250.00	27,750.00
Able Freight	7.25	2	1,620	38,880.00	11,745.00	27,135.00

Using the base information for ABC Freight, the planner then calculated which carrier would generate the most net profit for shipping days reduced. The planner used the following data:

1. *Cases*. The planner first starts with the use of XYZ Freight. The increase in cases is calculated as follows:

   (Current shipping cases [1,200] × case increase percent [5 %]) × (current delivery days [9] – new delivery days [6]) + the current shipping cases [1,200] or 1,380 cases. The same calculation is performed for the other three possible freight suppliers.
2. *Gross profit*. Next the planner calculated the net profit using XYZ Freight as follows: (Number of cases [1,380] × cost per case [US$200]) × margin [12 %].
3. *Transportation cost*. The transportation cost was calculated as follows:

   Rate per case [US$3.75] × number of cases [1,380].
4. *Net profit*. Finally, the net profit was calculated as

   Gross profit [US$33,120] – transportation cost [US$5,175].

Based on the net profit, XYZ Freight was chosen by the supplier.

Carrier Selection. Carrier selection follows five general principles. In the first, *carrier reduction*, transportation management focuses on reducing the carrier database. Concentrating the number of carriers into a few select suppliers permits shippers to develop a collaborative relationship that enhances mutual partnership; increases negotiating power, reduces rates, and increases service due to increased volumes and revenues enjoyed by a dedicated carrier; and reduces other logistics costs such as information technology, inventory, and warehousing.

Once carriers are identified, traffic managers progress to the next step: *comparing available alternatives*. The goal of this step is to match the shipment with the most appropriate mode of transport. This means, first of all, selecting a carrier that offers the best rate for the service. Second, a carrier should be selected with documented performance. Comparing possible carrier alternatives is a difficult task: Some transport modes have markedly different attributes not shared by other modes, rendering them not easily substitutable. Studies have shown that most selection is based on a number of criteria including rates, loss and damage record, claims processing experience, transit-time reliability, past negotiations experience, quality of on-time pick-up and delivery, and equipment availability.

The third principle of carrier selection is for traffic management to *continually review* their carrier selection processes with an eye toward continuous cost reduction and service improvement. In cases where the transportation fleet is privately owned, the firm is naturally averse to using public carriers, preferring to search for every opportunity to optimize internal resources. In other cases, the carrier selection process is the result of a strategic decision made at the time the supply channel network was structured, and there is resistance to change. In any case, traffic managers must continually search for ways to buy cost-effective transportation. Some of the methods which can be employed are as follows:

- *Freight bill audit*. Freight bills must be continually audited to ensure accuracy of the negotiated rate as well as the correct charges. Audits ensure that traffic management is aware of possible adverse rate changes occurring over time.
- *Monitoring demurrage/detention*. Shippers need to be aware of demurrage and detention charges. Proper internal scheduling reduces the time railcars, trailers, barges, and so on sit idle at the company site.
- *Packaging review*. Changes in containerization or packaging affect the choice of carrier. Reusable, lighter, or more efficient packing methods result in easier to handle loads that might warrant a reduction in cost or change in carrier.
- *Carrier relations*. Traffic management should always be working with carriers to mutually discover methods of improving service and reducing costs.
- *Outsourcing*. One method to handle all or part of a firm's transportation needs is to outsource them to a logistics services company. Some of the advantages are (1) keeping internal costs low by outsourcing tasks, (2) more customized services, (3) transportation cost reduction, and (4) acquisition of computerized capabilities, such as EDI and Internet, without have to acquire them.

Developing *selection criteria* constitutes the fourth principle of carrier selection. Selection criteria is broadly divided into three areas: *traffic related, shipper related*, and *service* related. These three areas are detailed in Table 13.8.

TABLE 13.8. Factors Affecting Modal Choices

Traffic-related	Shipper-related	Service related
Length of haul	Size of firm	Speed (transit time)
Consignment of weight	Investment priorities	Reliability
Dimensions	Marketing strategies	Cost
Value	Spatial structure of production	Customer relations
Value density	and distribution systems	Geographicals coverage
(weight and cube)	Availability of rail sidings	Accessibility
Urgency	Stockholder policies	Availability of special
Regularity of shipment	Management structure	vehicle/equipment
Fragility	System of carrier evaluation	Monitoring of goods
Toxicity		Unitization
Perishability		Ancillary services (bulk breaking,
Packaging type		storage, etc.)
Special handling		Computer capabilities/
characteristics		compatibilities

For the most part, size of shipment, length of haul, transit time, and cost are the key factors employed. In making carrier selection choices, planners usually trade off one factor against another, rather than consider each separately in an ordered sequence.

The formulation of a rigorous *selection procedure* is the final principle of carrier selection. It is feasible that a shipper could use concurrently several modes of transport. Each mode possesses strengths and weaknesses when matched against a particular shipment requirement. In practice, the process for selecting the best mode and carrier is one that meets the company's shipping and cost objectives. This does not mean that any form can be used just to meet or exceed service targets, nor does it mean that the cheapest mode should be chosen to meet cost objectives. Similar to carrying inventory, traffic planners plot cost and quality of service and establish the optimum trade-off. The criteria most likely to be used in any optimization analysis are cost, speed, and reliability. As is exhibited in Figure 13.7, a decision model is constructed using costs and transit times, several different types of carrier marked A, B, C, and D, and their *x* and *y* coordinates corresponding to particular combinations of cost and transit time. Shippers prefer carriers above the curve, and when two modes lay on or close to the curve, other factors are then be applied. Another method would be the use of a computerized transportation modeling application that would calculate the optimum transportation mode based on user-defined or weighted parameters.

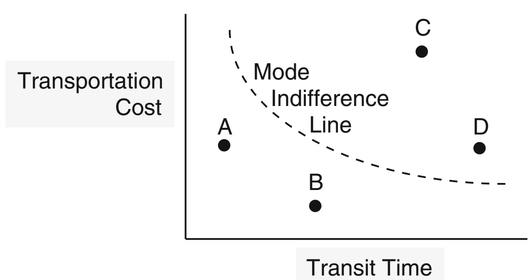


FIGURE 13.7 Plotting cost and transit time.

Traffic planners often find it advantageous to use more than one transportation mode to ship product. This circumstance occurs when the shipper uses intermodal methods; a given mode is regularly used for specific products, geographical locations, and types of customers; or emergency shipments or peak transit periods require different modes. Developments facilitating the use of multimode strategies include diversification of product ranges, growth in market areas, reduced dependence on a single mode, pressures driving inventory reduction, and innovations in intermodal systems. Such a strategy shifts transportation's concern from choosing the best mode, to an emphasis on deciding on the optimum allocation of traffic among several modes.

13.4.1.4 Negotiating Transportation Rates

When using public carriers, transportation managers must be diligent in negotiating shipment rates. Before deregulation, the rates charged by for-hire carriers were established by rate bureaus. Today, most rates are the result of direct negotiation between the shipper and the carrier. Although each for-hire carrier publishes transport rates, normally a series of negotiations involving specified services results in a discounted rate that serves as the actual price.

Rate negotiation is a four-step process. To begin with, shippers must assess the past, present, and expected products to be shipped and their shipping volumes. A critical activity is performing a *classification* of the products to be shipped by such criteria as density, stowability, handling, liability, and other value characteristics. The goal is to quantify the nature of the products, volume, origin and destination, and regularity of shipments that can be used during negotiations.

The second step is to contact carriers, present the relevant requirements, and solicit bids. In reviewing responses, some of the possible criteria shippers use include the following:

- The carrier's financial stability
- The carrier's reputation for reliable service
- Billing accuracy of the carrier
- The discount percent off the published rate proposed by the carrier
- The carrier's procedures for handling loss and damage claims
- Availability of special equipment, such as materials handling facilities, refrigeration, containerization, intermodal equipment, and others
- The location of the carrier's terminals

The final selection of carriers is determined normally by a combination of the price of the service and other quantifiable elements, as well as subjective predilection.

The third step in rate negotiations is the completion of any final discussions between shipper and carrier and award of the contract. The contract describes the extent of the services, plus other clauses relating to performance penalties and incentives. In addition, the contract should include the time limit of the contract, products and volumes to be shipped, assignment of liability, payment schedule, and the rates to be charged. The final step in the negotiation process is the ongoing administration of the contract after it has been awarded. A mutually beneficial contract includes the following:

- A pricing system that is simple to understand and execute for all of the shipper's/receiver's locations and commodities
- Price stability for the shipper during the life of the contract

- Shipping volume stability for the carrier during the life of the contract
- A simple and understandable freight bill payment process
- Capacity of the carrier to use computer technologies such as electronic data interchange (EDI) and scheduling systems
- Availability of data for auditing and performance measurement.

Exercise 13.3: Transportation Contract Estimating [22]
The traffic planner at Superior Sump Pumps, Inc. has been charged with negotiating a contract with the company's existing for-hire carriers. Superior has recently negotiated a purchase agreement with Ability Electric for a critical 1 hp. motor used in most of the company's finish pump products. The purchasing forecast for the next 12 months is 120,000 motors. The safety stock has been set to 50 % of the demand during the lead time. The anticipated purchasing lot size is 3,000 motors. The cost per unit is US$120, unit weight is 10 lb, and the carrying cost has been set at US$30.00 per motor.

As illustrated below, the traffic planner next compiled a list of the currently approved carriers, their shipping cost per hundred weight (cwt), and the demonstrated lead time for delivery from Ability Electric's plant to Superior's warehouse (Table 13.9).

TABLE 13.9. Base Transportation Cost Data

Transportation carriers	Base load (cwt)	Shipping cost (US$/cwt)	Lead time/days
ABC Motor Transport	200	$6.50	6
NW Rail	100	$7.50	12
Overland Motor	50	$9.00	4
Overland Motor	150	$7.50	4
Overland Motor	250	$5.50	4
Chicago Motor Carriers	100	$9.50	3
Chicago Motor Carriers	300	$6.00	3

Based on this information, the traffic planner has calculated the total cost to use the first carrier–ABC Motor Transport. In assembling the components of the total cost of the contract, the planner needs to consider several key elements:

1. What is the base cost for transporting the minimum lot size from ABC over the course of the next 12 months?
2. How much inventory would Superior be stocking on average for cycle, safety, and in-transit inventory?
3. How much carrying cost would Superior have to absorb for stocking all of this inventory?

With these data and objectives in mind, the traffic planner has calculated the total cost for using ABC Motor Transport. The calculation is as follows:

- Transportation cost = 120,000 × (US$6.50/10 lbs. weight) = US$78,000
- Cycle inventory = 2,000 (base load)/2 = 1,000 motors
- Safety inventory = (6/2 lead time days) × (120,000/365) = 986

- In-transit inventory = 120,000 × (6 days /365 days) = 1,973 motors
- Inventory cost = (1,000 + 986 + 1,973) × US$30 (carrying cost) = US$118,770
- Total cost of contract = US$78,000 + US$118,770 = US$196,770

The traffic planner must now perform the same calculation for the other carriers. (Note that Overland Motor) has several different weight and rate classes. The results appear in the below Table 13.10.

TABLE 13.10. Carrier Cost Analysis

Cost analysis							
Carrier	**Order size**	**Cost($)**	**Cycle inventory**	**Safety inventory**	**In-Transit Inventory**	**Inventory cost($)**	**Total Cost($)**
ABC Motor Transport	2,000	78,000.00	1,000	986	1,973	118,770.00	196,770.00
NW Rail	1,000	90,000.00	500	1,973	3,945	192,540.00	282,540.00
Overland Motor	500	108,000.00	250	658	1,315	66,690.00	174,690.00
Overland Motor	1,500	90,000.00	750	658	1,315	81,690.00	171,690.00
Overland Motor	2,500	66,000.00	1,250	658	1,315	96,690.00	162,690.00
Chicago Motor Carriers	1,000	114,000.00	500	493	986	59,370.00	173,370.00
Chicago Motor Carriers	3,000	72,000.00	1,500	493	986	89,370.00	161,370.00

Note that Chicago Motor Carriers with a base order size of 3,000 units has the least cost.

13.4.1.5 Scheduling and Routing

Scheduling and routing are two functions associated with transportation. *Vehicle scheduling* is defined as the selection of the customer orders to be delivered by a single vehicle. *Vehicle routing*, on the other hand, establishes the sequence in which selected customer orders are to be delivered during the transportation route. Transportation scheduling and routing begins with *load planning*. Planning the shipment load directly affects transportation efficiency. The selection of orders for the shipment schedule is normally the responsibility of a load or dispatch planner who must be familiar with vehicle capacities and product characteristics; match modes and select carriers; secure capacity; and monitor transportation spending. If a shipment is going to a single destination, load planning is concerned only with vehicle cube utilization and final routing. If, on the other hand, orders with multiple destinations are to be shipped in the same vehicle, planners must also sequence the orders on the vehicle to match the route and delivery schedule of each planned stop. After orders have been chosen, scheduling is normally executed based on zones containing clusters of customers, with the routing indicating the sequence of delivery within each zone. In motor transport, the driver is usually empowered to select the routing within each zone. When customers within a route are stretched across zones, the usual practice is to treat groups of customers in different zones as nodes to be serviced along the route. Once these nodes are reached by the vehicle, the driver chooses the delivery sequence based on knowledge of local roads and customer preferences.

The routing and scheduling of deliveries is a critical task. For small firms with a limited number of products, shipment routing is a repetitive affair with minimal variation. Larger firms, on the other hand, who ship a wide variety and volume of products to a widely spaced geographical customer base, must perform more complex routing analysis. For companies with their own fleets, effective scheduling and routing of transportation has long been recognized as pivotal in fully leveraging the significant capital investment in transportation equipment and facilities and the operating expenses incurred by the firm necessary to achieve service level and cost objectives. The key topics relating to routing and scheduling are single versus multiple deliveries, value of load consolidation, routing methods, and vehicle scheduling.

One of the fundamental elements of mode transport routing is the relationship between the number of delivery loads per vehicle and the number of delivery points constituting the route. Basically, as the number of load deliveries transported by a single vehicle declines, the complexity of the routing correspondingly declines. For example, if a single customer shipment filled the total capacity of the vehicle, the routing would consist of only one route and one delivery. On the other hand, as the number of load deliveries per vehicle increases, the number of delivery locations increases, and the more difficult it becomes to define a route that maximizes vehicle capacities and operating expense. Alongside the issue of routing complexity, the number of loads per vehicle also has an impact on the distance the vehicle will traverse in route to the customer. As a rule, as the number of deliveries increase per route, the overall distance of the route declines. While multiple delivery routes may indeed be more complex, the round distance is normally shorter than a straight radial distance that also entails vehicle backhaul.

In the past, the relation of load size and the routing favored direct deliveries. The reason for this stemmed from two factors. The first related to transportation cost per unit. Simply, the larger the load in relation to vehicle capacity, the lower the transport cost. Full load delivery, although it did, indeed, require running empty return vehicles, was more efficient than multiple delivery methods. The second reason is found in the assumption that customers preferred to have their inventory requirements met by shipping as large a lot size as possible. In the past inventory planning systems focused on ordering stock according to EOQs, max inventory levels, or other lot-sizing rules. The result was that transit practices using small, more frequent stops delivered only a portion of customer demand, whereas a full truckload could perhaps meet customer lot-size requirements in full. In addition, the larger the lot size, the larger the vehicle. On routes subject to multiple deliveries, so much time is spent in repeating delivery activities that only a relatively small payload can be delivered in the time allotted. As the distance between delivery sites decreases, payload can increase, but it cannot match the economies achieved by singe delivery routes.

As the era of JIT arrived, the pendulum between single and multiple deliveries began to swing dramatically in favor of multiple-delivery, LTL methods. Whereas unit-cost transport is still best served by as large a truckload as is possible, customer requirements for smaller lot sizes and more frequent deliveries caused a renewed interest in complex routing. Industrial customers who use flow production in their plants require a corresponding *flow of materials* to the process floor. Automotive giants like Ford and GM, for example, require multiple daily deliveries of products. One transport technique, called a *milk run*, consists of the pick-up and delivery of empty containers and product beginning at the customer's plant, progressing through the channel supply points, and ending up finally with delivery at the customer plant daily or several times during the day. For deliveries which must traverse long distances, milk runs can be combined with long-haul carriers to provide effective mixed-mode transportation.

Another method to increase load volume and minimize the number of delivery points is *order consolidation*. Shipment consolidation is basically the process of combining small, less-than-truckload (LTL) freight moving to a general destination. The logic of consolidation is simple: the larger the load in relation to vehicle capacity, the lower the transport cost. And the larger the load, the more deliveries are made along the transportation route. In today's time-based logistics, consolidating deliveries to simplify routing and scheduling and cut costs is challenged by customers' requirements for smaller lot sizes and more frequent deliveries.

Several methods have been developed to manage this problem. One way is to combine small shipments going to customers within a specific geographical area. Other methods are to limit shipments to specific days and use for-hire consolidators to pool deliveries for multiple shippers. The importance of consolidating shipments is seen in the following example. The below table shows four shipments being sent to the same customer on different days in the same week. By consolidating the four shipments for delivery on 5/24/20XX, the shipper can take advantage of the US$2.00 cwt (hundred weight) price for deliveries over 30,000 lb, resulting in a savings of US$490.00. Note that as the weight increases the cost per hundredweight (cwt) declines. Besides carrier cost savings, multi-company consolidation also assists in environmental issues such as declines in traffic congestion, fuel consumption, and pollution (Table 13.11).

TABLE 13.11. Shipment Consolidation

Order #	Ship date	Weight (lbs)	Rate (cwt)	Cost
10002	5/21/20XX	6,000	US$4.00	US$240.00
10005	5/22/20XX	7,000	US$4.00	US$280.00
10006	5/23/20XX	12,000	US$3.00	US$360.00
10009	5/24/20XX	11,000	US$3.00	US$330.00
	Total	36,000		US$1,210.00
	Consolidated	36,000	US$2.00	US$720.00
			Savings	US$490.00

When planning multiple delivery routes, transportation planners are faced with the problem of maximizing two related but constrained elements: the distance a vehicle can travel on a single route and the load capacity of the vehicle. If a vehicle had unlimited capacity to deliver all customer orders on a single route, these constraints would not apply. In reality, capacity is limited and planners must optimize routes and the sequence in which customer orders are delivered. This conundrum has been termed the *vehicle dispatching problem* and is defined as the process of establishing a route serving a number of customers which minimizes delivery costs within vehicle payload and distance (or travel time) constraints. A number of routing algorithms have been developed to solve this problem that are essentially divided into two classes.

In the first, *simultaneous methods*, solutions are determined by computing all feasible routes to satisfy specific customer shipping requirements, and then planners select the one that collectively yields the lowest cost. The problem with this method is the complex mathematical calculations that are performed. As the number of delivery points increase, the solution becomes more difficult to compute. The second type of vehicle routing algorithm, *sequential approaches*, attempts to overcome the problems associated with simultaneous methods by either dividing deliveries into smaller geographical regions of customers that are connected in a feasible route, or by constructing routes one at a time, adding contiguous links to a single route until distance and vehicle capacity constraints are reached. Many of the complexities of vehicle routing are facilitated by the introduction of transportation management systems (TMS) that contain applications for freight rating, rate shopping, traffic routing/scheduling, outbound appointment scheduling, transportation analysis, and in-transit inventory tracking. Computerization assists traffic planners to reduce costs, improve customer service, reduce clerical work, facilitate tracing of shipments, and collect data for performance measurement.

The final activities associated with transportation scheduling and routing is *shipment control*. When a shipment begins its route, traffic management is responsible for shipment control. Many consignees require that advance ship notices (ASNs) be generated to alert them that orders are shipped. Another task for traffic planners is responding to requests to have shipments expedited through the delivery process with no delays. Planners are also responsible for providing track and trace functions to assist in locating lost or late shipments. Finally, planners must also make sure that routing and scheduling decisions respect the hours of service rules governing limitations on the number of hours drivers can safely operate vehicles.

13.4.1.6 Documentation, Audit, and Claims

The final step in the transportation management process is the preparation of all necessary shipping documentation including carrier audit and claims management. U.S. domestic transportation (*international transport* will be discussed in the Chapter 14) utilizes several key documents to record, direct, and control shipments. Perhaps the most important is the *bill of lading*. Normally, this document is prepared in the shipper's traffic department and signed by the carrier. The bill of lading is a legal document whereby the carrier acknowledges receipt of the shipment and provides evidence of title to the goods. In addition, it also constitutes the basic contract of carriage between shipper and carrier, setting forth the rights and responsibilities of each party. The front side of the document is completed by the shipper or carrier. It contains information such as the names and addresses of the consignor and consignee, routing instructions, the shipping rate, a description of the goods and the quantities to be shipped, payment method, and other information. On the back of the document is found the contract terms, degree of carrier's liability, and other legal points. Railroads and truck carriers use standardized bills similar to the standard bill of lading. Freight forwarders, on the other hand, often use the bills of the mode of transport hauling the product. Both ocean vessels and air freight shipments use special air bills and ocean bills. Because of their uniqueness, pipelines use a *tender of shipment* form in lieu of a bill of lading. Finally, all contract shipping is subject to the terms of the individual carrier contract executed between shipper and carrier (Figure 13.8).

In addition to the bill of lading, there are a host of other shipping documents. *Freight bills* are tendered by the carrier to the shipper using the bill of lading and indicate the fees the carrier charges for the shipment. Much of the information on the bill of lading is found on the freight bill. The difference between the two documents is that the freight bill lists the shipment charges while the bill of lading details the terms of the shipment and is a document of title. Freight bills are submitted by the carrier when the shipment is picked up by the carrier (*prepaid shipment*) or when the freight is delivered (*collect shipment*). Other important documents are the *packing list* (prepared by the shipper listing the products and

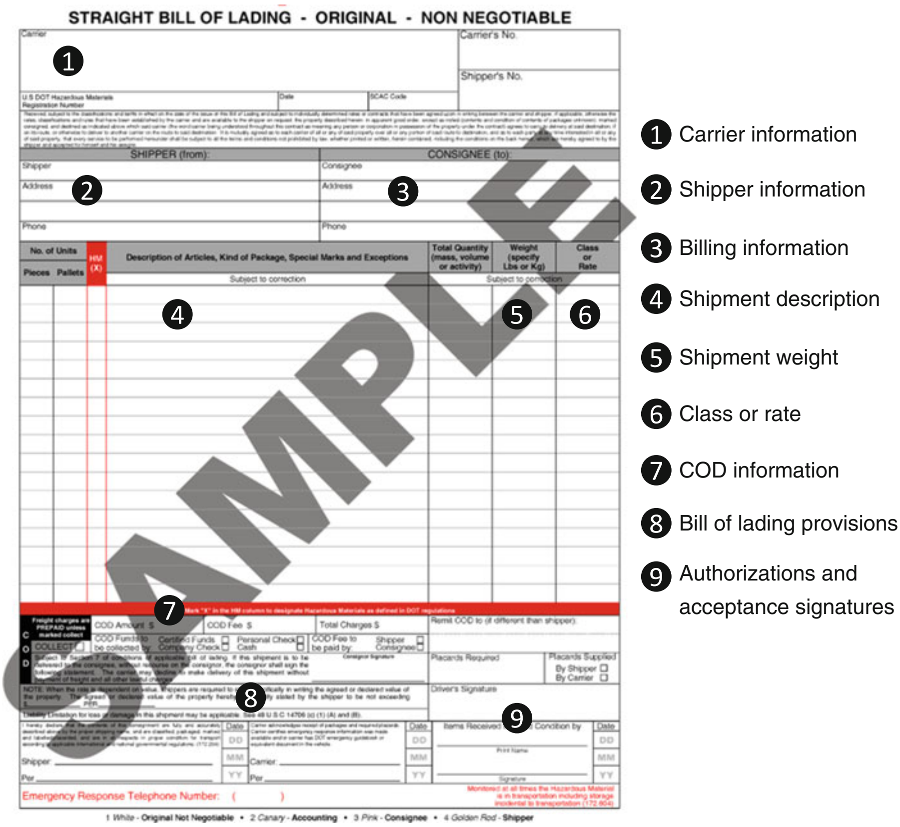


FIGURE 13.8 Straight bill of lading.

quantities in the shipment which is packed with the goods), *delivery receipt* (issued by the carrier to the consignee as proof of shipment receipt), *declaration of dangerous goods* (as needed), and *shipment manifest* (lists individual stops or consignees when multiple shipments are on a single vehicle).

Post-shipment documentation is concerned with the receipt, review, and payment of carrier invoices. As illustrated in Figure 13.4, this process consists of the receipt of the carrier invoice, invoice audit and possible adjustment, decision to pay, invoice payment, and, finally, performance measurement reporting. In today's tight economic times, the speedy performance of these steps has become of great importance to carriers who will often incent shippers by offering favorable early accounts payable terms. Up to 5 % of the total carrier invoice cost is consumed in administrative and financial costs. Administrative costs are composed of the processing costs of creating and delivering invoices, receiving payment, applying payment, resolving disputes with the shipper, and collections. Financial costs include two components: days sales outstanding (DSO) carrying costs and bad debt expenses.

Carriers have recently been looking to logistics partners and technology to accelerate the payment process. A widely used technique is to employ the services of third party payment providers (3PPs), which approach the problem from the shipper's A/P. These providers typically assume management of invoices and bill the shipper either through a percent of the payment processed or a per-invoice fee. The most advanced carriers have turned to the Internet and implemented *electronic bill presentment and payment* (EBPP) extensions to their web-enabled systems to automate the processing of freight payment and the generation of freight invoices. The advantage of Internet-based tools is that they provide carriers with real-time communication as well as collaborative approaches to document management, payment processing, and exception handling.

A final set of documents governs claims administration. The *freight claim* is used by the shipper to file a record of reimbursable losses with the carrier for such events as loss, damage, loss due to delay, and over-charging. The filing of claims is governed by law and the terms specified on the original bill of lading. There are two basic forms of claims. The first, *loss and damage*, is a claim against the carrier for partial or full financial loss due to shipment loss or damage while the goods were in transit. Claims for *overcharge/undercharge* result from unfavorable freight bill audits. Aggressive claims administration is important for two reasons: (1) claims recoveries require very attentive audit, and (2) the number of claims filed against a certain carrier provide a clear indicator of failure by the carrier to perform contracted services.

13.4.1.7 Transportation Performance Measurement

Transportation performance measurements provide traffic managers with quantifiable data to track shipping metrics and illuminate regions for increased productivity and competitive advantage. Designing effective performance measurements requires dividing transportation into two separate entities: transportation services that are purchased and transportation that is performed by company-owned equipment. Although both the cost and benefits of any performance measurement program will vary by business, in general, when transportation is purchased, performance is determined by tracking carrier pricing and delivery performance. For companies that possess their own transportation fleets, performance is measured by analyzing *fixed costs* (vehicles, maintenance facilities, terminals, computer systems, etc.) and *variable costs* (labor, repair and service, fuel, administrative staff, etc.).

An effective measurement in charting transportation performance is the *ton-mile* (TM). A ton-mile can be defined as the cost required to move 1 t of goods 1 mile. A ton-mile is calculated by multiplying the shipment weight by the number of miles from point of origin to the destination. If, for example, a shipment weighed 1,500 t and the delivery spanned 500 miles, the ton-mile (TM) is calculated as follows:

$$TM = 1{,}500\,\text{t} \times 500\,\text{miles} = 750{,}000\,\text{ton-miles}$$

To calculate the cost to ship one ton one mile is: cost/(number of tons $\times$ number of miles). Shipment productivity is computed by inverting the factors, or TM/cost. By comparing the ratio as a function of price charged by each carrier, it is possible to determine the best transportation productivity for the price. When a mix of transport modes is used, the TM and cost are calculated for each mode. Another variable to the ton-mile ratio is produced by load scale factors. Prices can change depending on the ratio of partial to full loads, average length of haul, and average weight of partial loads.

Keeping transportation price and modal mix on target is assisted by performance to budget. By collecting information relating to ton-miles, cost per ton-mile, service mix, product mix, and others, transportation managers can examine costs and changes to costs. In addition, a shipping budget can be developed that provides shippers with price and mix targets. Table 13.12 provides an example of a simplified transportation budget that is used to track actual quantity, cost, and modal mix. The planned mix percent and estimated ton-miles columns illustrate the forecasted usage by mode type. By multiplying the cost per ton mile for each mode by the estimated ton-miles results in the forecasted budget for each mode. Price optimization is attained through effective carrier negotiation. Modal mix is optimized by ensuring that shipment utilization is high per mix target and by avoiding premium-priced carriers. In both cases, pursuing the best transportation for the cost is really an entire company effort, requiring the cooperation of sales, warehousing, and transportation departments.

TABLE 13.12. Transportation Budget

Mode type	Planned mix %	Estimated ton-miles (Vol x Mix %)	Cost per T/M($)	Budgeted Transportation($)
Truck (TL)	40.00	320,000	3.25	1,040,000
Railroad	25.00	1,500,000	1.10	1,650,000
Truck (LTL)	13.00	450,000	7.25	3,262,500
Intermodal	17.00	1,250,000	7.50	9,375,000
Air	5.00	65,000	15.50	1,007,500
			Total	$ 16,335,000

When developing performance measurements for company-owned transportation, three questions must be addressed:

1. Does owning and operating a fleet provide a more cost-effective advantage than if the same service was contracted from a public carrier?
2. What should be the performance measurements used to examine internal fleet productivity and how should those metrics be collected?
3. Considering the multitude of changes due to costs and opportunities for new equipment and technology alternatives, what are the appropriate metrics to be employed for improving or at least maintaining the initial cost level?

The first step in measurement identification is to detail the major components and percent usage of transport cost. A possible breakdown appears in Table 13.13. This breakdown helps traffic planners isolate areas where cost improvements can have the most significant impact. The next step is to associate with each major cost component, such as employee compensation, vehicle costs (fixed as well as operating costs like depreciation and fuel), support expenses (facilities and equipment), and other expenses (cargo insurance, travel expense, general supplies and expenses) a productivity value. The value source includes such elements as miles per road driver-hour worked, miles per gallon fuel, miles per trailer, weight handled per platform-employee hour, and fleet miles per maintenance employee-hour. For example, when analyzing vehicle costs by using the *activities* expressed in Table 13.13, *value sources* such as ton miles per road driver worked, customer stops per local driver-hour, and shipments handled per platform-employee hour are calculated by each activity. The goal of the process is to chart through time changes occurring in each expense value. Opportunity for improvements focus on reversing an upward trend or decreasing a fairly stagnant cost. Possible examples for performance improvement include the following: usage of vehicles on second and third shifts, reduce empty backhaul mileage, increase vehicle space utilization, alter routes to reduce mileage and/or driving time, effectively mix private and public transport to maximize on private fleet utilization, improve equipment utilization, and others.

TABLE 13.13. Transportation Cost by Major Activity

Activity	Percentage of total cost (%)
Linehaul	82.0
Pickup/delivery	1.6
Platform	4.0
Maintenance	2.4
Indirect, others	10.0

A comprehensive transportation performance measurement program provides traffic managers with detailed performance metrics or key performance indicators (KPIs). The goal is to assemble a variety of objective metrics on how well for-hire or private fleets are performing against key KPIs. The actual performance of transportation is then gathered from transportation information systems and matched against expected performance targets. The KPIs can be used to evaluate current performance versus historical results, company goals, and carrier commitments. They can also be used to benchmark company performance against competitors and world-class organizations.

A critical activity is identifying and establishing relevant KPIs. An example appears on the performance scorecard in Table 13.14 for a specific for-hire carrier—ABC Transport Services. The following KPIs have been identified:

- *Quality of service*. The ratio of how well shipments are meeting customer expectations.
- *Cost of service*. The ratio of actual to budgeted costs for shipments.
- *Flexibility of service*. The ratio of ABC's ability to meet requests for different modal options and capacities to fit shipment characteristics.
- *On-time loading*. The ratio of times ABC's vehicles arrived at the scheduled appointment time to pick up loads.
- *On-time delivery*. The ratio of shipments delivered by ABC in a timely fashion.
- *Delivery consistency*. Compares the average origin to destination transit time of shipments to the transit time promises made by carriers.
- *Loss and damage claims*. The ratio of claims-free deliveries to the total number of deliveries.
- *Freight bill accuracy*. The ratio of accurate freight bills submitted by ABC to the total number of freight bills tendered by ABC.

TABLE 13.14. Transportation Performance Scorecard

Performance: ABC Transportation Services					
Performance criteria	Weight factor	Potential score	Performance %	Score	Variance
Quality of service	10	50	98.50	50	0
Cost of service	10	50	96.70	40	10
Flexibility of service	5	25	90.20	10	15
On–time loading	7	35	93.70	21	14
On-time delivery	9	45	97.30	36	9
Delivery consistency	6	30	94.70	18	12
Loss and damage claims	6	30	96.10	24	6
Freight bill accuracy	8	40	88.20	8	32
			Total Score	207	

Performance scale	Points
>98%	5
95 – 98%	4
92 – 95%	3
89 – 92%	2
85 – 89%	1
<85%	0

Once meaningful KPIs are established, a performance scorecard is constructed. In the example in Table 13.14, traffic managers weigh the KPIs (from a range of 1–10) that reflect company goals for transportation. The *potential score* is the optimal value for each KPI. The *performance %* shows the actual success of the carrier in performing the activities associated with the KPIs. The *score* is determined by finding the actual performance percent in the range detailed in the *performance scale* and then multiplying the corresponding *performance scale points* by the *weight factor* for each KPI. For example, the KPI for *quality of service* is calculated as $10 \times 5 =$ a score of 50. The results reveals how well ABC Transport Services is meeting the KPI targets. These measurements could then be used to assist in future for-hire carrier selection or in pricing negotiations.

The same performance scorecard could be applied to a private fleet. KPIs could include such elements as miles per road driver-hour worked, miles per gallon of fuel, miles per trailer, weight handled per platform-employee hour, and fleet miles per maintenance employee-hour. Additional metrics, such as employee compensation, vehicle costs (fixed, as well as operating costs such as depreciation and fuel), support expenses (facilities and equipment), and other expenses (cargo insurance, travel expense, general supplies and expenses), could be added.

13.5 ISSUES CONFRONTING TRANSPORTATION

Transportation, like all business functions in the today's global marketplace, is grappling with an accelerating rate of change and operational complexity. In the past, transportation was a fairly straightforward process concerned with rate and route calculations and carrier selection. Today, as the demands of global competition, new paradigms of customer services, and growth of computerization and Internet interoperability expand, architecting a successful transportation strategy requires coming to grips with a number of critical issues.

The first relates to the physical transportation environment in the first decade of the twenty-first century. The second is the dramatic growth in transportation risk management. Finally, the last issue is concerned with the application of computer systems capable of automating all areas of transportation management.

13.5.1 Transportation Infrastructure Issues

The management of today's transportation functions are confronted with the challenges of three infrastructure-related challenges: the state of physical transportation support systems, the impending crisis in driver shortages, and environmental sustainability.

13.5.1.1 Physical Transportation Systems

In the second edition of *Distribution and Planning and Control* (2004), a section was devoted to the growing crisis in transportation infrastructure. Regrettably, over 10 years later the situation has not only not improved but grown seriously worse. While the U.S. economy struggles past the recession years of 2008–2009 and the painfully slow economic recovery, the country's transportation system poses more a risk than a facilitator of economic growth. The May 2013 I-5 Skagit River Bridge collapse in Mount Vernon Washington was eerily similar to the 2007 I-35 Mississippi River Bridge in Minneapolis which buckled during rush hour killing 13 people and injuring scores more. In 2012, the Federal Highway Commission reported that 11 % of the nation's 607,380 bridges were structurally deficient. According to the American Society of Engineers' 2013 infrastructure report card, U.S. bridges as a whole were graded a C+. The major transportation modes were given the following scores: aviation was rated a D; inland waterways, a D−; rail, a C+; roadways, a D; and energy electric grids and pipelines, a D+. Dishearteningly, America's transportation GPA was graded at D+. Upgrading the U.S.'s transportation will require an investment of US$3.6 trillion by 2020 [23].

Unfortunately, most of the problems reside with the lack of a truly comprehensive U.S. federal government transportation policy. For years, U.S. transportation planning and funding has been heavily politicized. The U.S. Department of Transportation's Transportation Investment Generating Economic Recovery (TIGER) stimulus offers a prime example. The US$2 billion allocated to shovel-ready infrastructure projects through the first three rounds of grants turned into a pork barrel lottery that favored local earmarks over national needs. Through the first five rounds of TIGER, requests for funding have exceeded available funds. DOT has received more than 5,200 applications totaling more than US$4,114.2 billion, with TIGER allocating about US$3.6 billion to 270 projects. The most recent legislation—the 2-year Moving Ahead for Progress in the 21st Century Act (MAP-21)—was signed into law in July 2012. MAP-21 features two key provisions. First, it requires the U.S. DOT to establish a national freight network to assist states in strategically directing resources toward improved freight movement on highways. Second, it directs the DOT to develop a national freight strategic plan in consultation with states and other stakeholders.

While solutions to these problems are forthcoming, local governments, shippers, and carriers are gearing their strategies and transport assets to respond today. Local governments are looking to increased transportation taxes, fees, and municipal bonds to funds infrastructure repair projects. Shippers and carriers are looking to increased performance enhancements. One key area is the growth and integration of technologies with transportation management processes and infrastructure. This merger of information and processes should assist in the development of more effective transport strategies and practices that will enable system optimization.

Another area is the growth of *intermodalism*. Through the design of compatible vehicles and containers, intermodal transport optimizes mode utilization and efficiency by providing for quick loading and unloading. The goal is to ensure that at the various points of delivery and shipment transport activities are performed as cost-effectively and quickly as possible. In detail, carriers assist in removing transport bottlenecks by converting to equipment such as smaller, faster, lower cost locomotives that speed up rail movement; enhancement of loading equipment and rolling stock that facilitates the "piggy-backing" of motorized vehicles and containers; the use of side-loading trailers that permit quick loading and unloading; and the installation of docking bays that facilitate tailer cargo handling, application of conveyor systems, and cross-docking. These and other innovations support the new view of logistics as a continuous flow pipeline rather than as a stagnant system of warehouses connected by modes of transit.

13.5.1.2 Impending Driver Shortage

A critical challenge confronting transportation is the threat of an impending driver shortage. Even as the U.S. economy inches its way to recovery, a continuing problem is finding, hiring, and retaining qualified truck drivers. Estimates point to a potential shortage of 30,000 to as high as 180,000 qualified drivers. According to the American Trucking Association (ATA), turnover at large for-hire truckload fleets in the first quarter of 2013 hit 97 %, up from an annualized rate of 90 % in the fourth quarter of 2012. Turnover at less-than-truckload (LTL) fleets reached its highest level in more than 7 years, increasing to 15 % in the first quarter of 2013 from 10 % in the prior quarter. Most of the turnover was caused by "churn," the practice of jumping from one carrier to another. The reason for the high turnover was not specific factors, such as pay, benefits, more home time, or company culture, but the failure of companies to deliver on promises made during recruitment.

The problem is being compounded by new driver hours-of-service federal rules. Prominent are two regulations. The first is the Federal Motor Carrier Safety Administration's (FMCSA) Hours-of Service (HOS) regulations enacted on July 1, 2013. The law contains a variety of restrictions, such as a driver may drive a maximum of 11 h after 10 consecutive hours off duty; beyond the 14th consecutive hour after coming on duty, following 10 consecutive hours off duty; and after 60/70 h on duty in 7/8 consecutive days [24]. The end result is that HOS will reduce median driver wages by between 3.2 % and 5.6 % through a reduced work week and carriers will need more drivers and potentially more assets to do the same amount of work. The second and supporting mandate is the installation of electronic logging devices (ELDs) required on all trucks by 2016. It is estimated that ELDs will cause company drivers to lose about 3–4 % in miles, with owner-operators likely to suffer a 5–8 % loss. The goal of ELDs is to make it virtually impossible for drivers to cheat on their hours of service.

13.5.1.3 Transportation Sustainability

Without a doubt, the effects of the different modes of transportation on environmental sustainability is perhaps one of the most visible manifestations of the "green" movement. Transportation fleets, and motor carriage in particular, significantly affect the environment through the fuels they consume. The key term is the *carbon footprint*. While there is open discussion on its precise meaning, the common understanding is that a carbon footprint is equated with a certain amount of gaseous emissions that are relevant to climate change and are associated with industrial production and consumptive activities. Transportation fuel combustion is the second largest source of emissions in the U.S., where it constitutes 18 % of total emissions. Globally, transportation accounts for approximately 19 % of global energy use, 60 % of the world's oil demand, and emits about 23 % of the energy-related carbon dioxide (CO_2). The combustion of transportation fuel is projected to be the source of the fastest-growing greenhouse gas (GHG) emissions through 2050 [25].

Increasingly, many fleet operators are committing to a sustainability program. Many companies are thinking of reducing their carbon footprint by transitioning to low-carbon or alternative fuels. Several direct benefits are evident [26]:

- *Corporate citizenship*. Actively reducing emissions enables companies to be good corporate citizens, and many appreciate that playing an active role to accelerate the transition to more sustainable fuels improves the company's reputation. Examples include United Parcel Service (UPS) which will replace 1,000 gasoline- and diesel-fueled trucks with propane-powered trucks between mid-2014 and early 2105. LTL Pitt Ohio implemented a carbon calculator to measure is GHG emissions and began pilot programs on compressed natural gas (CHG) hybrid tractors [27].
- *Reduced costs from lower lifecycle fuel prices*. Some companies are already using natural gas and electric vehicles, which as of October 2013, were 40 % and 65 % cheaper per unit than diesel and may equate to payback periods with new vehicles of 3 years.
- *Shaping of public policy and marketplace choices*. As transport companies make the transition to lower cost fuels, they increasingly will have a voice in actively shaping the technologies, institutions, and perspectives that will define tomorrow's fuel economy.
- *Readiness to respond to rapid changes in markets and technologies*. By gaining early admission to fuel-sustainable vehicles and policies, companies can pilot technologies that position them to roll-out advanced low-cost fuels and vehicles as opportunities arise.

As supply chains expand around the globe, the use of petroleum-based fuels for commercial transport and the accompanying pollution will become increasingly a major environmental issue. The top users of transportation energy are road (passenger and freight), world marine vessels, domestic and international aviation, pipeline, rail, and inland and coastal navigation. The different types of fuels used worldwide are dominated by gasoline followed by diesel, jet fuels, compressed/liquefied natural gas (CNG/LNG), electricity, and coal.

For-hire carriers have responded to the rising cost of fuel and environmental charges by using several strategies. The most common is the application of surcharges to recover today's high fuel costs. Basically, fuel surcharges are calculated by using three elements: the *index* (an agreed upon price between shipper and carrier); the *peg/base* (the fuel cost level at which the fuel surcharge is neutral—with neither a charge nor a rebate); and the *escalator/ratio/multiplier* (the efficiency of a carrier's equipment). The formula used to calculate the surcharge is then $\frac{Index-peg}{Excalator}$ fuel surcharge [28]. Other methods to control fuel costs include focusing on shorter routes, reduced cruse speed, improved operational efficiencies, and new technologies such as electric hybrids.

13.5.2 Transportation Risk Management

Transportation management has always been concerned with the risks inherent in moving products across regional and international boundaries. Today, most companies face a much broader dimension of risk that includes supply chain, financial, and security. Supply chain risk is manifested in the extension of transport routes that span entire continents. As the distance between ship-from and receiving points expands, problems caused by weather, mechanical, geopolitical, and regulatory risk likewise has expanded. In addition, the increased use of logistics service providers (LSPs) transportation management has increased the potential for system failure. Transportation administration is confronted with several risks that threaten the effectiveness of daily operations. The most critical risks are:

- *Shipment loss*. The possible loss of a shipment through theft, piracy, hijacking, and misplacement constitutes a common risk confronting every shipment. Beyond the direct financial loss, shippers must also bear the indirect costs associated with lost sales, claims processing, expedited costs to replace the shipment, disruption to customer service, damage to brand image, and possible increases in insurance rates.
- *Shipment damage*. Shipment damage originates in the actions or inactions on the part of load handlers and equipment operators. Causes of damage are poor freight handling, improper transport equipment loading, and in-transit equipment accidents. Additionally, claims management adds to the cost of damaged goods.
- *Shipment contamination*. The shipment of perishables, consumables, and date-sensitive products risks contamination while in route from origin to destination. Primary causes of shipment contamination are vehicle climate control failure, product tampering, and exposure to contaminants. The longer the trip distance, the greater the opportunity for natural and man-made contamination to occur.
- *Delivery delay*. Reasons for shipment delay are traffic congestion on rail lines, port facilities, and roadways; climate changes or conditions that impact in-transit flow; and mechanical breakdown of delivery vehicles. Long distance transport adds to delivery complexity and risks further delivery delay.
- *Channel disruption*. Although disruptions to channel flow-through are intermittent, they can pose a severe risk. Disruptions are attributed to labor disputes, governmental regulations, catastrophic weather disasters, channel equipment capacity shortages, lack of skilled personnel, and carrier financial problems.
- *Security breach*. Today's global transportation environment is threatened from multiple quarters. Risks arise not only from potentially destructive forces seeking to exploit system flaws and security vulnerabilities, but also from governmental requirements for more extensive freight inspections, documentation, and costly countermeasures. Areas where threats arise are lax security processes that make shipments an easy target; unprotected transfer facilities that do little to retard theft, contamination, or possible terrorist damage; and shipment control failures where visibility to shipments "disappears."

An important source of transportation risk management is regulation and financial requirements stemming from governments, consumers, suppliers, and competitors. A specific regulation may be limited to a local region or cover the globe. A serious issue affecting transportation is the prohibition by some countries on certain goods entering or leaving the country for security reasons, domestic trade protection, or protection of the health and safety of its citizens. National, regional, and local taxes can impact transportation as well as compliance with import and export requirements. Companies are also under the constant threat of transportation partner financial failure.

Transportation risk is also affected by supply chain security. Since the terrorist attacks on September 11, 2001, countries have been diligent in erecting barriers to the possibility of using the world's transportation systems to export terrorism. Supply chain security consists in the application of policies, procedures, and technologies designed to lessen the risk of disruption by protecting assets, products, facilities, equipment, information, and personnel from theft, damage, and terrorism and to inhibit the transfer of unauthorized goods, people, and weapons of mass destruction. To manage security risks governments have enacted legislation and sponsored the formation of antiterrorism trade partnerships. In the U.S., examples of the former include the Maritime Transportation Security Act of 2002 (mandating that all vessels and port facilities conduct vulnerability assessments and develop security plans); the Container Security Initiative (mandating the identification and inspection of all inbound containers into the U.S. that pose a potential risk for terrorism); and development of Advance Manifest Rules (enables the U.S. Customs and Border Protection (CBP) to analyze container content information before loading at a foreign port before arrival in the U.S).

There are several examples of anti-terrorist trade partnerships. The Customs-Trade Partnership Against Terrorism (C-PAT) is a voluntary initiative to build cooperative relationships between the CBP and individual companies to strengthen and improve international supply chain and U.S. border security. The centerpiece of C-PAT is an agreement whereby companies submit extensive documentation on their supply chain security practices in exchange for preferential treatment of their import cargo at U.S. ports of entry. The Free and Secure Trade (FAST) program is an outgrowth of the North American Free Trade Agreement (NAFTA) between the U.S., Canada and Mexico. FAST seeks to apply common risk-management principles, supply chain security, industry partnerships, and advanced technologies to allow low risk goods from secure carriers and companies to move rapidly through U.S./Canada and U.S./Mexico borders and improve the screening and clearing of unknown or high-risk shipments. The World Customs Organization (WCO) consists currently of 161 countries involved in the Global Standards for Supply Chain Security, to develop and promote security guidelines to assist customs organizations achieve rapid clearance of low-risk cross-border shipments.

Managing risks to transportation operations requires adopting an effective methodology for risk identification and analysis that result in policies and strategies capable of mitigating sources of possible transportation disruption. A pragmatic approach consists of the following activities.

- *Identification*. In this opening step, managers accurately detail potential disruptions to transportation. The goal is to identify all possible threats and disruptions to the firm's domestic and international transportation.
- *Measurement*. Next, managers assess quantitatively the extent of the threat. The goal is to use numeric estimates of frequency of a threat to determine the *probability* of it occurring and the *impact* if the threat does occur.
- *Actionable risks*. Once transportation risks are identified and quantified, managers then select those risks that are within the power of the organization to control. The

output of the analysis is a decision as to how each risk is to be countered if it were to occur. Possible choices are:

– *Avoidance*. This solution calls for the business to cease performing the transportation activity altogether so that the threat is eliminated.
– *Acceptance*. This solution accepts the risk. Risks in this category are usually marked by low probability, low magnitude, or high costs of transfer or mitigation.
– *Transference*. This solution seeks to remove the risk by moving the affected resource or financial effects to a third-party organization.
– *Mitigation*. This solution accepts the risk and seeks to adopt policies and actions that proactively reduce the likelihood of a disruption or financial loss when the disruption does occur.

• *Realistic solutions*. For mitigated risks, managers determine if the organization possesses the financial, people, and skill resources to realistically find solutions to the identified risks.
• *Time-phased implementation*. Finally, managers should develop a time-phased implementation plan for each risk to be resolved, complete with roles, responsibilities, due dates, and project accountability.

Transportation risk mitigation occurs on three levels: *strategic, operational,* and *event-driven.* Strategic solutions focus on the establishment of viable alternatives to risk that ensure transportation resiliency in the face of catastrophic threats. An example is countering transportation system risk by developing partnerships with logistics service providers (LSPs). Operational solutions involve securing visibility and alternatives to transportation risk. Possible actions are building redundancies and flexibilities into transportation resources so that capabilities and capacities are quickly adapted to meet channel network points of need. And finally, event-driven solutions are designed to ameliorate the effect of day-to-day threats to transportation functions. The use of a transportation management system (TMS), for example, provides real-time information as to shipment statuses, route planning and equipment scheduling, yard management, appointment scheduling, and transportation procurement that can reduce risks to daily transportation operations.

13.5.3 Transportation Management Technologies

As it has done in virtually all areas of distribution management, today's information technologies are providing transportation with new tools to more effectively manage operations, provide visibility into the stream of data happening in real time across the supply chain, and networking together shippers and carriers to accelerate responsiveness and cost efficiencies. Important transportation technologies range from transportation management systems (TMS) to a variety of specialized applications for routing and scheduling and driver management devices.

13.5.4 Transportation Management Systems (TMS)

An effective way to use technology to respond to the challenges confronting today's transportation function is to utilize a transportation management system (TMS). One of the best definitions of a TMS is from ARC Advisory Group [29]:

> Transportation Management Systems are software solutions that facilitate the procurement of transportation services; the short-term planning and optimization of transportation activities, assets, and resources; and the execution of transportation plans. They address all modes of transportation, including Ocean, Air, Rail, Full Truckload, Less-than-Truckload, Parcel, and Private Fleet. In addition to managing the physical flow of goods, they also manage the flow of transportation-related information, documents, and money. TMS also includes performance management and collaboration capabilities.

The purpose of a TMS is to provide a single integrated solution that spans the transportation management cycle from order selection and carrier bid to delivery and performance measurement. With the information provided by a TMS, traffic planners can implement practices that integrate and streamline every aspect of the transportation system, reducing costs from and adding value to every step of the shipment process.

As illustrated in Figure 13.9, a TMS provides a wide array of transportation solutions.

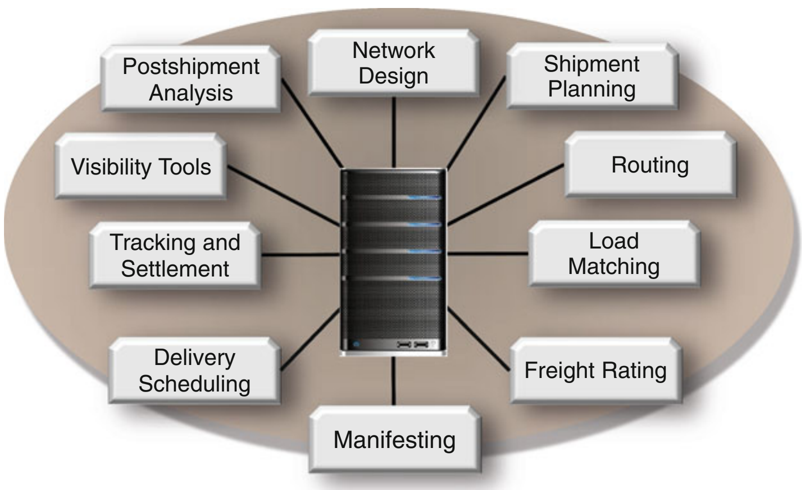


FIGURE 13.9 TMS functions.

In general a TMS provides transportation planners with advanced tools to perform the following activities:

- *Network design*. This function assists planners to map out or restructure the transportation network using computerized tools and optimizers.
- *Shipment planning*. These functions optimize the transportation network by using channel modeling and simulation. At the tactical level, it evaluates routes and carriers. At the operational level, it optimizes daily transportation plans.
- *Routing*. Routing applications enable planners to define rules for shipment routings and automatic selection of carriers. Mode switching tools enable optimization of the movement of goods across multiple modes (intermodal).
- *Load matching*. A TMS provides visibility to available resources so that the system can find optimal locations from which to fill orders. Common load matching/pooling functions include cross-docking, less-than-truckload (LTL) consolidation, and handling of special materials.

- *Freight rating*. By populating a rate tariffs database within the TMS, shipment loads are automatically rated by cost and reliability. The selection process uses carrier service levels updated on past measurements of cost, on-time delivery, and numbers of errors or damaged goods.
- *Manifesting*. A TMS can generate all required shipment documentation.
- *Delivery scheduling*. Each load lists carriers in order of preference, and each carrier is referenced in order until coverage is obtained.
- *Tracking and settlement*. Managers can view the detailed cost of shipments based on actual charges through real-time updates of proof of delivery, freight bills, and import/export documentation. The TMS generates invoices and bills of lading. Settlement includes auditing of freight bills, minimizing payment errors, and automating payment.
- *Visibility tools*. These functions allow companies and their suppliers and customers to view inbound and outbound shipments, in-transit inventory levels, and exceptions to expected shipments in real-time.
- *Postshipment analysis*. Traffic managers can print reports of freight bills, total landed costs, and loss and damage claims and their filing status.

The scope, functionality, and architecture of TMS applications have changed significantly since their introduction in the late 1980s. An estimated US$650 million industry in 2013 with an annual growth rate of around 10 %, today's software suppliers have been rapidly transforming TMS from a fragmented collection of applications to a unified platform where users can execute role-specific processes via configurable user interfaces, workflows, and web services. While the transportation automation processes are the centerpiece of the software, the flashpoint of web-enabled TMS is its ability to serve as the foundation for the networking of information between external parties, including carriers, suppliers, customers, and logistics service providers across logistics e-marketplaces. For example, Manhattan Associates provides an application called "Logistics Gateway" that provides easy linkage through EDI and the Internet between buyers and transport sellers. The application enables linkage to any logistics supplier to facilitate requisition management, PO management, inspections and quality assurance, fulfillment and shipping, and charge-backs. If parties lack Web /EDI toolsets, Manhattan's application provides online portals that open the door to electronic communications for spot negotiations and to exchange information on status, invoicing, invoice reconciliation and tender acceptance [30].

Probably the most exciting aspect of today's TMS, is the ability of enterprises to leverage the software as a service (SaaS) and cloud computing technologies versus the traditional hosted models to acquire TMS capabilities. By definition, cloud computing is the deployment of software where the TMS runs on multiple virtual servers as demand increases or decreases, whereas SaaS involves TMS applications hosted by a vendor or service provider and then distributed to customers via the web. Until recently, companies not using a TMS often voiced the concern that it was too expensive to purchase and implement. Today's technology architectures have negated this concern. On demand TMS has largely eliminated the cost and resource constraints, shorted the time-to-value companies traditionally face in implementing new technology and continuous improvement initiatives, and significantly increasing profitability. In a 2013 research study, research firm ARC found that over 40 % of respondents with a TMS felt that the system enabled them to reduce their freight costs by five to ten percent [31]. TMS achieves these savings through process enforcement, visibility, analytics, and optimization.

13.5.5 Yard Management Systems

An increasingly important technology for the control of inbound and outbound transportation is a *yard management system* (YMS). Historically, YMS applications were deployed by companies with large, complex operations needed to manage hundreds of transport vehicles. Normally folded into a logistics operation's TMS, the focus of an YMS is to facilitate the synchronization of yard operations, orchestrating loading dock activities, and streamlining dock door check-in. Key capabilities include:

- Establishment of a "control room" enabling centralized real-time tracking of all private fleet and/or third party trucking assets incoming to the site and/or within the yard or campus.
- Real-time visibility of shipments in the yard, inventory of transport vehicles in the yard, and yard security.
- Control over yard equipment for maximum efficiency.
- Real-time asset management capabilities for tracking the location of goods.
- Efficient appointment management to reduce load/unload wait time and delays.
- The scheduling of appointments for incoming loads so that vehicles are assigned to the right dock door and correct time.
- Graphical view and task management of yard moves with integrated labor management support for dock resources.
- Self-schedule shipment features for carriers that eliminate time-consuming, error-prone communications by e-mail, phone, or fax.
- Tracking of task completion so planners can perform inquiries, run reports, and review real-time information [32].

Transportation planners have their choice of two types of YMS. A "Yard Module" is typically an extension of a WMS and enables planners to find vehicles in the yard based on where they were in the past and allows yard drivers to locate and move vehicles to dock doors. On the other hand, a "best-of-breed" YMS is specifically oriented towards optimizing the use of labor resources and the movement of trailers within the yard. This type of YMS enables tracking and optimization of the movement of vehicle assets within one or more yards; optimization of the use of driver labor resources that are tasked to move equipment within the yard by minimizing task time duration and/or distance travelled; manage the scheduling and receiving of inbound loads based on configurable priorities; and capability to continuously adjust priorities throughout the day according to actual receiving and shipping volumes.

Regardless of approach, an YMS provides advanced key performance indicators (KPIs) and intelligence that enable transportation planners to continuously improve the quality, efficiency, and accuracy of their overall logistics operations. According to one study, a YMS can increase the efficiency of shunting (yard jockey) labor in the range of 25–35 %; increase a minimum of two to three more trailer moves per worked hour; reduce the time spent performing yard checks; reduce the cost for delayed for-hire trailers return (detention);

reduce in yard trailer rotation; reduce inventory losses for perishable goods and stock rotation; and increase by 10–12 % warehouse throughput efficiency for outbound operations during peak seasons [33].

13.5.6 Routing, Scheduling, and Event Management Systems

Normally an application within a TMS, routing and scheduling (R&S) functions have become essential in ensuring that orders are delivered to the right place at the right time. As today's customer demands visibility to every stage of a shipment, higher levels of service, and same-day delivery at lower rates, use of R&S applications has exploded. In the past, as software-based map databases and GPS were in their infancy, dispatchers and traffic managers did not know with any degree of certainty where their fleets were. Also, given that freight volumes fluctuated, the efficient routing and scheduling of vehicles was almost impossible. Today's R&S provides the tools to efficiently manage the transportation network by intelligently allocating vehicles on lanes that optimize costs while satisfying delivery constraints and enhancing customer service levels.

The effective use of an R&S system is estimated at achieving an estimated 10–25 % increase in the deployment of trucks drivers and hours of use, and around 5–15 % reductions in total distribution costs [34]. Actual costs are determined on a case-to-case basis and depend on such factors as the R&S system implemented, the extent of autonomy enjoyed by the system, the design of the R&S system optimization algorithms, and the goal of the implementation (for example, cost reduction versus improved service levels). R&S systems are separated into three functional areas.

- *Route planning* applications optimize the routes and plan the transportation assignments according to available resources and the different constraints relative to drivers (driving time, frequency of return journeys), transport conditions (speed, capacity), and delivery (schedules, types of vehicles).
- *Dispatching* applications responds to all the issues relative to the transportation activity including identification of locations for the pick-up, automatic incorporation into zones groups, and delivery; extensive recording of all data concerning clients' orders; simultaneous planning for drivers, capacity, and assignments; and taxation on sales and purchase and invoicing.
- *Route and driver performance* applications provide planners with visibility to traffic conditions in real-time, validate driver compliance with route regulations and enable communication with the driver in real time.

A final advantage of an R&S system is its ability to assist companies achieve their Climate Change Levy by avoiding unnecessary transport miles and reducing fuel consumption and vehicle emissions, thereby contributing to U.S. federal government environmental sustainability targets.

Supply chain event management (SCEM) software is another rising technology in transportation management. SCEM is described as an application integration layer that standardizes and transports fulfillment information as it flows between channel trading partners. SCEM applications provide transportation planners with the following functions: order and shipment tracking, workflow, alert messaging/notification, escalation processes, and performance/compliance management. Basically, the system is engaged when an event, either planned or unplanned, occurs requiring planner intervention. Depending on the impact of the event, the system will trigger a signal, often using Boolean-type logic, to alert planners through a generic workflow process that an occurrence in the fulfillment pipeline has violated predetermined event boundaries. For example, Unilever Home & Personal Care uses their SCEM system to create close Internet links to their third-party manufacturers. This permits them to be aware of logistics events such as whether a product is produced, on hold, released, or available for pickup. It also removed several days in the speed of cycle time fulfillment due to improved information flow through the supply channel [35]. However, while SCEM provides visibility to current events and permits planners to execute operational corrections, its real value is found on the strategic level where pre-defined KPIs, performance scorecards, and dashboards can detail long-term spending and fulfillment performance on shipments and compare the data over a variety of carriers, time periods, and transportation modes to pinpoint critical variances.

13.5.7 Driver-Focused Technologies

While the technologies discussed above focus on the management of transportation, regulatory compliance, and the supply chain, technologies are expanding to encompass the human element of transportation: the *driver*. Companies not only need to optimize the costs of driving – using technologies like GPS, Electronic Logging Devices (ELD), and *telematics* (an interdisciplinary field encompassing telecommunications, vehicular technologies, road transportation, road safety, electrical sensors and wireless communications and multimedia, Internet, etc.) – but also the costs, efficiency, and performance of the drivers themselves. Today's cab is both an office and a command center. Inside the cab, the connected driver is responsible for providing safe, timely, and regulatory-approved access to up-to-the minute data on routes, schedules, deliveries, and much more. Outside the cab drivers must seamlessly document deliveries and service and interact with suppliers and customers.

Drivers have access to a wide range of technologies as they begin their routes each morning. A driver's in-vehicle or handheld computing device has already been programmed with current information needed to maximize productivity from the beginning of the day to the end. Among the applications available are [36]:

- *Driver vehicle inspection report (DVIR)*. Inspecting the vehicle and completing the DVIR is a driver's first daily activity. Instead of a manual form, drivers can use handheld devices to compile and electronically post reports on vehicle status, including photos of vehicle problem.
- *Load planning*. Drivers can validate that their vehicles are loaded for maximum efficiently using the latest imaging technology for pallet and packaging dimensioning and load optimization, and ensuring deliveries are accurate and in the proper sequence for the route plan.
- *Route optimization*. The driver's in-vehicle computer or handheld provides dynamic up-to-the minute route optimization that assists in meeting tight delivery windows and fulfill expedited or emergency pickup and delivery request.
- *Fleet management and telematics*. A mandate by U.S. regulation, all vehicles must have an electronic logging device (ELD) to automatically read and update engine and vehicle safety and performance telematics. Output reports help to improve driver performance, as well as ensure the vehicles are being operated safely and running smoothly.

- *Turn-by-turn navigation*. The vehicle's GPS system guides the driver along the proscribed route in real time, providing current audio and map-based turn-by-turn navigation assistance, ensuring the on-time deliveries expected by the customer.
- *Document capture*. Applications on their handheld computers enable sophisticated document capture and transmission. Drivers have access to proof of delivery electronic signature capture streamlining proof of pickup through bill of lading (BOL) scanning and processing.

Today's next generation, technology-based pickup and delivery centered on sophisticated applications and handheld devices is fulfilling an increasingly critical role in optimizing customer service and maximizing ROI.

13.6 TRANSPORTATION MANAGEMENT LSPS

The role of logistics service providers (LSPs) was introduced in this chapter where the use of LSPs in warehousing was explored. The use of LSPs is an important business strategy. According to the *2014 Third-Party Logistics Study* conducted by Capgemini, companies use LSPs extensively to perform transactional and operational activities. These include domestic and international transportation (81 % and 78 % respectively); warehousing and distribution center management (73 %); freight forwarding (62 %); and customs brokerage (57 %). The continued growth of the use of LSP is dramatic. According to the report, shippers can expect an average logistics cost reduction of 11 %, average inventory cost reduction of 6 %, and an average fixed logistics cost reduction of 23 % [37]. On their part, LSP are expected to continue to experience strong financial growth (Table 13.15).

TABLE 13.15. Global LSP Market Size and Revenues

Region	2011 global LSP revenues (US$ billion)	2012 global LSP revenues (US$ billion)	Percent change 2011 to 2012 (%)
North America	US$159.9	US$170.6	+6.7
Europe	160.4	156.2	−2.6
Asia-Pacific	191.1	236.2	+23.6
Latin America	39.5	44.4	+12.4
Other regions	65.2	69.4	+6.4

13.6.1 Types of Transportation LSPs

In this chapter, three types of LSP were discussed: basic services LSPs, the 3PL model, and the 4PL model. It was also noted that these types of LSP often provide outsourcing services for both warehousing and transportation. Although the service offerings often cross-over into each other making precise categorization difficult, it is possible to identify five distinct forms of transportation LSPs: transportation-based, distribution-based, forwarder-based, financial-based, and technology-based [38].

- *Transportation-based.* LSPs in this type are primarily focused on providing the five modes of transportation to the marketplace. These businesses have emerged not only to provide transportation services, but also a comprehensive portfolio of logistics solutions including managing transportation operations for their customers, providing dedicated contract carriage, operating fulfillment centers, and developing logistics solutions. The most recognizable examples of this type of transportation LSPs include APL Logistics, FedEx, Schnieder National, and UPS.
- *Distribution-based.* This type of LSP primarily offers public and contract warehousing. While primarily involved with inventory management, product storage, and order management, many distribution LSPs also provide limited transportation services to assist their customers with the coordination, optimization, and execution of shipment via all modes. Recognizable distribution-based LSPs are DSC Logistics, Exel, and Caterpillar Logistics Services.
- *Forwarder-based.* This type of transportation LSP consists of freight forwarders, brokers, and agents that manage transportation search and administration for their customers. The prime characteristic of this type is that they do not own any transportation equipment. Instead, what they do is arrange transportation for LTL shipments, book air cargo and ocean freight, and assist in international freight movement, as well as prepare and process documentation and provide other transportation services. Some important freight forwarders are C.H. Robinson Worldwide, Inc., Hub Group Inc. and Kuehne + Nagel Inc.
- *Financial-based.* This type of LSP assists shippers with financial functions arising out of transportation activities. Services include freight rating, freight payment, freight bill audit, and general accounting. Other services include track-and-trace capabilities, electronic payment, international currency management, carrier compliance reporting, and freight claims management.
- *Technology-based.* This type of LSP provides transportation information technology resources to the marketplace. As technology capabilities have grown, LSPs have also found themselves shouldering the cost for managing information capabilities. Many companies simply do not have the financial and people resources to hook-up to today's fast paced technology tools and are increasingly looking to their LSPs to provide the expertise to collect and scrub data and drive it directly into their backbone systems, perform e-commerce functions, provide proactive exception management, and enable participation in the Web-driven supply chain. APL Logistics, for example, provides not only core logistics services, but also advanced technology capabilities to its customers. APL, in fact, has an entire division devoted to developing and integrating the latest in proprietary and industry-standard supply chain technologies for product visibility, exception management, execution systems optimizing shipping and warehouse decisions, Web-based decision tools, and performance reporting. Customers have the capability to then turn-up or phase down their use of these services depending upon on-going needs and level of internal expertise.

13.6.2 Range of Transportation LSP Services

Today's shipper has the ability to outsource just about any needed transportation service to a wide spectrum of LSPs. Services span the spectrum from strategic supply chain design to the execution of daily operations. Coyle, et al. divide LSP services into four primary types: freight movement, freight management, intermediary services, and specialty services [39]. *Freight movement* contains the traditional LSP services including for-hire carriage, contract carriage, shipment expediting, time-governed delivery, and intermodal. *Freight management* contains services associated with carrier selection, routing, and scheduling; contract compliance, performance analysis, fright bill audit and payment; and TMS hosting.

Intermediary services do not move goods but rather act as an agent for linking shippers with transportation alternatives. Services in this type include surface forwarding (LSP that assemble shipments and hire carriers to do the transport to the final destination); air forwarding; freight brokerage (an independent agent paid to arrange transportation); intermodal marketing (arrangers of rail transport); and shippers associations (nonprofit transportation cooperatives assisting members select transport modes). The final LSP service type is *specialty services*. Important services provided are dedicated contract carriage (carrier acts as a firm's private fleet); drayage (carrier provides local transportation of containers from ports and yards to end destination); pool distribution (carrier moves product in bulk and at the terminal separates into individual smaller customer quantities); merge in-transit (shipments from multiple suppliers are merged at a location close to the customer); and household goods movement (van lines used to haul the household goods of people and businesses).

13.6.3 Working with LSPs

The use of LSPs has grown in intensity over the years. According to the *2014 Third-Party Logistics Study,* companies reported that an average of 44 % of their total logistics expenditures are related to outsourcing, up from 42 % reported in 2012. Over 90 % of shippers reported that their relationships with LSPs were generally successful, while a higher percent of LSPs (97 %) felt their relationships with shippers were successful. Shippers also tallied measureable benefits by using LSPs in 2014. The average logistics cost reduction reported by shippers was 11 %; the average inventory cost reduction was 6 %; and the average fixed logistics cost reduction was 23 %. In addition, order fill rates increased from 66 % to 68 % and order accuracy increased from 68 % to 69 %. As with past years, just over half of shipper respondents (55 %) reported their use of LSPs had led to year-over-year incremental benefits [40].

The reason why businesses use LSP services is because they either do not have the transportation capabilities or the LSP can provide services at a lower cost than can be performed internally. According to *Inbound Logistics* ninth-annual *2013 3PL Perspectives* research, the top five reasons why shippers look to LSP are cutting transport costs (63 %), business process improvement (33 %), improving customer service (30 %); supply chain visibility (22 %); and managing inventory (20 %). Close behind were expanding markets, reducing labor costs, regulations/security/compliance issues and technology strategy [41].

Using a LSP requires that businesses also assume the following risks:

- *Loss of control*. Outsourcing logistics means surrendering control over some or all aspects of logistics. Managing an effective logistics strategy may be difficult when some aspects of logistics have been outsourced to an LSP.
- *Potential for inefficiency*. A poorly executed LSP strategy may actually cause logistics inefficiencies and loss of contact with the customer.
- *Loss of core competencies*. Outsourcing may have the effect of hollowing out internal logistics competencies. The business must continually review the arrangement, recapture the outsourced function, or rethink the entire outsourced strategy.
- *Potential for increased costs*. Despite the thoroughness of the LSP contract, changing business conditions and actual LSP capabilities may result in excess costs beyond what was negotiated.

As portrayed in Figure 13.10, the most frequently outsourced services identified in the *2014 Third-Party Logistics Study* tend to be those that are transactional, operational, and repetitive. Less frequently used services identified tended to be value added, strategic, and IT-intensive, such as transportation planning and management (28 %); IT services (22 %); 4PL services (15 %); and sustainability/green supply chain services (5 %).

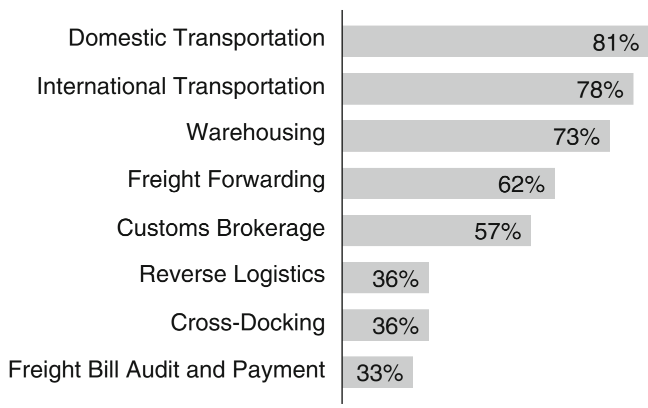


FIGURE 13.10 Critical requirements for LSP services [42].

Whether committing to a full 4PL or using a portfolio approach to LSP services, transportation strategists need to consider the following factors in their decisions.

- *LSP flexibility*. Logistics planners must draft a contract that provides flexibility to respond to service changes due to new technologies, channel remapping, new products, new competitors, and other issues. Open dialogue ensures both parties have commonly accepted definitions and terms, detailed performance measurements, and a methodology to adjust logistics functions and expectations to meet current realities.
- *Defined cost of services*. Rarely are all permutations of costs and scope of services fully defined contractually. Once actual services begin, actual performance sometimes varies widely from agreed upon contracted standards. An effective method to cope

with these issues is to plan for high, medium, and low costs in the contract. Consistently enforcing the low-cost solution will unsettle even the best relationship.

- *Managing the human side of outsourcing*. The introduction of a LSP requires the effective education and concurrence of the people in the organization. Outsourcing internal functions to an outsider can cause friction and uneasiness among affected employees. A plan that integrates managers, supervisors, and staff into the process ensures their feedback and support are a critical factor in reaching the outsource decision.
- *Realistic expectations*. False expectations about savings and effectiveness of outsourced services can sink even the most finely tuned LSP relationship. In reality, both parties must work closely together to establish realistic expectations and then structure a program to guide continuous improvement through time.
- *Technology misunderstandings*. Often customers and LSPs exaggerate their technical capabilities, as well as downplay what technology expertise is required of each other. Solving this problem requires a realistic statement of competencies to initiate technology improvements that enhance the partnership and drive new benefits.
- *Partnership commitment*. It is essential to secure the firm commitment of company management to the LSP arrangement. The executive team must be apprised of its role as leaders and supporters in the ongoing management of the relationship, both from a change management and an expanding collaborative partnership perspective.
- *Retain core competencies*. Companies must be vigilant to ensure that critical competencies and processes are not contracted away. An effective LSP strategy seeks to outsource the expense while retaining the core skill sets that make the business unique.

With these factors in mind, planners can institute a mutually rewarding LSP relationship. Five critical steps need to be performed. The first is to critically identify the services they needed from their LSPs. Second, planners must gain the support of management and staff. Third, search and locate LSPs with the necessary competencies. Fourth, evaluate LSP candidates, choose the best fit, and execute a viable contract. Fifth, determine the performance measurements to guide the ongoing strengths and benefits of the partnership and search for continuous improvement.

13.7 SUMMARY

Although warehousing has often been called the "heart" of the distribution channel, transportation can justly be described as the veins and arteries by which products are moved through the supply chain pipeline. By providing for the swift and uninterrupted flow of products, transportation enables companies to compete with other businesses in distant markets on an equal footing. Transportation also permits wider and deeper penetration of new markets far from the point of production. In addition, by maximizing vehicle and materials handling capacities, effective transportation permits enterprises to leverage economies of scale by lowering the per-unit cost of transporting product. Efficient transportation enables firms to reduce the selling price by holding costs down, thereby providing for more competitive product positioning. Finally, transportation provides other business functions with essential information concerning inventory place and time utilities, and transit costs and capabilities necessary for effective supply chain planning and operational execution.

There are several modes of transportation – motor, rail, air, water, and pipeline. Factors influencing transportation selection include the type of distribution environment to be serviced; enterprise strategic goals; financial capabilities; product order volumes; required delivery lead time; physical characteristics, such as size, perishability, seasonality, potential for obsolescence and theft; and intrinsic value, geographical size of the distribution channel, carrier type availability, and strength of the competition. Shippers have the choice of using four possible legal types of transportation. The first three types, common carriers, contract carriers, and exempt carriers, are operated by for-hire freight companies and are subject to various federal, state, and local statutes and regulations. In contrast, the fourth type, private carriers, use company-owned equipment to transport products and supplies through channel networks to the customer. Selection of transportation mode is governed by performance characteristics such as speed of delivery, minimization of changing modes during transport, dependability, capacity, frequency, and cost.

The effective day-to-day management of transportation activities is absolutely necessary for the smooth functioning of the business. The first step in the management process is to establish the cost-effectiveness of using private transportation fleets versus for-hire carriers. If for-hire carriers are to be considered, planners first determine the costs, rates, and prices before a detail carrier search begins. The goal is to ensure the highest level of customer service at the lowest possible price. The second step involves selection of the mode and public carriers to be used. Modes should be chosen that will best perform the service for the cost, satisfy any special shipping requirements, exceed the services offered by competing carriers, and minimize the likelihood of loss, damage, or delivery delay. The selection of a carrier is normally based on a combination of factors including the price of the service, carrier financial stability, reliability, mode availability, and subjective elements.

Once the mode and carrier is selected, shippers then perform detailed transport scheduling and routing. *Vehicle scheduling* is defined as the selection of the customer orders to be delivered by a single vehicle. *Vehicle routing* establishes the sequence in which customer orders are to be delivered during the transportation route. The fourth step in the process is the preparation and completion of the necessary shipping documentation, performing freight bill audits, and managing any shipment claims. Finally, mangers must be diligent in developing transportation performance measurements providing them with quantifiable data necessary for increased productivity and competitive advantage. Metrics should be developed for both purchased and internal transportation and should consist of price and carrier delivery performance.

The transportation industry in the twenty-first century is having to grapple with several issues ranging from the physical condition of transportation infrastructure to environmental and regulatory concerns. The first is the challenge posed by the poor condition of the nation's aging transportation infrastructure and operational problems in each of the nation's transportation modes. The second area is responding to the impending driver shortage, compounded by new driver hours-of-service federal rules. A new challenge growing in importance is transportation environmental sustainability that increasingly is impacting the entire globe. A fourth challenge stems from the need for transportation planners to increasingly calculate risk into their strategies. Broadly, transportation risk management includes supply chain, financial, and security issues. The fifth challenge is the opportunities offered by new transportation technologies such transportation management systems (TMS); yard management systems (YMS); routing, scheduling, and event management systems; and a host of driver-focused technologies detailing the costs, efficiency, and performance of drivers.

Finally, of the new developments impacting today's transportation manager, the use of *logistics service providers* (LSPs) is the most revolutionary. In today's complex, global logistics environments, companies are finding that they often do not have the capability to provide the full range of services to effectively execute end-to-end supply chain management requirements. LSPs fill this gap in non-core functions by providing the following critical services: *logistics services* associated with strategic management of lean supply chain initiatives, global trade, supplier management, payment and auditing, and product life cycle management; *transportation services* including all forms of transport from LTL and intermodal to fleet acquisition consulting and equipment leasing; *warehousing services* focused on storage facility outsourcing, VMI programs, and fulfillment; *special services* required for such activities as home delivery, international sales, reverse logistics, and transportation consulting; and, *technology services* providing access to computerized tools such as Internet connectivity and networking and cloud computing. Choosing an effective LSP partner has become a critical strategy for most transportation departments requiring a firm understanding of partnership objectives; depth of the relationship; defined cost, benefits, and expectations; and flexibility of services available.

DISCUSSION QUESTIONS

1. Why is transportation management so important?
2. What are the four principles of transportation operations?
3. Who are the main participants in transportation management?
4. Discuss the key challenges facing transportation management today?
5. How does the distance a load travels to its destination and its weight affect transportation cost?
6. What are some of the risks that can threaten the effectiveness of transportation?
7. What are the four potential costs involved in the actual shipment of a load?
8. How do companies with private fleets measure their performance?
9. What are the three principles of transportation?
10. Explain the concept of intermodal transportation. What are the benefits of using intermodal transportation?

PROBLEMS

1. ABC Motor Transports, Inc., operates a fleet of trucks and 40-ft trailers that travel from New York to Cleveland and Detroit. The fixed cost for the fleet per year has averaged US $7,500,000. ABC determined that the average variable cost between New York and Cleveland and Detroit is US$325 per truck and 40-ft trailer. If the company, for the past 12 months, has contracted 95,000 shipments, what would be the total cost to ABC Motors?
2. Based on the transportation data for ABC Motor Transports, Inc., detailed in problem 1, what is the average cost per truck and trailer?
3. The traffic manager at ABC Electronics needs to ship 20,000 lbs. of a popular TV from the main warehouse in Chicago to ABC's regional warehouse in Denver (1,500 miles). The load will fit in a single 40-ft trailer. The traffic manager is using a contract carrier to perform the shipment. The carrier has quoted to the following pricing information:
   - Transportation line-haul cost is US$15.50 per mile in the carrier's 40-ft trailer.
   - The pickup and delivery costs for the shipment is US$250.00.

   What is the total line-haul cost for the shipment?
4. Based on the data in problem 3, what would be the cost of the delivery per hundredweight?
5. Based on the data in problem 10, the carrier has informed the traffic planner that if ABC could assemble a second truck with the same weight of 20,000 lbs., the line-haul cost could be cut to US$3.75 and the pickup and delivery cost for both trucks cut to US$175. The traffic planner is interested in the proposal. However, the large quantity would mean that one of the trucks would have to make a terminal stop in Kansas City before proceeding on to Denver. A terminal stop would cost US$450.00. What would the cost of the proposal be to ABC?
6. The traffic planner at ABC Electronics has decided to search for an alternative carrier to ship the original order for 20,000 lbs. Fast Freight has provided the following base rate table to the planner.

Weight/lbs	5,000	10,000	15,000	20,000	25,000	30,000	35,000
Cents/cwt	2,000	1,800	1,500	1,400	1,300	1,200	1,100

What would be the price in US dollars (100 % equal one US dollar) for the shipment based on the table information?

7. The transportation planner at ABC noticed the following shipments coming from the manufacturer for a popular TV over the next 4 days.

Order #	Ship date	Weight (lbs)	Rate (cwt)	Cost
10002	5/21/20XX	7,200	US$3.00	US$210.00
10005	5/22/20XX	12,000	US$4.00	US$480.00
10006	5/23/20XX	8,000	US$3.00	US$240.00
10009	5/24/20XX	13,000	US$4.00	US$520.00

After conferring with the shipper, the planner found that shipments exceeding 35,000 lbs. received a rate of US$2.00 cwt. How much money could the planner save the organization if the four shipments were consolidated into a single vehicle (44,000 lbs. max capacity for one 40-ft trailer)?

8. The traffic planner at ABC Electronics must calculate the ton-miles for a delivery. If the shipment weights 700 t and is to be delivered to a destination 1,200 miles away, what is the total ton-miles?
9. The traffic planner must determine the cost for a rush shipment of a popular electronics product. The price for the standard lot size by motor carrier is US$850 and it takes 6 days for delivery. An alternative is to use air transport. The cost to transport the same lot size is US$2,100 and it takes one day for total transport time. The carrying cost for in-transit inventory for the item is US$150.00. What would be the difference in cost to expedite the shipment by air transport?
10. The traffic planner at ABC must send a replenishment order for a popular electronic product from the Chicago distribution center to the satellite warehouse in Seattle, a distance of 2,051 miles at a cost of US$6.50 per mile. The normal shipment size is 200 units. What is the line-haul cost per unit?

CASE STUDY

Solving a Transportation Problem at ABC Electronics

As the traffic manager for ABC Electronics, you have been charged with the task of reducing shipping costs for a fast selling cable product that is sold by the pound. You have a very satisfactory relationship with a third-party carrier who is currently giving you with a very competitive price. All orders are shipped to customers at a cost of US$0.05 a pound with a fixed US$50 fee per shipment. Over the past 2 weeks, daily demand for the cable has been tracked and appears in the table below.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Week 1	15,025	13,740	855	13,250	950	15,750
Week 2	16,025	10,005	14,525	995	17,500	15,250

Currently, ABC ships orders every day with a one day preparation time, which means that ABC has to process the customer order, pick and pack, and ship it within a two lead time. One of management's suggestions is to change the quoted shipment time by aggregating shipments by adding 1 or 2 more days. Sales and marketing have done research on extending the shipping time and have found that a small increase the lead time will have relatively little impact on sales.

What would be the impact on the transportation cost with a 3 day or a 4 day lead time?

Which would be the best choice?

REFERENCES

1. All references to the *APICS Dictionary* are from the 14th edition (2013).
2. Wilson, Rosalyn. 2014. *The 25th annual state of logistics report: Is this the new normal?* Oakbrook: Council of Supply Chain Management Professionals, Visual 2.
3. These international figures are found in Goldsby, Thomas J., Deepak Iyengar, and Shashank Rao. 2014. *The definitive guide to transportation: Principles, strategies, and decisions for the effective flow of goods and services*, 7–10. Upper Saddle River: Pearson Education.
4. These statistics were taken from U.S. Department of Transportation, *National Transportation Statistics – 2013,* Bureau of Transportation Statistics.
5. See the comments of Bowersox, Donald J., and David J. Closs. 1996. *Logistical management: The integrated supply chain process*, 314. New York: McGraw-Hill.
6. Bowersox, Donald J., David J. Closs, M. Bixby Cooper, and John C. Bowersox. 2013. *Supply chain logistics management,* 4th ed, 188–190. New York: McGraw-Hill Irwin.
7. These values are from Wilson, *The 25th Annual State of Logistics Report.*
8. Schultz, John D. 2014. Transportation Best Practices: Private Fleet Management – Tailored for Success. *Logistics Management,* May 2014.
9. Walmart website http://walmartprivatefleet.com/CompetitiveAdvantage/Stats.aspx
10. Schultz, John D. 2004. Top 50 Trucking Companies: Anticipating needs; exceeding Expectations. *Logistics Management,* April 2004.
11. ATRI. 2013. *Critical issues in the trucking industry – 2013*, 1–14. Arlington: The American Transportation Research Institute.
12. These statistics were taken from U.S. Department of Transportation, *National Transportation Statistics – 2013.*
13. These values are from Wilson, *The 25th Annual State of Logistics Report.*
14. Of the seven Class I rail companies, BNSF Railway, CSX Transportation, Norfolk Southern Railway, and Union Pacific Railroad have evolved as the dominant carriers in the U.S. None of these rail carriers services the entire country by itself; they work closely together via interline agreements to provide coast-to-coast rail service.
15. These statistics were taken from U.S. Department of Transportation, *National Transportation Statistics – 2013.*
16. These statistics were taken from U.S. Department of Transportation, *National Transportation Statistics – 2013* and U.S. Department of Transportation Maritime Administration, *2011 U.S. Water Transportation Statistical Snapshot* (November 2013).
17. See the analysis in Coyle, John J., C. John Langley, Brian J. Gibson, Robert A. Novack, and Edward J. Bardi. 2009. *Supply chain management: A logistics perspective*, 8th ed, 417–419. Mason: South-Western Centage Learning; and Coyle, John J., Robert A. Novack, Brian J. Gibson, and Edward J. Bardi. 2011. *Transportation: A supply chain perspective*, 7th ed, 359–364. Mason: South-Western Centage Learning.
18. Pitt Ohio Express. 2014. *Controlling Surface Transportation Costs.* Pitt Ohio White Paper.
19. These three elements are discussed in greater detail in Ballou, Ronald H. 1999. *Business logistics management,* 4th ed, 157–161. Upper Saddle River: Prentice Hall.
20. This table is adapted from Coyle, et al., 345.
21. This exercise is adapted from Ballou, Ronald H. 1992. *Business logistics management,* 4th ed, 190. Upper Saddle River: Prentice Hall.
22. This exercise is adapted from Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operation,* 4th ed, 376–377. Upper Saddle River: Prentice Hall – Pearson.

23. The full report card can be found at American Society of Civil Engineers, http://www.infrastructurereportcard.org
24. For a summary of HOS regulations see Federal Motor Carrier Safety Administration, http://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations
25. See U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011," 2013, www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf; Intergovernmental Panel on Climate Change. "Climate Change 2014: Mitigation of Climate Change," 2014, http://www.ipcc.ch/publications_and_data/publications_and_data.shtml. *World Energy Outlook 2008,* International Energy Agency, www.iea.org/media/weowebsite/208-1994/WEO2008.pdf
26. These points were adapted from Olson, Eric, and Ryan Schuchard. *Transitioning to low-carbon fuel – working paper*, 6–7. Business for Social Responsibility – BSR, April 2014.
27. Editorial Staff. 2013. It takes a Commitment. *Supply & Demand Chain Executive* 14(5): 8–16.
28. For a concise review of surcharges see Abramson, Molly, Ajit Sawant, and Kevin McCarthy. 2013. *Truckload Fuel Surcharges: How they Work and What They Cost.* C.H. Robinson White Paper.
29. See the comments in Gonzalez, Adrian. 2009. *The economy as a catalyst for change: The role of TMS and managed services. ARC Brief*, 1–12. Dedham: ARC Advisory Group.
30. See Manhattan Associates. 2010. *Transportation Lifecycle Management.* Manhattan Associates White Paper (2010).
31. ARC Advisory Group. 2013. *2012–2017 TMS Global Market Research Study*. ARC White Paper (July 2013).
32. These capabilities have been taken from the YMS offered by logistics software vendor Manhattan Associates and are fairly typical of packaged YMS systems available on the marketplace.
33. Wulfratt, Marc, and Gegory Braun. 2012. *Yard Management Systems.* Creative Collaborating Component Solutions C3 Inc. Whitepaper (September 2012).
34. These figures are found in Goldsby, et al., *Definitive Guide to Transportation,* 128.
35. Murphy, Jean V. 2002. Seeing inventory in real time lets you have and have not. *Global Logistics and Supply Chain Strategies* 6(5): 34–40.
36. These driver technologies were obtained from Motorola. 2013. *Next Generation Pickup and Delivery Puts the Customer in the Driver's Seat*. Motorola White Paper (2013).
37. Langley, C. John, and Capgemini. 2014. *2014 Third-Party Logistics Study,* 12. Capgemini White Paper (2014).
38. This distinction is made by Coyle, et al., *Transportation,* 399–403.
39. Ibid, 403–407.
40. Langley and Capgemini, *2014 Third-Party Logistics Study,* 10.
41. O'Reilly, Joseph. 2013. 2013 3PL perspectives. *Inbound Logistics* 33(7): 100.
42. These figures are adapted from Langley and Capgemini, *2014 Third-Party Logistics Study,* 12.

PART 5

INTERNATIONAL DISTRIBUTION AND SUPPLY CHAIN TECHNOLOGIES

CHAPTERS

Part 5 explores how two radically disruptive developments, the rise of the global marketplace and the application of information technologies, have virtually transformed the theory and practice of supply chain management (SCM). Chapter 14 explores the globalization of the world economy. The growth of global trade is the result of a number of marketplace trends. Some relate to the convergence of several information process technologies, particular the Internet, and their ability to network companies and markets across the globe into a common community. Other factors driving globalization are the maturing of the economies of today's industrialized nations and their need to explore foreign markets as sources of innovation and competitive advantage as well as of basic materials, cost-effective components and finished goods, and low labor costs. Major topics reviewed in this chapter are the formulation of global channel strategies, managing global trade networks, international purchasing, and international transportation and warehousing.

The final chapter in the text is concerned with the second disruptive development facing the supply chain manager: *information technologies*. As it has in all aspects of today's business environment, computer business applications that facilitate and accelerate the speed of information processing while providing the framework for the integration and interoperability of technologies across supply chains has dramatically shaped the theory and practice of SCM. In harnessing the power to automate and informate, supply chain have been able to utilize technologies to explore new regions of efficiency, channel relationships, and competitive advantage in ways previously thought impossible. A critical requirement in deploying SCM technologies is a thorough plan for implementation. Companies must conduct detailed hardware and software application searches and possess the project management skills to realize the full value of their technology solutions. Such a task requires a full grasp of the strategic and tactical objectives to be attained by the technologies; the impact of changes on the organization and it capabilities; the costs of resources and the time it will take to implement the technologies; and the expected gains in productivity and competitive advantage resulting from implementation. Effectively leveraging SCM technologies enables organizations to restructure their cultures and capabilities with a focus on promoting improvement and teamwork values; leverage new information tools such as graphics, workstation technologies, and Internet-driven network-to-network computer integration; and broaden the goals and skills of the enterprise's people resources.

14

INTERNATIONAL DISTRIBUTION

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_14) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*, DOI 10.1007/978-1-4899-7578-2_14,

When business historians look back at the period of the last 10 years of the twentieth century and the first decades of the new millennium, one of the most salient developments will be the emergence of the global economy. For several decades after the Second World War, companies rarely ventured outside their own national boundaries. While some of the world's largest corporations, such as Coca-Cola, Ford Motor Company, and Procter & Gamble, had historically engaged in a significant international trade, governments were fearful of exporting technologies, core skills, product, and wealth that might drain national resources in the face of the Cold War. In many cases, enormous markets, such as Eastern Europe, Russia, and China, were closed behind a seemingly impenetrable "iron curtain." Today, the Cold War has long been part of history. Some of the world's most vibrant economies, such as China, Brazil, and India, have emerged from behind once closed societies to engage billions of people in global commerce in the search for individual as well as national growth and well-being. The advent of connective technologies have enabled companies at the furthest ends of the earth to network their ideas and their businesses in real-time, accelerate the growth of the international marketplace, and integrate the world's economic activities.

Fundamental to sustaining this growth is the establishment of efficient and cost-effective global supply chain management strategies and processes. Issues relating to regional trading-blocks, collaborative partnerships, global materials and product sourcing, cost-effective storage, speedy transportation, and new concerns, such as risk management and environmental sustainability, have become the foremost frontiers of competitive advantage. As the world's industrialized nations intensify their search for new markets and new sources of products and services abroad, supply chain management has become increasingly pivotal for success. Nations that have substandard systems of roads, water-ways, rail, poorly trained labor pools, inadequate distribution support systems, and protectionist governments will find their entrance into the global marketplace on an equal footing difficult with an increased chance of being by-passed by global strategists. As globalization expands, it will be the responsibility of supply chain planners to design the logistics networks of the future, provide superlative customer services at the lowest cost, and engineer the sourcing, production, inventory control, warehousing, and transportation functions that will propel the global economy into the twenty-first century.

Exploring global trade and distribution is the focus of this chapter. After considering the economic, competitive, and supply chain trends fueling globalization in the early twenty-first century, the chapter proceeds to a discussion of the major features of an effective globalization strategy. At this point, the chapter explores the four major global strategies: exporting, licensing, joint ventures, and direct ownership. Critical to the success of a channel strategy is the effective management of the international distribution network. Topics discussed in this section are establishing the global channel network (service/cost elements and configuration of the trade network); global marketing issues (department organization, products and services offered, terms of trade, trade contracting, pricing, financials, and export/import documentation), and implementing a global trade management (GTM) system. An analysis of international purchasing and product importing forms the basis of the next section. Topics discussed are advantages of international sourcing, countertrade purchasing, and the international purchasing management process. The chapter concludes with a review of the transportation and warehousing requirements of global channel management.

14.1 GLOBALIZATION OF THE WORLD ECONOMY

The *APICS Dictionary* [1] defines globalization as

> The interdependence of economies globally that results from the growing volume and variety of international transactions in goods, services, and capital, and also from the spread of new technology.

In today's business climate, companies cannot help but look beyond national boundaries to acquire the materials and core competencies to compete on a global stage and well as gain access to markets previously unreachable. In many ways, the growth of the science of supply chain management has enabled companies to leverage the power of networking with supply and distribution partners to change the international business landscape. For example, some U.S. companies derive over 25 % of their profits from global sales. Simply, the cost and value activated by supply chain management determine a company's ability to compete across a global marketplace.

The data related to global trade reflects this new world of the global supply chain. Over the past 45 years, the growth of global trade has been dramatic. In 1970 the U.S. exported over $56.6 billion and imported over $54.3 billion. In 1990, exports reached $535 billion and imports $616 billion. In 2002 exports reached $971 billion ($682 billion in goods and $289 billion in services) and imports stood at $1.4 trillion ($1.16 trillion in goods and $240 billion in services). In 2013, exports of goods and services from the U.S. totaled $2.28 trillion; imports totaled $2.75 trillion [2]. In 1955, global trade in manufactured goods totaled US $495 billion. In 2005, the number grew more than 100 times, to reach nearly US$12 trillion. According to the World Trade Organization (WTO), total global exports in 2012 reached US $17.93 trillion and imports reached US$18.18 trillion [3] (Table 14.1).

TABLE 14.1. Value of Exports, Imports and Balance of Goods by Selected Countries: 2013 [4]

Value of exports, imports and balance of goods by selected countries: 2013			
In millions of U.S. dollars			
Country	**Exports**	**Imports**	**Balance**
Canada	172,461	201,912	–29,451
China	36,999	130,367	–93,368
Mexico	73,499	91,138	–17,639
Japan	20,791	46,381	–25,590
Germany	15,839	355,733	–339,894
United Kingdom	15,858	16,807	–949
South Korea	13,620	20,599	–6,979
Hong Kong	13,289	1,800	11,489
Taiwan	8,727	11,957	–3,230
France	9,936	14,228	–4,292
Singapore	9,734	5,930	3,804
Brazil	13,753	8,247	5,506

Research conducted in April 2013 by SCM World highlighted the growing complexity of cross-border trade [5]. Where globalization once meant low-cost country sourcing, today it is clear that goods move in all directions at once. Movement of product, whether raw materials, finished goods, or capital equipment, requires an approach to global trade management that is ever vigilant of the dynamics of regulations, taxes, transportation cost, and more. Among the findings, it was found that

- Three-quarters of the companies surveyed conduct trade across more than 10 countries, with almost half (48 %) trading across more than 50 countries.
- Over 41 % of the companies surveyed import more than half of their products from international suppliers.
- More than 97 % of respondents feel that product cost savings are either "important" or "very important" business drivers of global sourcing.
- Thirty-five percent of the companies realize more than half of their sales from customers located in foreign markets, and two-thirds expect their total share of international sales to grow by more than 10 %, while 28 % expect growth of more than 25 %.
- Forty-eight percent of respondents felt than an inability to control global transportation costs and the lack of visibility of global shipments moving through the global supply chain constituted their top business challenges.

While there has been a resurgence of reshoring manufacturing in the mid-2010s, where companies have or intend to bring back some of their production from low-cost, off-shore locations, global trade is hardly on the wane. The reality is that while low-cost country sourcing, particularly in China, has lost some of its competitiveness, the flow of product across borders is increasing, not decreasing, and is now bi-directional or multi-directional rather than one way.

This explosion in foreign trade and increasing interdependence of global markets is the result of a number of trends driven by continued world economic growth and the connective power of technology that are expected to accelerate the growth of globalization. This growing economic internationalism, however, is not assured nor universally accepted as evidenced by the recent violent protests in recent years accompanying the meetings of international bodies like the International Monetary Fund and the WTO. Among the barriers are found political and economic regulations, financial restrictions, and poor logistics infrastructures.

14.1.1 Trends Accelerating Globalization

There are a variety of forces driving today's growth in international trade. Among the key factors are: maturing of the economies of developed nations, growing foreign competition, acceleration in global deregulation, growth of strategic alliances, and closer integration of domestic and international distribution systems.

14.1.1.1 Maturing of the Economies of Developed Nations

The maturing of the economies of today's developed economies has fundamentally altered traditional thinking about global trade. For over a decade before the new millennium, it had become clearly evident that the era of high growth in developed economies was over as business consolidations, shrinking margins, aging populations, declining profitability, and production overcapacity indicated that many sectors of established economies had slipped from growth to maturity. While it is true that the U.S. still occupies a position of global economic hegemony, it is clear that continued economic growth can only take place in the context of increased dependence on international partnerships. Today, some of the largest global corporations are combinations of once solely owned U.S. companies and foreign companies.

As markets at home have stagnated, companies in developed economies have turned to the exploding markets of the Pacific Rim, Brazil, and Eastern Europe. The decline in global tensions, the explosion in communications technologies, the movement of former closed countries toward market economies, and the easing of protectionist attitudes have made foreign trade of critical importance in sustaining competitive advantage. In addition, countries like the U.S. can no longer avoid the fact that continued economic success is predicated on international trade. Many products, such as oil and other basic raw materials, must be imported; often cost-effective components assembled in foreign countries are critical for the production of domestic finished goods. Finally, there can be no denying that certain imported products are here to stay. China's growing leadership in the production of high-labor, low-cost commodities and textiles can only expect to expand; Japanese leadership in television sets and low-priced microelectronics and parity in the automobile market are testimony of the impact of foreign products on American purchasing habits.

14.1.1.2 Growing Foreign Competition

Over the past 20 years, the expanding internationalization of foreign companies, as well as the coalescence of trading blocks in Europe and Asia, have challenged the supremacy of traditional economies and altered the balance of trade. This globalization of competition has accelerated sharply in just the past few decades. The emerging economies in Eastern Europe, China, Japan, and South Korea have long looked to the U.S. import marketplace to sustain their growing economies and to gain trade parity. In addition, many developing countries, such as Brazil, Mexico, and Viet Nam, who enjoy lower operating costs, are also seeking to catapult their economies to "world-class" status by supporting domestic companies with leadership in textiles, apparel, and electronics. The U.S. has countered by refocusing its efforts at increasing exports, not only with the major industrialized nations, but also with developing countries on a bi-lateral basis. The result has been a clear-cut requirement for American businesses to continuously decrease production and distribution costs if they are to remain competitive.

Many nations have also come to realize that deregulation and opening avenues of foreign trade, reducing tariffs, and fostering free trade are essential building blocks to their continued expansion. The growth in incomes worldwide, the development of distribution channel infrastructures, and the speed of communications have increased global demand for new products and market opportunities. Multinational efforts to divide the industrialized world into three massive trading blocs in Europe, Asia, and North America have also made an enormous impact on U.S. trade and logistics. The surprisingly easy successes enjoyed by the European Union to effect continental economic unification and a common currency in 2002 are providing Europe with the potential to assemble a powerful economic engine.

A critical development has been the emergence of the Pacific Rim countries. In 2010 China became the world's second largest economy in terms of GDP and, if its current rate of growth is sustained, will be the world's largest economy in as little as 5 years. Despite over a decade of recession, Japan still possesses the world's third largest economy. Beijing, Hong Kong, and Taiwan are becoming one China from the standpoint of trade. In 1993, the United

States, Canada, and Mexico took the first step in signing the North American Free Trade Agreement (NAFTA) as a counterbalance to the emergence of the trading blocks in Europe and Asia. While much of the early fears of massive job losses and migration of businesses to Mexico have proven baseless as the agreement completes its second decade, NAFTA has helped to expedite trade between the U.S.'s largest (Canada) and second largest (Mexico) trading partners (Figure 14.1).

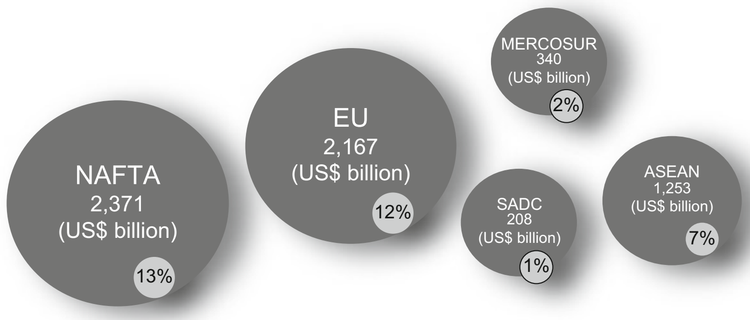


FIGURE 14.1 Top trading blocs 2013 (exports and % share of world trade) [6].

In order to manage the new era of global competition, the realization of supply chain strategies and the efficient operation of logistics is fundamental. As companies seek to export products not only to major trading partners but also to markets dispersed throughout the world, logistics costs involved in international warehousing and transportation are critical in holding down prices and assuring tolerable margins. In addition, as many U.S. companies seek to source components or relocate their operations overseas, corporate planners are having to formulate logistics strategies that will guarantee the smooth and efficient flow of materials and products through the domestic and international distribution pipeline. In summary, the goal of these movements toward regional trading blocs is to reduce tariffs and customs requirements, streamline and standardize shipping documentation, and establish compatible transportation and material handling systems that enable countries belonging to a regional trade union to act as if they were a single commercial entity.

14.1.1.3 Deregulation

A fundamental condition for the growth of global trade is the lessening or elimination of legal barriers to international trade. There are two major areas driving this trend: *financial* and *logistics deregulation*. The massive changes brought about by such events as the creation of the World Bank, the International Monetary Market (IMM), and the World Trade Organization (WTO), have enabled establishment of global financial standards, the extension and guarantee of long-term import/export credits beyond individual bank capabilities, and the mechanism to exchange currencies and trade futures at market rates. The decision of the U.S. to drop the gold standard in the early 1970s has assisted in removing previous restrictions on the setting of monetary rates. In addition, the adoption of the Euro in 2002 has greatly facilitated the flow of global trade by providing another stable medium of exchange. While currency issues surround the Yuan and Ruble and talk of an alternate basket of currencies, financial markets so far have been content to rely on the U.S. dollar and the euro as the standard mediums of exchange.

The second area of global trade deregulation is occurring in transportation. The decision of the U.S. in the early 1980s to deregulate transportation has been slowly but steadily expanding across the globe. Historically, governments rather than market forces determined the scope and price of transportation. Many nations did not allow foreign-owned carriers to operate within their borders. Many transport modes, such as the current rail system in Mexico, are still state owned or, as in Germany, a mixture of state-owned and private companies subsidized by the government. Today, removal of these barriers to free-market drivers in most industrialized nations have followed U.S. example. UPS, for example, currently operates via any combination of rail, motor, air, or water in over 190 countries in a seamless manner via ownership, joint marketing, and operating agreements. Beyond operating privileges and privatization, changes in *cabotage* (requirement that goods and passengers within a country only use domestic carriers) have been gradually relaxed, especially between countries in the European Union and NAFTA.

14.1.1.4 Strategic Alliances

The fourth major trend driving globalization is the expansion of strategic alliances and joint ventures. In the past, most companies pursued a strategy of *vertical integration*. The argument ran that if the enterprise owned not only the production and distribution processes but also the sources of supply, then corporate control over products, market share, and profits would be assured. Today, with the growth of competitors, both domestic and foreign, focused on price parity and value-added features, such as quality and service, vertical organizations cannot hope to sustain their previous market dominance without business partners. Global competition, high product and service quality expectations, short product life cycles, and rapidly shifting markets have motivated firms to seek partnerships and alliances both domestically and internationally.

Partnerships provide the benefits of vertical integration without the risks. Joint ventures permit participating companies to leverage the competencies of partners to increase the speed of product design, and process, quality and service flexibility. In addition, other partnering advantages include access to capital, communications, and markets that businesses acting on their own could not attain or which are closed by foreign governments or restricted by trade barriers. Some of the most important trading blocs are the European Union (EU), Association of South East Asian Nations (ASEAN), Gulf Cooperation Council (GCC), Southern Common Market (MERCOSUR), North American Free Trade Agreement (NAFTA), and the South African Development Community (SADC).

One of the best examples of global partnering is found in the auto industry. Auto dealers both in the U.S. and abroad often buy vehicles from other countries to satisfy customer requirements for imports. Many a U.S. Ford or GM dealer that formerly sold only domestic models often today have foreign import divisions for sales and services. Recent trends among global auto makers have indicated a flourish of joint ventures. The merger of Fiat with Chrysler, Toyota in Australia, Isuzu in Japan, and Daewoo in Korea are examples. In addition, GM has foreign-owned subsidiaries in Europe (Opel), the United Kingdom (Vauxhall), China, Korea, and South America (GM do Brasil). As the world moves closer to three trading blocks in North America, Europe, and Asia, U.S. firms that do not have either foreign subsidiaries or joint ventures might find themselves excluded from free trade with the European and Asian blocks.

14.1.1.5 Integration of Global Distribution Systems

The final area driving globalization is the use of international logistics service providers and information technologies to link companies spanning several continents. The objective of end-to-end service with real time order visibility and order tracking has become the mantra of today's logistics service providers (LSPs) as they search to expand their international footprint. These global LSPs provide continuity and visibility to the logistics needs of customers across the entire supply chain, rather than dependence on individual players who perform narrow local transactions and then pass shipments on to the next channel partner. The goal is to provide customers with technology tools to control the global supply chain by enabling them to manage both the velocity and delivery points of goods as they move across global networks. Such a capability is critical for companies utilizing forms of intermodalism that combine *ocean-land bridge* (ocean, rail or motor, and ocean), all water, or *ocean/mini-land bridge* (ocean and rail or motor) transport.

The key driver of global logistics integration is today's information technology tools, particularly the Internet. Through Internet marketing sites, customers can search the globe for competitive logistics service suppliers who provide as well as stimulate interest in products and services without regard for time or geographical limitations. e-Business Websites also provide anyone, anywhere on the earth the ability to buy products and participate in trading exchanges. Such tools enable companies to open real-time communication with global suppliers as well as eliminate cumbersome paper documentation relating to contracts, orders, delivery requirements, and customs forms. Finally, these systems are providing planners with real-time visibility to a range of critical functions from forecasting requirements to online track-and-trace of products in-transit and electronic bill payment.

14.1.2 Barriers to Globalization

While the above factors are driving companies world-wide to expand their international trade strategies, there remain significant barriers that threaten growth. Among these barriers are local tariffs and trade practices, cultural issues, financial restrictions, security, and logistics infrastructure weaknesses. Each of these barriers to globalization is detailed below.

14.1.2.1 Tariffs and Trade Practices

As companies draft globalization strategies, they are confronted with several regulatory barriers: international taxes, tariffs, and duties. Originally these charges were designed by governments to protect domestic industries by making imported goods more expensive. As such, they must be considered primarily as political instruments devised for the purpose of governing the practice of foreign trade within national borders. These costs not only can greatly fluctuate by country and region, they are often complex and continuously changing. While the impact of tariffs and trade regulations are compiled by every country's department of commerce, they are published in widely different formats, taxonomies, and languages. As one expert put it.

> Traditionally, the only accurate way to access this information is through customs brokers, who must often research the intended shipment before they can estimate the cost. This process is painful, slow, manual, error-prone, and often outdated by the time it's completed. It does not lend itself to rapid iteration, let alone optimization [6].

What is more, as the world grows smaller, countries and trading communities can utilize threats of increased tariffs, duties, or other restrictions as a powerful diplomatic tool. Retaliation is often swift, with talk of looming trade wars. For example, President George W. Bush's decision in 2002 to increase protective tariffs on U.S. steel brought a storm of protest from the European Union who in turn appealed to the WTO for punitive action.

Beyond the use of tariffs and restrictions to control trade, countries often promote national practices that give domestic industries an unfair advantage. Sometimes these practices are administrative and consist of unnecessary technicalities or regulatory requirements that simply add cost and retard trade. Many countries require that a portion of the material composition of the product and the labor force originate from the home country. More serious are license requirements and import quotas that limit trade and protect local immature industries. Perhaps the biggest barrier is global competitors that are supported by local governments. For example, even giant UPS cannot compete with the world's largest global shipping concern, Deutsche Post DHL, which draws financial support about (25 %) from the German government.

14.1.2.2 Cultural Barriers

Building a successful global trade strategy requires bridging cultural complexities that add new dimensions to the challenges of international channel management. While trade laws, exchange rates, tariffs and restrictions, coping with long transit distance, global finance, and handling political risk are difficult enough for the international planner, cultural differences pose a serious threat to success. A failure to understand local customs or an unintentional violation of social taboos can create a veiled resistance on the part of nationals to do business with offending outside traders. While many practices and the use of logistics assets are uniform across the world, global companies must be able to manage the following cultural issues [7].

- *Trade relationships*. The personal elements necessary to develop trade relationships vary widely by nation. For example, in the U.S. business is conducted over the phone or by e-mail. In Asia, face-to-face contact is a requirement.
- *Use of LSPs*. The use of LSPs is perceived in some countries as a negative factor, indicating that a trading partner does not possess sufficient competencies.
- *Contracts*. Many cultures have different views regarding the binding power of contracts. In the U.S., contracts are perceived as legal and moral documents that possess the force of law and personal commitment. In some countries a contract is understood as a statement of intent, and if the environment in which the contract was originally drafted changes drastically, parties are justified in abandoning their commitment to the contract.
- *Working styles*. The work ethic and considerations of holidays and pay may differ greatly from country to country. In Europe, for example, many nationals expect lengthy vacation and holiday seasons. The best way to manage local workers is to have local or regional managers guiding employee decisions. The golden rule is to strategize globally, but execute regionally using the local language and culture.

- *Speed*. In many cultures the signing of contracts or commitments to strategic decisions are a lengthy affair. While U.S. strategists are accustomed to quick deals and rapid decision deployment, many cultures often wish to deliberate over alternatives before making a decision.

Differences in national management, work ethics, and decision styles can cause considerable friction and frustration when developing international strategies. Besides possessing the skill to execute the proper number crunching and legal deliberations, effective global planning teams must also possess a deep familiarity with the cultural and linguistic sensibilities of proposed local partners.

14.1.2.3 Financial Restrictions

Financial barriers to global trade consist of two critical areas: generating effective financial forecasts and charting the capabilities of institutional and monetary infrastructures. The ability to forecast financial positioning is critical to effective business management. It is the responsibility of financial managers to forecast company investment (earnings, growth, and ROI), profits (revenues and margins), assets (cash, receivables, and plant), and capital (debt) in order to chart business strategy. Domestically, creating forecasts for these elements is a challenge in itself. When combined with a global perspective, computing in additional factors, such as exchange rates, customs and tariffs, inflation, and local government policies, render the tasks of financial forecasting even more complex.

Financial infrastructure barriers arise out of the practices found in every country governing how facilitating institutions, such as banks, insurance companies, law courts and the legal practice, and transportation carriers, operate. Often, many of the financial and legal services found in the highly industrialized nations are in their infancy or simply not available in many parts of the world. For example, Hewlet-Packard found out early that legal and operating expectations with LSPs varied greatly by region. HP has solved the problem by having each LSP sign a base agreement, but then tacks-on addendums that contain regional specifics. Through this approach, HP is able to standardize its processes on a global basis while structuring the business to accommodate local and regional differences. The lack of financial and institutional structure adds a significant degree of uncertainty and poses critical challenges to the development of competitive global trading strategies.

14.1.2.4 Security

While historically a serious consideration, international trade has become exponentially more difficult today as nations grapple with the growing problem of security, international terrorism, and piracy. In fact, since the terrorist attack of September 11, 2001, governments have been erecting compliance and security restrictions on passengers and cargo that have the potential to seriously impede global trade. Global transportation costs are rising as carriers add security surcharges and delays elongating transit times. For example, Con-Way Transportation Services began charging an $8 per shipment Homeland Security tax on January 1, 2003. The extra fee is used to pay the cost of U.S. government-mandated changes regarding registration of equipment, drivers, customs documentation, and security inspections at the U.S./Canadian border.

Several U.S. government initiatives have been passed that impact import/export operations directly. The Customs-Trade Partnership Against Terrorism (C-TPAT) and the

Container Security Initiative (CSI), both passed in the first half of 2002, are designed to protect the security of cargo entering the U.S. The Trade Act of 2002 requires exporters to electronically submit shipping documents to U.S. Customs 24 h after delivery to a port or 24 h before vessel departure. Other security measures are aimed at protecting the nation's sea-ports (Operation Safe Commerce – OSC) by making it mandatory for carriers to file electronic manifest information in advance of arrival. Such regulations were also enacted on international air cargo movements by late 2003. U.S. customs require that all carriers, deconsolidators, freight forwarders, and some consignment couriers use the Automated Manifest System (AAMS) to provide advance electronic cargo declaration information to U.S. customs.

The impact of these and other measures on global trade is potentially far-reaching. Already companies have begun to revisit their lean strategies and alter assumptions about inventory as lead times and delays elongate. Rules requiring transmission of shipment-level detail could add 24–72 h to inventory cycles, threatening to reverse decades of logistics productivity improvement overnight. These security measures have also generated a great deal more documentation which is often slower than the speed of the goods shipped, causing deliveries to languish while freight clears an increasingly entangled customs system. What is worse, as the outbreak of Severe Acute Respiratory Syndrome (SARS) in China during the first half of 2003 and the Ebola virus in later 2014 bore witness, security measures must grapple with non-terrorist attacks associated with the general health, food supplies, and well-being of trading nations.

14.1.2.5 Infrastructure Weaknesses

Beyond government policy, legal, cultural, and financial barriers, the lack of distribution infrastructure is perhaps the most critical impediment to global trade. Part of the problem resides in the lack of standardized transportation, material-handling equipment, containerization, warehousing, port facilities, and communications and technology that renders inter-country movement of goods difficult. Such barriers require products to be loaded and unloaded, sometimes by hand, from vehicles/containers as they cross national boundaries. What is worse, many developing nations do not have sufficient logistics infrastructures. Often basic transportation infrastructure, such as roads, rail lines, fuel depots, and customs agencies are rudimentary or, in some cases, non-existent. When it is considered that an average of 17–20 parties touch a typical international shipment in one way or another as it moves between carriers, brokers, and forwarders, and through customs and financial institutions, even minor problems in the global supply chain can cause major shipment delays.

14.1.3 Summary

Companies today are faced with many opportunities as well as challenges in the pursuit of global trade. Each year, an increasing number of products from steel to toys and jewelry are imported, whereas at the same time, more U.S. goods are finding their way to new foreign markets. Few businesses today can feel immune from the threat of foreign competition. Bender [8] has succinctly described the conditions propelling globalization as composed of three interconnected areas. The first consists of *strategic* reasons such as:

- Leveraging shrinking product and process life cycles and recovering development costs by selling products on a global basis.
- Denying marketplace sanctuaries to competitors. Companies can sell at a high profit margin to captive markets, making it affordable to sell at a lower margin to more markets.
- Avoiding government-directed protectionism as found in many developing countries.
- Balancing production and investment with the differing economic growth patterns and economic cycles occurring across the globe.
- Profiting from global financial systems, communications and media, and market demand homogenization.
- Establishing early presence in emerging markets.
- Maximizing opportunities arising from symbiotic relations between suppliers and customers based on long-term commitments and close relationships.

The second area fostering business globalization is associated with the following *tactical* issues:

- Capitalizing on foreign trade to increase profits. Companies participating in international trade are likely to grow faster and be more profitable than companies focusing only on national or regional markets.
- Participating in countertrade agreements. About one-third of all international trade involves countertrade (bartering), rather than cash transactions.
- Achieving stabilization by matching product and investment with global business cycles.
- Obtaining economies of scope by maximizing marketing, production, and logistics advantages through international trade.
- Reducing costs by transferring products across national boundaries that reduces taxes.

The final area focuses on *operational* issues and is concerned with the following:

- Reallocating production and distribution capacities to match global market demand.
- Reassigning production, purchasing, sales, and financing to take advantage of different rates of international exchange.
- Accelerating the learning effect. As a company learns more about the global marketplace, costs associated with manufacturing and distribution processes decrease.
- Exploiting automation's declining breakeven point. As the volume of product and processes increase, technology costs are recovered much quicker.

14.2 GLOBALIZATION STRATEGIES

When embarking on an international trade initiative, companies normally will pursue one of three possible strategies [9]. The first, and most common, strategy is the simple export and import of products and services as part of a general effort to penetrate the global marketplace. Often, companies pursuing this strategy will turn over the entire effort to a broker, freight forwarder, or LSP rather than establish an internal international organization to perform search, marketing, and logistics functions. In this model, the objective of the global initiative is more concentrated on executing basic trade functions than building a comprehensive strategy. Typically, the home company will pursue financial integration of the different regions where trade is performed, with less emphasis on integrating product development, marketing, and supply chain management and planning. Advantages of this model are enabling a company to expand into global markets without engaging in high infrastructure costs. Disadvantages are loss of flexibility and scalability and inability to respond to regional challenges and opportunities because of disjointed integration of operations and strategies.

In the second strategy, companies decide to pursue a limited form of international business. This approach abandons the home headquarter bias and focuses on local marketing, branding, sourcing, production, and distribution to ensure the transnational corporation is conveying a broad global perspective. While each region will typically have separate, autonomous supply chains, they are usually considered as secondary to the home corporate office which sets the overall business and global strategies. Generally, international operations are used to support home office operations, particularly with respect to sourcing production materials and finished goods for resale. The advantages of this model are the ability to engage in key growth markets while minimizing operational complexity between markets. Disadvantages involve loss of close customer contact and economies of scale.

In the final, and most advanced international strategy, regional facilities conduct different businesses designed to optimize the overall effectiveness of the transnational corporation. In this model, companies are truly conducting international trade and possess international brands. For example, sourcing may be done in China, production in Mexico, and distribution in the U.S. and the EU. Corporations such as Coca-Cola, IBM, Dow Chemical, Johnson & Johnson, Nestle, and Philips, utilize this model. Advantages of this model are a global focus on product, delivery, solutions, and delivery; flexible and scalable regional facilities; and significant economies of scale. Disadvantages are increased management effort necessary for coordination and information integration and loss of windows into individual market requirements.

14.2.1 Global Strategy Development

Regardless of the approach taken, an effective global strategy identifies the nature and scope of the international trade initiative, defines the appropriate marketing and logistics strategies, drafts operational objectives, designs channel structures, and, finally, develops the appropriate performance metrics to measure success and uncover regions for improvement. According to Keegan [10], an effective international trade strategy is composed of the following five elements: (1) environmental analysis, (2) global strategic planning, (3) organizational infrastructure, (4) implementation, and (5) performance measurement (Figure 14.2). The goal of the exercise is to develop "world-class" international trade operations that provide global companies with the mechanics to optimize and align the distribution system with each international target market.

14.2.1.1 Environmental Analysis

The first step in global strategy development is defining the strategic dimensions of the enterprise. There are essentially three areas to consider. The first is detailing the *external business environment*. This process should be divided into macro-economic, socio-cultural,

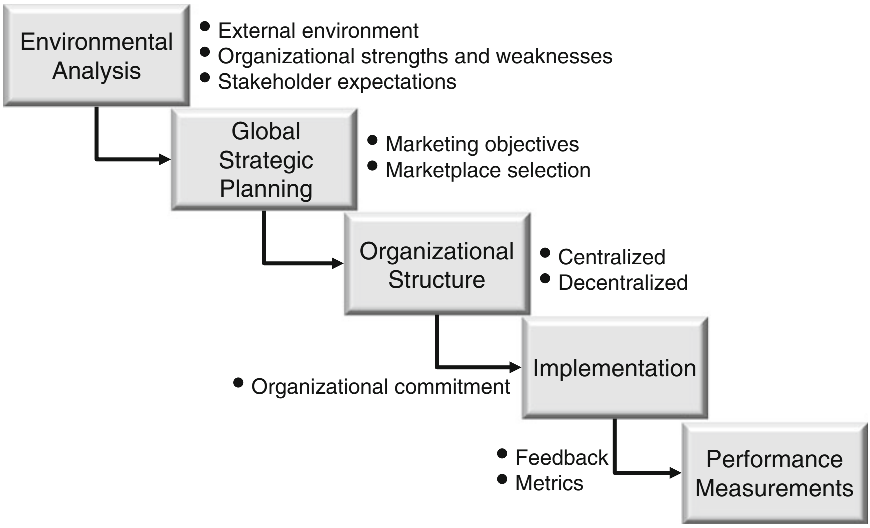


FIGURE 14.2 Global strategy development.

political, and technical factors, and then into micro factors, such as markets, costs, competitors, and governments. An effective analysis should cover the whole world, ensuring that no relevant market, competitor, or trend is overlooked. The second strategic dimension involves assessing *organizational strengths and weaknesses*. A firm understanding of this strategic area enables global planners to deal effectively with opportunities, threats, and global trends. In addition, the firm should identify its own particular area of distinctive competence. This means that planners should know the products to be offered and the markets served; technological, sales, distribution and resource capabilities; and growth and profitability targets.

The final strategic dimension is coming to terms with and matching *stake-holder expectations* with perceived enterprise objectives. Stakeholders, managers, employees, and customers often have conflicting values and interests regarding enterprise size and growth, profitability, return on investment (ROI), sense of social responsibility, and ethics. Before a global strategy is constructed, planners formulating the direction of the company must be sure that objectives are in alignment with the realities of the external environment, the capabilities of the organization, and the desires and assumptions of the stakeholders.

14.2.1.2 Global Strategic Planning

Once the strategic environmental dimensions have been identified, planners can proceed to detail the nature and scope of the overall global channel strategy and define in detail the unique characteristics of each national market. Normally, a company begins to explore the possibility of entering foreign markets either because it feels it must in order to sustain corporate growth and competitive advantage or it is solicited by an importer or a foreign government. Before detailed market analysis begins, however, it is important that the firm defines its international marketing objectives and policies. This process normally consists of three parts. To begin with, global planners must determine the desired proportion of foreign sales to total sales. This ratio depends on product, competition, logistics channel requirements, and market-place aspirations. Second, planners choose between marketing and distributing to a few target countries or to many countries. Generally, it makes sense to begin first by selecting a few countries in which a strong commitment and significant product penetration can occur. Finally, the firm must decide on the types of countries with which they would like to do business with. Issues relating to political stability, product fit, income, transportation substructure, geography, and others are possible elements to consider.

Once the global strategy has been determined, global planners must turn their attention to pinpointing which national markets are to be selected. Candidate countries should be rated on three major criteria: market attractiveness, competitive advantage, and risk. *Market attractiveness* consists in determining how well the company's products and culture will fit a local national marketplace. Key considerations are language, laws, geographical proximity, stability, cultural similarity, and other micro factors. Included in this criteria is how much of an effort an international company wants to expend to redesign or create new products and services for a local market. Termed *glocalization* [11], this effort is a combination of "globalization" and "localization." When used in a supply chain context, globalization is a form of postponement where a product or service is developed for distribution globally but is modified to meet the needs of a local market. The modifications are made to conform to local laws, customs, cultures or preferences.

Competitive advantage focuses on the level of existing competition the company can expect to encounter in the local market. Key decisions center on the cost of market entry and control; cost of product and communication adaption; potential for growth in local population and income size; and the presence of dominant foreign firms that can impose high barriers to entry. The third criteria, *risk*, is divided into three types: asset protection/investment recovery risk, which is concerned with the possibility of foreign government nationalization or limits to the transfer of invested resources, and operational profitability/cash flow risk, which arises from the likelihood of local economic depression, currency devaluation, strikes and other factors. The third type comprises risks stemming from the local business environment and includes [12]:

- Failure on the part of the company to understand customer preferences with the result that they fail to offer a competitively attractive product and supporting envelop of services.
- The company fails to understand the local country's business culture or is unable to work effectively with foreign nationals.
- The company fails to understand the depth of local regulations and incurs unexpectedly high costs.
- The company finds that it does not possess the internal managerial competency to effectively manage global businesses.
- The local country might change its commercial laws, devaluate it currency, or undergo a political revolution and expropriate foreign property.

Once these risks have been reviewed, choices are then made based on how the global strategy supports the overall corporate business plans and objectives, estimates of market potential, estimates of costs and profits, and, finally, validates the rate of return on investment.

14.2.1.3 Organizational Infrastructure

In the past, global logistics often suffered from poor organization, a lack of training, and the absence of inter-organizational power and influence. Logistics management was normally considered as playing a supporting role and not regarded as a key element in the enterprise's global marketing strategy. What is more, often the responsibilities of both domestic and global logistics were divided between competing business departments. Such immature infrastructures resulted in limited opportunities for integrating domestic and global organizations and pursuing simultaneous improvements in cost, efficiency, and productivity. Without effective global logistics organizations, the enterprise cannot hope to optimize on global opportunities and deter possible competitive threats.

The architecture of an effective global logistics organization can vary. For firms whose global effort is focused on a single country or homogeneous region, a centralized organization is particularly effective. When the scope of the logistics effort traverses many countries and diverse regions, the best form of organization is one in which the planning and control functions are centralized and integrated with other enterprise departments but the actual operations functions are decentralized. Simply, as the variety of differences in culture, governmental regulations, and knowledge of trends in local economic conditions expands, centralized global organizations become increasingly ineffective. In such environments, personal familiarity with the countries composing the international marketplace becomes invaluable.

14.2.1.4 Implementation

Once the global strategy has been completely structured, it must be implemented. This step entails obtaining and committing current resources to executing regional market, market cluster, and product life cycle plans. The key element in implementation is the presence of effective organizational infrastructures that cover all aspects of the global strategy from financial integration to logistics resource management.

14.2.1.5 Performance Measurement

A key component of global strategy is the drafting of a comprehensive program of performance measurements. The goal is to define essential metrics that are then compared with expected output. To the extent that the results of the strategy are consistent with original goals and assumptions, it can remain unaltered. If, however, wide performance variances occur, global planners must adjust the strategy by isolating specific areas for improvement. In addition, performance measurement must provide information that enables continuous strategic alignment with the external environment and organizational and value assessment assumptions established at the beginning of the strategy formulation process.

14.2.2 Strategy Development Summary

As globalization increases in the twenty-first century, corporate strategists must change fundamental methods of planning and operating the logistics functions of their companies. Firms with minimal involvement in foreign trade can defer logistics complexities to intermediaries who will handle the detailed operations necessary to conduct foreign trade. For multinational corporations who perform global logistics functions, however, a unified global strategy is necessary to ensure the smooth flow of product through the international pipeline. Effectively executing a global logistics strategy requires companies to find solutions to the following issues:

- Balancing company resources (capital and inventories) and organizational structure with the needs of the global marketplace.
- Monitoring and managing the constant changes occurring in global trade. Trends include shifting attitudes toward tariffs, administrative procedures, restrictions on inter-country transportation modes, and warehouse storage, as well as managing the pace of rapidly changing marketing and logistics strategies, new product introduction, and increased information linkages. By responding effectively to change, multinational firms can increase the speed and reliability of global delivery and reduce overall transportation and inventory carrying costs throughout the global channel network.
- Extending and tailoring the supply chain to meet the distribution structure of each foreign nation or geographical region. Distribution channels in Europe, for example, are very mature and require local distribution centers, local management of transportation owing to the number of transit countries, knowledge of local customs, and regulations dealing with the European Union. Trade with Japan requires short delivery cycles and local inventory to meet planned and random demand patterns. Distribution in the Pacific Rim requires using local freight forwarders and lead time planning to counter delays due to the lack of a fully developed logistics infrastructures and protected local industries.
- Executing distribution for simultaneous multicountry, multiproduct introductions.
- Working with value-added taxing found in many foreign countries and transfer price regulations both domestic and foreign.
- Implementing information systems that provide for worldwide inventory planning and stock availability and customer order status.
- Benchmarking global channel performance with that of international competitors.

Effectively managing these and other global trade issues is more operational than strategic. The companies that will succeed in the highly competitive international marketplace of the twenty-first century will be those that can leverage information and decision support technology tools to solve global differences in market preferences, logistics structures, perceptions of quality and service, and performance measurement.

14.3 CHANNEL STRATEGIES

Few companies embark on a globalization strategy fully prepared to engage in international trade. Most companies begin by responding to an opportunity to sell goods and services abroad and, as the volume of sales increases, turn to the development of strategies and channel structures that will enable it to sell on a more systematic basis. According to David and Stewart [13], there are several factors influencing a company's entry into the global marketplace. An important factor is the size of the market. There is a very real difference between entering into a US$10 million and a US$100,000 million marketplace. Another factor is whether the target market is stable or growing. A market in which the exporter can become a major player will require a strategy different from one where the size of the competition inhibits the exporter from being nothing more than a niche player. Another important factor is the type of product being offered. A product line competing on high quality and cost with a long life cycle will require a different entry strategy than an exporter that sells commodities or products with a short life cycle. Finally, global entry strategies are affected by the infrastructure of the local country, the sophistication of trading partners, and the overall culture and receptiveness of the local market to imported products and services.

When entering a global channel, international businesses pursue basically four alternative strategies. A company may choose to follow one or a combination to match particular objectives or marketplace conditions. The four strategies are *exporting, licensing, joint venture*, and *direct foreign investment* (ownership). Of the four, exporting is the easiest to execute. The remaining three strategies are in order increasingly more complex because they involve the establishment of production or warehousing facilities *within* foreign countries and the integration of company-owned domestic and foreign distribution channels (Figure 14.3).

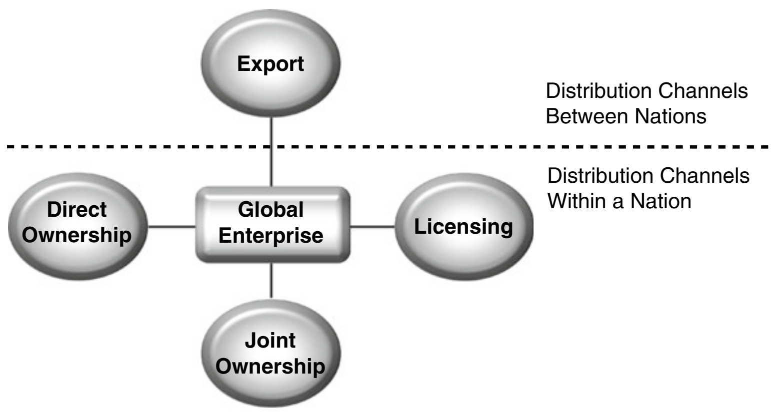


FIGURE 14.3 Alternative channel strategies.

14.3.1 Exporting

The most common form of global trade is the export of products into foreign markets from domestic facilities. Exporting requires the least involvement on the part of companies because the actual marketing and logistics activities are carried out by some form of international trading house or intermediary. Exporting can be pursued as either a *passive* or an *active* strategy. In a passive strategy, companies might engage in exporting products to foreign markets from time to time, or in response to an unsolicited order from a foreign customer. Active exporting, on the other hand, occurs as part of a strategic decision to expand sales into foreign markets. Regardless of the policy, exporting as a method of approaching foreign markets has the least impact on company product lines, distribution channels, internal organization, investment, and enterprise mission. Exporting can take two forms, depending on how involved the firm wants to become in the export process. Exporting can be executed *indirectly* through a variety of specialized export logistics service providers (LSPs) or *directly* by working with foreign merchants or wholesalers.

14.3.1.1 Indirect Exporting

Indirect exporting involves the least amount of effort and is the method normally pursued by firms taking their first steps toward engaging in international trade. This type of exporting is *indirect* because the company deals with some form of intermediary that is located in the local market. The major advantage of indirect exporting is that the business can engage in foreign trade without having to deal with the complexities of global logistics, tariffs and taxes, international marketing contacts, and accompanying paperwork and legal issues. In addition, it requires little risk or investment, the bulk of the work for export management falling upon the intermediary. Finally, indirect exporting renders the firm immune to possible foreign political and economic upheavals, as well as permits easy exit from a foreign market that fails over time to realize sales or profit targets. Negatives surround the company's loss of control over the ultimate cost and delivery of its products.

The various types of indirect export intermediaries (LSPs) are described below.

- *Freight forwarder*. This type of export LSP arranges transportation for cargo shipped from a domestic to a foreign market. A forwarder LSP is not by itself a carrier, nor do they buy and resell space on carriers. Instead, they act as an intermediary between the shipper and the carrier. Among the activities performed are quoting carrier rates, arranging charters or booking vessel space, preparing and presenting documentation, obtaining insurance, managing payments, and arranging inland transportation. In the U.S., forwarders must be licensed by the government, but they are not subject to certification requirements. Forwarders derive income from a combination of fees, markups, and commissions.
- *Export trading company (ETC)*. This type of export LSP is an excellent choice for a company that is a newcomer to global trade or is unwilling to undertake any of the activities required of an exporter. An ETC itself is an exporter rather than a consultant to an exporter. An ETC works with producers and distributors that provide the finished goods that it wants to buy and resell in a foreign market. ETCs perform many export-related functions such as the purchasing and selling of goods, arrangement for the transportation and warehousing of goods from the export company to the foreign customer, financing currency conversion and absorbing rate fluctuations, assisting with consulting advice, and other logistics issues. More complex structured ETCs are known as *international trading companies*.
- *Export merchants*. Export merchants act as a form of international wholesaler. Similar to domestic wholesalers, they purchase goods from domestic producers and distributors and then pack and ship them to foreign markets. Although some export merchants may have facilities located in foreign countries close to the target market, they mostly deal with foreign intermediaries in the country of destination.
- *Resident buyers*. Foreign firms and governments often locate buyers directly in the import country. Their responsibility is to locate, purchase, and ship goods to their home countries. Sears, for example, maintains buyers in foreign countries who buy direct from producers for resale in the United States.
- *Export commission house*. This type of intermediary performs the same functions as a *resident buyer* except that the buyer is not an employee but rather an independent agent empowered to negotiate, buy, and ship from firms in the exporting country. In return, the commission house is normally paid a commission by the foreign buyer.

- *Allied manufacturer*. Exporting through a business partner is an easy, cost-effective way of shipping overseas. In the arrangement, a company with well-established foreign trade activities negotiates to "piggy-back" the products of other domestic firms with shipments of their own products to foreign countries. The advantage is mutual. For the shipping company, carrying other products assists in presenting foreign markets with extended product lines or achieving a higher utilization of transportation and warehousing capacities. For the exporting firm, the arrangement provides them with a good deal of the benefits of a mature foreign trade system without the investment.
- *Export management company (EMC)*. An export management company is a product line or foreign market specialist who works that export for one or a group of noncompeting producers. Although most act as selling agents and consultants directly for their export clients, some of the larger firms do purchase products for resale. By working with an EMC, the exporter gains access to current information about the preferences of the local market, national customs, and government regulations.
- *Ship brokers and agents*. This type of export LSP assists exporters with the details of arranging ocean transport. A broker is an independent intermediary that brings exporters together with ship operators that have cargo space available to carry the exporter's freight. In contrast, a ship agent works for the carrier. Agents arrange for the arrival of ships, berthing, and clearance; while the ship is in port, the agent coordinates unloading, loading, and fee payments.
- *Export packing companies*. This export LSP provides exporters with specialized packing services required for cargo being transported across continents. Besides optimizing packing space and minimizing damage, the LSP ensures that the cargo will pass customs inspection in the target nation.

14.3.1.2 Direct Exporting

Despite the advantages offered by indirect exporting, some firms choose to export directly to foreign nations. The choice of this strategy requires the establishment of company-owned exporting management functions. Usually this means the founding of an export department whose responsibility it is to establish the necessary distribution channels appropriate to each trading nation; find, maintain, and motivate intermediaries in targeted foreign countries; plan and execute all international shipping requirements; and, execute all export documentation. The major advantage of direct exporting is increased control over products sent to foreign markets. Disadvantages are found in the extra costs and overheads that arise from shipping directly to a foreign nation. The various types of direct export functions are described below.

- *Domestic-based export department or division*. Many companies have an export department or division in their organizations manned by an export manager and staff. This group executes actual selling and, in some instances, will perform other tasks associated with shipping, establishing logistics channels, and draft export documentation.
- *Foreign sales branch/subsidiary*. Companies with a significant presence in certain foreign countries might elect to locate a sales branch or subsidiary in each country. Overseas branches permit the exporter a much greater control over marketing decisions and product positioning and provides on-site skills and services necessary

for effective sales or marketing activities. In addition, branches may handle warehousing issues and promotions.

- *Traveling export sales representatives*. Export firms may send sales representatives directly to foreign nations to solicit and execute export arrangements and sales.
- *Foreign wholesale agents and merchants*. There are several types of agents and merchants. A *foreign sales agent* is an independent contract sales representative that promotes and sells for an export company. The agent is generally compensated through commissions. The actual sale is shipped and paid for by the exporter and the foreign buyer. On the other hand, *foreign merchant distributors* buy the goods directly from the exporter and establish their own pricing, promotions, and other marketing strategies except where prohibited by contract.
- *Direct sales*. This is the least used form of direct export. In this technique, exporters seek to sell products directly to foreign retailers or even end-customers. Normally, this type of exporting is used only for high-ticket and specialty items sold to foreign governments, businesses, or institutions.
- *Global web strategy*. Within the past decade some of the world's leading companies have embarked on a direct export strategy using Internet e-commerce. The Internet has enabled companies to explore radically new avenues of reaching customers, sourcing from international suppliers, building global brand awareness, and conducting business transactions unthinkable in just the recent past. Companies from GM to direct-mail businesses such as L.L. Bean, Land's End, and Amazon.com use the web to penetrate global markets and gain significant boosts to their bottom line. For example, retailer and cataloguer The Sharper Image gets more than 25 % of its online business from overseas. e-Commerce provides an effective and cost-effective mechanism for gaining free exporting information and guidelines to conducting research and offering customers across the globe a secure process for searching, ordering, and paying for products.

14.3.2 Licensing

Similar to exporting, licensing is a relatively simple, cost-effective method of entering global markets. Licensing is defined as a contractual arrangement by which a firm (the licensor) in one country agrees to permit a company in another country (the licensee) the right to use a production process, trademark, patent, technical assistance, trade secret, merchandising knowledge, or other skill or technology. In exchange, the licensor will receive a fee or royalty. The objectives of a licensing agreement are straightforward: The licensor is able to gain access to a foreign market with a minimum of risk and capital expense; in turn, the licensee receives the right to distribute brand name products or access to proprietary processes either to found a business or to add to existing product lines. The best known examples of global licensing are Coca-Cola and McDonald's. Both firms penetrate foreign markets by licensing (franchising) product name, processes, and products to bottlers and food service companies across the globe.

There are several advantages licensing has over exporting. To begin with, licensing provides the licensor with a degree of control over how the product is marketed and distributed. For example, the local producer can modify products or services to meet local tastes and customs while the licensor retains control of the brand name, quality standards, and so on. Also, licensing normally does not require a great deal of capital investment. Like exporting strategies, licensing provides licensors with a less risky method of gaining access to foreign markets than direct ownership, while providing sufficient flexibility to cancel unprofitable arrangements. On the negative side, the licensor has less control over the licensee than if the firm had established a directly-owned business. If the licensee does not live up to the terms of the contract, all the licensor can do is threaten to end the agreement. Finally, if the licensor decides to cancel the contract, they might find that they have not only lost control but have created a competitor with a strong market position in a foreign country where the licensor might subsequently find it difficult to penetrate on their own.

There are several forms of licensing in foreign markets. One is to execute a *management contract* in which a licensor sells management services for a fee to a foreign company to assist in managing a factory, distribution center, hospital, or other organization. Management contracts are low-risk methods of gaining entrance to a foreign market, especially if the contracting firm provides an option to purchase a portion of the business. Another method is *contract manufacturing*. In this method a firm licenses and agrees to assist a foreign company produce or distribute its products. Although licensing has the drawback of potential loss of control over processes, it does provide the firm with the opportunity of partnership or acquisition if the market matures. Perhaps the most recognizable form of licensing is *franchising*. In this model, the licensor offers a complete brand and marketing concept and a mature operating and structural format. In exchange, the licensee must buy product and infrastructure from the licensor and pay a royalty or fee.

14.3.3 Joint Ventures

Unlike the first two strategies, the decision to execute a joint venture with a foreign company directly involves a company in the management of a foreign enterprise. Normally, a joint venture occurs when a firm decides to join with a foreign company for the purpose of exercising joint ownership and control over a business. Joint ventures may occur when a firm invests in the production and distribution operations of an existing foreign company, or the two parties may join together to found an entirely new company.

Companies decide to enter into joint ventures for several reasons. The most obvious is to significantly increase local control over the product, distribution, and marketing strategies of the foreign company due to its financial partnership. A firm may also enter into a joint venture to utilize the specialized skills or gain access to the production or distribution systems possessed by the foreign partner. Companies are sometimes prohibited by foreign governments from entering alone into a local marketplace (such as India). Such restrictions often occur in less developed countries where government is actively promoting the growth of home industries. A partnership with a local firm may provide an avenue around this difficulty. Finally, a firm may lack the capital, managerial, and personnel capabilities to enter a foreign market on its own without the assistance of an established foreign company.

There are a number of drawbacks associated with joint ventures. The most obvious is the significant degree of risk involved. Outside firms normally invest capital in foreign ventures that they wish to convert to profits that are returned to the home country. Disagreements with the partner or even government restrictions may inhibit return on investment expectations. In addition, disagreements might also arise over local product, marketing, and distribution channel strategies. Settling these differences might be a difficult affair requiring some compromise on the part of both parties. Finally, joint ventures might even impede a multinational company from executing specific marketing and distribution strategies on a worldwide basis.

14.3.4 Direct Ownership

The direct ownership of production and distribution companies in a foreign country represents the highest level of control and involvement an enterprise can have in the pursuit of foreign trade. Instead of working through an intermediary or a venture partner, the firm assumes all responsibilities for facilities, personnel, marketing, and product distribution. Ownership occurs through two methods. In the first, a company may seek to build a new facility. This method is the more difficult of the two. The company must gain the permission of the government and fulfill all regulations, establish marketing contacts and distribution channels, select the site, hire personnel, acquire equipment, and provide for capital funding among other things. A far more cost-effective method is to acquire an established foreign firm. All the company has to do is to buy into the preexisting structure, making alterations as required to meet changes in regulatory, product, and marketplace emphasis.

There are some significant advantages to direct ownership. As the company now controls the foreign venture, it can determine the marketing, product positioning, and distribution strategies to be pursued in the local market without interference from a local partner. This point is critical for multinational enterprises seeking to develop long-term, unified strategies throughout the globe. Second, direct ownership provides the ability to compete more effectively on price. Because the cost of transportation of the product from the home country is eliminated along with import taxes and customs duties, the foreign subsidiary can become more price competitive. Third, the new venture might be able to achieve cost economies in the form of cheaper labor or raw materials, foreign government incentives, or process improvements. Fourth, the company's image may improve in the foreign country due to its commitment to the local economy. Finally, as the company's knowledge of the foreign country grows, it might be able to improve on its marketing techniques and product offerings to match the ongoing needs of the local community.

Although the benefits of direct ownership are substantial, so are the drawbacks. The most obvious negative is the enormous risk a company takes in investing in a wholly-owned foreign venture. Some of the concerns are currency devaluation, political unrest, declining markets, and nationalization. In addition, the investor company can find its flexibility to respond to home or other foreign markets circumstances curtailed because of the financial commitment involved in a foreign venture. In addition, if the company decides to discontinue the operations, it may involve not only forfeiting the cost of the plant, equipment, and personnel but also the company's reputation in that region. Finally, reorienting the product and the sales environment in response to overall changes in the company's internal objectives might be more difficult to implement due to governmental and regional regulations.

14.3.5 Other Methods of Entry

International trade strategies include other methods of entry.

14.3.5.1 Foreign Trade Zones (FTZ)

An inexpensive and non-complicated method of engaging in foreign trade is to use a foreign free trade zone. A FTZ is defined in the *APICS Dictionary* as

> Areas supervised by U.S. Customs and Border Protection that are considered to be outside U.S. territory. Material in the zone is not subject to duty taxes, which are payable when the material is moved outside the zone for consumption. There is no limit on the time material may remain in the zone. Internationally, similar areas are called free trade zones.

FTZs can also be defined as labor intensive production centers that involve the import of raw materials or components and the export of factory products [14]. Typically, goods are landed, repackaged, produced or reconfigured, and re-exported without the intervention of local customs authorities. If the goods are re-exported, they never pay duty to the local government in which the FTZ is located. If they are sold in the country the FTZ is located, they must pay the necessary duties when they leave the FTZ. Some countries aggressively encourage FTZs by allowing just about any economic activity in the zone. FTZs are usually found around major seaports, international airports, and national frontiers, such as Hong Kong, Singapore, New York City, and Los Angeles.

There are several advantages to using FTZs.

- *Deferral, reduction, or elimination of certain duties*. FTZs receive goods without any customs formalities or import duties. This includes exemption from inventory taxes and quotas.
- *Duty exemption on re-exports*. Since an FTZ is considered outside the commerce of the local government, a company importing materials or components into the FTZ does not pay customs duty until the inventory enters the nation's commercial system. If the inventory is exported from the FTZ, no customs duty is due.
- *Duty elimination on waste, scrap, and yield loss*. Since a producer in an FTZ does not pay duties on imports until the goods enter the commerce of the local country, it is essentially paying for the duties on the materials after they have been processed. As a result, duties owed do not include production waste and scrap, thereby reducing the amount of goods taxed.
- *Relief from inverted tariffs*. When the duty on imported components is higher than the duty on the finished product, it is called an "inverted duty." To avoid the duty, a producer can bring low cost production inventories into the FTZ and process them into a finished good for export. When going through customs, the producer pays the duty on either the components or the finished goods, whichever is more advantageous.
- *Weekly entry savings*. Instead of filing an entry every time a shipment enters a country, an importer in an FTZ only needs to file one customs entry a week, thereby reducing documentation costs.
- *Improved compliance, inventory tracking, and quality control*. FTZs allow companies to more closely track their inventory. By bringing inventories into an FTZ warehouse controlled by the company, it is possible to identify and classify goods at the warehouse instead of at the port at a customs control location.
- *Indefinite storage*. A company can hold goods in an FTZ indefinitely. If there are quotas, the goods can be held until they are entered into the local country's commercial system without falling under quota restrictions.

- *Avoidance of fines*. Imports can be processed, relabeled, and repackaged in an FTZ before going through customs. This would help a company with potential product compliance problems to correct the violations before going through customs. The same conditions would apply for products that need to be inspected and tested prior to paying import duties.

14.3.5.2 Maquiladoras

Maquiladoras offer exporters another easy way to engage in international trade without absorbing the administrative and assets costs. A maquiladora is a company located in Mexico that has the status of an FTZ. The company imports production inventories from the U.S. duty-free, process them into finished goods, and then re-exports them back to the U.S. The only customs duty imposed is on the value-added in Mexico. Maquiladoras have declined in popularity with the passage of NAFTA.

14.4 MANAGING GLOBAL TRADE NETWORKS

The establishment and maintenance of a global trade network is a complex affair involving most of the functions of domestic distribution and logistics, plus additional requirements associated with structuring global market channels, financing and terms of sale, pricing, and documentation. What is more, whereas the functions of distribution and logistics are universal, the structure and performance criteria of global trade networks vary throughout the world. It used to be assumed that the level of distribution channel structure development found in one country paralleled the structures of other countries that had attained the same degree of economic and technological development. As international trade exploded over the past decades, it was found that actual global network structures are so closely intertwined with a country's social, cultural, technological, and political conditions and stage of economic development that it is impossible to generalize about one specific form or structure throughout the world. As a result, firms aspiring to participate in global trade must constantly rethink and adjust to the marketing and logistics channel structures of their trading partners if effective global strategies are to be realized.

In general, structuring a global trade network requires making many of the same decisions concerning cost, product positioning, sales and profitability, channel control, and flexibility that are made when defining the objectives for domestic channels. There are, however, a number of issues that are specific only to global channels. Managing these issues will be the subject of the sections below.

14.4.1 Establishing Global Distribution Channels

Establishing and maintaining effective global trade channels requires significant planning and understanding of international markets.

14.4.1.1 Cost Versus Level of Service

In the creation of any distribution channel, planners must begin by charting the desired customer service level targets and the cost of meeting those objectives. This factor is even more critical when it comes to structuring a global trade channel. Because of the increased number of variables and constraints clearly understanding service and cost ratios can be a difficult exercise. The flow of communications is easily interrupted by distance and differences in language, culture, and legal factors. Documentation is more extensive, often resulting in long delays. Financial flows are full of roadblocks in the form of cash and payment transaction conversions, pricing, credit management, insurance, and liability. Furthermore, the presence of legal and regulatory restrictions, duties and taxes, export and import restrictions, and local laws and customs make measurement difficult. Finally, the number of channel echelons in the pipeline, the use of intermodal freight carriers over long distances, and packaging and labeling make it difficult to create precise metrics to weigh the cost versus the level of service.

Bender [15] feels that four service criteria (response time, order completeness, shipping accuracy, and shipment condition) are critical in making any evaluation of service versus cost. *Response time* refers to the time elapsed from receipt of a customer order until goods are received by the customer. Viewed from a service/cost perspective, as global lead times decrease, the cost of operations increases. When it comes to global distribution, the market is less sensitive to long lead times. Owing to the size and complexity of the channel, most foreign customers normally increase lead times and inventories to compensate for longer delivery times. Still, a global distributor must constantly search for methods of increasing delivery service while maintaining or lowering costs. Developing alternate distribution systems, streamlining paperwork flows and operations, and using computerized supply chain management applications, and others are possible avenues for improvement.

Due to the length of the channel and the time required for order delivery, the last three service elements are of much greater importance. Probably the most critical of these elements is *order completeness*. Order completeness is defined as the percentage of how close the actual shipment matches the products and quantities originally ordered. As the percentage of order completeness grows, logistics costs decline correspondingly. Simply, the less a company has to handle backorders and expediting, the less the cost for order completion processing and shipping.

The next service element, *shipping accuracy*, is the ratio between the number of deliveries that have the correct products, quantities, prices, and so forth, and the total number of deliveries for a specific time period. The level of accuracy depends normally on the level of control. However, as the level of control increases, the greater the expense. The cost of poor accuracy in global distribution is excessive, including paying for and processing returns, reshipping orders, canceling orders, and loss of customer goodwill.

The final service element is *shipment condition*. This measurement is defined as the ratio between the number of orders delivered in good condition and the total number of orders shipped. Unlike domestic shipments, international orders are often handled many times as they move through the global pipeline. At each occasion, the order is exposed to the possibility of delay, damage, and theft. Considering the cost of backorders, packaging, and time spent in order replacement, undamaged orders are a significant service versus cost element. Improving the five service versus cost elements requires global organizations to constantly search for ways to continuously increase service/cost ratios.

Finally, effective management of a global distribution network requires close supervision of channel operations costs. Many of these costs are the same whether they are associated with domestic or foreign distribution channels. Costs for administrative facilities and warehouses, transportation rates and fleet maintenance, purchasing, value-added processing, inventory, and information processing are part of both domestic and international channel management. In addition, global channels incur costs such as developing new marketing channels, maintaining an internal international trade department, carrying the cost of in-transit inventory, insuring deliveries, and incurring product packaging, customs duties, and taxes. As a result, areas for cost controls and potential improvement grow significantly as the size and scope of the global channel expands.

14.4.1.2 Understanding International Distribution Channels

Unlike domestic distribution channels, global trade channels often move goods through several levels of geographically dispersed channel control points. As illustrated in Figure 14.4, there are several international links to consider when constructing a global channel network.

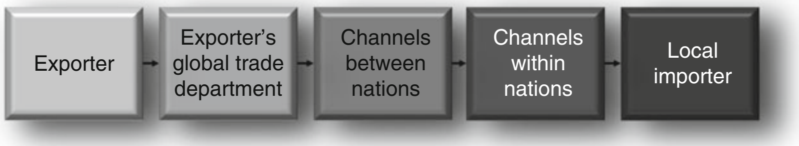


FIGURE 14.4 Global trade network.

The exporter is the first link in the global trade network. The exporter decides how products are being stored in the home country, what marketing efforts are underway, the nature of the physical channels of distribution the network must traverse, and other issues. Once a global trade strategy has been drafted, the exporter's global trade department or international division determines what the physical network channel will look like and other critical marketing decisions, such as product mix and service performance targets.

In the next link, channels between nations, the product is moved from the domestic market into international channels of distribution. Often shipments pass through several iterations of unloading and reloading, transport consolidation, and warehousing occurring in different foreign countries. These distribution nodes can represent an intermediary, government customs and tariffs check points, or stocking locations. In addition, because of the relative size of the distribution channel, there are a significant number of options available to suppliers and customers. One option is a strategy that enables customer orders to be filled from multiple locations in the global channel. Because of the size and flexibility of the global network, it is of critical importance that planners structure a channel that optimizes cost and service objectives and is in alignment with marketing, product, and financial strategies.

The fourth global network link occurs when the product arrives at the destination country and enters the local distribution channel. Depending on the nature of the trade agreements, the product could traverse a variety of intermediaries from FTZs, to local brokers and LSPs, to customer distribution channels. For example, to sell soap in Japan, Proctor & Gamble must sell through a labyrinth of intermediaries starting with sales to a general wholesaler, who sells to a product wholesaler, who sells to a regional wholesaler, who sells to a local wholesaler, who finally sells to retailers [16]. At the end point of the global trade network is final delivery to the customer.

In a classic article, Picard [17] segmented global channels into four systems. These systems cut across the channel strategies described above. In the first system (Figure 14.5), products are shipped directly from the home country to intermediaries or customers in a single foreign market. The advantages of this system are that there is no need for foreign warehousing or shipment consolidation and there is less product in the distribution channel. A serious drawback of this system is the accompanying long lead times and delivery costs for customer delivery. In addition, the length of the supply line renders the shipment subject to possible disruption and delay. Finally, the packaging and documentation costs associated with this system are normally higher than for the other three systems.

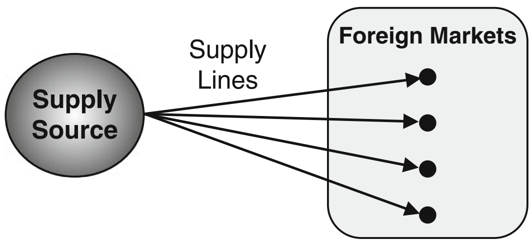


FIGURE 14.5 Direct system of global trade.

The second channel system (Figure 14.6) attempts to solve some of the problems of the direct system by interposing a shipment consolidation center in between the domestic warehouse or producer and the foreign market. The purpose of the consolidation center is to decrease the overall cost of transportation and shorten service lead-times. Product can be shipped from the home country in bulk and then converted (bulk break) into individual customer orders and stocking units and distributed within the foreign market.

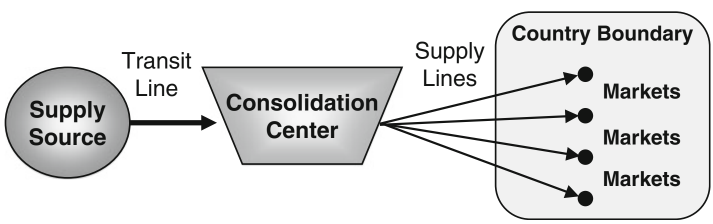


FIGURE 14.6 Global trade consolidation strategy.

The last two global channel systems are distinguished from the first two by the fact that they both require the creation of a consolidation warehouse in the foreign market. In the third system (Figure 14.7), inventory is shipped from the home country to a stocking warehouse located within the foreign market. The benefits of this arrangement are obvious. Delivery to the foreign warehouse can be done in bulk and with slower transportation modes, thereby decreasing shipping costs; order lead times are shorter that in the first two systems; customers have greater flexibility in product and quantity selection; and, because the shipment is really an intracompany transfer, the costs associated with tariffs and documentation are reduced. Negatives to the system are the cost associated with maintaining a foreign facility and higher levels of pipeline inventory.

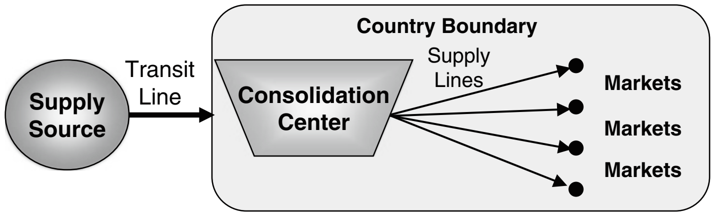


FIGURE 14.7 Consolidation strategy within a country.

The final global channel system (Figure 14.8) expands on the concept of a foreign consolidation warehouse by enabling product sales to multiple foreign markets from a single strategically positioned warehouse. The most significant advantage of this system is reduction in facilities and inventory stocking costs while preserving shorter lead times and customer flexibility. Benefits, however, might be compromised by transport and administrative costs as shipments are sent to other foreign countries. Multicountry warehouses should ideally be located in a free-trade zone, thereby eliminating costs arising from local tariffs and taxes.

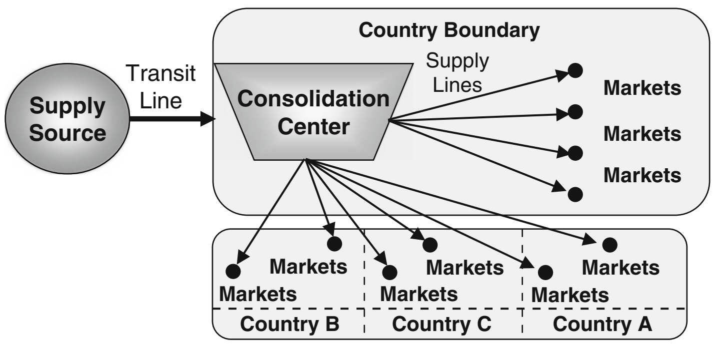


FIGURE 14.8 Consolidation strategy for multiple countries.

In deciding which channel system or combination of systems to implement, channel planners must carefully review a number of key factors relating to the nature of the product, the target marketplace, export requirements, and the local country environment. *Product*-related issues focus on such attributes as value density, product line variability, perishability, obsolescence, position in the product life cycle, and expected turnover rate. *Market*-related issues refer to the number and size of the foreign customer base, level of expected service, sales volume, quality of foreign intermediary or company-owned distribution channels, fitness of product, and prospects for growth. *Export*-related factors center on export marketing strategy, sophistication of intermediaries, and firm size. *Foreign environment* issues focus on sophistication of global channel infrastructure, political and economic stability, degree of government regulation and customs constraints, and the presence of strong, cost-effective foreign partners and transit contractors. By using these key factors, planners have the ability to develop several different global channel systems. For instance, a direct channel system could be used to supply bulk shipments to large foreign customers, whereas a multicountry approach could be employed simultaneously to penetrate several different countries supplied from a central foreign warehouse.

14.4.2 Global Marketing Issues

Although there are great similarities when constructing domestic and global trade channels, there are also a number of significant differences regarding products, pricing, contracts and terms of sale, and marketing department organization that are unique to international transactions. These features are described below.

14.4.2.1 Global Marketing Department Organization

Probably the first place to start in conducting global trade is deciding on the type of global trade department to be established. Large multinational companies may pursue several types based on their global channel strategies. The least complicated type of organization is the domestically based *export department*. As discussed previously, such a department normally consists of an export clerk, a sales manager, and a few assistants, or it can be a complex business unit with expanded roles and service offerings. Exporting departments can be *indirect*, contracting with domestic or foreign wholesalers or distributors, or *direct*, shipping product directly to foreign buyers.

If a company decides to expand beyond just exporting and importing goods into more complicated global trade activities, such as licensing, joint ventures, or direct ownership, they will need to establish an *international division*. This organization is staffed by dedicated global trade specialists capable of provide a wide array of services to various operating units. According to Kotler and Keller [18] the division could be organized in several ways. They could be formed as a *geographical organization* reporting to a regional country vice-president responsible for the salesforce, branches, distributors, and licensees in the local country. Another option would be to organize the division into *world product groups*. In this format, each operating unit would have a national vice president responsible for worldwide sales of the corporation's product groups. Finally, operating units could be organized as *international subsidiaries*, each with a president reporting to the president of the international division.

Finally, some organizations have become so big that they consider themselves *global organizations* rather than national marketers. Companies like Walmart, Apple, Microsoft, Black and Decker, Warner Lambert, and others are involved in the planning and execution of global distribution channels, involving local production, marketing strategies, and financial systems. Bartlett and Ghoshal [19] distinguish three global organizational strategies: (1) the world is treated as a single market–selected when the company has a very strong product; (2) the world is treated as a portfolio of national opportunities–selected when the company is competing with other strong players in the local market; and (3) a combination of strategies 1 and 2. In the end, finding a successful balance is a tricky affair where even giant corporations like Coca-Cola and McDonald's have often pursued what turned out to be a failing strategy.

14.4.2.2 Products and Services

An important step in global distribution surrounds several decisions regarding the marketing approach driving product positioning. Classically, the product marketing strategy takes one of two approaches. In the first option, international marketers choose to follow a *standardized approach* by offering the same products, prices, advertising, promotions, distribution channels, and value-added services to all foreign market segments. This option is the less costly, as little or no modification is made to the product and global marketing strategy. On the other hand, marketers might pursue a *customized approach* in which the product and distribution support structure is tailored to meet the needs of local markets. Many international trading companies develop a strategy somewhere in between these two extremes, searching for ways to leverage the two approaches in an effort to optimize sales and profits while reducing costs.

Regardless of the approach selected, even heavily branded and labeled products such as Coca-Cola, Toyota automobiles, and McDonald's, often require some adaptation to meet local tastes in foods, fashion, or other attributes. Keegan [20] has identified five possible product and communications strategies. In the first, *straight extension*, the product is offered to the marketplace without modification to local needs. This is the least expensive of the options and is used for most durable goods such as appliances, cameras, consumer electronics, tools, and machinery. Although a tempting option, since it requires no additional R&D, production, or promotional modification expense, it can be costly in the long run.

The second product strategy is *product extension-communications adaptation*. In this strategy, the product is offered to the marketplace essentially unchanged; the only adjustment required is in marketing communications. For example, the product is standard while the brand message varies in language, name, colors, and so on to meet the local market. Another approach is to use the same product theme globally, but the content used is adapted to each market. An example is the use of women in advertising which can be radically different by country. Another approach is to have a pool of ads, from which each local market selects the one that best fit its home environment. Bicycles and motor scooters are examples of products that fit this approach.

The third product management approach is *product adaptation*. This strategy requires changing the existing product to meet the standards or tastes of local nations. There are several alternatives in this strategy. In the first, the exporting company produces regional (Western Europe, Middle East, and so on) or local country versions of its product. This strategy can even extend to micro-versions of products geared to a specific city or retailer. This option is particularly important for food distributors who must change seasonings, textures, and colors to meet local preferences. Durable goods, such as automobiles, sometimes are modified to fit the safety requirements of foreign countries.

The final option, *product invention*, occurs when a firm decides to create a new product just for the regional or local market. This option can take two forms. The first, termed *backward invention*, occurs when the exporting company reintroduces previously successful products to the former local market. *Forward invention* involves creating a new product to capture the market of a local country. This option may result in significant advantage as the new product can be introduced into different markets as well as the home market. Still, it is a risky and costly strategy, the benefits of which must be closely tracked.

Another key area in this sphere is the use of advertising and promoting products in foreign lands. This area is a critical activity that requires an intimate knowledge on the part of the exporting company's marketing team of the cultures, languages, and histories of each local market. Even small things such as name, color, and nuance can have an enormous impact on foreign market acceptance. One alternative is to promote products using the same messages as those used in the domestic market. The familiar sight of the Coca-Cola logo and MacDonald's "Golden Arches" are good examples. However, sometimes product names, advertising media, and labeling need to be changed because of local customs and language.

For example, the color purple is associated with death in most of Latin America, and white in Japan with mourning. Finally, the utility of advertising media throughout the world varies. Television is a universal medium in the U.S. but limited by country in Europe and almost nonexistent in poor countries. The same variance in global audience occurs for ads placed on the radio, in newspapers or magazines, or available through the Internet.

14.4.2.3 Terms of Trade

In the process of conducting global trade, several activities need to be performed, such as clearing the goods for export; arranging for the transportation of the goods between the exporter and the customer, often performed using different channel intermediaries and means of transport; and clearing customs in the importing country. Three major terms of sales are critical in an international environment: Incoterms®, harmonized system (HS) codes, and preferential fees, duties, and taxes.

The purpose of the *International Commerce Terms* or *Incoterms®* is to determine the contract of sales detailing whether it is the responsibility of the exporter or the importer to perform and pay for these activities. Incoterms® were first introduced in 1936 to help exporters and importers clarify issues regarding title transfer and responsibility for costs and insurance during shipping. Since their initial introduction, the Incoterms® rules have been periodically updated, with the eighth version published on January 1, 2011. Incoterms® determine whether the exporter or the importer assumes the risk at certain points in the shipment in addition to indicating which party is responsible for each task in the transportation process. Incoterms® attempt to minimize the confusion over the interpretation of shipping terms by outlining who is obliged to take control of and/or insure goods, who is responsible for the clearance of the goods for export or import, and who is responsible for executing requirements on the packing of items. Although Incoterms® are not legally binding, they are globally accepted as the standard terms to use in contracts of carriage. Incoterms® by themselves *do not*:

- Constitute a contract;
- Supersede the law governing the contract;
- Define where title transfers; nor,
- Address the price, payables, currency, or credit terms.

The current Incoterms® are divided into two categories *based on method of delivery*. The larger group of seven rules applies regardless of the method of transport, with the smaller group of four applying when international trade is entirely conducted by sea and inland waterway. The 11 Incoterms® are described in Table 14.2.

Table 14.3 illustrates buyer and seller responsibilities for major international transportation activities by Incoterm®.

Besides Incoterms®, the terms of sale in an international environment are governed by the following two other factors:

- *Harmonized system* (HS) *codes*. These six-digit codes (some countries like the U.S. have added four additional digits to make a 10 digit code), which vary by country and number in the hundreds of thousands, detail the fees and restrictions associated with the transport of goods across national borders. Their main purpose is to facilitate the recognition of cargos by customs officials to ensure that the correct items and duties can be assessed on a shipment. These codes are defined and harmonized for all

TABLE 14.2. Incoterms®

Group	Term	Description
General transport		
E	Ex Works (EXW)	The importer agrees to take possession of the shipment at the point of origin and to bear all of the cost and risk of transporting the goods to the destination
F	Free CARRIER (FCA)	The exporter incurrs the cost of delivering the shipment to the carrier designated by the importer. FCA is normally used with intermodal transport
	Carriage Paid To (CPT)	Same as above, but is applied to any transport mode. Risk passes to importer when shipment delivered to the main carrier
	Carriage and Insurance Paid To (CIP)	Same as above, but importer bears the risk of loss or damage
D	Delivered at Terminal (DAT)	Seller delivers goods to a named place of destination. The seller bears all risks involved in bringing the goods to and unloading them at the place of destination
	Delivered at Place (DAP)	Seller delivers goods at the buyer's disposal arriving for unloading at the named destination. Seller bears all risks involved in bringing the goods to the named place
	Delivered Duty Paid (DDP)	Same as above, plus exporter is responsible for clearing the goods for import and paying the customs duties
Sea and Inland waterway		
F	Free Alongside Ship (FAS)	Same as above, but is used for water transport only. Risk is transferred when goods are delivered alongside the ship. Importer pays cost of loading
	Free on Board (FOB)	Same as above, but is used for water transport only. Risk is transferred when goods cross the ship's rail. Exporter pays for loading
C	Cost of Freight (CFR)	Shipment contracts that obligate the exporter to obtain and pay for shipment. CFR is used for shipments by water only. Risk passes to importer at ship's rail
	Cost, Insurance, Freight (CIF)	Same as above, plus exporter pays for the cost of insurance. Risk of damage is the s ame as that for CFR and CPT

TABLE 14.3. Incoterm® Buyer/Seller Responsibilities

	General transport							Sea/Inland waterway			
Function	EXW	FCA	CPT	CIP	DAT	DAP	DDP	FAS	FOB	CFR	CIF
Export customs declaration	Buyer	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Carriage to port of export	Buyer	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Unloading of truck in port of export	Buyer	Buyer	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Loading of truck in port of export	Buyer	Buyer	Seller	Seller	Seller	Seller	Seller	Buyer	Seller	Seller	Seller
Carriage (sea/air) to port of import	Buyer	Buyer	Seller	Seller	Seller	Seller	Seller	Buyer	Buyer	Seller	Seller
Insurance	Buyer	Buyer	Buyer	Seller	Seller	Seller	Seller	Buyer	Buyer	Buyer	Seller
Unloading of truck in port of export	Buyer	Buyer	Buyer	B/S	Seller	Seller	Seller	Buyer	Buyer	Buyer	Buyer
Loading of truck in port of export	Buyer	Buyer	Buyer	B/S	Buyer	Seller	Seller	Buyer	Buyer	Buyer	Buyer
Carriage to place of destination	Buyer	Buyer	Buyer	Buyer	Buyer	Seller	Seller	Buyer	Buyer	Buyer	Buyer
Import customs clearance	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Seller	Buyer	Buyer	Buyer	Buyer
Import taxes	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Seller	Buyer	Buyer	Buyer	Buyer
Export packing	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller	Seller

goods crossing a border. Currently, the coding system is used by more than 200 countries and economies as a basis for their customs tariffs and for the collection of international trade statistics.

- *Preferential fees, duties, and taxes*. This area can be separated into three broad areas:
  - Import tariffs are normally comprised of *general* and *preferential duty rates*, in additional to other fees and charges. Preferentially duties are influenced by such elements as *most favored nation's* (MFN) status and duty rates based on specific country agreements.
  - Other charges, such as the *anti-dumping duty* (ADD), are often imposed on certain products (steel, for example) from certain countries to offset unfair pricing of the imported product.
  - Finally, transportation managers must be aware of taxes, such as *valued-added tax* (VAT), *general services tax* (GST), and *merchandise processing fee* (MPF) and a host of fees collected for *other government agencies* (OGA), including excise taxes, harbor fees, trade promotion fees, control taxes, and others, that impact global trade.

14.4.2.4 International Trade Contracting

Another factor associated with international sales is contacting. When a business decides to engage in international trade, it often enters into a number of contracts, written and implied, with many different trading entities. Examples include the contract of sale between the exporter and importer; insurance contracts; carriage contracts involving the exporter, importer, and shipper; and financial contracts associated with payment arrangement and letters of credit. Unlike contracts executed within a country, global trade contracts are often negotiated within a complex framework of local laws and traditions, multilateral governmental agreements, and international treaties. Sometimes there is even debate about what a contract represents in the first place.

Since there is no set of jurisprudence and legal expertise common to all nations to govern contracts, global traders depend on a universally accepted trade law termed *Lex Mercatoria*. David and Stewart define this convention as

> The sum total of all the international agreements, international conventions, and other international trade customs that complement the domestic laws of any given country, and to which all international trade transactions are subject. [21]

Lex Mercatoria is complex because it includes a number of different international source of law and jurisprudence such as United Nations treaties and other decisions; international agreements, such as the General Agreement on Tariffs and Trade (GATT); the World Trade Organization (WTO); European Union conventions; NAFTA; and others. For the most part, contracts of sale are covered by the United Nations Convention on Contracts for the International Sale of Goods (CISG). Established in 1980, the CISG has been ratified by more than 60 countries and represents more than 80 % of all world trade. CISG is substantially different from the Uniform Commercial Code (UCC) of the U.S., noticeably in contract formation and remedies in the instance of nonconforming goods or late delivery.

Another type of contract is one executed between an exporter and its representatives (agents and distributors) located in foreign markets. An agent represents the exporter who, for a commission, performs the duties of promoting and executing the exporter's products in the local market. Both represent the decisions regarding price, delivery and other sales terms specified in their contracts. A possible issue is whether the courts in a dispute will consider the contract as "between equals" or between "unequal partners." When the former is the case, normal contract law will be applied; in the former, the practice is to ignore the terms of the contract and apply local laws to arrive at a remedy.

14.4.2.5 Pricing [22]

Closely aligned with terms of sale is global pricing. Similar to the process of determining domestic prices, global prices are set in accordance with the price-setting behavior of competitors, customers' ability to buy in various national markets, strategic cost and profit goals, place of product in the product life cycle, and local legal and pricing regulatory environments. At the base of international pricing is the problem of *price escalation*. For example, a product made in the U.S. would sell in the domestic market for US$100, but in Europe the price might escalate to US$205. The difference between the two prices is the cost to the exporter for transportation, tariffs, importer margins, wholesale margins, and retailer margins above the factory cost. To solve this problem, exporters have three options. A company may, first of all, establish a *uniform price* for all markets. When pursuing this policy, all nations, whether rich or poor, would pay the same price. A second method would be to set a *market-based price in each trading country*. In this strategy, the firm would charge what each country could bear. Finally, a firm may pursue a *cost-based price in each country*. Selling price would be cost plus a standard markup. In any case, prices for products sold in foreign countries are likely to be higher than in domestic markets.

There are several additional pricing problems in global trade. The first involves the price the domestic country charges a foreign subsidiary or *transfer price*. If too high a price is charged, the company may end up paying higher tariff duties. On the other hand, if it changes too little, the company may be accused by the importing nation of *dumping*. Dumping occurs when a company charges less than cost or less than what it charges in the domestic market in order to enter or win a market. When such abuses are caught, various governments force the subsidiary to charge the *arm's-length price* or the same price as being charged by local competitors. Another pricing problem occurring when a distributor in a low-cost country buys excess product and diverts some of the quantities to a high-cost country to capitalize on higher prices (termed the *gray market*). The European Union has been able to virtually eliminate this practice through a common currency. Another leveling practice is the use of e-commerce. Customers can easily compare prices from different vendors and choose the lowest one.

Once a pricing policy has been determined, actual pricing is governed by the terms of sale. The pricing set by the terms of sale differs in the way transportation, insurance, tariffs, and other costs are incorporated into the total price. Prices charged at the point of origin are normally the domestic selling price minus any export discounts. Beyond *Ex* (point of origin) pricing, pricing schemes normally fall somewhere in between two basic methods: *ex works*, where the foreign customer bears the freight and insurance costs, and *delivered* pricing. When using delivered pricing, the shipper's price includes not only the price of the goods but the cost of transport, customs, tariffs, insurance, documentation, and other expenses. Delivered price provides certain advantages. To begin with, the seller gains control over the distribution process, thereby ensuring customer service and pricing competitiveness.

Second, the seller may be able to obtain bulk discounts, which ultimately allows price reduction. Finally, delivered pricing has the effect of increasing the nation's balance of trade and utilization of domestic logistics services.

There are several forms of *FOB* pricing depending on the type of carrier. The price is basically a composite of the transportation costs associated with packing, marking, loading, and transit freight costs. To this price is added other charges for unloading/loading, material handling, and transit duties. *CFR* pricing includes the FOB cost plus the ocean freight charge, export license, and export duties and taxes. *CIF* pricing consists of *CFR* cost plus marine insurance. *Ex ship* and *ex quay* pricing consists of *CIF* costs plus expenses for consular invoices, certificate of origin, unloading, import licenses, tariffs and taxes, customs clearance, and additional marine and war risk insurance coverage.

14.4.2.6 International Trade Financials

An enterprise involved in global trade is faced with a number of financial issues that are not present in the domestic market. These issues are concerned with such factors as cash flow and currency conversion, fluctuating cost for inventory, the role of government, and methods of payment. Without a doubt, cash flow is of prime importance. Typically, global companies need a great deal of working capital to pay for plant and equipment, transportation services, inventories, and credit. Much of the reason lies in the great distances goods have to travel and the normal administrative delays encountered in foreign trade. Even when the transactions are relatively simple, customs clearance, the transfer of international payment documents, government restrictions, and shipment disputes can hold up payment. In addition, variations in the rate of currency exchange can severely impact capital planning. This is particularly true when it is considered that the value of the currency upon which the price was based could devalue between the time of shipment and the time of delivery. For this reason, very few global transactions are financed by payment in advance or cash on delivery. Besides cash flow issues, currency variation will have an effect on local costs associated with warehousing, labor, transportation, information processing, and other costs. Finally, there are also potential collection issues arising from inadequate credit reports on customers, problems of currency exchange controls, distance, different legal systems, and the cost and difficulty of collecting delinquent accounts.

While it has been pointed out that international trade requires exporters and importers to detail the *terms of trade* (who has responsibility for what trade activities as specified in the Incoterms®), two other issues need to be resolved: the *terms of sale* (the agreed upon method of payment) and the *currency* used for the trade transaction.

Terms of Sale. There are essentially six basic forms of rendering payment in a global transaction. Each of these methods has its advantages and disadvantages, but in the end the form of payment is determined by weighing the risk of not getting the sale versus the risk of nonpayment. Trade with high risk countries usually warrants less risky methods such as cash in advance or a bank letter of credit. Using such conservative methods, however, risks the potential of lost sales.

- *Cash in advance*. In this method, the exporter requires payment in advance before shipment of the goods occurs. The transaction is performed by an electronic transfer of payment from the importer's to the exporter's bank. In this method, all of the risk is placed on the importer and is the recommended method when dealing with very risky trade transactions.

- *Open account*. In this method, once the goods are shipped, the exporter sends an invoice to the importer. The exporter expects payment based on the accounts payable agreement executed between the two parties. The agreement will state such key provisions as number of days until past due, possible early payment discounts, cost of risk insurance, and possible interest charges on late payments. This form of payment is only used when the exporter has established a firm partnership and feels that there is minimal risk of nonpayment from the importer.
- *Letter of credit*. In this method, a bank in the importer's country issues a commercial letter assuring the exporter that the importer can make payment for the purchase of goods and that the bank will honor a draft issued by the importer up to that amount. The letter of credit is therefore a contractual agreement between the issuing bank and the exporter independent of the exporter/importer relationship. This means that the bank, if the importer is unable to pay, is contractually obliged to pay the exporter. There are three types of letter of credit:
  - *Irrevocable*. This type of letter of credit cannot be canceled by the issuing bank without the consent of the exporter. Most letters of credit are executed as irrevocable.
  - *Confirmed irrevocable*. In this situation, a foreign bank issues the letter of credit and it is guaranteed by a bank in the exporter's home country. The drawback of this option is that it is more expensive than an irrevocable letter of credit.
  - *Revocable*. Normally, this letter of credit is really a pro-forma document to be used as a basis when preparing irrevocable letters of credit.

A letter of credit would be used when there is a significant risk of nonpayment.

- *Documentary collection*. In this method, the importer asks the bank not to release key shipment documents, such as bill of lading which transfer ownership of the shipment, until the importer pays for the shipment or promises to pay within a certain time window.
- *Procurement cards*. Using the idea of the standard *P-card* used in domestic purchasing, a bank offers credit cards to be used by the importer. Similar to a consumer credit card, a procurement card allows an importer to make purchases directly with an exporter. When the transaction is completed, the bank immediately pays the exporter, minus a certain transaction percentage usually around 2 %. This method present a very low risk way of conducting international trade.
- *Direct debiting*. With the advent of the Internet and electronic networking, most global trade systems enable direct, electronic debiting of an importer's purchase and immediate payment into the accounts payable of the exporter. How the process works is when the shipment takes place, the exporter's accounts receivable module automatically debits the bank account of the importer, subject to the payables agreement executed between the two parties. This type of automatic payment is fundamental to e-commerce.

Currency Issues. Beyond terms of trade and terms of sale, companies engaging in global trade must be aware of currency issues. When selecting a currency for the transaction, three options exist: use of the exporter's currency, the importer's currency, or a third party currency. When deciding on the currency, two factors should be considered:

- *The risk of currency fluctuation*. This factor is associated with the possibility of currency gain or loss and who is incurring the risk. If the exporter's currency is used, the importer incurs the risk, and vice versa. This risk can be mitigated significantly by using a benchmark currency such as the U.S. dollar or the euro.
- *The convertibility of the currency*. This factor is associated with the ease in which a currency can be converted into other currencies. A currency that can easily be converted into another currency is termed a *hard currency*; a currency that is not easily convertible is termed a *soft currency* or one that cannot be converted at all is termed an *inconvertible currency*.

A final issue to consider is the use of *exchange rates*. An exchange rate is the value of one currency expressed in units of a second currency, for example U.S. dollars into euros. An exchange rate used for immediate trade is termed a *spot exchange rate*. For longer-term risk management, parties may engage in *currency hedging*. Some of the financial instruments available is using a *forward exchange rate* where the parties are committed to a forward currency contract to be delivered 30, 90, 180 days, or 1 year from the quote. Other tools used in hedging are currency futures (where currencies are traded in futures' markets similar to other commodities such as wheat and corn), swaps, and options.

14.4.2.7 International Trade Documentation

Another aspect differentiating international from domestic distribution is the additional documentation. International trade documents must be completed in a very specific fashion taking into consideration such things as the country of destination, the type of goods, the method of transportation, the method of financial settlement, the bank(s) involved, and more. In addition, these documents must contain very detailed information and filed in a certain time frame with the right administrative trade bodies. A problem that is just recently being overcome is the requirement of many nations that all trade documents be issued in paper in favor of electronic versions issued through software such as a global trade management (GTM) system.

International trade documentation can essential be broken down into six basic types. While this text will not go through all of the various types of documentation the more important ones will be singled out [23].

Invoices. The invoice is simply the bill for the shipment to be paid by the importer. There are several types of invoice:

- *Commercial*. This is the most recognizable type of invoice which is presented to the importer upon shipment and receipt of commercial goods. The invoice contains a very precise definition of the goods shipped, the terms of trade (Incoterms®), all order charges, and the terms of payment and currency.

- *Pro-forma invoice*. This type of invoice is actually a quote detailing the final cost of an anticipated order provided by the exporter to the importer for the purpose of the importer obtaining a letter of credit.
- *Consular*. This type of invoice is nothing more than a commercial invoice that is printed on stationary provided by the consulate of the country in which the goods will be imported.

Export Documents. The purpose of export documentation is to record data about what products have been exported from a country.

- *Export license*. This document is used to attain authorization from the exporter's government for the shipment of a specific product. Normally, governments require export licenses to control foreign trade for political or military reasons.
- *Shipper's export declaration*. This document is required by U.S. customs for all exports valued at more than US$2,500 per item category (as determined by the Harmonization Codes) and that require a valid export license.
- *Export taxes and quotas*. Some countries require exporters to pay taxes on certain goods as well as conform to all quotas on certain exported goods.

Import Documents. There are several objectives for using import documents. Among the uses are ensuring that only quality goods are imported; determining the proper tariff classification and the correct value of the goods; protecting local importers from fraudulent exporters; and to limit the volume of certain imported commodities.

- *Certificate of origin*. This is the most common import document which must be signed by the exporter's Chamber of Commerce authenticating that the goods *originated* from a certain country. This document is also used by importing countries to determine the tariff to be applied to the goods.
- *Certificate of manufacture*. This document, provided by the exporter's Chamber of Commerce, authenticates that the goods to be imported were produced in the country in which the exporter is located.
- *Certificate of inspection*. This document, provided by an independent inspection organization, validates that the imported goods conform to their stated description.
- *Certificate of certification*. This document, provided by an independent inspection organization, validates that the imported goods conform to the standards set by the importing country.
- *Import license*. This document must be obtained by the importer from the importing country (mostly developing nations) authorizing the importation of a particular product or commodity.

Transportation Documents. These documents govern the transportation of goods and commodities.

- *Bill of lading (BOL)*. The BOL fulfills three critical roles in transportation: it is a *contract* in which the transportation agrees to transport goods from one place to another and to deliver to a designated consignee; it is a *receipt* for the goods signed by the consignee; and it is a certificate of title to ownership of the goods. In case of loss, damage, or delay, the BOL is the basis for filing freight claims. There are several types of BOL: an *ocean BOL* is used for goods on oceangoing vessels; an *air waybill* is use for goods transported by air; a *soiled (foul) BOL* reflects the fact that the goods transported are damaged in some way; a *clean BOL* reflects the goods transported are in good condition; a *uniform BOL* is used in the transportation of goods on trucks and trains, domestically or internationally; an *intermodal BOL* is used in intermodal transportation of goods domestically or internationally.

- *Packing list*. This document always accompanies the shipment and specifies the exact content of the shipment, such as number of boxes or containers. Some shippers combine the invoice and the packing list in one document.
- *Shipment of dangerous goods*. There are several forms of this document depending on how the goods are transported, the nature of the hazardous goods, and country of import.
- *Manifest*. This document is internal to the shipper and lists the exact makeup of the cargo, its ownership, its ports of origin and destination, special handling instructions, and so on.

Electronic Documents. Over the past several years, international trading companies have been migrating their documentation to two forms of electronic transfer.

- *Electronic Data Interchange (EDI)*. This technology sends international trade documents from the shipper's computer to the buyer's computer expressed in a format acceptable to both parties.
- *Internet networking*. This technology uses the medium of the Internet to transmit international trade documents from the exporter to the various trade intermediaries, ending with the final receiver of the goods.

14.4.3 Global Trade Management (GTM) Systems

Companies going global today are beset by a range of problems: unexpected transportation costs, increasing regulations, higher inventory investment, and longer and more unpredictable cycle times, while experiencing demand for lower costs, more unique services, and improved responsiveness. Many shippers working in the global market know that the typical international transaction involves up to 30 different parties, 200 data elements, and 40 or more documents. In addition, shipments are expected to arrive on time, complete, and within budget. As a result, businesses are searching for ways to render global supply chain processes more reliable, more flexible, and less expensive. As the increased risk and complexity associated with the effective management of export/import cost management, government compliance, documentation, and security regulations grow, companies have been turning for solutions to a relatively new software application termed *global trade management* (GTM).

Historically, global trade management was a small part of a typical company's business, run typically through stand-alone spreadsheets. Today, managing the flow of goods, information, and money across borders (totaling more than $32.5 trillion in 2008) is a highly complex, regulated, and dynamic process that can no longer rely effectively on manual processes. In some ways, a GTM solution can be considered as simply supply chain management applications with a world-wide reach. As illustrated in Figure 14.9, a GTM system links the exporter's ERP/WMS systems to a set of software applications that enable global trade departments to optimize, automate, and monitor transactions with trading partners and service providers. Transaction data used by the exporter, its vendors, LSPs, customers, and other trading partners flows through a central GTM platform. The flow of data, in turn, triggers other transactions and the system ensures each party receives the information it requires. For example, an international importer might use GTM functionality to transmit purchase orders, share information with suppliers, book transportation, track shipments, and perform several other activities involved in global procurement and moving goods.

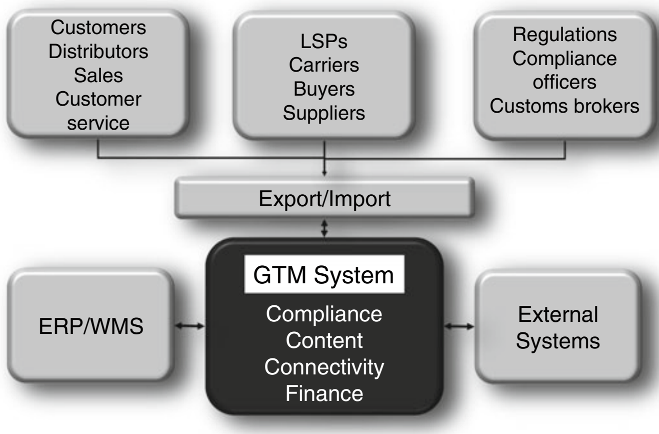


FIGURE 14.9 GTM system architecture.

The components of a GTM system are defined as a software solution that manages global trade events by achieving efficiencies and excellence in four critical areas:

- *Compliance*. Functionality in this area provides capabilities focused on automating customs and regulatory compliance activities, such as product classification, restricted ship-to party screenings, and embargo checks, trade documents, calculation of total landed costs, assignment of export and import licenses, electronic communication with legal authorities, management of customs processes and transit procedures, and determination of preferential trade eligibility. A GTM can also help global traders profit from foreign trade agreements and FTZs, and participate in security programs such as C-TPAT.
- *Content*. This area is concerned with establishing accurate and complete trade content for every country a company trades with in order to successfully comply with trade regulations and prevent customs clearance delays. Such data include denied parties and embargoed countries; harmonized system chapters and descriptions; license

codes, descriptions and requirements; document templates; and value-added tax, excise tax, and seasonal tax. Real-time databases of import duties, tariffs, and other charges, as well as exemptions, help shippers calculate complete landed costs. A GTM enables global traders to update the "trade content" continuously, so that any time a shipper performs a transaction, the system applies the latest information automatically.

- *Connectivity*. Establishing and maintaining connectivity with trading partners, as well as keeping up with customs modernization efforts around the world, is a critical component of a GTM system. Because global trade involves multiple transportation modes, a GTM connects those modes so shippers know where their goods are and identifies and improves bottlenecks and finds cost reductions. With a complete picture of the global supply chain, global companies can better manage inventories. Many of today's GTM software vendors have solutions utilizing cloud computing; other vendors enable companies to host the system inside their firewalls.
- *Finance*. Global trade requires the effective management of transaction financing. A GTM must be able to create, present, and manage all documentation required for export and import letters of credit. For more advanced relationships, companies can use GTM functionality for open account payment methods to support international trade transactions. This method streamlines paperwork and documentation, automates invoice flows, and protects transactions from exceeding credit limits.

Today's GTM attempts to assist global traders solve several key challenges: gaining visibility to the global supply chain; leveraging essential financial tools to achieve increased bottom-line results; modernizing the antiquated global trade management process; and ensure global compliance requirements are met. An effective GTM system enables global traders to focus on these challenges by increasing overall supply chain efficiency. The following five essential advantages are provided by a GTM [24]:

- *Streamlining the export management process*. A GTM relieves global traders of the task of manually screening every order from an international customer to ensure the customer and associated parties are not on the sanctioned party lists of various governments and that they conform to export license requirements. GTM functionality instantly either clears or inhibits orders, preventing shippers from experiencing costly bottlenecks and delays in shipment.
- *Elimination of order processing delays*. After order authorization, global shipments are subject to an array of documents that must be completed accurately and filed correctly. When it is considered that around 10 % of international orders are delayed due to documentation or license requirements errors, such delays can significantly affect delivery and customer satisfaction promises. An effective GTM enables shippers to notify customers of violations in a timely fashion and avoid potential fines due to non-compliance.
- *Visibility to landed costs*. GTM systems enable global traders to quickly and accurately determine shipment landed costs and to factor in decisions on product pricing, rebates, and discounts. A clear understanding of landed costs assists global companies to locate plants, production sites, and warehouses in countries where landed cost is lower due to smaller import duties on materials and finished goods.

- *Reduction of inbound shipment delays*. By providing visibility to shipment status and ensuring the right documentation is prepared and ready, a GTM can assist in significantly lessening customs delays. In the very near term, this means importers can carry less inventory and still maintain targeted levels of customer service.
- *Streamlining financial trade*. A GTM facilitates the accurate and complete submission of financial instruments, such as Letter of Credit documents, thereby reducing payment delays and additional fees.

14.5 INTERNATIONAL PURCHASING

As was discussed in Chapter 11, the outsourcing of materials, component, and finished goods to companies across global space and time has become a critical strategic in the quest for competitive advantage in the twenty-first century. Increasingly, global purchasing decisions are having an important impact on product quality, delivery reliability, increased flexibility, and cost competitiveness. As companies intensify their dependence on global partners and expand their use of e-commerce to leverage the competencies of low-cost countries and reach new markets in far-away lands, planners have increased their efforts to use global purchasing to search for new sources of supply outside the domestic market. The effective management of this movement toward international sourcing is pivotal to the acquisition of the best products to meet ever-accelerating levels of customer service and cost efficiencies to match global competitors.

14.5.1 Overview

Historically, U.S. firms first embarked on a serious concern with importing products and raw materials as far back as the 1960s. At that time, the motive was purely to reduce the cost of labor. By the 1980s, this central concern with cost reduction, a somewhat negative approach to foreign sourcing, began to be replaced by the realization that a number of dramatic changes in the global economy had altered the traditional view of international sourcing and ushered in the current era of globalization. There have been several changes in the basic business mechanisms of nations that have facilitated the emergence of international purchasing as a strategic weapon.

To begin with, the growing competitive intensity and interdependence of the global marketplace, complicated by pressures in all countries to reverse trade deficits, have "internationalized" the purchasing function. Second, pressures to reduce costs while simultaneously increasing quality and customer satisfaction in mature markets has pushed purchasers to look for the best, and lowest-cost sources of supply, either domestic or foreign. Third, purchasers regard importing foreign components as a way to increase their company's flexibility to quickly retool product design, production processes, and delivery channels. Capital invested in new products and process equipment is expensive and restricts the firm's ability to rapidly respond to changes in the market. Importing components permits them to sustain "world-class" leadership by purchasing demonstrated international engineering, technological, and process capabilities. Leveraging the competencies of supply partners enables companies to reduce cycle times for new product development and increased quality. Finally, importing provides purchasers with the ability to leverage the technologies and cost-efficiencies of other nations to acquire commodity-type components and mass-distributed finished goods such as industrial machinery and consumer electronics. Instead of being merely a market for cheap labor, overseas suppliers are now viewed as prime sources of strong production and distribution expertise that enable businesses to be as agile and close to the demand-pull of the customer as possible.

14.5.2 Advantages of International Sourcing

There are many reasons for today's purchasing function to explore international sources of supply. Key sources of value-add are:

- *Availability*. Due to the growth of foreign competition, many products that were once made domestically are now available only through international sources. Among such products are many electronic components, machine tools, capital equipment, specialty metals and alloys, and electromechanical equipment.
- *Quality*. Many buyers look to global sources for products that meet the levels of quality demanded by the marketplace. Although the quality and JIT/lean movements in U.S. manufacturing have enabled many domestic producers to quickly close past "quality gaps," the lead in quality seized by some foreign companies provides buyers with little alternative but to purchase from them.
- *Timeliness*. As lean techniques and management styles continue to decrease inventories, the need for reliability in meeting schedule requirements correspondingly has grown in proportion. Many purchasers have had to import products from global companies who have developed philosophies, production, and delivery techniques focusing on 100 % customer satisfaction at significantly less-than domestic prices.
- *Continuity of supply*. Increased demand and competition for goods worldwide have made purchasers sharply aware of possible shortages in raw materials and finished components due to strikes, economic downturns, or even political unrest. Today's purchasers must be aware of and cultivate alternative sources of supply to ensure continuity of product availability.
- *Cost/price*. Generally, foreign companies have been able to offer international buyers lower prices on goods because of lower material, labor, and overhead costs. This is particularly true of products, such as textiles, apparel, shoes, molds and dies, assembled components, and automobiles. Coupled with this advantage, some foreign producers also possess specialized skills, technologies, or patent rights that provide them with an overwhelming competitive advantage. In exploring cost advantages, buyers must be careful to calculate the total landed cost, including transportation, communication, import duties, source investigation and so forth, when pursuing global sourcing.
- *Technology*. Many foreign nations have historically prided themselves on the high level of craftsmanship and quality that characterizes their products. Today, there are many foreign nations, particularly Japan, Germany, and China, which possess strong technology competencies in some industries comparable to U.S. companies who often are charging a higher price. Buyers who do not take advantage of this technological leadership to acquire high-quality products might find themselves losing to competitors that do. In addition, the strong technology competencies of some foreign

companies may permit other firms to "acquire" the technology without investing in the development of the process itself. Importing the products of these technologies permits companies to remain focused on core competencies while leveraging imported components to offer to the market a wide variety of highly competitive products.

- *Market entry*. Some nations require foreign exporters to also buy from their country, or have a certain percentage of the export product be produced from materials or components originating from the home country. International purchasing requires buyers to know the overall sources of products if they are to effectively procure components or finished goods in support of marketing, production, and sales plans.

14.5.3 Countertrade Purchasing

Countertrade defines any transaction in which payment is made partially or fully with goods instead of money. Countertrade links together two normally independent functions: the export of sold goods to a specific country and the import of purchased goods from the same country. Countertrade occurs for a number of reasons. For example, the importing country has balance-of-payments, currency exchange, or political restrictions preventing cash purchase. Sometimes this condition is imposed by governments in an effort to promote local products or to gain imports while also keeping currencies inconvertible. In this environment, countertrade provides certain advantages such as facilitating sales, expanding competition, improving profit potential, opening responsive markets, developing new capabilities, and retarding inflation. There are, however, drawbacks. It complicates purchasing, adds administrative costs, extends transportation time and cost, incurs duties and taxes, drains home technology resources, and imposes unfamiliar activities to be performed.

There are five types of countertrade. These types, in turn, are driven by four variables: (1) the nature of the goods, (2) the percent of payment made in goods, (3) length of time before full payment is made, and (4) the number of parties involved [25]. The five major types of countertrade are:

- *Barter*. This is probably the oldest form of transaction. Barter is the direct exchange of goods or services or both between two parties without the exchange of cash. Problems with this type of countertrade are the normal lag in time before goods are fully received, the possibility that one party may receive goods they cannot use, or one party receives goods that are less than the expected value.
- *Counter-purchase*. Many times two companies will agree upon reciprocal buying arrangements. Both companies agree to buy the products of each, pay for the majority of their purchases in cash, and fulfill their mutual sales obligations within a specified time period.
- *Offset*. This type of countertrade is similar to counter-purchase. The difference is that some or 100 % of the counter-purchase obligation is offset by buying from any company in the foreign country. Offset countertrade agreements are normally executed with countries with centrally planned economies.
- *Compensation or buy-back*. In this type of countertrade a company agrees to build a plant or supply technology, equipment, and/or technical advice to a foreign country, and, in exchange, takes a percentage of the output from the facility as payment. Occidental Petroleum, for example, negotiated a US$20 million deal with Russia to

build several plants there and receive ammonia over a 20-year period as partial payment. Normally, the host country receives ownership when the terms of the agreement are completed.

- *Switch-trading*. This countertrade method utilizes a third-party trading house that buys the selling company's counter-purchase goods, services, or trade credits, and sells them to another company that requires them.

Purchasing plays a key role in countertrade. On the strategic side, a successful global countertrade system requires effective global purchasing planning. It is the role of purchasing to develop the long-term relationships with foreign suppliers necessary for the effective acquisition of products, skills, and technologies from across the globe in support of internal enterprise production and distribution requirements. In detail, it is purchasing's responsibility, along with marketing, to pursue, negotiate, and schedule delivery of those products whose value will assist in competitive sourcing. Also, it is purchasing's role to monitor and control the costs involved in countertrade transactions. These costs are comprised of the cost of fees paid to trading agents and companies and the discount from the perceived or fair-market value of the goods versus the value actually received.

14.5.4 International Purchasing Management Process

Perhaps the best way to look at the process of international purchasing is to divide it into several critical activities. As illustrated in Figure 14.10, the first step is to identify that a foreign source is necessary or economically feasible for the procurement of raw materials, a component, or a finished good. This step could be undertaken for a variety of reasons: product unavailability in the domestic market, requirements for a higher level of quality than can be found from domestic suppliers, search for alternate suppliers other than domestic sources, and search for lower-cost alternatives. In addition, more detailed criteria, such as the length of the supply line, strategy for supplier partnership and involvement, stability of product design, completeness of engineering documentation, length of the product life cycle, superiority of production methods, necessary materials and tooling, and terms and conditions of contracts, are also critical criteria that must be determined ahead of any outsourcing negotiation.

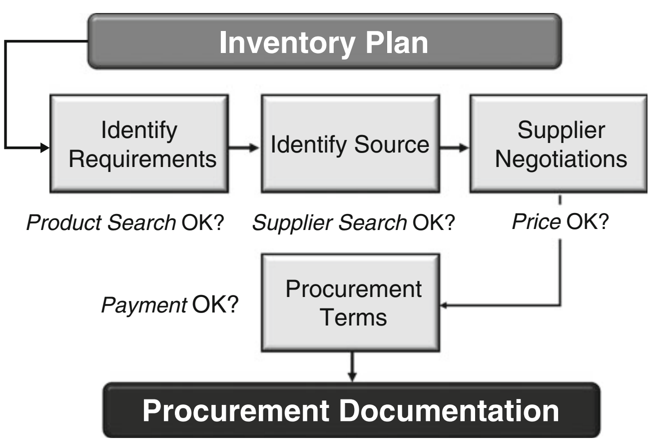


FIGURE 14.10 International procurement process.

As procurement planners begin to map out the first leg of the process, it is critical that they also detail the drawbacks as well as the advantages of international sourcing. In most cases, purchasing from foreign sources is a good deal more difficult than buying from domestic sources, requiring the ability to solve not only the same kind of problems encountered in domestic procurement but also problems accentuated by language, culture, currency, transportation, and government regulations. The contrast between domestic and global purchasing are illustrated in Table 14.4. In managing these and other differences, global purchasers must continually review foreign sourcing to ensure that anticipated advantages associated with lower prices, better service, quality, and technological innovation do not evaporate over time.

TABLE 14.4. Comparison Between Global and Domestic Purchasing

Domestic purchasing	Global purchasing
Culture Single nation and culture	Multinational/multilingual factors
Communications Single language; short lines of communication	Multilingual; long, complex lines of communications
Currency exchange Single currency	Currencies differing in stability and value
Customs regulations Relative freedom	Complex customs and tariff requirements
Lead times and inventories Stable/decreasing lead times and inventories	Long lead times and large safety stocks; need for repackaging and relabeling
Payment Cash and credit transactions	Letters of credit, electronic payment, and countertrade
Quality Common quality standards and specifications	Different standards of quality
Government involvement Minimal interference	Direct involvement in national economic plans
Economic stability Uniform economic environment	Variety of financial climates ranging from over-conservative to wildly inflationary
Operational coordination Easy access to plant visits and technical assistance	Long-distance coordination with local managers

Once the determination to use a foreign source is made, the next step is to begin the search for a global partner. This step can be as easy as making a phone call or as complex as a small project. Information concerning prospective suppliers can be gathered from trade journals and newspapers, directories of manufacturers and distributors, government trade lists and surveys conducted by the U.S. Department of Commerce, professional purchasing associations, global trade brokers, and word of mouth. A critical part of the process is deciding whether the goods are to be purchased directly from a foreign supplier or indirectly through a trading intermediary. If the latter is chosen, purchasing will have the choice of working with import merchants, commission houses, manufacturer's/distributor's agents, import brokers, or trading companies. Some of these intermediaries assume financial risk and carry inventory; brokers and agents, on the other hand, do not.

Global purchasers that choose to buy direct must perform the services normally executed by intermediaries. Besides administrative functions, the most important of these services is qualifying the prospective supplier. Intermediaries, through long experience, know the international market and can make arrangements with the best foreign companies. When buying direct, the importing company must verify the supplier on its own. Among the criteria that should be used are: (1) evaluation of the supplier's experience and management expertise in global trade; (2) supplier's financial strength and capability to meet requirements for new equipment and inventories; (3) availability of excellent communications for speedy decision-making on markets, equipment, and inventory control; (4) ability to maintain levels of inventory necessary to meet longer lead times and faster delivery; and (5) willingness of the supplier to enter into a long-term partnership. Sometimes firms with strong global purchasing functions will establish foreign offices to assist in supplier relations. Such offices normally cost less than intermediary fees; provide purchasing with better controls over price, quality, and delivery; provide more current information; and encourage better understanding with the supplier [26].

With the selection of prospective suppliers, the next step in the global purchasing process is *request for quotation* (RFQ). The purpose of this step is to detail the purchase requirements and evaluate the total landed cost of the proposed purchase. The former consists of such elements as submission of necessary specifications and drawings, statement of quality requirements, special packaging needs, likely lead times, and estimated annual volume and quantities. Calculating the total cost also requires extensive analysis. Closely monitored costs ensure that price advantages are not lost over time due to cost changes that erode the initial total landed cost advantage. Among the cost elements to be considered are transportation, customs duties, tariffs, licenses, transfer fees, taxes, insurance and broker costs, inventory carrying costs, risk of damage or spoilage, fees for documentation, terminal and port costs, and letters of credit.

Of particular importance in price negotiation is currency valuation management. One of the realities in international purchasing is that no matter what currency is used for the base price, fluctuation in exchange rates will ultimately shift currency values. Currency fluctuation is influenced by such factors as government policies, domestic interest rates, recession, inflation or deflation, and relative balance of trade. There are several strategies purchasers can use to counter currency fluctuations. The most radical approach is to insist that negotiation and payment be executed in the home currency. Another alternative is for buyer and seller to split fluctuations in value either 50/50 or by some other agreed upon formula. Many buyers will negotiate a price along with a variance, say of plus or minus 5 %. If the price exceeds the variance threshold, buyer and seller would equally share in the variance. Finally, some companies hedge currency fluctuations by purchasing fixed rates via currency futures or forward contracts [27].

Negotiations with prospective foreign suppliers, once price and product issues have been resolved, require purchasers to acquire a good deal of understanding and insight about the supplier's country and customs. Although the normal planning activities associated with a negotiation, such as team membership, establishment of objectives, and issues up for compromise, are critical, purchasers must be prepared to tailor the process to meet the often very different practices and perceptions of foreign negotiators. One of the most critical decisions to be resolved during negotiations is shipping terms and method of payment. Most of the Incoterms® reviewed earlier in this chapter relating to exports (Table 14.2) also apply to product imports. Among the most common are FOB, Ex Works, FAS, CFR, CIF and DDP. Traditionally, a number of payment methods are used when transacting international trade including the following:

- *Cash in Advance*. Often when buyers do not have a good credit rating or are unknown, or when the buyer's country is politically or economically unstable, sellers will require them to pay for purchased material in advance.
- *Open Account*. Although this is the preferred method of payment for domestic business in the U.S., it is not often used in international purchasing. The reason stems mostly from the uncertainties in currencies and international political conditions.
- *Drafts*. This is currently the most widely used of the payment methods. A draft is a negotiable instrument that contains an order to pay. When a sale takes place, the seller forwards the transfer documentation and draft through its bank to the buyer's bank for payment. A *sight draft* is executed when the buyer pays the draft. A *time draft* requires that the buyer pay the draft on a specific due date. In a *clean draft*, the seller presents its draft to the buyer for collection and the transaction documents are delivered directly to the buyer.
- *Letter of Credit*. In this method, letters of credit are arranged by the buyer with a bank, and the supplier can draw payment against the credit with the submittal of the appropriate transaction documents.

The final area relating to pricing and terms is the payment of tariffs or duties on imported goods. Tariffs are used by countries as a method for revenue generation, a device to protect domestic industries, and a means to discourage the importation of certain products. There are three major types of tariffs: ad valorem, specific, and compound. *Ad valorem*, the type of tariff most applied, is calculated as a percentage of the appraised value of the goods received. A *specific* tariff is defined as a specified amount per unit weight or other unit of measurement. For example, $0.20 per gross. Finally, a *compound* tariff is calculated as a combination of both an ad valorem and a specific rate. The payment of tariffs can be delayed by warehousing goods in a *free-trade zone*. Tariffs are not paid on the goods until they are removed from the free-trade zone and sold. Another method used by firms that re-export products is a duty *drawback*. The drawback provides for a 99 % refund of ordinary customs duties paid when the goods were originally received.

The last step in the international purchasing process is the completion of the trade documentation. Whether handled by an international freight forwarder, customs-house broker, or the company's own agents, the proper execution of documentation is critical. The following represents the key purchasing import documents:

- *Arrival Notice*. This document is sent by the carrier and informs the buyer of the estimated arrival date of the shipment, identifies the shipment with details such as number of packages and weight, and indicates when "free time" will expire. The notice is often used as a freight bill.

- *Customs Entries*. There are several different types of forms used when entering imported goods into the U.S. The first type, *consumption entry*, is required of all entering goods by U.S. Customs. The form contains information as to the origin of the cargo, a description of the merchandise, and estimated duties applicable to the particular commodity. Estimated duties must be paid when the entry is filed. The second type of entry form, an *immediate delivery entry*, is used to expedite the delivery of cargo. It allows up to 10 days for the payment of estimated duty and processing of the consumption entry. In addition, it permits delivery of the cargo prior to payment of the estimated duty and then allows subsequent filing of the consumption entry and duty. It is also known as "I.D. entry." The third type of customs entry, *immediate transportation entry*, allows the cargo to be moved from the pier to an inland destination via a bonded carrier without the payment of duties or finalization of the entry at the port of arrival. It is also known as an "I.T. entry." The final type of customs entry, *transportation and exportation entry*, permits goods coming from or going to a third country to enter the U.S. for the purpose of transsshipment. It is also known as "T&E entry."
- *Carrier's Certificate and Release Order*. This document is used to advise U.S. Customs of shipment details, ownership, port of lading, and other information. By means of this document, the carrier certifies that the company or individual named in the certificate is the owner or consignee of the cargo. It is commonly known as the "Carrier Certificate."
- *Delivery Order*. This document is issued by the consignee or authorized customs broker to the ocean carrier providing authority to release the cargo to the inland carrier. It includes all data necessary for the pier delivery clerk to determine that the cargo can be released to the domestic carrier. This document is also known as a "Pier Release."
- *Freight Release*. This document provides evidence that the freight charges for the cargo have been paid. If in writing, it may be presented at the pier to obtain release of the cargo (Normally, once the freight is paid, releases are arranged without additional documentation). It is also known as a "Freight Bill Receipt."
- *Special Customs Invoice*. This is an official form usually required by U.S. Customs where the rate of duty is based on shipment value exceeds $500. The document is usually prepared by the foreign exporter or authorized forwarder and is used by Customs in determining the value of the shipment. The exporter or designated agent must attest to the authenticity of the data furnished.

The execution of the international purchasing process is significantly different than domestic purchasing and must be effectively managed if it is to be successful. As illustrated in Figure 14.11, the first step is the development of a formal global purchasing plan. This exercise should detail international sourcing requirements, the methods to be followed for achieving these requirements, and how the strategy is to be aligned with and supportive of overall enterprise goals. The second step is the organization of an international purchasing function whose role is to gather information and evaluate opportunities, as well as execute the activities associated with managing global channel inventories, foreign negotiations, pricing, and delivery issues. This department can be organized several ways, including the use of a resident foreign purchasing office, import broker, merchant or international trading company, or formal structure within the corporate purchasing function. Third, the international purchasing organization needs to be closely integrated with other company and channel functions. This will assure that individual departmental objectives as well as the supply chain strategy are effectively supported. Finally, the purchasing planners must devise detailed procedures that assist in international sourcing program evaluation. Among key activities are review of cost-reduction strategies, pursuance of targeted value-added services, maintenance of quality levels, and others.

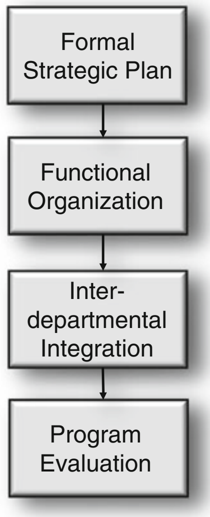


FIGURE 14.11 Managing the global procurement process.

14.6 INTERNATIONAL TRANSPORTATION AND WAREHOUSING

The scope of an enterprise's global supply channel dictates the structure and defines the boundaries of its international trade strategy. The *execution* of the global channel strategy is the function of transportation and warehousing. As is the case with other elements of the supply chain, international transportation and warehousing have a number of distinguishing factors that require them to perform operations differently than their domestic counterparts. The most obvious differences are found in the long distances goods are transported, heavy reliance on intermodal transport methods, and interaction with foreign companies and governments. More subtle differences are found in political issues, such as trade imbalances, the right of nations to use their own carriers for all domestic trade (known as *cabotage*), and arrangements made by nations to facilitate and make international transportation more affordable.

14.6.1 INTERNATIONAL TRANSPORTATION: OPENING ISSUES

All nations engaging in global trade are concerned about their balance-of-trade position. A favorable balance of payments occurs when more goods are exported than imported into a country. The objective is to ensure that more "hard" cash is entering the country than leaving it. Beyond fiscal concerns about product, pivotal to this strategy is the possession of viable transportation modes that span global boarders. To this end, governments will subsidize the growth of local carriers with international capabilities to ensure that as large a portion as possible of exports and imports are carried in home country transport modes. Also, nations sometimes have cargo preference laws requiring that certain types of goods can only be carried by domestic carriers. For example, all military supplies and cargoes arising from U.S. government appropriations, such as charitable foodstuffs being sent to foreign lands, must be carried in U.S. vessels.

Transportation services may even themselves be considered an export product that is offered to the global community. For nations wishing to engage in cross-border trading, the possession of a diverse transportation fleet acts as an additional competitive advantage when engaging in global trade. An example is the huge advantage enjoyed by China in maritime shipping, considered a backbone of Chinese economic growth. Cross-border trading occurs when a country's maritime vessels or aircraft is contracted to transport products of other nations. Some nations have attempted to control cross-border trading by a pooling agreement. Such agreements require that all or part of the products moving between the agreeing countries must be transported by their own international carriers.

14.6.2 Surface Transportation [28]

Companies wishing to either export or import products have a wide range of transportation modes available. Most trade flowing from the U.S. to Canada and Mexico use motor carriage and rail to move goods. International shipments, however, must traverse large distances and overcome oceans and long delivery times. In such cases, the surface shipment requires a combination of more than one of the five transportation modes. As introduced in Chapter 13, the basis of intermodal forms of transportation resides in the development of systems that integrate or combine together various elements of the five modes of transportation. For example, a U.S. shipment to Asia might require containerization of the goods, motor carriage to a local rail siding where the container is loaded onto a flatbed car, delivery to a West coast port where the container is loaded on ocean transport, and arrival in China where rail and motor carriage are again used to complete the delivery.

The selection of the most efficient and cost-effective intermodal combination is a complex affair requiring an expert knowledge of intercontinental transport mediums and the internal transport systems of foreign nations. Many exporters will use the services of a freight forwarder in structuring the proper mix of transportation modes for foreign shipments. The capacity and efficiency of ocean transport, combined with container, motor, and rail transport enables goods and materials to be rapidly transported to their destinations across global space and time efficiently and at the lowest cost making international trade economically and marketplace-wise possible.

A critical part of intermodal selection is the ability of the transport mode to handle *unitized* loads. Although the transfer of products in bulk, such as petroleum, coal, and grains, comprises an enormous portion of the world's international trade, specialized vessels and equipment are usually employed. Non-bulk products, on the other hand, are best handled through unitization. Whether packed in a container, rigid boxes, shrink wrapped pallets, or other packing forms, unitization is significantly more efficient than handling loose individual products. It facilitates loading, marking, and shipment identification as well as intermodal product transfer. Furthermore, it removes the need for enclosed storage space at ports, consolidation points, and freight terminals. Finally, it also reduces the chance of damage or theft while in transit.

An important form of unitization is containerization. The use of standardized containers to transport large quantities of non-bulk items has been a critical part of materials handling since the dawn of the Industrial Revolution. Containers have been designed to realize two goals: (1) maximization of the cubic capacity within the container and (2) maximization of the cubic capacity within the transport equipment. The great advantage of containers is that they can be used practically with any transportation mode. In today's global environment, containers are built to standardized dimensions, and can be loaded and unloaded, stacked, transported efficiently over long distances, and transferred from one mode of transport to another – container ships, rail and semi-trailer trucks – without being opened. Containers enable companies to greatly reduce transport costs and are a fundamental building block of international trade. As of 2009, approximately 90 % of non-bulk cargo worldwide is moved by containers stacked on transport ships.

There are five standard container sizes: 20 ft (6.1 m), 40 ft (12.2 m), 45 ft (13.7 m), 48 ft (14.6 m), and 53 ft (16.2 m). United States domestic standard containers are generally 48 ft (15 m) and 53 ft (rail and truck). Container capacity is often expressed in *twenty-foot equivalent units (TEU)*. An equivalent unit is a measure of containerized cargo capacity equal to one standard 20 ft (length) $\times$ 8 ft (width) container. As this is an approximate measure, the height of the box is not considered; for instance the 9-ft 6 in. (2.9 m) *high cube* and the 4-ft 3-in. (1.3 m) *half height* 20-ft (6.1 m) containers are also called one TEU. The maximum gross mass for a 20-ft (6.1 m) dry cargo container is 24,000 kg, and for a 40-ft (including the 2.87 m (9 ft 6 in.) high cube container), it is 30,480 kg. Allowing for the tare mass of the container, the maximum payload is therefore reduced to approximately 22,000 kg. for 20-ft (6.1 m) and 27,000 kg. for 40-ft (12 m) containers.

There are many different types of containers. For example there are general purpose (dry), closed ventilated, open top, refrigerated, heated, tanker, and air freight. A critical advantage of containers is that many small, non-bulk products are stored conveniently and safely for transport. Other advantages are security and physical protection of goods, reduced handling, a "through" bill of lading, and the use of containers for outside storage. Disadvantages of containers are:

- Containerization increases fuel costs and reduces the capacity of the transport because the container itself, in addition to its contents, must be transported.
- Containers have been used to smuggle contraband. The vast majority of containers are never subjected to scrutiny due to the large number of containers in use. The U.S. government has advanced the Container Security Initiative (CSI), intended to ensure that high-risk cargo is examined or scanned, preferably at the port of departure.
- The cost of transporting an empty container to a place where it can be reused is considered to be higher than the worth of the container.
- They can be lost, particularly at sea.
- The high cost of shipping a less-than-full container.
- Mixed reception of the intermodal transportation concept. Containers are 27 % smaller than the standard motor trailer.

Besides containers, trucking is an important facilitator of international surface trade. While in the U.S. trucking is primarily used for domestic transportation, in other parts of the world it is vital to international trade. For example, in 2009 more than 70 % of EU cross-border trade was by motor carrier. Drawbacks are traversing the great amount of rules and regulations involved in cross-border trucking, state of local infrastructures, fuel taxation, and capabilities of local rail service. Tractor trailers are, in essence, a form of self-mobile or partially mobile container. When used in an intermodal fashion, trailers can be accompanied by a tractor or shipped alone. In the latter case, the trailer is usually loaded aboard a rail car or canal or ocean vessel and sent "piggyback" to the next terminal, where it is then transferred to another form of transportation. Besides advantages associated with handling, trailers pass relatively easily through customs, thereby reducing lead times and speeding overall trailer utilization. Disadvantages to utilizing trailers are the cost of operating the tractors and paying for drivers and other support staff. Unaccompanied trailers normally take longer to move from terminal point to terminal point and require a high level of organizational control.

14.6.3 Ocean Transport [29]

Ocean transportation is probably the most import type of transport in sheer volume of international goods carried. Ocean transport carries around 80 % of global trade merchandise by volume and 70 % by value. In 2011, the total volume of goods transported globally was 8.7 billion tons. Ocean transport varies from domestic water transportation in the variety and sizes of the vessels used and in the required services provided. Ocean transport is a very diverse industry with a variety of service options, vessel types, service providers and pricing alternatives. Ocean transport offers basically two types of service. The first is *liner* vessels that operate on a pre-established schedule with specific ports of call. Normally the size and equipment of the vessels depends on the type of cargo carried and the ports-of-call. The second type of service is *charterers* or *tramp* vessels. This type of vessel does not have scheduled destinations but rather is for hire or has a charter with the shipper referencing ports-of-call, product, terms and conditions, and so forth. Normally these vessels transport bulk products such as grains, oil, and other commodities and large or bulky goods such as automobiles.

There are at least five different types of ocean vessel, which can be further divided into several subtypes based on size, intended use, and specialization. The five types are described as follows:

- *Break-bulk freighters*. These vessels primarily transport individually packaged or crated cargoes, each of which is loaded one piece at a time. Often these vessels carry cargoes for dozens even hundreds of individual shippers at a time. These vessels may specialize in carrying products that require refrigeration or other services. A negative feature of this type is the huge costs involved in loading and unloading cargoes.
- *Container vessels*. These vessels primarily transport products stored in containers. The containers are brought to the seaport by other modes of carriage, loaded aboard ship, and distributed at destination seaports by other modes of carriage. Container ships normally stow all types of containers. A great advantage of container vessels is their loading/unloading speed, intermodal transferability, and freight protection. The most common types of container vessel are *Panamax ships* (capable of transiting the Panama Canal); *New Panamax ships* (carrying 15,000 containers and capable of

transiting the New Panama Canal); and *Post New Panamx ships* (reaching 18,000 containers).

Containers moving between the Far East and Europe often make use of the *landbridge route* across the United States. In this process, containers are unloaded in U.S. West coast ports, then moved by railroad across the country to the east coast, and then reloaded aboard vessels for the voyage across the Atlantic. Landbridges have the advantage of dramatically reducing transit time by avoiding much slower and often circuitous water routes, and increasing the utilization of containerships. A variation of container vessels are *Lighter Aboard Ship* (LASH) and *Roll-on/Roll-Off* (RO/RO) vessels. LASH vessels handle floating containers and are used most advantageously in areas where the central port is connected to inland areas by shallow waterways. RO/RO vessels are designed to transport trucks, tractor trailers, and other self-propelled vehicles that roll on and off when loading or unloading.

- *Dry-bulk vessels*. These vessels are designed for transporting non-packaged dry goods commodities such as grain, coal, and ores. They rarely carry more than one type of product at a time and usually service only one shipper, or a few shippers, on one voyage.
- *Tankers*. These vessels have been designed to transport liquefied products. Among these products are crude and refined petroleum, liquefied gases, chemicals, wine, and molasses. Much of the world's total shipping tonnage is the transportation of petroleum.
- *Seagoing barges*. These types of vessels are carriers involved with small cargoes, short hauls, or routes with narrow or shallow channels. These vessels are much larger and built sturdier than river barges. Normally seagoing barges can handle bulk, bulk break, containerized, and liquid cargoes.
- *Combination ships*. These are multipurpose vessels capable of transporting different types of commodities and load types. Normally, these vessels are structured to carry bulk cargoes below decks, a tweendeck to hold vehicles or break-bulk products, and a main deck used to carry containers. Their versatility and small size are ideal for small markets and developing countries.

The control of shipping rates differs by type of service. There are three basic types of service provided by ocean vessels: liner, tramp, and industrial carriage. *Liner service* provides scheduled for-hire carriage for general goods between ports based on published freight rates. Ocean general cargo (or break-bulk liner) rates are set by *shipping conferences*. A conference is an organization consisting of all vessel owners operating in a common shipment lane who have legally agreed not to compete on price and agree to charge the same rate for the same type of cargo and the same voyage. A common rate or *tariff* is published for each commodity and is to be charged by all members of the conference. *Tramp services* are offered by vessels that literally "tramp" from port to port looking for freight. Tramp vessels do not follow established schedules or routes, and rates are established by individual charters with shippers. This type of service is used by most of the world's bulk freighters, tankers, and seagoing barges. The final type of service is *industrial carriage*. Here the shipper uses its own, or a leased vessel, to transport its own goods.

14.6.4 International Air Transport [30]

Whereas air transportation accounts for only a small fraction of the total international freight, it has become, nevertheless, the fastest growing mode of transportation. The amount of international freight transported by air grew from 75 billion FTKs (freight ton kilometer, measured as the number of metric tons of freight carried multiplied by the distance carried) in 1994 to 120 billion FTKs in 2002 to 145 billion FTKs in 2005. In 2012, international freight amounted to a US$6.4-billion business accounting for 35 % of global trade by value. Nations big and small have the ability to open lanes of international trade simply by buying aircraft and opening an airport. In many nations, the air transport industry is either wholly- or partially-owned by the state.

The main advantage of air transport lies in the speed by which goods traverse the globe in comparison to other carrier modes. Although even the largest cargo aircraft has a tonnage-carrying capacity of about 1 % of a fairly small break-bulk ocean vessel, it can make a delivery within a few hours or a few days that would take an ocean vessel several weeks. International air carriers are normally used to transport small quantities of high-value, low-weight, semifinished and finished goods. Typical products include computers, extreme seasonal and perishable commodities, products sensitive to fashion, precision instruments, and electronics. Often, such products would never be able to find their way into foreign markets without air transportation. The negative side to air transport is obviously the cost for aircraft, maintenance and repair, terminal fees, and facilities costs. Recently, airline transport was significantly challenged by the recession of 2009, the continuously rising cost of fuel, and the threat of terrorism. In addition, the limited storage capacity of aircraft and the inability to carry many types of products limit its use to all but emergency-type deliveries.

Broadly speaking, international air transportation consists of two types: passenger services and cargo operations. Passenger services account for almost 94 % of total traffic. Similar to ocean transport, air offers two modes: *scheduled* and *charter*. Using scheduled air consists of two options. The first is using freight space in the "belly" of passenger flights (United, American) and the second is all-cargo air freighters (FedEx and the USPS). When using this mode, shippers have the benefit of planning delivery almost anywhere in the world by consulting the published routes of commercial airlines. The second mode is a charter flight. Companies can charter an aircraft from a variety of private and commercial services. Although chartering an aircraft is expensive, it could be justified for the shipment of a product whose nature or demand requires extreme reduction in transit time over other forms of carriage. Theoretically, tariffs follow the guidelines established by the International Air Transport Association (IATA), a cartel consisting of almost all of the world's airlines. In practice, rates are based on the principle of charging what the market will bear. Tariffs are normally charged on the basis of volume or weight, whichever is higher.

14.6.5 International Warehousing

International warehousing is divided into two basic categories. The first consists of a variety of different types of consolidation warehouse. These facilities are privately owned by the exporting firm or offered for public use by local LSP companies and are found at seaports, airports, and in most large cities. The basic purpose of consolidation warehousing is to receive foreign shipments and prepare them for the next leg through the home-country distribution channel as they move toward the end customer. The functions of international consolidation centers are similar to those performed by domestic counterparts. Operations may consist of such activities as bulk breaking, conversion of the shipment to other modal means of transport, repacking, labeling, and marking. Among this type of warehouse are the following:

- *Transit Sheds*. This is perhaps the most basic form of international warehousing. Transit sheds are normally enclosed facilities at piers used to temporarily store shipments. The shed provides sufficient protection against weather conditions and assists in organizing the shipment for the next carrier. Transit sheds usually contain cargo, such as containers and trailers that have been unloaded from an ocean vessel and are waiting to be loaded onto a rail or motor carrier.
- *In-Transit Storage*. Often, international shippers need to temporarily store inventory while performing consolidation activities and negotiating rates with local carriers. In-transit storage warehousing provides this service. These warehouses are normally provided by the nation's railroad system and are located at seaports and airports.
- *Hold-on-Dock Storage*. This type of storage is offered by ocean carriers who permit shippers to warehouse cargoes in their facilities, usually at no charge, until the next scheduled sailing. Often shippers take advantage of the free storage to warehouse goods and perform consolidation activities.
- *Public Warehousing*. When shipments are delayed or held by the customer or government regulation, shippers may contract with a public warehouse to store the cargoes. Practically all international ports offer public warehousing to foreign shippers.
- *Shared Warehousing*. It is not uncommon for foreign shippers to pool their resources and contract as a co-operative for public warehousing. This practice enables companies to retain public warehouse storage at lower costs.
- *Bonded Warehouse*. This type of warehouse is operated under government customs supervision for the express purpose of storing imported goods. Bonded warehouses are owned directly by the government, by private companies for their imported goods only, or by public warehousing LSPs. All shipments to and from bonded warehouses are handled by government-licensed bonded carriers. While they are stored in a bonded warehouse, goods cannot be further processed or manufactured.
- *Foreign Trade Zones*. As discussed earlier in this chapter, FTZs are a special type of warehouse in which imported goods are stored duty free until they are sold in the foreign market. In addition, goods marked for re-export do not pay any duties as long as they remain in the free-trade-zone location. While in storage, goods can be further processed or manufactured. Shippers must be thoroughly familiar with the regulations affecting both bonded and free-trade-zone warehouses [31].

The second category of international warehousing is privately owned warehousing. The decision criteria for building and maintaining a foreign warehouse is fairly close to that for owning a domestic warehouse. Criteria are divided into two sets of elements: macro and micro. *Macro* elements can be divided into five major factors.

- *Transportation*. One of the most critical factors when making a decision to locate a warehouse in a foreign country is the availability of local transportation. The site should provide easy access to foreign terminals, such as sea docks and airports. Also, the state of local land transportation is critical. Quality and accessibility of the road system, availability of local carriers, and ability to use a private fleet must be determined before site selection.

- *Labor*. Once a warehouse has been built, it will need to be staffed. Issues considered are the level of education and skill possessed by the local work force, requirements for training, ability to recruit local management, attitudes and customs of the local populace, and government restrictions and labor laws.
- *Land*. The property occupied by the warehouse must be thoroughly investigated. Key issues are ownership of the land, the existence of public services such as sewers, water, roads, refuse pick-up, police and fire protection, governmental construction requirements, terrain, and possibility for expansion.
- *Energy and utilities*. A constant and uninterrupted source of power is crucial for effective warehouse operations. In countries where utilities are inadequate, companies may have to construct and operate their own power plants.
- *Taxes and incentives*. When looking for an off-shore warehouse site, companies often get local governments to assist in construction and operation, as well as to grant special tax breaks. The reverse can just as easily be the case, with some nations placing high taxes and restrictions on foreign operations in an endeavor to protect local businesses.

Once these macro factors have been addressed, the firm must consider a host of *micro* concerns. Some of these issues relate to the following:

- Currency exchange rates
- Government and social stability
- Currency stability
- Ability to take profits out of the country and availability of barter agreements
- Popular attitude of the locale toward the company
- Government attitude toward the company
- Depth and complexity of import and export regulations
- Availability of required materials handling equipment
- Free trade or most-favored nation status
- Culture and customs of the host country

14.7 SUMMARY

The globalization of the marketplace has become one of the most critical components shaping today's business climate. The explosion in international trade is the result of the maturing of the economies of the highly industrialized nations, growing global competition, the formation of powerful international trading blocks, the establishment of strategic alliances and joint ventures with foreign companies, and the development of integrated logistics systems focused on attaining the best cost and service possible. While global trade offers many advantages, companies need to be aware of the many barriers that render an international trade initiative difficult. Global strategists must be prepared to find solutions to such barriers as tariffs and trade practices, cultural issues, financial and regulatory restrictions, security requirements, and local logistics infrastructure weaknesses.

Embarking on global trade requires companies to develop a comprehensive international trade strategy to effectively guide the effort. The construction of such a strategy is composed of five steps. In the first, planners identify the strategic dimensions of the internal and external business environment. The goal of this step is to isolate the macro economic, political, and governmental environments as well as the micro factors of markets, costs, and customers, and determine how well the organization is posed to handle identified opportunities, threats, and trends. In the second step, planners select those markets that match enterprise aspirations and capacities. The third step consists in defining the structure of the organization to optimize objectives given existing skills and resources. The fourth step is implementing the product, marketing, communications, and logistics channels detailed in the third step. The final step is concerned with the measurement and monitoring of the success of the strategy.

In developing the strategic approach to the global marketplace, firms have four possible alternatives. One strategy is to export products into foreign markets from domestic sources passively through the use of a domestic intermediary, or actively by seeking out intermediaries in foreign countries. A second possible avenue is licensing. In this strategy a company (the licensor) agrees to permit a company (the licensee) the right to use a production process, trademark, patent, trade secret, or other skill or technology in exchange for a royalty or fee. Another strategy, joint venture, differs from simple exporting in that the firm invests and is directly involved in the management of a foreign enterprise. The final strategy is direct ownership of a company located in a foreign country. Once the international channel strategy is defined, it must be effectively managed. Maintenance of a global channel is a complex affair involving most of the decisions required to run domestic functions, plus additional requirements associated with the realities of international trade. Of critical importance is the management of international transportation and warehousing. Transportation is essential in delivering the product through the distribution channel to foreign destinations and warehousing with consolidating and storing it on its way to the customer.

Managing global networks also requires handling additional functions associated with establishing global market channels, financing and terms of sale, product marketing, investment and payment, pricing, and documentation. International companies can facilitate and streamline the management of these activities by implementing a global trade management (GTM) system. Broadly speaking, a GTM provides software solutions to assist companies in four areas: (1) automation of customs and regulatory compliance activities; (2) establishing accurate and complete trade content (duties, tariffs, taxes, interdicted products and nations, and others) to reduce regulatory and customs delays; (3) establishing and maintaining connectivity with trading partners and changing regulations; and (4) facilitating the execution of international transaction financing.

Global companies have also turned to global purchasing as a critical source of competitive advantage. The advantages of importing products from international sources are access to low cost, quality products produced by advanced engineering, technological, and production processes without investing in those resources. Fundamental to effective global sourcing is the execution of the international purchasing management process. The first step in the process is to identify the feasibility of using a foreign source for the procurement of a component or finished good. Once the decision to outsource is made and appropriate suppliers are identified, the second step is request for quotation. The purpose of this step is to detail the purchase requirements and evaluate the total cost of the proposed purchase. After the list of perspective suppliers is finalized, purchasers negotiate prices, delivery schedules, and contracts detailing the scope and length of the proposed partnership. The final step in the process is the completion of the shipping documentation.

The execution of international trade strategies is the function of global transportation and warehousing. In many ways, global logistics performs the same functions as domestic transportation and warehousing. The most obvious differences are found in the long distances goods are transported, heavy reliance on intermodal transport methods, and interaction with foreign companies and governments. The selection of the most efficient and cost-effective intermodal combination is a complex affair requiring an expert knowledge of intercontinental transport mediums and the internal transport systems of foreign nations. Many exporters will use the services of a freight forwarder in structuring the proper mix of transportation modes for foreign shipments. The capacity and efficiency of ocean transport, combined with container, motor, and rail transport, enables goods and materials to be rapidly transported to their destinations across global space and time efficiently and at the lowest cost rendering international trade economically and marketplace-wise possible.

DISCUSSION QUESTIONS

1. What are the major trends driving globalization?
2. What are some of the barriers blocking globalization?
3. What are the three possible globalization strategies?
4. What are the four global trade channel strategies?
5. What is a Free Trade Zone (FTZ) and what are some of its advantages to global traders?
6. What are the service criteria reviewed by global planners when evaluation the level of service versus the cost?
7. What are the strategies a company can pursue regarding marketing products in a foreign country?
8. What are the six basic forms of rendering payment in a global transaction?
9. What are the advantages of using a GTM?
10. What are the differences between domestic and international purchasing?

REFERENCES

1. All references to the *APICS Dictionary* are from the 14th edition.
2. U.S. Census Bureau, U.S., Bureau of Economic Analysis. 2014. *Exhibit 1: U.S. international trade in goods and services, 2013*, 4 June 2014, 1.
3. U.S. Census Bureau. 2014. *Exhibit 14a: Exports, imports, and balance of goods by selected countries and areas: 2013*, 17.
4. World Trade Organization. 2013. World commodity profiles for 2012. http://www.wto.org/english/res_e/statis_e/world_commodity_profiles12_e.pdf
5. SCM World. 2013. Managing global trade: Rising importance but lagging execution. *SCM World White Paper*, September 2013, 4–18.
6. Horne, David J. 2003. Global sourcing scenario. *APICS: The Performance Advantage* 13(5): 21–24.
7. See the discussion in Harps, Leslie Hansen. 2003. Bridging the cultural divide. *Inbound Logistics* 23(3): 4–40.
8. Bender, Paul S. 1994. International logistics. In *The distribution management handbook*, ed. James A. Tompkins and Dale A. Harmelink, 8.2–8.4. New York: McGraw-Hill.
9. Some elements of the discussion are summarized from Bowersox, Donald J., David J. Closs, M. Bixby Cooper, and John C. Bowersox. 2013. *Supply chain logistics management*, 4th ed, 273–276. New York: McGraw-Hill Irwin.
10. Keegan, Warren J. 1989. *Global marketing management*, 4th ed, 41–49. Englewood Cliffs: Prentice-Hall.
11. This term is from the *APICS Dictionary*, 14th edition
12. These points have been summarized from Kotler, Philip, and Kevin Lane Keller. 2006. *Marketing management*, 12 ed, 668–670. Upper Saddle River: Pearson-Prentices Hall.
13. David, Pierre, and Richard Stewart. 2008. *International logistics*, 2nd ed, 56. Mason: Cengage Learning.
14. This shortened definition can be found at www.cscmp.org/resources-research/glossary-terms.
15. Bender, Paul S. 1985. The international dimensions of physical distribution management. In *The distribution handbook*, ed. James F. Robeson and Robert G. House, 784–786. New York: The Free Press.
16. This example is described in Kotler and Keller, 685.
17. Picard, J. 1982. Topology of physical distribution systems in multi-national corporations. *International Journal of Physical Distribution and Materials Management* 12(6): 26–39.
18. Kotler and Keller, 689.
19. Bartlett, Christopher A., and Sumantra Ghoshal. 1989. *Managing across borders*. Cambridge, MA: Harvard Business School Press.
20. Keegan, *Global marketing management*, 378–382. See also the analysis in Kotler and Keller, *Marketing management*, 678–683.
21. David and Stewart, *International logistics*, 78.
22. Part of this section on pricing draws on the topic discussed in Kotler and Keller, *Marketing management*, 684–685.
23. For an extensive discussion of global trade documentation see David and Stewart, *International logistics*, 178–204.
24. Gonzales, Adrian. 2009. Beyond software: The role of content and connectivity in global trade management. *ARC Advisory Group Whitepaper*, Dedham, August 2009, 2.
25. See the discussion in Norquist, Warren E., Robert H. Lees, James E. Morton, and Frank Tahmoush. 1993. Global purchasing. In *The purchasing handbook*, ed. Harold E. Fearon, Donald W. Dobler, and Kenneth H. Killen, 194. New York: McGraw-Hill.

26. Carter, Joseph R. 1993. *Purchasing: Continued improvement through integration*, 121–122. Homewood: Business One Irwin.
27. For more information on currency issues see Heinritz, Stuart, Paul V. Farrell, Larry C. Giunipero, and Michael G. Kolchin. 1991. *Purchasing: Principles and applications*, 8th ed, 196–198. Englewood Cliffs: Prentice-Hall.
28. This section on surface transport draws from Coyle, John J., C. John Langley, Brian J. Gibson, Robert A. Novack, and Edward J. Bardi. 2009. *Supply chain management: A logistics perspective*, 8th ed, 359–368. Mason: South-Western Centage Learning; Goldsby, Thomas J., Deepak Iyengar, and Shashank Rao. 2014. *The definitive guide to transportation: Principles, strategies, and decisions for the effective flow of goods and services*, 174–178. Upper Saddle River: Pearson Education, Inc.; and David and Stewart, 290-306.
29. This section on ocean transport draws from Coyle, et al., *Supply chain management*, 368–374; Goldsby, et al., 162–168; and David and Stewart, 248–272.
30. This section on air transport draws from Coyle, et al., *Supply chain management*, 375–380; Goldsby, et al., 168–174; and David and Stewart, 278–286.
31. See the discussion in Bender. The international dimensions of physical distribution management. In *The distribution handbook*, 799–802.

15

Information Technology and Supply Chain Management

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7578-2_15) contains supplementary material, which is available to authorized users.

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2_15,

As it has in all areas of today's business environment, the application of information technology has caused a revolution in the concept and practice of supply chain management (SCM). Many areas impacted by the computer have already been discussed in previous chapters: integration of the operating functions of the enterprise, e-commerce solutions accelerating ordering processes and shrinking delivery times to customers, Internet and electronic data interchange (EDI) applications providing connectivity between companies, planning systems that facilitate channel inventory management, simulation programs eliminating the guesswork involved in transportation routing and scheduling, and many others. The use and robustness of such computerized tools are only expected to grow, changing the way companies have traditionally serviced their customers and how they communicate with supply channel partners.

The implementation of information technology is an absolute requirement for success in today's business environment. Several factors are driving this movement. To begin with, companies have turned to computerized applications to deal with the increasingly complex requirements of doing business in a fast-paced global environment. Second, customers and suppliers continue to demand instantaneous response and full information visibility, online, in real-time. Third, the rapidly changing contours of dealing with shrinking life-cycles for everything from product development to delivery have made the ability to closely link customers, producers, and suppliers a requirement for competitive survival. Fourth, the integrative power of the Internet requires supply chains to rapidly transfer transaction information and marketplace intelligence from buyer to supplier. And finally, information technology has it itself become a competitive advantage. Mal-Mart's satellite connected systems, American Airline's Sabre System, Federal Express's package tracking systems, and Cisco's "virtual manufacturing environment" are examples of how technology automates complex tasks, generates useable information, and networks supply chain nodes tightly together to manage complexity and expand competitive advantage. It has even been debated that a company's data, phrased today as "big data," actually constitutes an asset as valuable as inventory or physical plant and are the real foundations for competitive advantage [1].

Exploring the impact of information technology on supply chain management is the subject of this chapter. Discussion begins by exploring how computer technologies have reshaped the way companies utilize information to plan and control internal functions and create interactive, collaborative relationships with their supply chain customers and trading partners. Topics discussed are detailing the principles of information processing, integration, and networking. Following, the chapter focuses on an in-depth exploration of SCM technology basics. Attention is centered on exploring the five basic functions of information systems: database management, strategic planning, management control, transaction management, and decision analysis and simulation. The heart of the chapter is an exploration of the three levels of SCM technologies: core applications, advanced applications, and networking applications, culminating in a review of the content of enterprise resources planning (ERP) and SCM business systems. Next, the advent of SCM Internet-driven technologies is examined. Topics included are Web-based marketing, e-commerce, e-business, and e-collaboration. The chapter concludes with a discussion of the processes necessary to properly identify and evaluate today's range of information technology solutions, making technology choices, and implementation and continuous improvement issues.

15.1 FOUNDATIONS OF INFORMATION TECHNOLOGY

As the importance of timely, accurate, and robust information increases in the business environment, information technologies have progressively become the key enabler integrating the global supply chain. Today's enterprise must consider computerized technologies not only as a tool to accelerate the speed and productivity of business functions, but also as a key driver that enhances the opportunity for supply chains to continually activate new relationships and operating structures that change the way they compete in the marketplace. *Internally*, information technologies enable companies to develop databases and implement applications that provide for the efficient management of transactions and the timely collection, analysis, and generation of information about customers, processes, products, services, and markets necessary for effective decision making. Building a real-time knowledge repository creates the pathway necessary to seamlessly synchronize the capabilities of individual companies with their customers and trading partners. *Externally*, information technologies enable supply chain strategists to architect channel networks that are collaborative, agile, scalable, fast flow, and Web-enabled. The goal is to present customers anywhere in the supply chain with a single, integrated response to their wants and needs by creating unique value-chain networks. Connectivity and synchronization at this level require the elimination of channel information silos and the construction of collaborative, channel-wide communication and information enablers directed at a single point: *total customer satisfaction*.

While it is said that supply chain management is perhaps the single most important driving force in today's global business environment, at the heart of SCM is found the integrative power of information technologies. Deploying this power requires both planners and technologists to rethink their use of the computer. Actualizing the potential of today's information systems requires companies to move beyond traditional paradigms that utilize computerization purely as a means to automate and control business processes. In fact, connectivity enablers, like the Internet, now permit companies to escape from the narrow boundaries of their own information environments to network with a universe of geographically dispersed channel trading partners and create real-time strategies, operations, and planning systems previously thought unattainable. Today's boundary-spanning technology tools enable companies to harness the explosion of data that continuously emanates from every plane in the supply chain galaxy, integrate it with internal business systems, perform sophisticated analysis of the information, make visible an accurate picture of individual enterprise and supply chain partner performance, and architect revolutionary capabilities and competencies for the generation of new sources of products and services, whole new businesses and marketplaces, and radically new forms of competitive advantage.

15.1.1 Information Technology Concepts [2]

Information technology utilizes computer-based devices [3] and software applications to assist people in the management of information arising from processing activities in support of the knowledge requirements of their organizations. While today's computers have grown exponentially more powerful and ubiquitous, by themselves they provide little use outside of their calculative power. Information technology is most useful when the data it contains and its ability to network the thoughts and purposes of people is directed at activating capacities for both task management and innovation. In essence, information technology succeeds when people, the computer systems, and information are tightly integrated.

The application of information technology to any human enterprise consists of three separate yet inextricably linked concepts of knowledge. The first type is the use of computerized technology to *automate* knowledge. The second type arises when technologies are used to enable people to collect, process, select, and sort data that can be used to create new forms of knowledge, provide unique insights, and engineer disruptive innovation, such as additive manufacturing (AM), more popularly known as 3D printing. An interesting word that was coined by Zuboff to describe this category of knowledge is *informate*. New sources of knowledge about activities, events, and objects are made visible when a technology *informates* as well as *automates* [4]. The third and most sophisticated type of information arises when people use technology to *network* their tasks, ideas, and aspirations to produce a form of collective, opt-in/opt-out fusion of opened-ended knowing and experiencing.

15.1.1.1 Using Technology to Automate Knowledge

Accompanying the rise of civilization is the use of physical devices created to reproduce and extend the capacities of the human body to perform work. Beginning with the advent of the Industrial Revolution, the complexity and sophistication of machines to perform work have grown exponentially. In place of human hands and skills making products, machines have increasingly been deployed to *automate* productive processes. The advantages of machine automation are dramatic. The human body is fragile, limited in range and speed, and, when used in production, prone to imperfection, fatigue, and variation. Machines, on the other hand, are programmed and rationalized to respond to the tasks of production with unwavering precision, accuracy, and speed. The benefits of automation are substantial: labor reduction, elimination of repetitive tasks, improvements in worker productivity, increased order accuracy, working nonstop 24/7, immunity to hazardous processes, and standardization of processes.

The success of automation resides in the ability of designers to incorporate the human knowledge necessary to perform tasks directly into a machine. In a "manual" work environment the knowledge and skills to perform a task are invested in the worker. The act of work is action-centered, based upon sentient information derived from physical cues, and marked with a level of *personalism* where there is a strong link between productive competence and the produced object. While there has grown an enormous debate on the implication of the impact of automation on the worker that is beyond the scope of this book, it is true that the linkage of human knowledge and machine programmability and predictability has generated tremendous wealth and drives the living standards of the modern world.

The very foundations of computerization are traced to the ever-expanding desire to automate all forms of human activities. When computers were first introduced into business, their job was to facilitate calculative tasks such as forecasting, mathematical modeling (inventory, queuing, facility location, and so on), order pricing and costs, and payroll. As the concept of software developed, businesses began to utilize databases containing fixed records, such as customer and supplier masters and variable records such as sales and purchasing history for the performance of tasks and decision making. Technology developers were also quick to see that by transferring and then standardizing process knowledge, such as order taking and purchasing previously performed by humans, work could be rendered more accurate, controllable, visible, and accessible. In today's world, it would be hard to function without the automation of many of our daily tasks provided by personal computers, personal data assistants, smart phones, and Internet connectivity.

15.1.1.2 Using Technology to Create Knowledge

As computerized technology was introduced, a powerful by-product was identified: automated functions produced a new form of information *about* the activities performed. For example, when a purchase order is launched from a software program an array of new data is automatically created that provides a window into such information as supplier performance, accounts payable detail, inventory values, schedule deliveries, and so on. Thus the use of a computerized technology not only utilizes work information in the form of a programmed instruction, it also produces usable information.

> It both accomplishes tasks and translates them into information. The action of a machine is entirely invested in its object, the product. Information technology, on the other hand, introduces an additional dimension of reflexivity: it makes its contribution to the product, but it also reflects back on its activities and on the system of activities to which it is related. Information technology not only produces action but also produces a voice that symbolically renders events, objects, and processes so that they become visible, knowable, and shareable in a new way. [5]

According to Zuboff, this dynamic of information technology both *automates* and *informates* [6]. Automation is the result of the transfer of knowledge from people to machines and, in the process of performance, has enabled the generation of new knowledge that illuminates the value of further automation.

The impact of technology engendered knowledge on people is dramatic. Where work is performed with very simple or no technology, the worker is individualized, with the skill or knowledge used to produce self-contained, sentient, and centered on manipulating "things." This dynamic is significantly changed with the advent of information technology. As process knowledge is absorbed into the automation, work becomes much more abstract and workers are required to master new skills associated with understanding and manipulating information. The result of this technological-based transformation also fundamentally alters the relationships between people, who now become more collaborative, interactive, and intimate. As information becomes more integrative across time and space, traditional roles in organizations evolve from isolated departments into cross-functional, cross-knowledge teams capable of further leveraging the data emerging from the performance of technology-driven work to enable new value-adding possibilities.

As our dependence on information technology continues to expand exponentially, the debate that raged in the concluding decades of the previous century about the alienation of the worker in the face of automation seems now irrelevant [7]. Much of the reason is that the fear that automation would destroy worker knowledge and self-worth and subject them to increased rationalization, control, isolation, and eventual impotence simply has not occurred. Instead of stunting people's creativity, today's information technology has had a liberating, empower impact. Businesses have implemented an array of information technologies that permit their employees to have access to and manipulate vast storehouses of data and to activate new opportunities to generate radically new processes and products and then to communicate them to the marketplace.

15.1.1.3 Using Technology to Integrate and Network Knowledge

The third type of information residing at the core of today's computerized technologies rests on two fundamental principles. The first is the availability of a technical infrastructure that links computer systems and people. The word used to describe this process is *integration*. Unfortunately, there has been a great deal of confusion concerning the definition of this principle. It is often erroneously used synonymously with *connectivity* and *interfacing*. Connectivity means connecting processes together, such as when a telephone system connects customers with order management functions. Interfacing means bringing information from one system and presenting it for input to another, such as occurs in an EDI transaction. Although both assemble and transmit information, neither connectivity nor interfacing has the capability to integrate people and processes. In fact, both processes treat information as proceeding serially through the information channel: they consider transacting parties simply as independent business functions transmitting and receiving data as separate entities governed by local technology infrastructures.

In contrast, *integration* is about the elimination of the barriers separating functions and people within or between an organization and its business partners. Integration means to come in touch with, to form, coordinate, or blend into a functioning whole. Organizationally, integration means leveraging information technologies that enable physically remote pools of people, data, and processes to function together as if they were a single, merged database directed at the same objectives and performance goals. Integration accomplishes this goal by activating the creative thinking within and between organizations and then enables them to work as a single, virtual enterprise. Integration attempts to bring into alignment the challenges and opportunities offered by information technologies and the cultures and capabilities of the modern organization.

The second principle at the core of information technology is *networking*. In the past, computer system architecture permitted only hierarchical communication. As each processor completed its task, the output was then available for the next processing task, which, in turn, passed its output to the next downstream processor. With the advent of client/server architectures and Internet browsers, the process of communicating information shifted from processing hierarchies to connecting different computers and their databases horizontally in a network. The growing availability of open source operating systems like Linux and programming language like Java are targeted at solving the problem of the dissimilarity of hardware operating systems that inhibit networking.

An advantage of networked systems is that information can be stored and retrieved from a central location in the network from any connected computer. The storage location could be a remote server or information stored in the "cloud." In addition the network provides a collaborative medium where people can now communicate directly to other people in the network regardless of physical location. This peer-to-peer networking enables companies to combine the capabilities, skills, and experience of their people by integrating and directing their talents so they can work more efficiently and productively. What is more, the establishment of cross-enterprise teams can occur not only inside the organization but also can be extended to suppliers, customers, and trading partners constituting the entire value chain.

15.2 TECHNOLOGY ARCHITECTURE BASICS [8]

Today's robust information systems enable companies to view internal business, information system, and inter-organizational channel architectures as a fully integrated set of components as portrayed in Figure 15.1. A detailed discussion of each component is as follows.

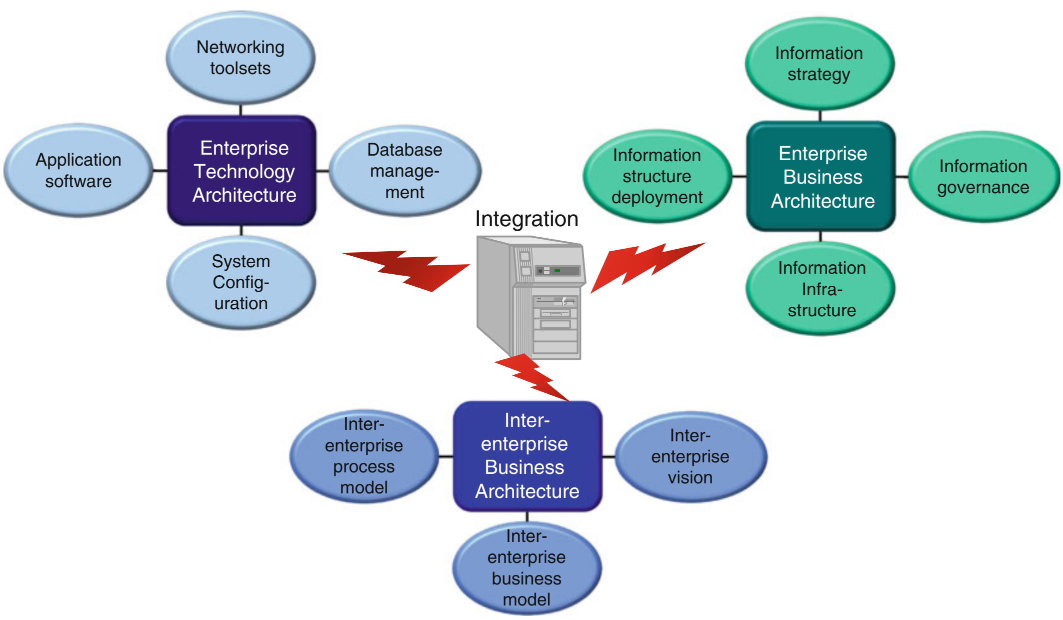


FIGURE 15.1 SCM technical architecture.

15.2.1 Enterprise Technology Architecture

The technology architecture determines how the enterprise's computer systems are structured. At the core of organizational enterprise technology architecture are four essential components. Perhaps the most important component is the *database*. The database is the repository of all data that has been collected during database management and transactional processing. It consists of various categories of information from numerical values to words to graphics. There are several different types of database. A hierarchical database stores related information according to predefined categories arranged in a "tree-like" arrangement. A network database is used by a network installation tool to allocate and track network resources. And finally, the most common type is the relational database. This database is the model used in today's business software systems. A key feature is the centralization of key master records such as items, customers, and suppliers that can be referenced by multiple software applications without duplication [9].

The second component of today's enterprise technology architecture is *networking*. A network is defined as two or more computerized devices linked together over a geographical area. Networking permits users to access and exchange the same data through software connecting them to the network. The computerized communication devices are connected to either a *local area network* (LAN) used for internal networking in a private company, or devices are connected to a *wide area network* (WAN) that is used in a dispersed networking environment such as the Internet. There are several possible variations. An *Intranet* is a proprietary network that restricts access to information and application software to certain users, such as employees inside a company. An *Extranet* is a private network utilizing the Internet protocol and the public telecommunications systems permitting selected individuals outside a closed system to gain access to certain data and software in a proprietary network. Finally, a *virtual private network* (VPN) utilizes the public telecommunications infrastructure (such as the Internet) to allow users access to a network through secured entry.

The third component is *application software*. Software is a general term used to describe the various kinds of programs that are used to enter, maintain, display, and access information resident in databases. Well-designed software enables users to easily create and access database information and enables networking with other users. In today's Internet and social networking age, software success, or failure, has a dramatic impact on the well-being of the organization. In addition, information management personnel must be ever vigilant to ensure that the usability of their software systems keeps up with the changes in programming languages and application design necessary to ensure compatibility of their information systems with their operations and marketplace strategies.

The final component of an information technology infrastructure is the actual *configuration* of hardware, database management software, and application software. In the past, computer systems consisted of dumb terminals and peripherals hard-wired directly into the computer located in the IT department. Today, most system architectures utilize powerful PCs, middleware applications (linking PCs and servers), and communications enablers, like the Internet, to build wireless networks capable of integrating people and knowledge both internally and externally. Recently, companies have been exploring "cloud computing" to link their networks. Instead of a resident server, the cloud enables companies to access application software used by multiple businesses located on a third-party server. A sample view of a WAN and cloud configuration is illustrated in Figure 15.2. In this example, company ABC has two warehouses in Chicago and Los Angeles that sell finished goods. Each has their own servers that contain their supply chain management software. Both are also networked via the Internet to each other and to cloud customer order applications. They sell to same customer. In this architecture the customer is networked to both warehouses and to applications and data resident in the cloud for e-commerce. In this setup the customer can place orders, review order status, and change orders in either warehouse directly through ABC Company's marketing Web-site or the cloud.

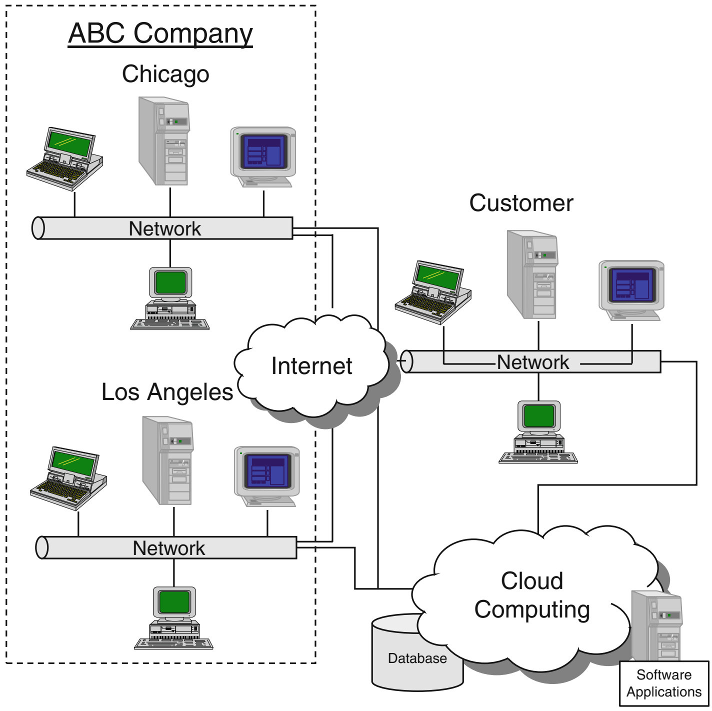


FIGURE 15.2 Networking integration architecture.

15.2.2 Enterprise Business Architecture

The term *enterprise business architecture* has a wide meaning. It encompasses the business functions responsible for the performance of ongoing transactions involved in buying, making, and selling products. It also refers to the corporate culture that has evolved over time and drives current and future attitudes, expectations, and value judgments defining the mission of the enterprise. It consists of the particular configuration of human and computerized resources that accumulate, analyze, and utilize the enterprise's repository of information. And finally, it consists of the core competencies of its human resources that design, produce, sell, and distribute the firm's goods and services. Without an effective business architecture an enterprise's evolution to more successful models would cease and its ability to adapt to change in the face of new business paradigms and technologies would rapidly disintegrate.

The foundation of an effective enterprise business architecture resides in the creation of a comprehensive enterprise technology strategy and business architecture that directs the organization towards a coherent, integrated environment for managing and delivering information in support of both short-term objectives and long-term the business goals. The effectiveness of a business architecture is the ability of its processes and systems to respond to changing conditions and customer interactions as they occur. Operational responsiveness means capitalizing on opportunities like shorter cycles times, new sales, lower spend, and reduced risk by identifying and handling problems quickly and accurately. Strategic responsiveness means capitalizing on opportunities by quickly adjusting business processes and channel configurations to pursue new marketplaces, drive greater efficiencies by engaging in options like outsourcing or partnering, and reducing risk by mastering complex challenges emerging from a changing business and regulatory landscape.

A well-design business enterprise architecture follows a fourfold agenda [10].

1. *Information strategy definition*. The information strategy establishes the principles guiding the organization's efforts to create and exploit their information system databases and software application functionality. The information strategy provides an end-to-end vision for all components constituting the information system structure and is driven by an organization's business strategy and operating framework. The information strategy establishes the culture, nomenclature, and common objectives to assist all levels of users realize the information system vision. Organizationally, the strategy ensures that current and future investments in people, processes, and technologies align with and support an agile and flexible information environment. The information strategy represents a commitment across the enterprise to recognize and treat the information system and its contents as strategic assets.
2. *Information Governance*. Defining the content of a business information repository and its governance is a critical component of an enterprise business architecture. This is a "nuts-and-bolts" issue that requires answers to basic questions as to the nature, completeness, and accuracy of system information, where it is located, how long it is kept, and how the business accesses and uses it for decision-making. Effective governance of information system data requires establishment of a specific corporate organization whose mission is to define the policies and managing practices of information assets over their lifecycles. Some of the objectives of information definition and governance include:
    - Defining the governance infrastructure and the toolsets deployed to ensure ongoing database and application excellence.
    - Defining ongoing governance processes.
    - Developing technology and business system architecture standards and practices.
    - Providing for initiatives aimed at monitoring and improving database and process quality.
    - Establishing necessary organizational policies and cross-organizational oversight.
    - Establishing an effective training program aimed at all levels of the organization.

    Information governance is easily overlooked. However, if the business architecture is to provide the level of information capable of revealing competitive advantage and expanding business performance, governance must be seriously embraced as a critical pillar of overall information system accountability.
3. *Information Infrastructure*. An information business system that is expected to provide a company with competitive advantage must be grounded on an effective enterprise-level information infrastructure. Without a world-class information architecture, companies are subject to significant operational inefficiencies associated with data duplication, inaccuracy, and inaccessibility. An enterprise information infrastructure framework identifies the technology necessary to establish the database management systems, application software, networking toolsets, and the actual

configuration of these components into a technology solution governing the functioning of the enterprise. According to an IBM study [11], enterprise information infrastructure frameworks include the following elements:

- *Information integration management systems*, such as enterprise intelligence (data warehouse) solutions, enterprise resource planning (ERP), and customer relationship management (CRM) that integrate transaction data for decision-making.
- *Data master file management* enabling master data – such as customer, supplier, items, and employee data – to be easily accessed to provide accurate information for any business application.
- *Dynamic data warehousing* to provide the capabilities to turn historical data into relevant, real-time predictive analytics that enable timelier, more insightful business decisions.
- *Enterprise content management* (ECM) provides content management, discovery, and business process management to guide enterprise transformation.
- *Operations management* encompasses servers and data management tools supporting various platforms.
- *Business intelligence and performance management* provides decision makers across the organization with information they need to understand, oversee and drive the business so they can align their actions with organizational objectives.
- *Metadata management* enables designers to organize and define the meaning of data within an organization's system. The goal is to assure consistency, completeness, and visibility through service directories, data directories, content directories, translation, retrieval, and navigation processes.

4. *Information Structure Deployment*. The enterprise business architecture must provide a deployment roadmap that defines how the various technology applications and toolsets will be configured, maintained, and improved over time. Among the critical tasks constituting the action plan are leveraging existing investment in hardware and software, prioritization of technology projects, effective project management, dates for technology roll-out, capabilities required to support and access relevant information, reference to forthcoming business and governance practices, and discussion of future investments in emerging technologies.

15.2.3 Inter-enterprise Business Architecture

Much has already been said about using information technology to integrate and network knowledge not only within the enterprise, but also between business partners found along the supply chain continuum. While internal business integration and networking is critical, the really significant gains in productivity and competitive advantage are realized when integration and networking link companies to their channel trading partners. This movement from a company and product-centric strategy to a customer-centric, channel network strategy requires the constant aligning and optimizing of the value delivered by the entire supply chain and not just an individual company. Realizing this strategy requires the adoption of new technologies and new roles forcing organizations to adapt, expand, and transition to meet the requirements of an effective inter-enterprise business architecture. Such an objective involves the following critical processes.

1. *Architecting a shared inter-enterprise vision*. The development of an inter-enterprise information structure strategy that does not include supply chain trading partners is destined to failure. When developing the enterprise information architecture, strategists must be careful to ensure that the technology vision is capable of fitting into a much wider supply chain vision. Such an undertaking requires a comprehensive knowledge of channel partner core competencies, technology capabilities, and commitment to supply chain integration and networking. The goal is to create a framework that provides for an operational system of cross-channel business as well as a mechanism to leverage the entire business ecosystem to discover breakthrough propositions made possible by sharing a common information platform. The process used to guide this process is straightforward: an optimized or "greenfield" architecture is envisioned and documented. Next, the existing "as is" structure is matched against the optimized architecture. Strategists then perform a gap analysis, uncovering where resources and competencies in the existing supply chain occur. Finally, a model of the inter-enterprise architecture should emerge that can be used as the basis for all subsequent technology strategy enhancements.
2. *Inter-enterprise business modeling*. The next process is establishing the inter-enterprise business model that describes how supply chain entities will be integrated together. The model provides a high-level description of the technology integration points connecting each business in the supply chain network. The inter-enterprise business model objectives should detail the following marketplace dynamics:
   - Identify the target market/market segment, including expected share, profitability, service goals, customer retention, and new customer acquisition.
   - Products and services, including product line profitability, life cycle management, new product/service introduction, and production strategies.
   - Financial elements, including ROA management, ROI management, potential revenue growth, and internal productivity cost measurements.
   - Product distribution, including logistics management, depth of channel integration, cost structure, levels of automation, and cost management.

   A critical element in the inter-enterprise business model is the information architecture. It is the responsibility of the each channel partner's information architects to configure and maintain a repository of computerized process components that enable the desired levels of communication and networking among channel members. By effectively designing these technology components, solution developers can integrate internal business work rules, roles, tasks, and policies with those of their channel partners as well as rapidly respond to supply channel business environmental changes.
3. *Inter-enterprise process modeling*. Once the inter-enterprise vision and business model have been formulated, the next step is to detail the process model that describes the external processes that govern the daily performance of supply chain functions. Developing the process map requires strategists to know precisely which business functions are going to be inter-enterprise processes, what technology infrastructures must be in place, and how the organizational structure should be constructed. Constructing effective inter-enterprise processes is a critical project consisting of the following steps.

- *Engineer trading partner processes*. The task of generating the desired inter-enterprise linkages must involve the full participation of customers and suppliers regardless of the desired complexity of the proposed network. For example, using the Internet versus the use of applications located in cloud computing will require different strategies. While a significant degree of process standardization is the target, architects must be prepared to fashion process components that are customizable to meet individual service requirements. For example, Internet buying process components, such as the work flows associated with internal RFQ, sourcing, approval, and order management, must be able to interact with complimentary work components resident in the supplier's business technology architecture.
- *Degree of Process Interaction*. The technology architecture deployed provides companies with the option of exploring multiple levels of connectivity depending upon the business requirements of channel trading partners. At the lowest level is the *loose coupled model*. This level of connectivity utilizes technologies, such as EDI and the Web, simply as a medium to replace paper-based documentation. At the next level, *process handoff*, channel connectivity is architected to permit transactions to automatically trigger processes in the systems of trading partners. For example, a sales transaction posted in a retailer's system will trigger a replenishment notice in the planning system of the retailer's supplier. At the highest level, *virtual enterprise*, the process components are used jointly and operate in real-time. This level of architecture provides each linked node in the supply chain full access to information across the channel network galaxy. For instance, information concerning a customer would be available to every trading partner, thereby removing unnecessary database redundancies.
- *Internal infrastructure and system reengineering*. Regardless of the level of supply chain connectivity deployed, the work force is required to function in a cross-enterprise mode, and not simply according to the needs of a single company. Technology-wise, supply chain interoperability requires enhancements to existing systems or the purchase of point solutions, such as B2B, to supplement legacy system deficiencies. Normally, this process will require customization of the "wrapper programs" of existing ERP/SCM systems to accommodate the linkages needed to work with new packaged software, portals, and other interoperability solutions.
- *Application architecture*. The cross-channel application networking architecture that emerges should support the inter-enterprise business strategy. The completed architecture should contain the definition of what the networked infrastructure should look like, how networked resources will be accessed, the source and type of the data the networked resources will utilize, and resolution of data, hardware, process, and human resource ownership ambiguities.
- *Pilot, go live, and iterate*. The challenges of developing and implementing a comprehensive inter-enterprise technology solution are fraught with difficulties, potentially enormous expenses, and significant trauma to even the best of organizations. Most experts caution against trying to do too much in the first round. Implementers should view the process as iterative: utilize a

minimalist approach and begin with the easiest processes or the ones that provide the biggest payback. The goal is to keep expectations, costs, and trauma to the organization realistic and "do-able" while ensuring the company is pursuing a path that keeps it at the forefront of the competition.

15.3 INFORMATION SYSTEM FOUNDATIONS

The *APICS Dictionary* defines an information system as the "Interrelated computer hardware and software along with people and processes designed for the collection, processing, and dissemination of information for planning, decision making, and control." Activating the full value of an information system means finding answers to such questions as

- What are the components of an information system?
- What are the principles underlying information systems?
- How should information technology be applied to realizing the objectives of all levels of the organization?
- How does an information system use data and software applications to automate, informate, and network the organization and its channel partners?
- How is the information to be organized in a meaningful manner so that it can be accessed, manipulated, and presented for use in process management and decision making?
- What software applications do businesses need to ensure the targeted level of integration and networking with supply chain partners?

15.3.1 The Five Basic Functions of Information Systems

At the foundation of every information system reside five common functions as portrayed in Figure 15.3.

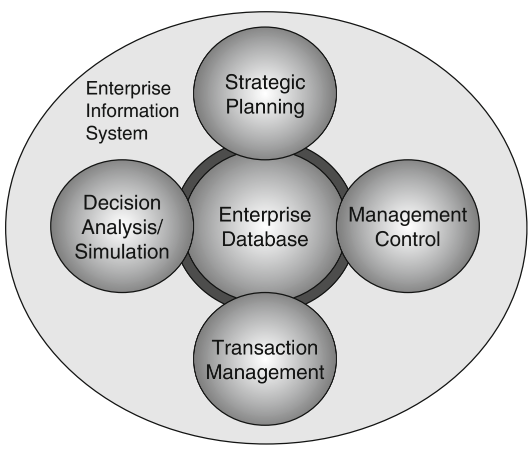


FIGURE 15.3 Basic functions of information systems.

- *Enterprise database*. The centerpiece of a business's information system is the *database*. Simplistically, a database is defined as "an organized collection of data." The database is separate from the system applications which create and use the data for informational reporting and review. The database is, for the most part, composed of two types of data. The first, *static data*, consists of core information repositories, such as customer and supplier masters, item masters, product costs, warehouse geography, bills of material (BOMs) and routings, product equipment, and channel structures that do not change during the performance of transactions. The second type, *variable data*, consists of databases, such as open order, inventory balance, shipping, and accounting, which are impacted by the performance of transactions through application programs. Today's computing technologies enable companies to have a single database (relational database) that all internal departments can use jointly. Furthermore, the advent of connectivity tools, like the Internet, provide the capability for *database networking*, where key database files such as forecasts, channel inventories, and open order statuses, can be viewed by authorized supply channel partners.
- *Transaction management*. Transaction functions enable system users to use system application programs to enter and maintain database information such as order entry, inventory balance maintenance, order selection, allocation and shipment, and accounts payable and receivable. Transaction management programs serve several purposes. They provide for the accurate and timely performance of business transactions as they occur; they automate difficult and time-consuming recordkeeping; they enforce rules governing transaction data entry and maintenance; and, they enable companies to collect large volumes of information that in turn is used for business analysis, management control, and strategic planning. The overall goal of transaction management functions is to ensure an accurate record of the firm's day-to-day operations.
- *Management control*. The entry of transactions and the compilation of a database are meaningless without defined best practices and performance measurements that control the accuracy and completeness of the company's database. Management control is enabled by system application developers that use a variety of programming and best practices to create standardized data entry and maintenance applications that enforce uniformity both within and outside the organization. The value of this control is manifested in the ability of users across channel businesses to "mine" enterprise data in an effort to uncover and detail operational information and financial measurements relating to such issues as inventory balances, customer order status, costs, asset management, customer service, productivities, quality, and others. Management control has the following goals:
  - ensure rationalization of business functions.
  - provide the feedback necessary for the timely reformulation of operations plans and activities.
  - provide for the on-going measurement of the competitive capabilities of the enterprise.
  - enable the development of plans providing for continuous improvement.
- *Decision analysis/simulation*. An important enabling attribute of an information system is the ability of planners to utilize a variety of computerized modeling tools to assist in managing simple to increasingly complex processes for decision-making. Some of these applications, such as MRP and capacity management, provide mature

and easy-to-use applications to simulate the impact of demand on inventories and productive capacities. Other computerized applications assist in the identification, evaluation, and comparison of alternative courses of action, such as vehicle routing and scheduling. Finally, in this area is found powerful advanced planning systems (APS) and supply chain management (SCM) applications utilizing complex mathematical algorithms to design supply chains, determine plant locations, optimize production floor build schedules, and aggregate demand and supply data across channel networks. The goal of these functions is to provide planners with the capability to identify and evaluate the best choices from a range of competing alternatives.

- *Strategic planning*. Enterprise information systems contain strategic planning applications providing managers with the capability to construct long-term plans and forecasts to determine enterprise financial goals, explore strategic business partner alliances, determine channel facilities and fixed assets, define aggregate capacities necessary to support product and service requirements, and others. The plans developed in this function provide the basis for enterprise-level management control, decision analysis, and performance, and are used to drive the operations plans executed by transaction applications. The overall goal of business system strategic planning applications is to provide corporate decision-makers with decision-support tools, such as performance reporting capabilities, performance dashboards, balanced scorecards, and other tools for managing the enterprise and its supply chain.

While the exact structure of the applications used by today's enterprise information systems varies by industry, a base architecture must provide the business with a common database, a suite of relevant transaction programs, reporting and data displays, some form of simulation, and tools for on-going operations management and control as well as long-range planning.

15.3.2 Principles of System Management

Whether the capture of historical data for forecasting or creating a sales order, an effective information system requires transaction entry and information retrieval functionality that provide the highest accuracy and are easily understood by the user. The following seven principles of information system management are fundamental to an efficiently run enterprise business system [12]:

- *Accountability*. While computers provide the functions for the entry and maintenance of data, responsibility for the quality and integrity of that data resides squarely with the people who use the system. Without accountability, an information system will quickly spin out of control and lose its ability to provide meaningful information for planning and decision-making.
- *Transparency*. One of the fundamental keys to an effective enterprise information system is how easily the database is maintained and accessed. Transparency means that the mechanics of how the system works are simple, understandable, and apparent to the user. For the typical user, the elegance and sophistication of the technical architecture of the system is irrelevant. The issue is simply one of relevance and usability. If the mechanics of a particular application are easy to work with and conform to best practices, the system will be intelligently and competently used. Transparency also means that the system provides the user with answers as to why and how the system requires a particular activity to be performed.

- *Accessibility*. One of fundamental problems of paper-based systems is that data is not readily accessible for decision-making. Computer systems remove the difficulties surrounding data retrieval by containing programs that provide for quick access and update of critical information, such as order status, that span company departments or even databases belonging to channel trading partners.
- *Data integrity*. The usefulness of information technology is directly dependent upon the accuracy and timeliness of its databases. *Accuracy* is defined as the degree to which actual physical data corresponds to the same data recorded in the system. As a metric, the accuracy of most data should be 99 % at a minimum. *Timeliness* is defined as the length of the spatial delay between the moment a transaction occurs and the point when it is recorded in the system. The speed of data update is critical in providing users with the ability to perform activities in a timely manner. Similar to accuracy, high levels of timeliness enable companies to remove uncertainties and increase the accuracy of decisions.
- *Valid process simulation*. If an information system is to provide useful information, the transactional and maintenance programs in the system must work the way the business actually works. In effect, a business application is a *representation*, a simulation of the actual physical action performed during process execution. For example, if the act of physically receiving a product to a location is not mirrored by the transaction entered in the application, data integrity is diminished and the ability of users to keep inventory data records accurately decreases exponentially as invalid data cascade through the system.
- *Flexibility*. An effective information system provides users with the ability to easily configure and reconfigure system functionality to match the necessary transactions and manipulate data to meet the needs of both the business and customers and suppliers. For example, inventory allocation and shipping functions should permit interbranch transfer orders to be created restricting delivery to a single receiving location or alternatively allow multiple delivery points on a single order. In addition, the software itself should enable easy upgrade capabilities without causing the company excessive cost or implementation time.
- *Control*. A fundamental benefit of an information system is the ability to control business processes. Applications should provide users with reporting and exception messaging designed to alert them as early as possible to actual or pending out of control processes. For example, a forecasting module should be able to recognize changes in basic historical patterns or relationships at an early stage and provide forecasters with warning alarms to take preemptive action.

Without these basic disciplines in place, it would be virtually impossible to achieve the necessary levels of performance from an enterprise information system regardless of its sophistication and elegance.

15.3.3 Objectives of Information Technology in the Supply Chain

Companies pursue several levels of objectives when applying information technologies to supply chain management. Strategic objectives have already been discussed. On the next level down, tactical and operational objectives include:

- *Increasing supply chain velocity, agility, and scalability*. By providing integrative and networking capabilities, supply chains participants can rapidly form collaborative partnerships to engage in managing new product development, exploit new market opportunities, accelerate product delivery to targeted customers, and leverage the core competencies of channel partners to quickly scale production and distribution resources.
- *Provide global visibility of real-time channel information*. Combining technologies like the Internet and cloud computing with supply chain software applications provide supply chains with visibility to channel events and the ability to rapidly make informed decisions.
- *Tame the supply chain bullwhip effect*. Access to real-time channel inventory information enables channel planners to see unnecessary build-ups of channel inventories and to simulate inventory movement to diminish the effects of poor channel forecasting by channel participants.
- *Replace supply chain inventory with information*. The use of networking technologies providing the entire channel with real-time data allowing planners to respond rapidly to actual shifts in demand without stockpiling inventories.
- *Move from push to pull*. The ability of networked databases enables companies resident at all channel points that touch the customer to stream demand and substitute push channel replenishment with pull systems that empower planners to rapidly respond to actual shifts in demand.
- *Facilitate the formation of new supply chain partnerships and deepen existing partner relationships*. The ability to link inter-channel strategies and tactics through information integration and the use of networking for real-time information sharing enables companies to form and grow supply chain relationships.

15.4 SUPPLY CHAIN MANAGEMENT BUSINESS TECHNOLOGIES: FOUNDATIONS

Managing today's globally-networked enterprise requires assembling the array of supply chain business technologies into a comprehensive business system that facilitates the goals and objectives of the business. SCM technologies consist of a wide range of functions from task automation and generation of information used for decision-making to networking the knowledge of people within the organization and externally in the supply chain. The goal of assembling an enterprise business system is not to create monolithic, rigid systems, but rather to configure scalable, highly flexible information enablers that provide enterprises with the capability to respond effectively with value solutions and collaborative relationships at all points in the supply channel network. Today's portfolio of SCM technologies encompass three possible levels of functions and applications. The first is concerned with applications that enable the core functions of a business and are concerned with the integration of *internal* data and processes. The second dimension is concerned with the integration of a basket of advanced applications that significantly enhance core enterprise functions. The third, and final, dimension is concerned with an array of applications and technologies enabling the networking of the enterprise with businesses located in the supply chain.

15.4.1 Identifying Core SCM Business Technologies

The suite of core SCM business technologies constitute the information workhorse of an enterprise and truthfully can be said to constitute the hub or "backbone" of a company's information infrastructure. Effectively implemented and utilized core SCM technologies integrates the functions of the business; provides the technologies necessary to efficiently perform transactions, eliminate processing redundancies, accelerate the speed of individual and jointly performed processes; enables users to access information for reporting and governance review; and structures the information platform for the performance measurements and analytics revealing a company's progress toward corporate performance objectives.

As illustrated in Figure 15.4, core SCM technologies consists of eight tightly integrated business modules, one for each of the core functions found in a typical business. The *SCM application architecture* refers to the computer configuration, programming languages,

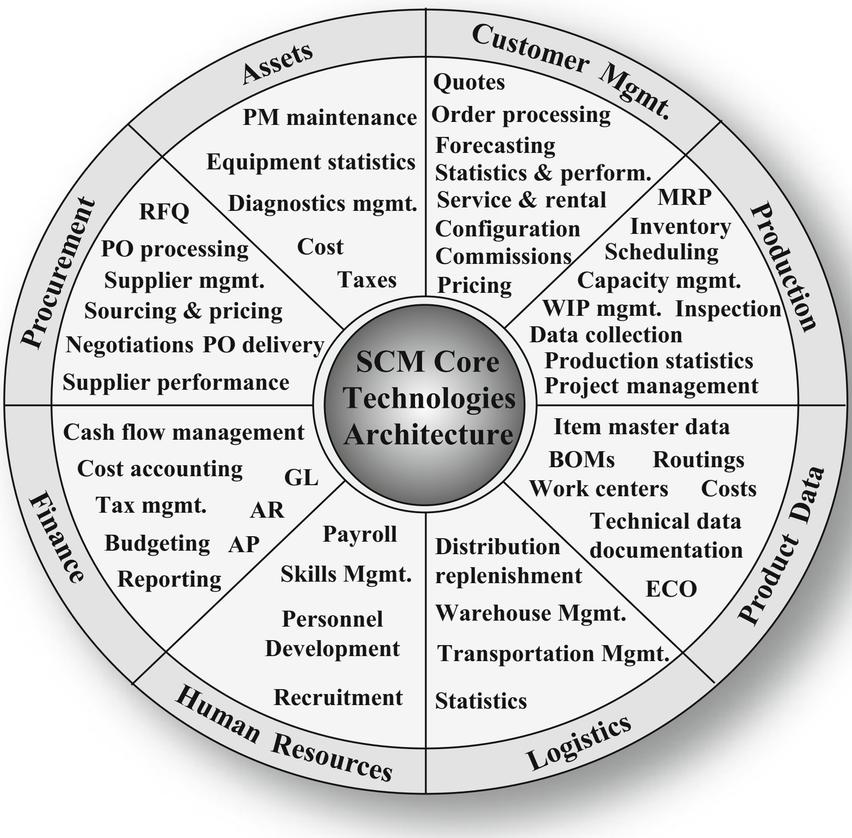


FIGURE 15.4 Core SCM technologies.

graphic presentation, document output capabilities, database designs, and a host of other components constituting a functioning business system. In a wider sense, the application architecture structure describes how the different modules and their functions are assembled in the business system. The architecture could be constructed to assemble a single, homogenous, fully integrated enterprise information system or it might be the result of a company's decision to assemble a best-of-breed portfolio model linking third party point solutions to a home-grown or previously implemented packaged solution.

Clustered around the SCM application architecture are the following eight core modules: customer management, production, procurement, logistics, product data, finance, asset management, and human resources. Depending on the nature of its production and distribution processes, an enterprise may utilize some or all of the modules. For example, a system for a manufacturing company that performs distribution functions will have all eight modules activated. A wholesale distributor would most likely have all modules except for production functions. A B2C catalogue e-tailer would most likely have selected customer management, human resources, finance, procurement, and some limited logistics functions. Regardless of the business environment, every company will at least have to install customer service, order management, and finance. These base modules would be difficult to outsource without losing corporate integrity. A description of the eight modules is as follows.

- *Customer management*. The primary role of this module is to provide availability to the order entry, order promising, and open order status maintenance programs. Order entry and service maintenance is the gateway to the sales and marketing database. Second, this module provides the data necessary to perform real-time profitability analysis to assist in calculating the costs, revenues, and sales volumes necessary for effective quotation and ongoing customer maintenance. Third, this module equips marketers with tools to design sophisticated pricing schemes and discount models. In addition, the software should permit the performance of miscellaneous functions such as order configuration, bonus and commissions, customer delivery schedules, tax management, currency conversion, customer returns, and service and rental. Finally, the customer database should be robust enough to permit the generation of sales budgets for forecast management and statistical reporting illustrating everything from profitability to contributing margins analysis.
- *Manufacturing*. The manufacturing module is one of the oldest in a modern day business system. Originating as a *bill of material* (BOM) processor, this module has been enhanced over the decades to include MRP processing, production order release, overall shop floor scheduling and control of WIP management, and production cost reporting. An important element is the real-time linkage of demand to order-to-production and WIP modeling, while promoting real-time available-to-promise (ATP) and capable-to-promise (CTP) to assist in customer order management. In addition to these basic tools, today's production module contains functionality for activities such as quality inspection, project management, capacity/resource management, and the compilation of production statistics. Finally, advances in technology have enabled the interface of the production module with "bolt-on" data collection devices and advanced planning, scheduling, and optimizing software.
- *Procurement*. The ability to effectively integrate procurement requirements with a variety of supply chain concepts and technology tools is one of the most important

components of an effective business system. Although much press has been given to Web-based B2B and B2C, the management of base procurement functions is essential to all businesses. The integrative nature of SCM technologies facilitates the close integration of MRP planning and purchase order and requisition management. Today's procurement module contains robust functionality to facilitate request for quotation, purchase order processing, delivery scheduling, open order tracking, receiving, inspection, and supplier statistics and performance reporting. In addition, detailed request for quotation (RFQ) must be available that ties back to customer demands and extends out to supplier management, negotiation, discounting, and pricing capabilities. Finally, the module's technology architecture must enable easy entry into e-procurement functions for online ordering, catalog management, online auctions, buying exchanges, and other Web-based capabilities.

- *Logistics*: The ability to link in real-time logistics functions to sales, production, and finance is fundamental to competitive advantage. Today's SCM technologies must provide the mechanisms to run the internal logistics functions of the business as well as the necessary connectivity with supply chain trading partners located on the rim of the supply network. Critical tools in the module drive distribution channel configuration, warehouse activity management, channel replenishment planning, distribution order management, and the generation of distribution, asset, and profitability reporting. Also, of growing importance is the integration of logistics functions with "bolt-on" warehouse (WMS) and transportation (TMS) management systems, as well as applications supporting Web-based customer and supply chain management systems.
- *Product Data*. An essential core module is the database describing the raw materials, components, and products that a company purchases, produces, and distributes. The product databases contain data ranging from engineering descriptions and classifications to details concerning costs, planning data, sourcing and supplier data, and product structure. Besides the obvious uses for inventory and production planning and shop floor management, these databases are critical for marketing product life cycle management analysis, engineering product introduction, and financial reporting and analysis. As the speed of time-to-market and ever-shortening product life cycles accelerates, progressive companies are looking to channel partners to implement collaborative technologies through the Internet that link in real-time joint development, quality management, value-added design, and design documentation in an effort to compress lead times out of new product development, introduction, and phase-out of existing products and services.
- *Finance*. One of the strong-suites of a typical business system are the tools provided to support management accounting. In fact, one of the criticisms leveled at structured systems, such as enterprise resources planning (ERP), are that they are really accounting systems requiring everyone in the business to report on an ongoing basis each transaction they perform with 100 % accuracy. Today's financial applications provide for the real-time reporting of all transaction information originating from inventory movement, accounts receivable, accounts payable, asset management, taxes, foreign currencies, and journal entries occurring within the enterprise. The more timely and accurate the posting of data, the more effective are the output reports and budgets that are used for financial analysis and decision-making at all levels in the business.

- *Assets*. Effective management of a company's fixed assets is essential in calculating the ratio of asset expense to return on asset (ROA) investment and to identify requirements for the future acquisition of the productive resources necessary to meet competitive strategies. System databases in this module center on the establishment of equipment profiles, diagnostics and preventive maintenance activities, and depreciation tracking.
- *Human Resources*. The last module composing the core of today's business system is the management of an enterprise's human capital. Functions in this area are broken down into two main areas. The first is concerned with the performance of transaction activities, such as time and attendance reporting, payroll administration, compensation, reimbursable expenses, and recruitment. The second is focused on the creation of databases necessary to support employee profiles, skills and career planning, continuous training and education, and employee evaluations and productivity statistics.

15.4.2 Advanced SCM Business Technologies

Realizing today's requirements for supply chain speed, agility, real-time control, and exceptional customer satisfaction requires enterprises to explore technology applications beyond the eight core modules. As illustrated in Figure 15.5, there are an ever expanding number of advanced SCM applications resident in many of today's commercial business software packages as well as specialized third-party best-of-breed applications that can be bolted on to the core application system. For example, mega-software companies, such as SAP and Oracle, provide many of today's advanced applications that are purchased and configured during implementation of their standard ERP and SCM business software suites. Best-of-breed suppliers, such as Logility and Kinaxis for example, provide expanded depth

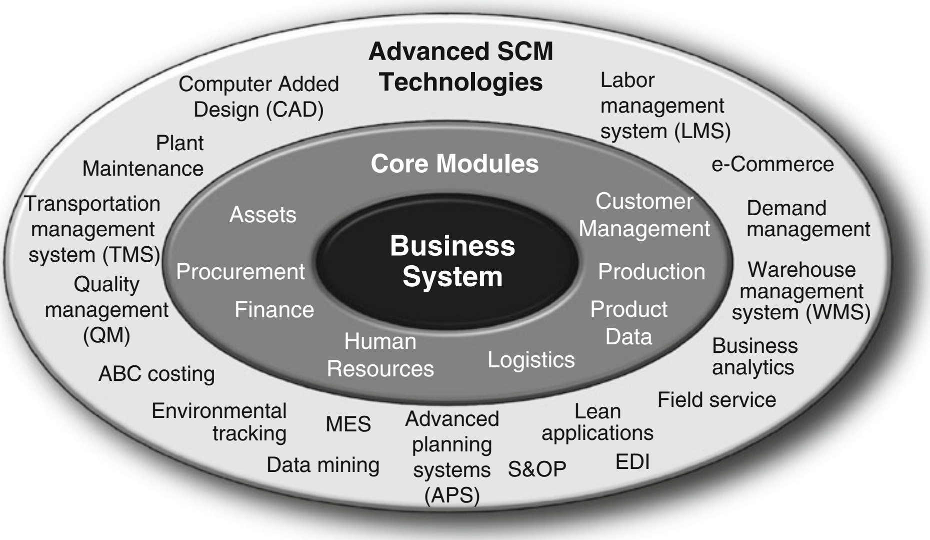


FIGURE 15.5 Advanced SCM technologies.

and functionality for their supply chain management (SCM) systems. Regardless of the combination of core SCM applications, data collection devices, supply chain planning suites, and others, a key imperative for businesses is that the technology solutions can be rapidly configured and are capable of being disassembled and rapidly reassembled into a single framework to match the changing needs of the marketplace.

At first sight, the variety of SCM application suites appears to be a maze of software products with new ones appearing periodically on the horizon. CRM, LMS, EDI, SRM, MES and other acronyms litter current business literature and impart an impression of incoherency, discernable only to a select club of industry analysts and "techies." Despite the confusion, the overall goal of supply chain leaders is to build information technology muscle by optimizing core application modules and using advanced applications in the outer ring for innovation.

The selection of which advanced applications are to be included in an enterprise system are usually the result of various pressures businesses are experiencing. A good example is pressure coming from the customer, who has been conditioned by the success of Internet-based companies, such as Amazon and Dell, to expect a wide range of product choices, a superlative customer buying experience, and a high level of service. For such a company, applications such as e-commerce, demand management, business analytics, field service, and TMS would constitute important add-ons to the core system. On the other hand, for a company concerned with reducing exposure to risk and costs, ABC costing, environmental tracking, LMS and lean would be viewed as important advanced applications.

15.4.3 Networking SCM Business Technologies

Today's business system can be integrated with a variety of information and communications technologies that enable enterprises to escape the boundaries of the organization in search of collaborative relationships with supply chain customers and suppliers. This evolution from enterprise-bound to cross-supply chain information systems utilizing toolsets for channel partner connectivity and networking has been enabled by changes to computer technology architecture, programming languages, and utilization of the Internet. Companies today are seeking to deploy applications that facilitate intracompany activities from instantaneously passing data and intelligence about marketplace events, accessing the status of orders and inventory balances, and executing payment and billing, to the construction of multicompany functional work teams that interactively work on projects and processes simultaneously across global space and time.

Figure 15.6 illustrates the components of today's networked business system. In the center oval is found the SCM core and advanced applications needed to run the enterprise. The traditional applications for production planning, master scheduling, capacity management, material requirements planning, purchasing, shop floor management, and the supporting financial functions are found in this area. Also in the center oval is the array of advanced applications that businesses may decide to integrate into the core to solve particular information needs in engineering, logistics and distribution, financial planning, human capital management, and advanced planning and shop floor management optimizers and schedulers.

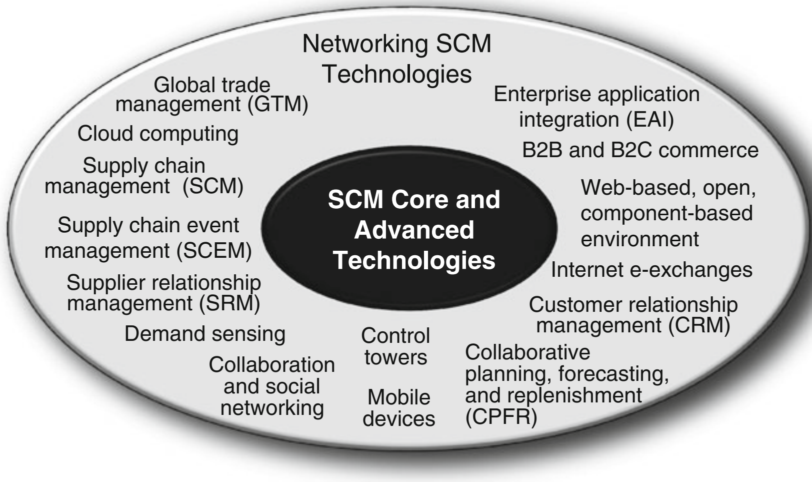


FIGURE 15.6 Networking SCM technologies.

In the outer oval are applications that are primarily focused on enabling connectivity and networking between a company's business system and supply chain customers and suppliers. A brief review of some of these applications reveals the diversity they offer to integrate a business with its supply chain.

- *Collaborative planning, forecasting, and replenishment (CPFR).* The mission of CPFR is to network all partners in a supply channel to facilitate collaborative planning processes based on the timely communication of forecasts and inventory replenishment data to support the synchronization of replenishment activities necessary to effectively respond to total supply chain demand. CPFR represents the maturation of *quick response* (QR), *vendor managed inventory* (VMI), and *efficient customer response* (ECR). CPFR begins with an agreement between trading partners to develop a consensus forecast that begins at the retail level and makes its way back to the producer. CPFR interoperable technology permits this data to be freely transmitted up and down the supply channel so that planners at any node in the network can see demand and adjust the plan within certain limits based on possible exception conditions, such as promotions, store openings, or capacity constraints that could impact delivery or sales performance anywhere in the channel. Trading partners would then collaborate to resolve any potential bottlenecks, adjust demand and replenishment plans, and then execute alternative courses of action. The final step in the process, channel replenishment, occurs after consensus on the final forecast.
- *Cloud computing.* The robustness of today's networking technologies have spawned a new industry directed at relieving companies of the cost and organizational burden of implementing cutting-edge software and network-building by providing major business system applications and technical infrastructure for a subscription fee. Using the software-as-a-service (SaaS) model, what cloud computing basically does is to provide companies with the ability to lease software over a secure Internet-accessed network. The cloud-hosting company provides the software and the related IT

services, including upgrades and maintenance. The host company also provides the network linking the client's offices, homes, and operating locations (internal cloud) to the data center (the public cloud). Finally, the host company provides the licenses, implementation, training, system management, and user support necessary to ensure the subscriber receives the anticipated value. In return, the hosting company charges the customer on a pay-as-you-go basis. As illustrated in Table 15.1, there are various cloud configurations that must be decided upon [13].

TABLE 15.1. Cloud Options

Type	Description
Multi-tenant	Cloud architecture configured so that several companies share the underlying infrastructure resources, without compromising the privacy of any single customer's data.
Elastic	The cloud service delivery infrastructure can expand and contract automatically based on capacity needs.
On-demand	All cloud services are available over the internet and can be used as needed.
Flexible pricing/usage metered	Resource usage in monitored, controlled, and reported providing transparency for both the provider and consumer. Billing may be based on actual usage
Self service/location independent	All services are accessed directly by the user from a user interface (UI) or an application programming interface (API)
Speed/time to value	Supply chain delivers integrated solutions for cloud, enabling rapid time to value for client access to the cloud.
Multi-enterprise collaboration	Cloud computing provides interoperability of supply chain end-to-end business processes and technologies.
Visibility	Transparent supply chain operations are managed through real-time, cloud based data and analytics to provide broad visibility

Salesforce.com, a $1 billion a year company, provides an excellent example of SaaS cloud computing functionality (Figure 15.7). At the center of its cloud strategy is Force.com, the platform where Salesforce hosts its own CRM, sales force automation, customer service, and other applications. The platform also enables subscribers to build their own applications using Salesforce's programming language, APIs, and custom interface framework offered through the Salesforce online store, AppExchange. Since so much of the basic code for a needed application is already running on Force.com, it is easier for developers to customize existing apps or write small, limited-function apps of their own. The range of applications offered by cloud-hosting companies varies, and ranges from companies like Cloud Logistics that specializes in transportation management to mega technology companies like SAP and Oracle which offer their entire suites of software products via the Internet.

- *Supply chain event management (SCEM)*. SCEM is an application integration layer that provides visibility to inventory information as it flows between channel trading partners. SCEM applications provide logistics planners with the following functions:
  - *Monitoring*: Providing real-time information about supply network events, such as the status of channel inventory levels, open orders, production, and fulfillment.

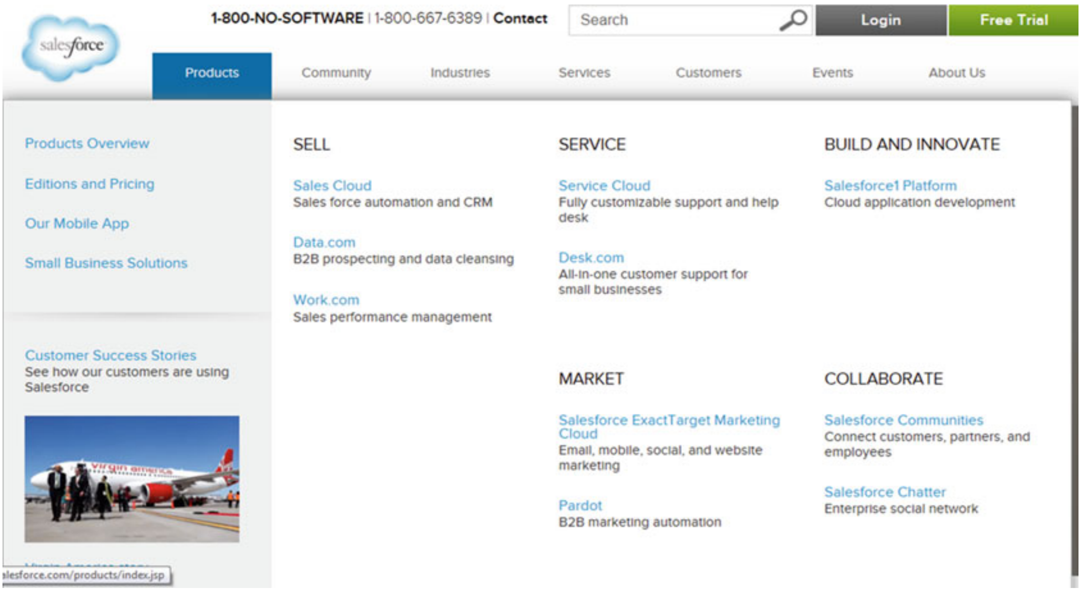


FIGURE 15.7 Salesforece.com website.

- *Notifying*: Providing real-time exception management through alert messaging that will assist supply channel planners to make effective decisions as conditions change in the supply pipeline.
- *Simulating*: Providing tools that permit easy and fast supply channel modeling and what-if scenarios that recommend appropriate remedial action in response to an event or trend analysis.
- *Controlling*: Providing channel planners with capabilities to quickly and easily change a previous decision or condition, such as expediting an order or selecting less costly delivery opportunities.
- *Measuring*: Providing essential metrics and performance objectives or KPIs to assist supply chain strategists to assess the performance of existing channel relationships and to set realistic expectations for future performance.

Basically, SCEM is engaged when an event, either planned or unplanned, occurs requiring planner intervention. Depending on the impact of the event, the system will trigger a signal, often using Boolean-type logic, to alert planners through a generic workflow process that an occurrence in the fulfillment pipeline has violated predetermined event boundaries. For example, companies such as barnesandnoble.com, the Web-based sales arm of bookseller Barnes & Noble, are using fulfillment event management applications to monitor and send alerts, create workflows, and set up escalation processes to enhance customer service, cut logistics costs, and improve supply chain efficiencies. Once an order is placed via their Web-based entry process, the company keeps customers informed of the stages through which their order is progressing. Fulfillment data, such as when shipments are packed and shipped and when delivery can be expected is e-mailed directly to the customer and is also available on their Web site.

Altogether, the benefits of applying the latest computerized techniques that seek to automate logistics functions and increase the accuracy of logistics decisions can produce enormous benefits not only for individual companies, but for entire supply chains. Among the benefits are faster response times so less expensive expediting is required; production work-in-process (WIP) is decreased; channel and in transit inventories are reduced; the accuracy of order processing and tracking is improved; the velocity of order management is increased; returns are reduced; and labor requirements are decreased. Additional hard benefits are decreased inventory holding costs, increased inventory turns, and reduction in channel safety stocks.

- *B2C and CRM*. These application suites enable businesses to utilize the Internet, mobile sales, and social networking to understand the customer in real-time and to provide sourcing and ordering tools to sell directly to the customer. CRM applications enable companies to closely manage all aspects of a customer's relationship with an organization focused on increasing customer loyalty, retention, and profitability. CRM toolsets provide an integrated view of customer data and interactions allowing sales and marketing to be more responsive to customer needs. CRM components typically include the following: Internet-driven order management, sales force automation, promotions and event management, social networking, customer information storage, analytics for marketing research, and customer service.
- *B2B and SRM*. Networking tools in this part of the extended business system application suite are focused on deploying Internet-based independent, private, and consortia exchanges to facilitate materials and finished goods acquisition, requisitioning, sourcing, contracting, ordering, and payment utilizing online catalogs, contracts, point-of-sale (POS), and shipping notices. Similar to CRM, supplier relationship management (SRM) software ensures that effective collaborative supplier relationships are being formed, the right suppliers are being used, supplier performance targets are being hit, and buyers are paying the right price for the quality and services contracted.
- *Supply chain control towers* [14]. With all the available cross-channel networking applications, companies need a technology that provides a way to leverage the data arising from these tools to effectively manage the complete end-to-end supply chain. The emerging solution is an organizational structure termed a *supply chain control tower*. The objective of the structure is to integrate all supply channel players to improve visibility and performance through a centralized, shared service. Utilizing the vast amounts of information arising from core and advanced SCM applications (such as ERP, SCM, TMS, and WMS), cloud technologies connect these data sources along the supply chain, regardless of execution platform. With this information, the tower assists supply chain members predict the consequences of an event. Will it affect customer service? Will more inventory be required? Will the delivery schedule be met?

The key to the supply chain control tower is constructing the right architecture that fits the needs of supply channel members. As illustrated in Figure 15.8, the control tower architecture starts by identifying the networking applications used in the supply chain. These applications are then integrated with the help of a common middleware software. Once completed, all supply chain information is gathered at a centralized location where it is then used to audit and make effective decisions for supply chain planning, sourcing, producing, and delivering. The control tower provides information regarding every item ordered from a supplier; a comprehensive SKU-view of inventory; a global map of all suppliers; how goods were transported through the channel system; every event generated in the flow from production to delivery; and what markets bought which products. Control towers provide superior supply chain flexibility for dynamic planning and routing and the robustness of data to enable supply chain managers to turn it into actionable insight and more informed decisions.

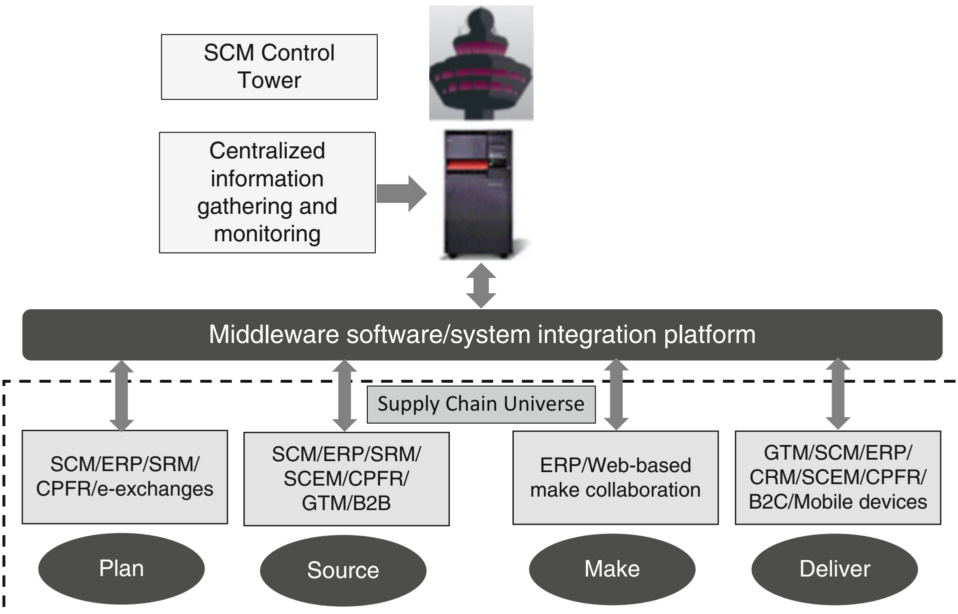


FIGURE 15.8 Supply chain control tower architecture.

15.4.4 SCM Business System Maturity Model

Regardless of how it has been assembled, a company's business system can be categorized by the level of the maturity of the use of its business technologies. The level of maturity is measured by how well the firm is using the business system in general and how well each business function is exploiting the potential of its portion of the system. As outlined in Figure 15.9, there are five levels of SCM business technology use ranging from the enablement of core modules for basic processing to the deployment and integration of advanced SCM applications. High performers utilize techniques to drive high supply chain profitability and competitive advantage.

The levels of SCM technology maturity are described as follows:

- *Data management system*. This level of SCM maturity is described as having the core applications of the system enabled. At this basic level, SCM technologies are used only to perform essential transactions, such as sales order entry and account receivables. Most decisions are made using systems residing outside the SCM system, such as Excel spreadsheets. SCM application modules are organized by business function with no or a low degree of integration.

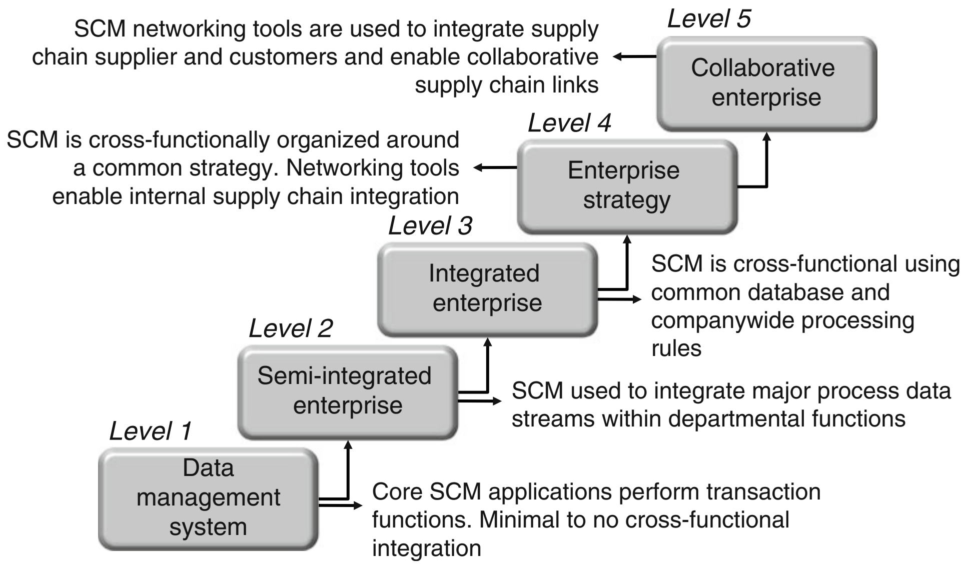


FIGURE 15.9 SCM technology maturity model.

- *Semi-integrated enterprise*. At the next level of maturity, companies use SCM applications to pursue high levels of integration within major process streams, such as order entry through to accounts receivable. The SCM system is used by functional managers to drive initiatives targeted at expanding the automation of key functions and the use of databases to increase the informating capabilities to explore new ways of engineering process control. The goal is to use SCM technologies to improve the effectiveness, efficiency, and quality *within* functional areas. Enterprise functions are usually at different levels of system use. Functions still pursue silo strategies, lack clear, integrated processes, and often are out of alignment with company objectives.
- *Integrated enterprise*. At this level, SCM technologies are used by the business to closely integrate department functions around a common database and set of strategic priorities. Managers use the system to break down the walls of functional information silos by deploying such processes as sales and operations planning (S&OP) with a focus on companywide processes rather than individual functions. Departments share a common database; planning and execution is integrated starting with the business strategy and ending with operations performance. The organization understands that the system provides data for decision-making that other functions can be held responsible for executing.
- *Enterprise strategy*. On the fourth level of SCM application maturity, the enterprise is cross-functionally organized around a common business strategy facilitated by the use of advanced communications and networking technologies. Organizations optimize decision-making across the internal supply chain, deploy sophisticated application toolsets for problem solving and speeding process flows, and involve the participation of key suppliers and customers in the decision-making processes.
- *Collaborative enterprise*. At the fifth and highest level, the business uses multi-enterprise connectivity technologies, such as cloud computing, “big data,” and mobile

devices, to network in real-time with suppliers and customers. Technology is used to set common supply chain business objectives, enable collaborative links with trading partners, and improve efficiency and product and service quality both internally and across the supply chain.

15.5 STANDARD SCM BUSINESS SYSTEMS

The three levels of SCM technology functionality provide companies with an almost limitless opportunity to configure the exact information system architecture that corresponds to their particular needs. In place of configuring a solution by piecing together the various SCM technologies, companies have the opportunity to choose a predesigned SCM system from a number of software suppliers. In this section, the two most common systems for producers and distributors are explored.

15.5.1 Enterprise Resources Planning (ERP)

A common software system that has been applied by companies for many decades to manage their businesses is *enterprise resources planning* (ERP). Historically, the value of ERP systems was found in their ability to serve as a foundation for company information and process integration and collaboration. Achieving competitive advantage requires all units of the organization to work together toward a common goal. ERP assists in achieving this objective by providing a central database that collects information from and feeds information to the business's functional applications areas so that effective transaction management, shared management reporting, and decision-making are effectively performed.

Beyond these integrative characteristics, an ERP system also possesses the following architectural elements [15]:

- *Flexible*: The architecture of today's ERP system enables users to select and configure a custom system instead of a "one-size-fits-all" solution. By integrating special industry-focused libraries and enabling or disabling module and application flag settings, users can choose the core, advanced, and networking applications from the portfolio of SCM technologies to configure a unique solution that meets the exact needs of their organizations. The capability for complex system configurability is a significant enhancement of today's ERP over past systems which were both rigid and monolithic and difficult and expensive to customize.
- *Modular and open*: A world-class ERP system has an open architecture permitting any module to be interactive with any other module without impairing system integrity, system functions, and performance. An "open system" means that the software can be run on multiple hardware platforms (IBM, Oracle, Microsoft, etc.).This feature is particularly important for businesses that have multiple systems and third-party point solutions.
- *Comprehensive*: The ERP system should support as wide a variety of organizational functions as is possible and support a wide range of industry verticals. In addition, the ERP should support "best practices" so that implementers are assured their application configuration and functional processes meet industry standards without modification.

- *Networked*: The ERP system possesses functionality that allows companies to escape beyond the four walls of the enterprise by possessing Internet networking and integrating them with supply chain partners.

The functions of the typical ERP system is illustrated in Figure 15.10 [16].

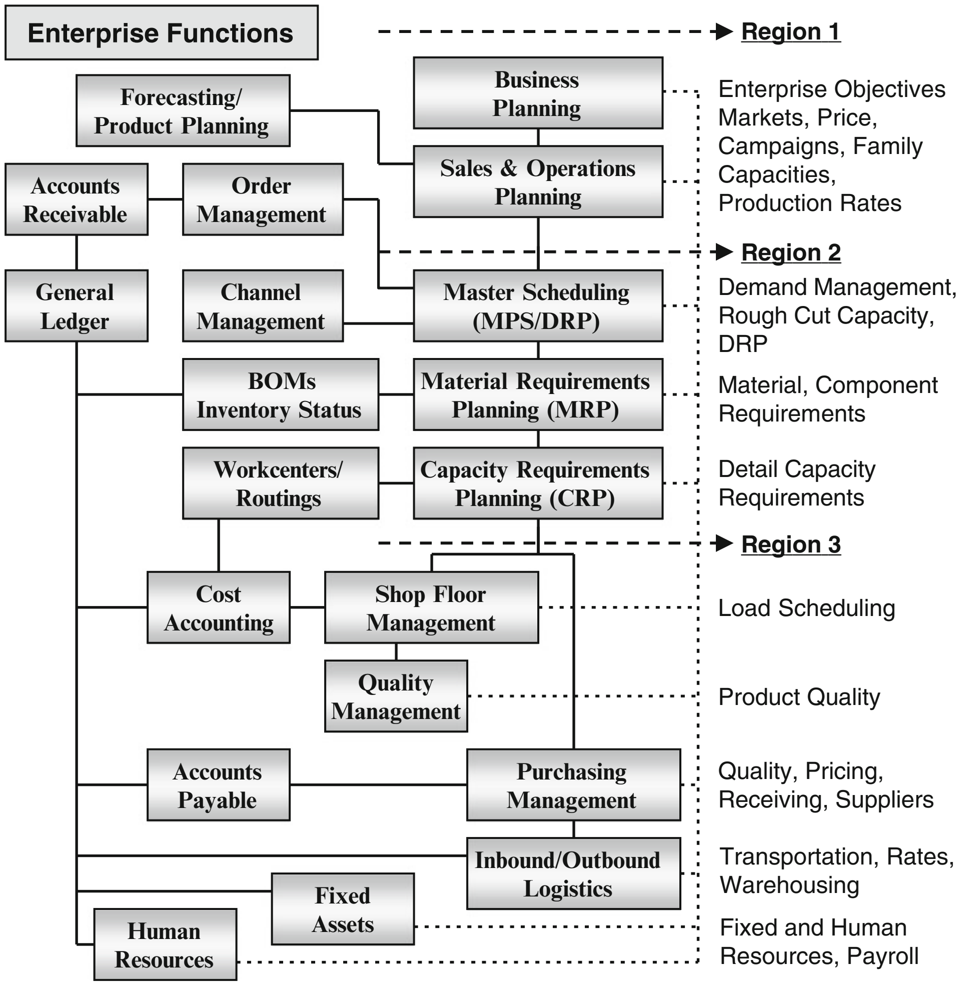


FIGURE 15.10 Basic ERP functions diagram.

The architecture of an ERP system attempts to integrate all of the information processes of the enterprise and uses the resulting synergy of planning and control to continuously improve customer performance, increase profitability, and decrease costs through process automation and application best practices. An ERP system is best understood by dividing Figure 15.10 into three regions. In *Region 1* is found applications used for the development of enterprise-level plans governing the overall direction of the business, products and market programs, sales and promotions campaigns, and aggregate product family priority and resource capacity planning. Activities in this region begins with the utilization of detail transaction databases that are used for long-range forecasting and decision making.

The strategic business plan developed from these decisions is then used as a framework determining the goals and objectives guiding the substrategies of marketing and sales, finance, engineering, production, and logistics departments. An ERP system automatically integrates and translates these business plans into a common language that each department is able to utilize to define their own set of performance objectives. Sales & operations planning (S&OP) enables the business to build consensus demand and operations teams that translate the business objectives into aggregate sales, production, and inventory tactical plans. S&OP also enables the enterprise to continuously revise demand forecasts and realign operational capacities to meet changing circumstances. The output from S&OP is then feed into the next ERP region.

Region 2 is divided into tactical-level demand and supply planning. The primary role of demand management applications is to provide quotation management, quick and accurate order entry, order promising, open order status reporting, customer maintenance, and accounts receivables. Next, these applications provide the tools for the design of sophisticated pricing and discount models. In addition, the software permits the performance of miscellaneous functions such as order configuration, bonuses and commissions, customer delivery schedules, global tax management, customer returns, and service and rental. Finally, the customer database should be robust enough to permit the generation of sales budgets for forecast management, meaningful customer segmentation, and the generation of statistical reporting illustrating everything from profitability to contributing margins analysis.

The second component of *Region* 2 is supply planning. At the heart of ERP is found the oldest software applications resident in the system: the master production scheduling (MPS) and material requirements planning (MRP) processors used for planning finished goods, component and raw materials, and distribution channel inventories. This module contains functionality enabling the generation and maintenance of inventory database records and parameters, the efficient and timely replenishment of inventories, and inventory planning simulation. The master production schedule (MPS) receives demand on finished goods from the production plan, forecasts, actual customer orders, and interbranch demand and calculates the replenishment quantities necessary to maintain customer demand targets. Once completed, this application sends finished goods requirements down to the MRP by exploding product *bills of materials* (BOMs) where component and raw materials are then calculated to provide the company's plan for materials and product replenishment.

Once MRP has generated the inventory plan, it is reviewed against production and supplier capacities. Plant constraints arise from a variety of sources including insufficient production capacities, warehouse space, staffing, and material handling equipment. Supplier constraints include supplier capacities, transportation, and quality. Today's ERP provides planners with real-time visibility into plant and supply channel process bottlenecks that inhibit the efficient execution of inventory replenishment priorities. If priority and capacity plans are not in balance at any planning level, planners must resolve the imbalance by resource acquisition, outsourcing, or postponement of production or delivery. Finally, advances in technology have enabled the enhancement of these applications with the addition of "bolt-on" data collection devices, manufacturing execution systems (MES), and advanced shop floor planning and optimizing software (APS). Once the inventory and capacity plans have been authorized, they are then driven down into the third ERP region.

Region 3 of the standard ERP system is concerned with the execution of the production, purchasing, logistics, and accounting plans established in Region 2. The shop floor management module controls order release; order scheduling, dispatching, and operations synchronization; inspection; ongoing *work-in-process* (WIP) management; order completion and issue to finished goods; and the compilation of production statistics. The purchasing module controls the tasks associated with the acquisition of all purchased components and raw materials. Today's ERP contains robust functionality to facilitate negotiation and pricing, purchase order processing, delivery scheduling, open order tracking, receiving, inspection, supplier statistics, and performance reporting. The logistics applications are concerned with synchronizing interbranch inventory replenishment and coordinating transportation, warehousing, labor, and material handling equipment with the place and time requirements of the company's demand plan. Finally, ERP accounting modules enable integrated budgeting, fixed asset, cost accounting, payables, receivables, and general ledger transactions and financial reporting.

15.5.2 Supply Chain Management (SCM) Systems

In this section the architecture of a system for a distribution enterprise is examined. For many software suppliers, the actual difference between ERP and SCM systems is negligible. For example, software vendors SAP, Oracle, Epicor, JDA, and Infor include production planning and shop floor management as part of their standard "SCM" solution. These major vendors have simply expanded their ERP packages to include SCM functions such as supply chain planning (SCP), sales and operation planning (S&OP), multi-business platform collaboration, warehouse and transportation management, mobile computing, and e-commerce and then provided users with the ability to configure the exact supply chain solution needed. There are, however, vendors like Logility and Manhattan Associates whose software contains modules only for demand planning and forecasting, inventory optimization, order lifecycle management, transportation, and distribution [17]. The standard module configuration of a SCM solution for a distribution company is illustrated in Figure 15.11.

This diagram illustrates the integrative, interactive, and closed-loop nature of the typical activities occurring within a distribution enterprise. Similar to the general ERP model, the SCM applications present a systemic approach. The flow of information begins with business planning functions, proceeds through operations and financial execution, and concludes with performance measurement. Besides providing a systems approach to directing and measuring the entire enterprise, from internal functions to the management of supply channels, SCM functionality provides a solution to the following problems plaguing the distributor:

1. The creation of business plans addressing the strategic decisions defining enterprise mission, market demand, and the allocation of financial, physical assets, and human resources. SCM provides the mechanism to disaggregate strategic plans through logistics resource planning (the planning of supply chain capacities) and distribution requirements planning (the planning of channel inventories). The goal is the generation of time-phased plans where the demands of the entire supply chain are balanced against individual enterprise and total channel inventories, postponement and value-added processing, transportation and warehousing, and purchasing capacities.
2. The ability of supply chain companies to be agile and flexible enough to respond to the many changes occurring in the business environment by providing visibility to customer demand and real-time status of supply chain events. Changes in market demand, supplier delivery problems, excess inventories, inventory channel

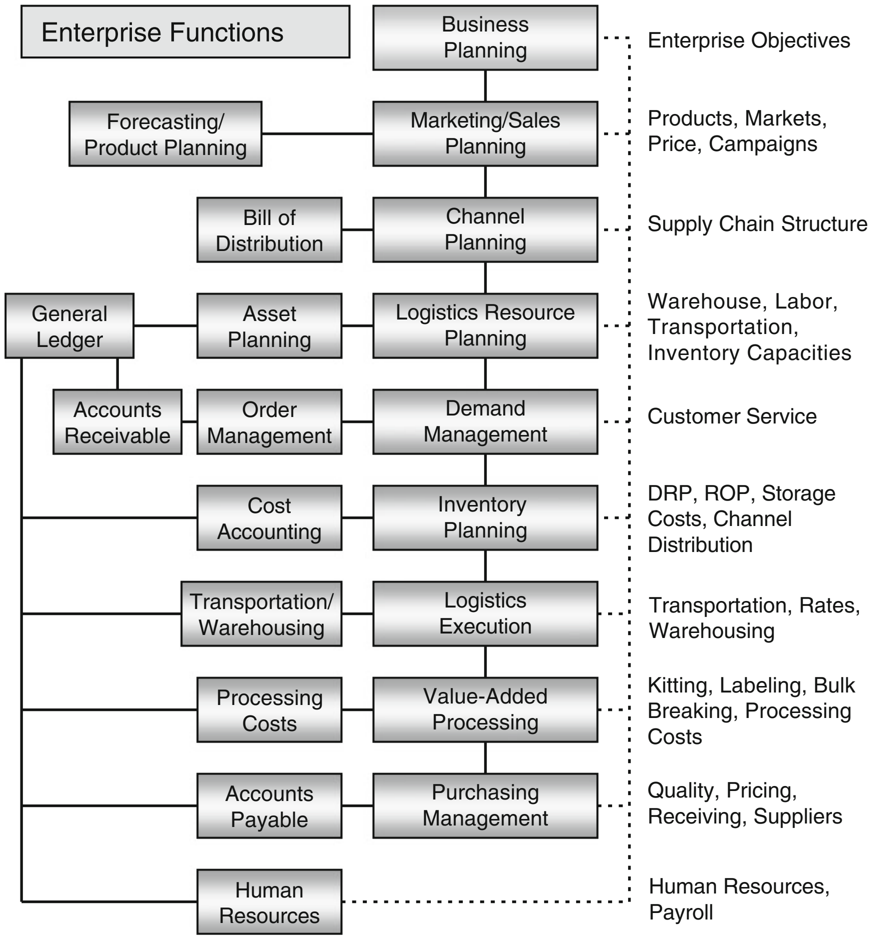


FIGURE 15.11 Distribution enterprise system diagram.

imbalances, marketing promotions, and a host of other events are made visible along with the mechanisms to adjust and reallocate critical resources.

3. By applying the time-phased logic of distribution requirements planning (DRP) and the ability to structure an integrated channel planning structure through the *bill of distribution* (BOD), the SCM model provides planners with a detailed workbench to keep channel inventories low and evenly distributed to meet the demands placed on each channel node, while providing the tools to resupply the supply chain as efficiently and cost effectively as possible. SCM architecture also enables the design of performance measurement programs that look beyond local agendas to how well each channel segment is supporting the overall business plan.
4. Finally, when integrated with today's newest supply chain networking applications, the SCM model provides a catalyst for the application of Internet-based technologies and lean principles targeted at removing barriers in supply chain time and space as well as to quality and excellence.

SCM software solutions offer distributors a comprehensive business systems to run the supply chain that is fully compatible with today's newest Web-based technologies. As a suite of integrated business applications, SCM software permits distribution companies to synchronize demand and supply up and down the channel network and link their systems with the system applications of supply chain partners. Such an approach enables entire supply chains to compete as if they were a single, seamless entity focused on channel cost reduction and superior customer service.

15.5.3 Evaluating Information Technology Solutions

While technology provides the enterprise with the ability to achieve order-of-magnitude breakthroughs in productivity and competitiveness, companies must be careful to match technology solutions with the information needs of the business. Perhaps the first action to be undertaken is identifying clearly the scope of the business problems to be solved and opportunities to be realized. This step will significantly narrow the range of possible SCM solutions. An effective requirements definition greatly assists companies to avoid critical errors, such as buying technology that is overkill, does not address the critical issues, or narrows future technology options because of hardware or software enhancement limitations. In addition, the requirements definition determines whether the company wishes to merely automate activities that are currently being done manually or enable networking capabilities linking a group of business functions or the whole supply chain. This determination is critical. For example, the cost and effort on the part of the organization to automate activities is significantly less than it is to integrate business functions.

The following five steps assist enterprises in leveraging the range of their technology solutions for competitive advantage [18].

1. *Assess information intensity*. Before a solution is chosen, companies must evaluate the existing and potential information intensity of their products and operations processes. The objective is to determine the *breadth* of the information required both to run the supply chain and manage product and service processes. The former includes the number of customers and suppliers in the channel, scope of marketing and selling information, number of product variations and depth of product variety, and length of cycle times. The latter includes product-related issues such as complexity, requirements for buyer knowledge and training, and the ability of the product to service alternative uses. Technology solutions enable the enterprise to leverage product and process information content to achieve marketplace leadership.
2. *Industry impact*. Companies must closely examine the impact of the introduction of new technologies on marketplace competitive forces. Technology can dramatically alter a firm's bargaining power with suppliers, ability to offer new products and substitute products, and capability to fight off new as well as existing competitors. Effective technology strategies enable a company to seize marketplace leadership and force competitors to follow. Costco, the chain of warehouse club stores, uses its information systems to track product movement to ensure that new products are integrated with successful existing lines to provide customers with the assortments they want. These data also drive stocking decisions that optimize floor space usage.
3. *Search for ways technology increases competitive advantage*. By targeting activities that represent a large proportion of supply chain costs, are critical to marketplace

differentiation, or compose critical links within the supply channel, technology assists companies to identify new avenues for sustainable competitive advantage. In addition, technology provides the opportunity for strategists to explore changes in competitive scope. Does the solution permit the enterprise to enter new market segments or invade the preserve of strong niche players? Will the solution enable the company to compete globally or to exploit interrelationships with other industries?

4. *Investigate how technologies spawn new industries*. Information tools spawn new businesses by diversifying existing organizations. Can a company's technologies provide sources of information or processing capabilities that can be sold? Does the solution enable the development of ancillary products that complement existing product lines? Take, for example, North American Van Lines who has created an information services and logistics software business that is complimentary to their traditional product and services strategy.
5. *Develop a long-term plan that seeks to continuously leverage new information technologies*. Strategists must be diligent in instituting a formal methodology for the ongoing review of new technologies, the strategic alignment of business opportunities and new technologies, the investments necessary to implement new hardware and software, and the impact technologies will have on supply chain linkages. Successfully enhancing competitive positioning no longer occurs simply by entrusting the exploration of new information technologies to the firm's *chief information officer* (CIO). Tomorrow's successful companies will require the participation of all functional levels both within the organization and outside in the partner channel if business technologies tools are to be effectively utilized.

An effective way to ensure a technology and business strategic match is to chart out the critical relationships between the level of business functionality and the scope of planning and control information desired. Such a chart can be found in Figure 15.12 [19].

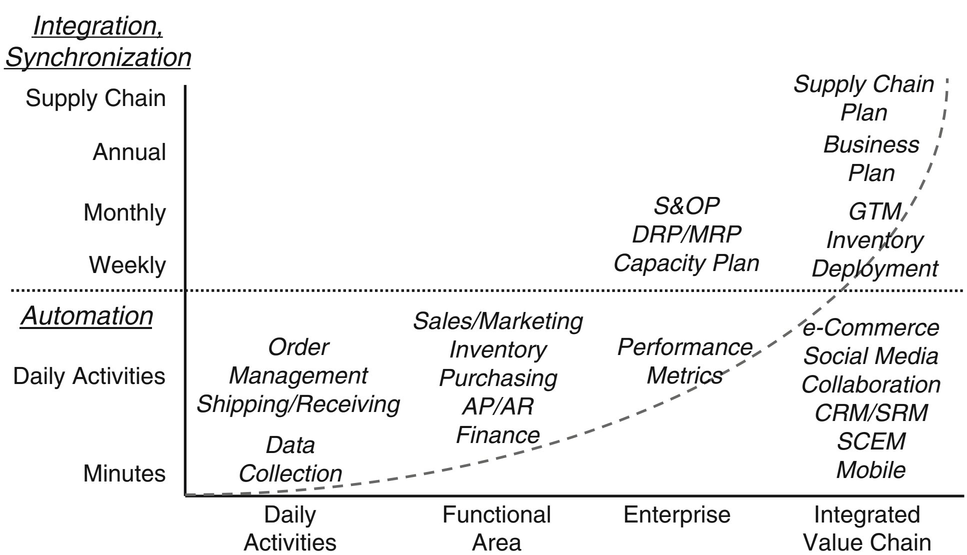


FIGURE 15.12 Charting business and technology solutions.

Along the vertical axis is the type and time-scale of required information processing. On the lower end of the scale is found information that is transaction based, such as order entry or accounts receivable, and occurs in the immediate time frame. New technologies that increase productivity and performance through automation target this area. As the vertical axis is ascended, information requirements move more into the realm of planning and control, concluding with strategic channel planning. Correspondingly, the information time frame moves from the short term to the long term. The horizontal axis details the level of business function, beginning with technologies seeking to automate and accelerate the processing of daily activities and progressing through functional area, enterprise, and integrated supply chain information management needs. The curve in the diagram represents the relative cost and time required to implement targeted technologies.

15.5.4 SCM Business Technology Configuration Choices

Considering the opportunities and the risks of designing and implementing a SCM business system, companies need to have a well-defined strategy encompassing real choices that include the configuration of both hardware architecture and business application selection. There are five alternatives paths businesses can following when choosing a SCM business solution. Deciding on a particular path is governed by several factors such as length of implementation time, cost, system flexibility, software complexity, quality of the solution, enterprise fit, and intensity of the demand for staff training and participation.

- *Build*. In this option a company decides to build its own suite of business applications. In the past, this choice was distinctly unfavorable, but with today's new composite-application tools or by engaging an inexpensive, high-quality third party developer this option has become viable especially among many non-manufacturing organizations.
- *Buy*. This approach is the most common. According to a recent report, there are about 52 packaged SCM application systems available from over 50 vendors with new SCM software packages, application add-ons, and utilities appearing regularly. In 2013, general SCM packaged software sales generated US$8.9 billion and sales are expected to climb to US$9.8 billion by 2018 [20]. These packages are divided into Tier 1 (very expensive, robust, complex software) for large corporations and Tier 2 (less complex or software with special industry functionality) for small-to-medium-sized companies.
- *Best-of-Breed*. In this approach, the core business modules of a standard system are integrated with one or more "best-of-breed" modules created by one or more software companies specializing in the business area (such as forecasting or warehouse management). A more radical option is to buy "best-of-breed" modules from multiple software developers and then integrate them together to form a complete SCM business system. The decision to select one of these paths is driven by the technology needs of the organization, the business strategy, and the presence of existing systems. The advantage of a best-of-breed approach is that it allows a company to deploy point-solution software with deep functionality and agility to manage special business problems that are not available in the standard ERP or SCM. The disadvantages center on implementation and integration costs to stitch together multiple systems, upgrade maintenance, and risk of long-term vendor viability.
- *Rent*. In this approach a company chooses to rent business applications via a hosting software-as-a-service (SaaS) provider. The growth in popularity; the ability of

software vendors, such as SAP and Oracle, to offer hosted solutions; breakthroughs in data and application security; and cloud computing have made this option more attractive. Companies can choose to run the application stand-alone or to integrate it with internal systems. A hosted solution enables companies to minimize risk of system failure; cut costs associated system ownership, upgrades, bug-fixes, modifications, and IT staffing; leverage deployment flexibility; and enjoy speedy use of application functionality without long implementation time frames.

- *Outsource*. Some companies have decided to let SaaS service providers manage all of their information technology needs, from daily maintenance to software modification, via strategic outsourcing. The goal is to eliminate the cost of IT equipment, software product, and maintenance overhead. This option is often pursued by very small companies with limited capitalization.

Regardless of the option selected, Chaffey [21] has identified ten major criteria that should be referenced when configuring an SCM business system.

- *Functionality:* the array of resident applications and the level of fit to company business processes.
- *Ease of use:* the speed by which users overcome the functional learning curve and the transparency of the applications relative to company processes.
- *Performance:* the processing speeds by which data is entered, processed, maintained, and retrieved.
- *Scalability:* the ability of the user to enable or disable software modules during implementation, and as the company's demands on the software expand or change.
- *Interoperability:* the easy by which the software is interfaced, integrated, or networked to other software systems.
- *Extensibility:* the easy by which modifications or software enhancements are made to the base software system.
- *Stability/reliability:* the software's basic data integrity and freedom from bugs or invalid calculations.
- *Security:* capability of restricting access to users, groups of users, or outside the organization supply chain partners and customers.
- *Support*: the quality of implementation assistance, on-going consulting, application documentation, and training.
- *Vendor viability*: financial strength of the vendor organization to provide periodic system enhancements and on-going support and services.

15.6 ADVENT OF SCM INTERNET TECHNOLOGIES

While the various form of SCM systems provide manufacturers and distributors with effective technology tools for the management of internal and supply chain business functions, the application of computer-to-computer connectivity and networking is providing companies with the ability to link in real-time demand and supply functions directly with customers and suppliers. In the past, even the most technology savvy company was constrained by the inability of computerized applications to connect and synchronize the vital information passing between customers and suppliers out in the supply channel. Even simple data components, like inventory balances or forecasts, were communicated with great difficulty to sister warehouses or divisions, let alone to trading partners, whose databases resided beyond the barriers of their information systems. By the opening of the twenty-first century, the past constraints on data networking were overcome. Using the new connectivity technologies, companies discovered that they could effectively leverage integrative information technologies to open new opportunities for commerce and effect the collaboration of supply chain partners would be able to successfully take advantage of emerging global marketplaces. Radical breakthroughs in Internet technologies were providing the communications and networking mediums that enabled business information to move from a decoupled, serialized flow to a real-time integration and synchronization of channel network business partners.

15.6.1 Defining Internet Business

The application of the Internet to business is best understood by dividing it into two separate, yet connected concepts and set of practices. The first is termed *e-business* and is defined as the use of Internet technologies to network customers, suppliers, and productive capabilities with the goal of continually improving a company's supply chain performance. The second concept is termed *e-commerce* and is defined as the ability of businesses to transmit data and documents and to buy and sell goods and services over the Internet. Often these terms are used as if they are interchangeable. In reality, e-business is a more powerful concept that seeks to utilize the Internet to build integrative, collaborative relationships among supply chain members, while e-commerce is a subset of e-business concerned with the electronic performance of commerce transactions.

Internet technology models are separated into four major categories [22].

- *Business-to-consumer (B2C)*. This model is the most widely known and applies to any business that utilizes the Internet to sell products or services directly to consumers. Companies using the B2C model are often termed *e-stores* or *e-tailers*. The goal of this model is to simulate an actual store shopping experience where consumers browse through catalogs or use search mechanisms to locate, price-compare, and order products and services to be shipped directly to their homes. Some of these B2C sites, such as Amazon.com, are *pure-play* in that they sell only through the Internet. Other types, such as Barnesandnoble.com, sell online as well as from a physical store outlet and are termed a "bricks and clicks" business.
- *Business-to-business (B2B)*. This model applies to any company that utilizes the Internet to sell products and services to other companies. Also termed *e-procurement,* this model is used by the buy-side organization for the purchase of production inventories, finished goods, and MRO goods and services based on a preexisting contract (*systematic sourcing*) or random purchasing (*spot sourcing*) from various types of MRO hubs, catalog hubs, and exchanges. The B2B model was explored in depth in Chapter 11.
- *Consumer-to-consumer (C2C)*. This model applies to Internet sites that enable customers to buy from each other. C2C's are consumer-driven and consist of online communities that interact via e-mail groups, Web-based discussion forums, or chat rooms.

Currently, this area is undergoing dramatic change as the concept of *social networks* gain traction. An example of a C2C business is ebay.com.

- Consumer-to-business (C2B). This model applies to any consumer that utilizes the Internet to sell products or services directly to a business. This area is also expected to be dramatically affected by the growth of online tools like *Facebook, twitter,* and *U-Tube* that allow consumers to directly communicate with businesses. An example would be priceline.com that sells products and services to individuals or to companies.

15.6.2 Evolution of Internet Business

During the early decades of the Information Revolution companies were limited in their ability to pass information between computer systems, much less than with supply chain partners. By the 1990s a new technology, the Internet, began to emerge with the potential to achieve the level of information connectivity necessary to link supply chains anywhere, at any time, on the globe. Fueled by the explosion in personal computer (PC) ownership, advancements in communications technologies, and the declining cost of computer hardware and software, companies eagerly began to explore the new technology as a way to sweep away the previous limitations governing the flow of supply chain information. The rise of Internet connectivity is portrayed in Figure 15.13 and is briefly described below [23].

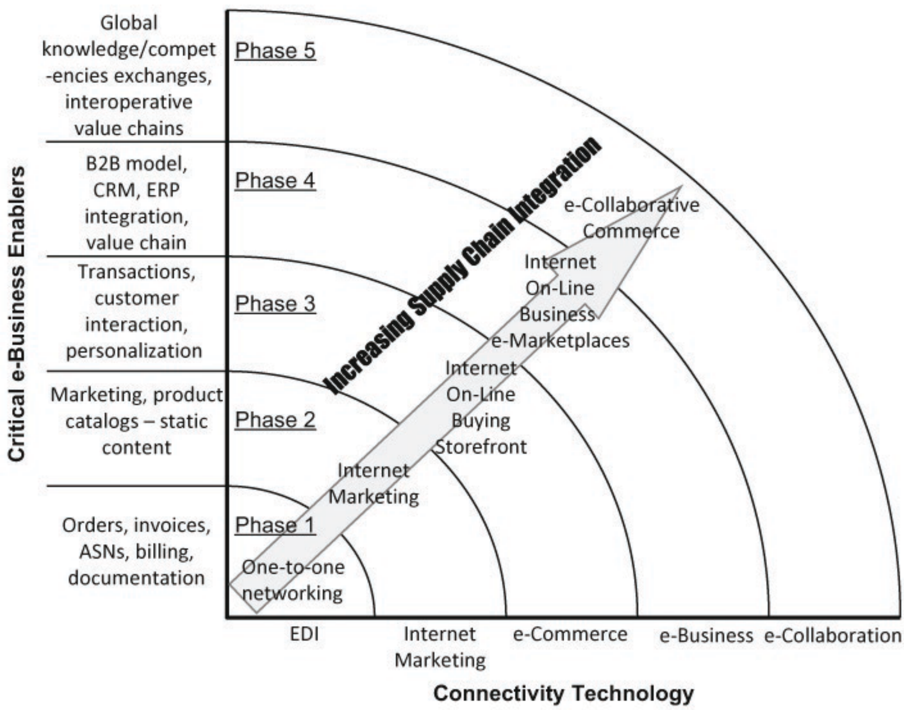


FIGURE 15.13 Phases of Internet business evolution.

- *Phase 1: EDI.* The first major technology breakthrough enabling companies to link with other companies was electronic data interchange (EDI). EDI provides for the computer-to-computer exchange of business transactions such as customer orders, invoices, and shipping notices. EDI is an *extranet* system consisting of a packet of transactions driven by a mutually agreed upon set of data transfer standards usually transmitted via private *value-added networks* (VANs). The EDI standards act as a "translator" that utilize the transmission protocols to take the data residing in the computer format of the sending company and converts it into the data format used by the business system of the receiving company.

Traditional EDI has a number of drawbacks. It is expensive and time consuming to implement. In addition, the basic data elements of the EDI transaction are centered on transmitting whole packets of information that must be sent, translated, and then received through trading partner systems. Furthermore, the proprietary nature and cost of EDI renders it a poor supply chain enabler. With the rise of the Internet, some of these limitations have been lifted. Simply, Web-based EDI is defined as using the Internet instead of VANs to send transactions accessed by the receiver using a PC and browser. The major advantages are less cost to implement and maintain, less cost for transactions, virtually unlimited scalability, and easy adaption to different business system infrastructures.

- *Phase 2: Internet Marketing*. The first use of the Internet for business purposes occurred in the early to mid-1990s and took the form of using the Web as a source for marketing products, services, and company stories. In the past, businesses were forced to utilize expensive advertising, printed matter such as catalogs and brochures, trade shows, industry registers, promotions, and direct sales that represented a *physical* and passive approach to marketing. The application of the Internet revolutionized the concept of marketing. Internet marketing enables marketers to place information about their companies on the Web where they are easily searched for and accessed *actively* by prospects anywhere, at any time, around the world utilizing relatively simple Internet-based multimedia browsing functions. Today it would be hard to find a company, both large and small, that does not have an Internet marketing site.
- *Phase 3: e-Commerce*. While Internet marketing sites provide information about company products and marketing strategies, they were never designed to allow browsers to actually order products and services through the Web site. During the mid- to late-1990s, a new type of Internet site began to emerge – the pure-play Internet storefront or (B2C) – designed specifically to sell and service customers on-line. By the end of the decade, on-line e-tailers like Amazon.com, eBay, and Price-line.com were offering Web sites that combined Internet marketing, on-line catalogs, and advertising with order management functions, such as site personalization, self-service, interactive shopping carts, and credit card payment, that provided actual on-line shopping. The pure B2C trading exchange caused a virtual revolution in customer-supplier connectivity by combining ease of shopping via personal PC or mobile device with an immediacy, capability for self-service, access to a potentially limitless repository of goods and services, and information far beyond the capacities of traditional business models.
- *Phase 4: e-Business*. By the year 2000, a new Internet approach that sought to utilize the interactive and integrative power of the Web to connect companies began to emerge. The differences between e-commerce and e-business are pointed. To begin with e-business is focused on using the Web to construct e-marketplaces for transactions between businesses (B2B). Second, the business relationship established

is different. Instead of a focus on the consumer and creating brand (Internet site) loyalty, B2B resembles traditional purchasing in that the goal is to use the Web to generate long-term, symbiotic, collaborative relations between businesses through the deployment of real-time connectivity. B2B relationships are divided into three types: *independent trading exchanges* (ITX) composed of buyers and sellers networked through an independent intermediary focused on spot purchasing; *private trading exchanges* (PTX) defined as a single trading community hosted by a single company that requires collaborative membership as a condition of doing business; and *consortia trading exchanges* (CTX) whereby a few powerful companies organized into a consortium establish a trading group consisting of the collective supplier base.

- *Phase 5: e-Collaboration*. For the most part, the e-business solutions that arose around the turn of the twenty-first century were primarily focused on facilitating the flow of information and transactions across the supply chain. Over the ensuing years, e-business solutions attempted to move beyond the transactional to collaborative strategies that sought to closely network customers, information, and core competencies with people, process, and inventory resources. In place of the traditional linear supply chain, e-collaboration calls for the generation of *value webs* described as any-to-any connections that drive procurement webs, production webs, and even linked business strategies. The goal is the architecting of real-time, integrated Web-based connectivity that permits supply chain members to share their planning systems and core competencies directly wherever they are located on the globe.

Internet-driven business connectivity has resulted in a virtual revolution in the management of the supply chain in that it now underlies the very foundations of business in today's global economy. The benefits are undeniable [24]:

- *Increased market supply and demand visibility* enabling more customer choice, potentially better fit of products to buyers, and a larger market for sellers.
- *Price benefits from increased competition* through auctions and e-markets to increase price competition and dramatically lower procurement costs.
- *Increased operational efficiencies* through improved procurement, order processing, and selling processes. Efficiencies also include faster order cycle times.
- *Improved partner and customer segmentation* that transforms customer marketing objectives and provides appropriate levels of services to customers with alternative value propositions.
- *Improved supply chain collaboration* that enables buyers and sellers to work together collaboratively for product design, planning, and marketplace introduction; marketing campaigns and promotions; and life-cycle management programs.
- *Synchronized supply chains* where visibility into operating information across the value chain allows companies to drive efficiencies across the entire value chain. These include increased inventory turnover, faster new product introductions, lower WIP inventories, and others.
- *Efficient payment transfer* that greatly facilitates transaction final settlement. Often, especially in retail sales, the payment for the goods/services occurs at the moment of purchase either through cash, credit card, P-card, or the use of a third party such as PayPal. Payment at the time of sales greatly increases the financial "float" of

companies like Dell, who can immediately invest the money some 30–90-day before they have to pay their suppliers.

- *Impact on cost* for enterprise infrastructure, inventory, facilities, and transportation. e-Business models that utilize extensive backward and forward integration find their technology infrastructures and call-center services dramatically increased, while experiencing decreases in inventory through improved supply channel cooperation, reduction in facilities costs by centralizing or outsourcing operations, and increases in direct and partner-based transportation. Transportation can be reduced to almost nothing for digital businesses, such as NetFlix, Best Buy, and Microsoft, who can offer product delivery directly through Internet downloads.

15.6.3 Impact of Internet Business on the Supply Chain

While there are different e-Business models, collectively they have had a dramatic effect on the operations, designs, and service factors of SCM. According to Chopra and Meindl [25] the impact of e-Business on SCM can be divided into two spheres: the first is associated with sales/service performance and the second with cost/operations management. Providing detail answers to these two groupings of factors is essential to the effective pursuit of a profitable supply chain e-business initiative.

15.6.3.1 Customer Service-Driven Elements

The ability to enter, track, and pay for orders through the Internet is probably the most radical facet of e-business. Critical elements of Internet-driven customer management impacting the supply chain are:

1. *Product variety*. An e-commerce site enables customers to choose from a much wider array of products than is possible in a ‘bricks and mortar’ store. Pursuing a ‘virtual inventory’ model means that supply chains that service the customer will be complex, closely integrated by information technologies and contractual relationships to business partners, and capable of seamless customer delivery.
2. *Product planning*. The ability of Internet-enabled businesses to utilize networking technologies provides them with the opportunity to broadcast customer demand continuously through the supply chain, providing visibility to inventory availability all the way back to the producer. This capability enables supply chains to plan using the demand pull or, at a minimum, more accurate forecasts leading to a much closer match of channel supply and demand.
3. *Shortened time to market*. Because the product development life cycle can be shortened by using collaborative design practices involving channel partners, an Internet-enable business can introduce new products to the marketplace much faster than a conventional business. This in turn adds pressure on the supply chain to facilitate the flow thorough of new products. Supply chains will have to cultivate close relationships with producers and channel intermediaries so that promotion, pricing, advertising, documentation, forecasting, and other sell-side components are swiftly executed and relayed down the supply chain.
4. *Flexible pricing, promotions, and product offerings*. Changes to company price, promotions, and the product portfolio must be matched by a mechanism that rapidly

communicates these changes to the supply chain. Such changes will quickly have a bull-whip effect on channel inventories if poorly communicated to channel distributors and producers.

15.6.3.2 Supply Chain Operations-Driven Elements

A decision to move to an Internet-driven channel format will have a significant impact on the structure, objectives, and capabilities of supply chain operations. Critical elements of Internet-driven operations management impacting the supply chain are:

- *Customer response time*. The easy by which customers browse online catalogs and generate orders through shopping cart functions places a significant burden of expectation on the supply chain. Unless the product is directly downloaded (such as computer software), customers have to wait to physically receive their purchases. Alternative channels for delivery will need to be devised that are commensurate with the shipping lead times demanded by the customer as well as offered by the competition.
- *Inventory*. A critical element of Internet business is the ability of firms to offer an extensive portfolio of products. For companies that inventory products, an Internet business strategy enables them to aggregate inventories at warehouses strategically positioned in key geographical locations. Because demand is channeled to these aggregation warehouses, Internet businesses can stock significantly less inventory than traditional businesses that must disperse duplicate lot sizes of inventories over multi-echelon channels of physical store locations. For "virtual inventory" businesses, those organizations must heavily depend on the strength and robustness of their supply chain stocking and delivery partners. Since product variety is one of an Internet business's strategic attributes, stock out of even low-demand, low-cost products risks loss of integrity of site branding.
- *Facilities*. For those businesses that choose to stock all or a portion of their product offerings, selling through the Internet imposes several requirements. To begin with, the cost of the facilities must be carefully calculated to guarantee the promises of product availability and delivery lead time claimed in the website prospectus and experienced by customers over time. The complexity of serving an entire customer base, often with very small order sizes, will impose a significant burden on existing operational procedures, staff, and information technologies. In addition, an Internet strategy may force the organization to deepen forward/backward integration of facilities functions currently performed by other channel companies.
- *Transportation*. Internet businesses will have to dramatically improve the quality, capacity, and delivery reliability of transportation both to stocking points and to the marketplace. The failure of businesses to actually delivery products to their web customers in a timely manner is one of the most serious problems plaguing businesses as witnessed by the Christmas delivery problems encountered by UPS in 2013. Without delivery consistency, even the most sophisticated website and business proposition will be abandoned for other Internet companies that literally can "deliver."
- *Information technology*. Effective Internet business requires the close networking of all members of a supply chain. The Internet serves as a conduit where critical information such as forecasts, the customer demand-pull, and visibility to disruptions

in product and/or transportation movement are communicated up-and-down the supply chain. While the cost of supply chain management systems and networking integration software is high, businesses must weigh the initial costs versus the ability to execute their business propositions on a continuous basis.

- *Returns*. Companies engaging in e-commerce will have to engineer convenient methods for customers to return unwanted products or to engage repair or warrantee service from some node in the supply chain. Internet sales poses an especially challenging environment for returns, customer crediting, and return of reworked product.

15.7 SCM TECHNOLOGY IMPLEMENTATION ISSUES

Enterprises seek to acquire information technology to solve a broad range of opportunities for improvement. Most problems experienced by companies are universal and are at the core of productivity and performance deficiencies in just about every business. The requirements are familiar:

- Faster customer order turnaround time
- Continuous reduction in inventories and carrying costs
- Increased information accuracy
- Better equipment utilization and reduced labor costs
- Reduction in transportation costs
- Closer integration of business functions
- Reduction in capital investment
- Closer integration with supply chain partners

This list could be expanded to cover the myriad of other problems that contribute to rising customer complaints, shrinking profit margins, and loss of business to competitors. Attacking these challenges by implementing SCM business technologies, however, is a significant challenge where the benefits must outweigh the risks and answers found to such questions as:

- What impact will the implementation of new information technology have on the customer service, logistics, and financial functions of the current organization?
- What will the implementation of new technology cost in terms of resources and operational trauma to the existing organization?
- How is new technology to be integrated with legacy systems?
- What new resources will be required to operate the new technology?
- What new opportunities for competitive advantage will be available to the enterprise?

15.7.1 SCM Technology Benefits and Risks

The decision to implement SCM business technologies requires significant forethought as to the advantages as compared to the tremendous risks involved. The tangible and intangible benefits are substantial (Figure 15.14).

Tangible Benefits of SCM Technologies	Intangible Benefits of SCM Technologies
Closer alignment of demand and supply	High customer retention
Reduction in operations errors	Deeper penetration of the customer marketplace
Increased sales volumes	Higher customer service
Greater financial returns	Improved scheduling
Lower overheads	Workforce skills optimization
Reduced cash-to-cash cycle	Higher employee satisfaction and efficiency
Lower inventory and carrying costs	Better integration of business functions
Lower transportation costs	More effective change management
Reduction in purchasing costs	Networking of channel skills and competencies
Detailed order tracking	Visibility to disruptive events in the supply chain
Comprehensive data reporting	Better decision-making capabilities

FIGURE 15.14 Benefits of implementing SCM technologies.

As a planning and control mechanism, the array of SCM technologies enables whole enterprises to organize, codify, and standardize business processes and data. Achieving such objectives in turn permits strategists and planners to optimize the business's *internal* value chain by integrating all aspects of the business, from purchasing and inventory management to sales and financial accounting. In addition, by providing a common database and the capability to integrate transaction management processes, data is made instantaneously available across business functions, enabling the visibility necessary for effective planning and decision making, while simultaneously eliminating redundant or alternative information management systems and reducing non-value-added tasks.

SCM technology systems provide other benefits. As companies grapple with managing continuous change to products, processes, and infrastructure, strategists are looking to the suite of "best practice" process designs embedded in today's SCM application business functional work flows to assist in the removal of ill-defined or obsolete processes and the substitution of "best in class" processes. Finally, as enterprises evolve to meet new challenges, companies with standardized processes encapsulated in SCM technology architectures are more adaptable to change. A single, logically structured, and common information system platform is far more resilient to changing competitive circumstances than a hodge-podge of systems with complex interfaces linking them together.

While benefits are dramatic, so are the risks companies assume during an implementation. The most direct is cost. Depending on the size and technology requirements of the company, implementing a robust ERP or SCM system requires huge expenditures: according to a Panorama Consulting Group 2013 survey extending back over a period of 4 years, the average cost of implementing an ERP system was US$6.5 million and the average length of the project was 16.1 months. This cost included hardware and software as well as education and consulting fees, customization, integrating and testing, data warehouse integration, and data conversion. What is more, the Panorama Consulting Group survey indicated that approximately 54 % of implementations go over budget. Distressingly the survey indicated that a full 66 % of respondents felt that they were receiving less than 50 % of the anticipated benefits and only 63 % felt their ERP project was a "success" [26]. Even more risky is the emotional and physical trauma an implementation has on a company's personnel, processes, and customers. Often senior executives feel that they are engaging in a "bet-your-company" gamble driving the organization through what can only be described as a virtual skeletal transplant as the old culture and operations are pulled out of the corporate body to be replaced by the new SCM technology configuration.

15.7.2 Managing the Implementation Project

The decision to undertake the implementation of information technology is a critical one for the organization. Whether it is automating a process, integrating a group of processes, or implementing a comprehensive ERP/SCM enterprise system, success depends on thorough planning, design, and commitment from all enterprise professionals from the president to the operators on the loading docks. According to Walton [27], there are three fundamental processes essential to the success of any sized SCM technology project: alignment of enterprise business, organizational, and technology strategies during the course of the implementation; user commitment and ownership; and user competence and mastery. Lack of development in any one of the three processes is fatal to the realization of information system potential. Without proper alignment efforts focused on commitment and system mastery, the new system will be misdirected and still-born. Without a sense of full enterprise commitment, system mastery will always lag behind strategic objectives. Finally, without system mastery users will never realize the full potential of their SCM enterprise investment. A comprehensive SCM technology project consists of four closely integrated parts.

15.7.2.1 Part 1: Aligning SCM Business Technologies and Enterprise Strategies

The starting point for any information technology project is to, in effect, unfold a broad vision of the *goals* to be pursued and how the integration of technology and organizational strategies will assist in the pursuit of those goals. It is critical before a technology solution search begins that top management clearly articulates a comprehensive strategy that can be used to align the enterprise business vision, organizational goals and values, and information systems. The objective is to activate management team thinking about the development and communication of a coherent strategy detailing the expectations and anticipated opportunities. This strategy should include such elements as a clear definition of enterprise strategic priorities, organizational structure and values, operational implications, and appropriateness of the proposed SCM technology solutions to the culture and objectives of the firm.

Perhaps the most difficult task at this juncture is defining business objectives to be achieved by the implementation. Normally, firms begin a software search in response to problems occurring at two levels:

1. *Strategic objectives*. On this level, companies are searching for systems to provide solutions to broad enterprise problems regarding profitability, high costs, competitive positioning, sales and marketing objectives, products and services, financial capacities, and marketplace realities. These strategic problems influence the performance of the enterprise on the macro level and cut across all business functional areas. An example of a strategic objective would be increasing enterprise profitability by decreasing total logistics costs and increasing sales.

2. *Tactical objectives*. Solutions on this level are focused on increasing functional or business area performance and productivity. These objectives are attained either through automating activities or integrating members in a business area or group of business areas. Examples of tactical objectives would be decreasing transportation costs, reducing warehousing storage costs, increasing the speed of customer deliveries, and reducing the number of days accounts receivable outstanding.

Companies can reduce the risks involved in matching enterprise strategies with available SCM technologies by deploying the framework detailed in Figure 15.15 [28].

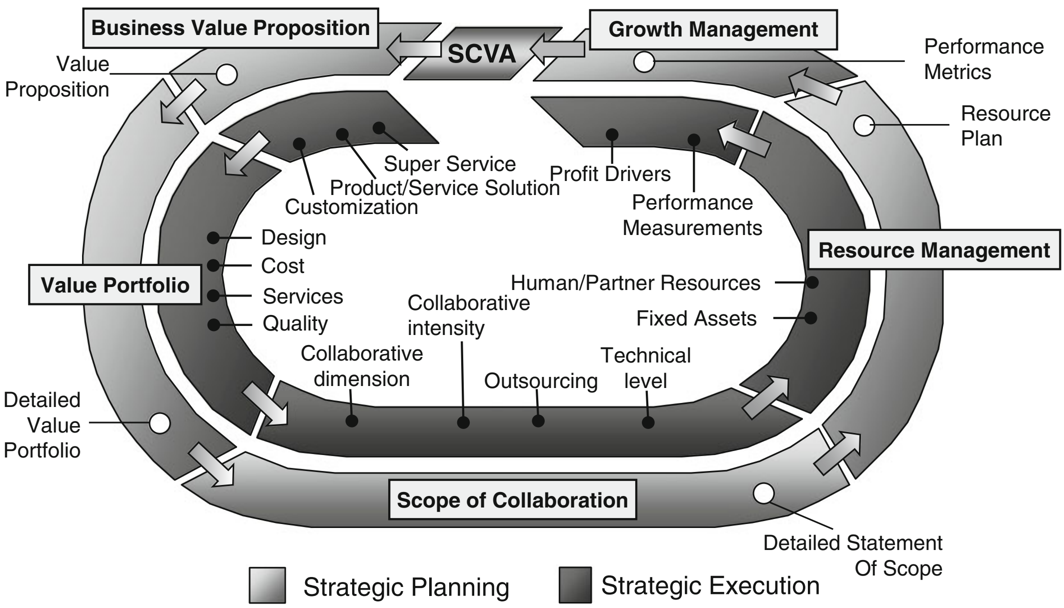


FIGURE 15.15 SCM technology strategy framework.

While a generic model, the SCM technology strategic framework offers a detailed roadmap that can assist planners to effectively execute their SCM technology selection, configuration, and implementation plans. The framework is portrayed as a never ending cycle where SCM technology architecture solutions and enterprise strategies are continuously reviewed and used as a source for current and future strategy/technology alignment. Also, the diagram shows that the framework consists of two interconnected flows, one focused on continuously driving *innovative strategic planning and thinking* and the other *strategic execution*. The value of the framework stems from the fact that by following sequentially the five sections implementers are provided a clear path to success.

- *Business Value Proposition*. The overall objective of this opening section in the framework is matching SCM technology enablers with the firm's *business value proposition*. The purpose is to determine how the range of SCM technologies being considered by the business will support the realization of the product/service value proposition the firm is offering to its customers. In this section planners will need to identify how the technology solutions match the firm's current product/service solutions and need for customization required by the marketplace. The milestone for this opening part of the strategic framework is a concise statement of the company's value proposition and which SCM technologies are to be selected for implementation.

- *Value Portfolio*. Most companies today are subject to ever shrinking product and service lifecycles. When selecting SCM technologies, planners must be careful to identify what products and services will be offered to the marketplace and how often they will change. For example, if products are moving toward increased customization, SCM technologies enabling rapid and easy customer configuration through make-to-order or assemble-to-order applications should be considered. If the strategy is to offer products to a global marketplace, sophisticated SCM applications should be considered. The milestone for this section is the *detailed value portfolio* were the product/service strategy is linked to the appropriate SCM technologies.
- *Scope of Collaboration*. This section of the SCM technology framework is focused on identifying the level of supply chain collaboration the business technologies must support. Key decisions to be made center on the level of *collaborative intensity* (arms-length, information sharing, and creating knowledge and new insights); the *complexity of technology networking capabilities* (non-Internet, visibility applications, direct server-to-server, or integrating inter-company processes at the applications level); and *outsourcing* of functions currently performed by the firm. The milestone at the end of this section should detail what levels of collaboration the enterprise wants and which technologies are to be implemented to realize collaboration objectives.
- *Resource management*. The enterprise's people, financial, and physical asset resources are defined as the repository of knowledge, skills, and productive capabilities found within an organization that result in the creation of products, technologies, systems, processes, and relationships. With the implementation of new SCM technologies, many of these functions will undergo deep changes, requiring enhanced learning and development. The resource milestone at the end of this section of the framework should consist of a catalog of the necessary knowledge, skills, and capabilities available to undertake the work of implementation and perform the new processes once the technologies have been deployed.
- *Growth management*. The last section in the SCM technology framework is concerned with developing the processes for continuous system and strategic alignment. This section consists of two processes. The first is the structuring of performance measurements and profit drivers that enable managers to gauge the actual level of enterprise performance stemming from the new technologies to the planned performance. The goal is to identify gaps resulting from poor technology usage or mismatch of actual processes and technology functionality. The second is the identification and prioritization of opportunities for applying technologies to meet new strategic challenges. The output of this process is the population of the *supply chain value assessment* (SCVA). Performing an effective SCVA is distilled into three fundamental steps.
    1. A collaborative team consisting of company and supply chain partners is formed. It is the responsibility of the team to identify company and supply chain business issues, prepare an 'as-is' model of competitive processes, and begin detailing new approaches to utilizing SCM technologies for competitive advantage.
    2. In the second step, the SCVA team breaks their findings down into *critical performance indicators* (KPIs) and supply network opportunities. As the broad outlines of possible SCM technology applications become apparent, the team

begins to investigate and detail solution approaches and concerns, obstacles and risks, and benchmarks to validate future performance.

3. In the third step, the SCVA team begins to match KPIs with proposed SCM technologies to determine such decision points as objective of the initiative, risk/return profiles, major risk factors, outcome metrics, value-adding processes affected, competencies required, and over-all impact on the organization and the supply chain. When the exercise is completed, both the firm and its supporting supply chain partners should be left with a detailed portfolio of possible SCM technology alternatives to select from.

15.7.2.2 Part 2: Selecting SCM Technology Solutions

Once a comprehensive technology strategy that matches the enterprise's business strategies and tactical objectives is formulated, the next task is to configure the appropriate business solution. Implementers have two basic alternatives in identifying and beginning the process of assembling the business system. The first is to develop the system configuration in-house using internal technical staffs who will undertake the programming and perform the configuration. There are a number of pros and cons to this approach. On the benefits side, the completed system will possess the functionality exactly fitted to the information and transaction requirements of the business. In addition, as changes to the business environment require system updates, local IT staffs can easily develop and retrofit programming code due to their grass-roots familiarity with the system.

There are a significant number of negatives to in-house development. Creating business systems applications and then stitching them together involves a great deal of time. Developing and executing an ERP or SCM project, for example, is a multiyear project that involves a tremendous commitment of organizational resources. In the end, the cost of development and implementation may far exceed the cost of purchasing and implementing a packaged system. Second, a significant danger encountered in in-house development projects is spending enormous resources on functionality that currently is available in commercial packages. Although in-house development will result in a system that has been custom-fitted to the needs of the organization, design teams may find themselves rediscovering all the mistakes that software suppliers made and solved years ago. Third, even the best run systems development project may not succeed in realizing the original business objectives. One of the benefits of a commercial package is that it can be seen in operation in existing customer sites. Finally, applications developed in-house reflect the requirements of the organization as it exists *today*. As time and the needs of the enterprise move forward, software that once answered business information requirements can become obsolete. In addition, home-grown software must be able to change to meet the rapidly developing technology environments of tomorrow.

The second method of acquiring a SCM business system is to purchase it from a software supplier. In today's marketplace there are literally hundreds of technology companies marketing products designed to service the special needs of every industry. They range from very small PC software companies offering low-cost products targeted at specific business needs, such as EDI and freight rating systems, to full-blown integrated manufacturing and distribution resource planning systems that also possess the ability to network with other systems. In today's technology environment, most of these suppliers offer applications that are based on open systems principles and are designed to work through Internet technologies without dependencies on proprietary hardware.

The advantage of using commercial software is the immediate availability of applications that are compliant with today's "best practices," state-of-the-art technologies, portability to migrate across hardware platforms and database management systems, and availability of maintenance, support, training, enhancements, and documentation. The disadvantages are the need to modify applications to fit internal processes or development of whole new functions not supported by the package; high cost of training and implementation due to the number of applications and complexity of functionality; and finally the trauma often experienced by ordinary system users and internal technology groups who must often learn new functionality, programming languages, networking, and system administration functions.

Exercise 15.1: SCM System ROI Analysis

As the SCM system project team begins the process of canvassing standard system vendors, it is essential that they engage in a ROI for the proposed project. The goal is simple: what type of improvement in sales and cost reductions can be expected with the new functionality provided by the system; what are the approximate costs of implementing the configured solution; how long will the organization have to wait to recover its expenditures on the new system; how are tangible and non-tangible benefits to be quantified. Table 15.2 provides a common, high-level analysis tool to chart a possible ROI. In the example, the software

TABLE 15.2. SCM Technology ROI

Number of employees	625		
Tangible benefits estimate	**Year Value**	**Percent**	**ROI Value**
Sales	$ 75,000,000	3.0%	$ 2,250,000
Inventory	$ 110,000,000	2.5%	$ 2,750,000
Inventory carrying cost	$ 22,000,000	1.5%	$ 330,000
Operations cost	$ 20,000,000	2.0%	$ 400,000
SG&A	$ 1,500,000	4.0%	$ 60,000
Distribution	$ 45,000,000	3.5%	$ 1,575,000
Procurement	$ 8,000,000	1.5%	$ 120,000
IT	$ 15,000,000	7.0%	$ 1,050,000
Labor	$ 55,000,000	2.5%	$ 1,375,000
Total annual benefit			$ 9,910,000
Intangible benefits estimate	**Current**	**Percent**	**Improvement**
Average on-time delivery %	75.0%	8.0%	83.00%
Average financial close time (days)	15	35.0%	5.25
Order fulfillment time (days)	12	30.0%	3.6
Credit authorization (days)	8	10.0%	0.8
Scm business system cost	**Low estimate**	**High estimate**	
Software license	$ 1,562,500	$ 2,062,500	
Project management	$ 3,500,000	$ 5,000,000	
Technical project management costs	$ 1,900,000	$ 2,400,000	
Misceleaneous costs	$ 700,000	$ 1,100,000	
Total costs	$ 7,662,500	$ 10,562,500	
Summary			
Return on investment	29.33%	–6.18%	
Payback period in # of years	0.77	1.07	

vendors contacted price the software by number of users. The lowest estimate received is US $2,500 per seat and the highest is US$3,800. The other system costs have been estimated. The tangible benefits have been estimated by taking their current value times the estimated percent improvement because of the new functionality. The intangible costs are not part of the ROI calculation.

The ROI is calculated as follows:

$$ROI = \frac{Total\ Benefits - Total\ Costs}{Total\ Costs} \times 100$$

The final activities in software selection revolve around live software demonstrations by the short-list vendors. Some consulting firms recommend the use of sophisticated checklists to compare vendors' applications with the firm's application and technology requirements. Effective "demos" consist of both application as well as technical demonstrations. Application demos will reveal such system attributes as easy of navigation, maintenance, entry, inquiry, and reporting. Technical demos should reveal system architecture and programming standards. Perhaps the most critical aspect of the demo process is positioning the firm's user base at the forefront of the process. Their acceptance and buy-in are the foundations of implementation success, and it should be their concerns and recommendations that are the determining factors in the final selection.

15.7.2.3 Part 3: Business Technologies Implementation

Once the technology solution is selected, the next step is system implementation. Many a top executive has assumed that most of the hard work in implementing a system ends with software selection and hardware installation. In reality, implementing a SCM business solution is one of the greatest challenges an enterprise can undertake. An implementation project requires a great deal of time, effort, and expense on the part of the company and all of its employees. Many times an implementation project is misperceived as purely a computer system and properly the responsibility of the firm's technology department. In reality, the promise of SCM technologies is found not just in streamlining business processes but in activating new repositories of information and networking that enable whole supply chains to achieve radically new opportunities for competitiveness. To be successful, the implementation should be considered as a formal management process consisting of the following project elements:

- Obtaining top management's commitment to the new system
- Developing a strategic plan detailing project scope and objectives
- Establishing a detailed and achievable project plan and budget
- Executing a full education plan and conference room pilot test of the software
- Defining and performing necessary modifications
- Conducting effective ongoing system performance measurements

An effective SCM business system implementation consists of four interwoven components: people resources; project control; computer hardware, software and data; and enterprise structure, policies, and procedures. The central requirement of a successful project is to keep these four elements on track as the organization moves toward successful implementation. In managing this process of alignment, project teams can utilize a number of management tools and techniques. Perhaps the most critical is the structuring and publishing of a comprehensive *project plan* and detailed *project schedule*. The project plan outlines the time lines, project milestones, costs, and resources. The project schedule consists of a detailed plan of all the phases, steps, and activities necessary to complete the implementation on time and within budget. The project schedule also time-sequences all implementation tasks, specifying start and completion dates, responsible roles for task execution, conflict resolution, change management, and the project budget.

The second essential project management component is the establishment of an effective project organization (Figure 15.16). It is the responsibility of the project organization to define the strategic objectives of the new SCM system, provide funding and enterprise resources, execute the project schedule, resolve project impasses, and review performance measurements. The project organization defines all project roles and organizational structures necessary to successfully execute the *project schedule*.

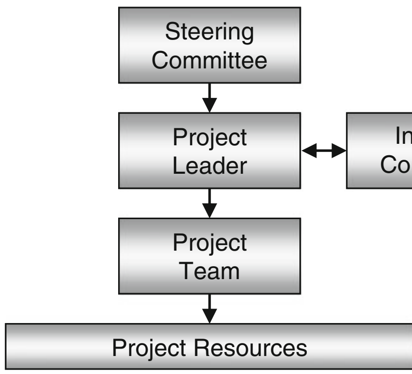


FIGURE 15.16 Implementation project organization.

The third component of an SCM technology project is the placement of *project milestones* at key junctures in the project's life cycle. The purpose of the project milestone is to provide the project organization with a measuring stick detailing implementation progress. Each milestone contains a set of activities, beginning and completion dates, and project roles. As each milestone is reached, the project organization should review completion of all tasks to be performed from the past milestone to the current milestone; the actual time to completion versus the planned completion times; costs incurred against the milestone project budget; conflicts, problems, and resolutions occurring during the milestone timeline; and new opportunities that surfaced as the project activities progressed. After review, the project schedule detailing activities, time lines, budgets, and resources necessary to reach the next milestone are defined.

The final component of a comprehensive SCM technology project is developing effective *project management skills and techniques* that will assist in assigning, executing, and evaluating the success of project resources in performing project activities and accomplishing tasks on time and within budget. Types of project management techniques include education and training, project tracking, interviewing, analysis, conceptual and technical design, development, and quality assurance.

15.7.2.4 Part 4: Continuous Improvement

After completion of Part 3 of the implementation framework and go-live with the configured SCM business system, everyone in the organization must understand that the continuous review and reinventing of the business solution through time is the new normal if the enterprise is to explore the use of new technologies and applications and the opportunities they provide for alternative avenues of competitive advantage. The availability of a business system does not automatically guarantee that the operational constituents will use it properly nor that it will activate an ongoing process of improvement and competitive advantage. In order to realize the full value of any technology system, implementers need to constantly reexamine and revise the current solution. As introduced earlier, driving continuous system improvement requires pursuit of the three fundamental processes of system implementation.

- *Alignment*. Although a particular SCM technology solution was chosen to respond to a particular portfolio of strategic business and tactical needs, companies can be assured that the original objectives will shift over time. Change can come from either the firm's strategic or operational sectors. A redirection of the enterprise's business mission, expansion in the distribution channel, or entry into international trade, may require an overall restructuring of the original business system. Just as important, shifting operational requirements may also require system modification. Such things as Internet technologies, interface with third-party applications, and the automation of activities previously performed manually will alter not only the way the system is currently being used but also the level of user mastery and the way the system is applied to enhance user performance.

  Finally, the need for realignment may emerge out of the technology environment itself. This need for realignment can be the result of continuous incremental changes or breakthroughs that permit the system to move to new technological levels. For example, incremental functional enhancements may provide constituents with new opportunities to eliminate costs, streamline processes, and improve information throughput. On the other hand, advancements in technology, such as the migration of business applications to a cloud-computing network, may provide new information technology vistas or even obsolete current systems.
- *User Commitment and Ownership*. Ideally, the commitment to and ownership of the business system on the part of the user constituency should have been gained during Part 2 of the implementation framework and strengthened during Part 3 with the final design and implementation of a solution that fulfills the needs of users and other stakeholders. In Part 4 of the implementation framework, management must seek to confirm and extend this commitment and ownership.

  SCM business system implementations are always characterized by a spectrum of user support. In most projects, support for the solution proceeds essentially through two stages. In the first, found during the execution of Part 3, the user constituency is often divided into three groups: those who are *committed* to the new system, the mass of the users who are *uncommitted* with a "wait and see" attitude, and a small percentage of *nay-sayers* who feel the initiative will be a failure. By the time Part 4 of the implementation framework is reached, this original division should be dramatically altered. The majority of users should be fully committed and prepared to take ownership of the system. *Naysayers* should have completely disappeared. The ability of management to continually expand system commitment and ownership becomes especially important as incremental and technological advancements change original system objectives and the social contract between the user constituency and the enterprise.

- *User Competency and Mastery*. Earlier in this chapter it was stated that as the functionality of the SCM business system becomes more robust, the knowledge and flexibility required of the user constituency to effectively utilize it grows exponentially. With this fact in mind, the critical question then becomes, "*How can system users develop and expand system competency so that it is operationally aligned, progressively owned, and increasing mastered?*" During Part 3 of the implementation framework, users should have been closely involved in system definition, exploration of system capabilities, and assessment of potential system results, as well as determining regions for user learning and self-management. In Part 4 of the implementation framework, managers must be careful to develop metrics illustrating the *skills gap* between the user constituency and the operational requirements and potentialities of the new system. The goal is to close this gap by illuminating the alignment between the system and the business vision, ongoing training and education, performance measurement systems, encouragement of user innovation, and participation in system functional evolution. This developmental process is detailed in Figure 15.17.

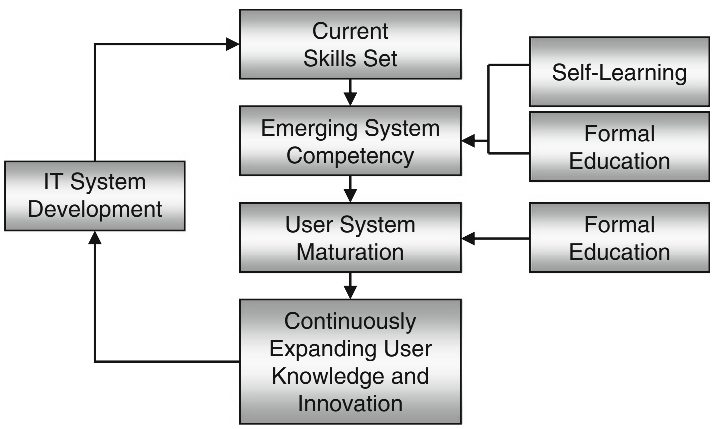


FIGURE 15.17 Developing system mastery and competence.

Regardless of the complexity of a given technology solution, implementers must continually realign technology and the enterprise's strategic and operational objectives. Walton [29] has proposed an iterative process for ensuring the alignment of IT and business requirements. As illustrated in Figure 15.18, the process consists of three elements.

In the first, *design/redesign*, implementers configure systems that are in alignment with business realities and enterprise strategic and operational goals. Once designed, the IT system enters the *introduce/operate/institutionalize* phase. In this phase, the solution is applied to the business environment. Because no system design can be considered as definitive, current design must continually be under a process of *evaluation/reevaluation*. This process occurs because of changes to technology, enhancement to system functionality,

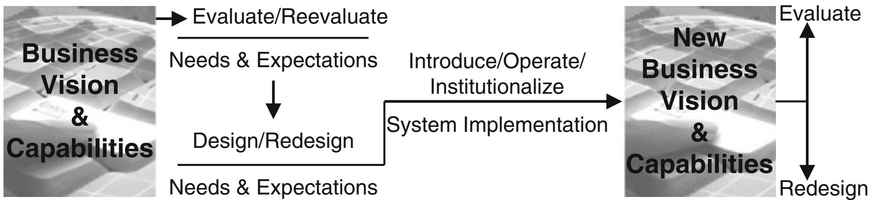


FIGURE 15.18 Business system development process.

or even rising user expectations concerning system capabilities. Figure 15.18 is meant to illustrate both the iterative nature of Part 4 of the implementation framework, as well as the objective of attaining ever-expanding business system results.

15.8 SUMMARY

The advent of information technologies has caused a virtual revolution in the concept and practice of supply chain management. In today's business climate, the importance of timely, accurate, and complete information has increasingly become an important enabler of marketplace advantage. *Internally*, information technologies enable companies to develop databases and implement applications that provide for the efficient management of transactions and the timely collection, analysis, and generation of information about customers, processes, products, and markets necessary for effective decision making. *Externally*, information technologies enable enterprises to architect channel boundary-spanning networks that are collaborative, agile, scalable, fast flow, and Web-enabled. Actualizing the potential of today's technologies require companies to move beyond viewing technology as purely a tool for *automating* business functions. The real value of information technology is found in its ability to enable integration and networking between channel trading partners that provide for revolutionary capabilities and competencies for the generation of new products and services, whole new businesses and marketplaces, and radically new forms of competitive advantage.

The ability to leverage the power of information technologies requires a detailed knowledge of basic technology architectures as well as a thorough grounding in the principles of modern system management. Today's system architectures consist of five basic elements: the *database* (the static and transactional data captured during system processing); *transaction management* (the performance and recording of daily operations); *management control* (the performance feedback necessary for purposeful planning); *decision analysis/simulation* (the use of modeling tools to manage complex processes); and *strategic planning* (the development of long-term forecasts, market approaches, and business partner alliances). Effectively utilizing these general system features requires a firm grasp of the seven principles of system management: *accountability* for the entry, maintenance, quality, and integrity of data; *transparency* as to how the system works and is applied to practical business problems; *accessibility* to data and retrieval utilities for reporting and decision making; a *valid simulation* of the way the business actually works; *flexibility* to perform transactions or manipulate data; and the capability to use system exception messaging for the *planning* and *control* of business management processes.

A critical characteristic of today's enterprise business software is its ability to be configured to meet any particular industry or specific business requirement. The goal of the system architecture is to facilitate, either through existing application suites or through software vendors, the creation of scalable, highly flexible information enablers that provide the business with the capability to respond with customized customer value solutions and collaborative relationships at all points in the supply channel network. The configured system must be capable of encompassing three possible solutions. The first is concerned with solutions that integrate the *internal* data and processes of the enterprise. The second is concerned with the availability of networking tools necessary to link *external* parts of the enterprise together. Finally, the technology solution must link the business with the customers and suppliers constituting the supply chain network.

When exploring the application of SCM technology solutions, implementers must ask several critical questions focused on determining the optimal alignment of information tools and expected increases in enterprise productivity and serviceability. Perhaps the most critical decision made at the beginning of the technology search is clearly defining the scope of the business problems to be solved. Successfully completing this step will narrow the range of possible technology solutions and ensure the effort is focused on core business issues. Equally as important is charting the effect the technology will have on the organization and its capabilities. In fact, the more encompassing the implementation, the more robust are the requirements for learning and change management necessary to utilize the solution.

This alignment of the organization with the proposed technology solution impacts the enterprise in three ways. To begin with, the integrative capabilities of today's SCM business systems require implementers to restructure the culture and capabilities of their organizations to promote values fostering continuous improvement and teamwork. Second, SCM systems enable the organization not only to rethink traditional enterprise information flows but also to leverage new tools such as graphics, workstation technologies, and Internet-driven network-to-network computer integration. Finally, the effective application of new information technologies requires a redefinition of the goals and skills of the enterprise's people resources.

In addition to orchestrating changes to organizational structure and cultural fabrics, implementers must also apply a detailed methodology designed to guide them successfully through the entire project from technology solution search to the implementation. Four steps are recommended. In the first, project managers use a five-step framework that identifies the company's strategic directions and what SCM technologies would best serve the firm's value proposition and portfolio. The second phase of the methodology encompasses the technology search process, culminating in the selection of the optimal solution. There are two possible avenues that can be pursued: legacy software is enhanced to meet new enterprise information requirements, or a totally new software system is purchased. In phase three, the new information system is introduced, users trained, the software tested, modifications performed, and the configured system implemented.

In the final phase, a program targeted at continuous improvement in organizational capabilities and identifying new technology tools is initiated. By far, of the four phases of the methodology, the greatest challenges to the organization will be found in planning and controlling the implementation processes found in phase three. Successful technology projects occur when implementers create a functional project organization and run the project according to a detailed project plan and budget.

DISCUSSION QUESTIONS

1. It has been said that information technologies are one of the most important drivers of SCM. Explain why this is so.
2. What are the three concepts of human knowledge available with today's information technology?
3. What are the difference between computerized connectivity and interfacing and computer networking?
4. Briefly describe the four basic components of technology architecture.
5. What are the five basic functions of information systems?
6. What are the seven principles of effective system management?
7. What are some of the tactical and operational objectives expected when applying information technology to the supply chain?
8. What are some of the *networking* applications available that users can add to the supply chain management core and advanced process applications.
9. What are the range of technology configuration choices available to companies as they investigate SCM business system selection?
10. What are the benefits to organizations engaged in e-business connectivity?

REFERENCES

1. Laney, Doug. 2013. Infonomics: The new economics of information. *Financial Times*, 12 Sept 2013 found at http://www.ft.com/cms/s/0/205ddf5c-1bf0-11e3-b678-00144feab7de.html.
2. Some of the concepts in this section are abstracted from Ross, David Frederick. 2011. *Introduction to supply chain management technologies*, 2nd ed, 37–41. Boca Raton: CRC Press.
3. The term "computer" is used here in its widest possible definition and includes everything from *personal digital assistants* (PDA), to notebooks, tablets, smart-phones, and desktops, to minicomputers, mainframe computers, and supercomputers.
4. See the discussion in Zuboff, Shoshana. 1988. *In the age of the smart machine*, 10. New York: Basic Books.
5. Ibid., 9.
6. Ibid., 10.
7. The debate about the impact of information technology is by no means dead. In a revealing study produced by the Pew Research Center, termed *The Internet of Things Will Thrive by 2025,* (May 2014), states that the rise of embedded and wearable computing will bring the next revolution in digital technology. Experts felt that the upsides are enhanced health, convenience, productivity, safety, and vastly more useful information for people and organizations. The downsides were also listed as challenges to personal privacy, over-hyped expectations, and tech complexity that will frustrate and render us immobile.
8. Parts of this section have been adapted from Ross, *Introduction to supply chain management technologies*, 41–53.
9. For a detailed discussion of database management concepts see Haag, Stephen, Paige Baltzan, and Amy Philips. 2006. *Business driven technology*, 61–66. New York: McGraw-Hill-Irwin.
10. These four points have been adapted from the IBM Whitepaper "The Information Agenda: Rapidly Leveraging Information as a Trusted Strategic Asset for Competitive Advantage" found at ftp://ftp.software.ibm.com/software/data/pubs/papers/info-agenda-wp.pdf.
11. Ibid.
12. There are many descriptions of what constitutes an effective enterprise business system. One of the earliest and most important is Wight, Oliver W. 1982. *Manufacturing resource planning: MRPII*, 100–106. Essex Junction: Oliver Wight Limited Publications, Inc.
13. This list is adapted from IBM's cloud offering appearing in Ward, Thomas, and Vasanthi Gopal. 2014. How they did it: Moving IBM's smarter supply chain to the cloud. *Supply Chain Management Review* 18(2): 29.
14. References for this section are Bentz, Brooks. 2014. Supply chain control towers help organizations respond to new pressures. *Supply Chain Management Review* 18(4): 34–39 and Capgemini Consulting. 2015. *Global supply chain control towers*, accessed http://www.capgemini-consulting.com/resource-file-access/resource/pdf/Global_Supply_Chain_Control_Towers.pdf.
15. These four points are derived from Haag, Stephan et al., 120–121.
16. This figure is adapted from Ross, *Introduction to supply chain management technologies*, 85.
17. Trebilcock, Bob. 2014. Top 20 supply chain management software suppliers. *Modern Materials Handling* 69(7): 28–33.
18. Porter, Michael E., and Victor E. Millar. 1985. How information gives you competitive advantage. *Harvard Business Review* 63(4): 148–152.
19. This figure is adapted and updated from Gopal, Christopher, and Harold Cypress. 1993. *Integrated distribution management*, 153. Homewood: Business One Irwin.
20. Trebilcock, Bob. 2014. Top 20 supply chain management software suppliers. *Modern Materials Handling* 69(7): 28.

21. Chaffey, Dave. 2007. *E-business and E-commerce management*, 573. New York: Prentice Hall.
22. Further discussion of these four models is found in Haag, Stephen et al., 310–319.
23. For a more in depth analysis of the evolution of Internet business see Ross, *Introduction to supply chain management technologies*, 95–109.
24. These benefits have been summarized from Ibid., 108–109.
25. Chopra, Sunil, and Peter Meindl. 2010. *Supply chain management: Strategy, planning, and operation*, 4th ed, 86–99. Boston: Prentice Hall.
26. Panorama Consulting Solutions. 2014. *2014 ERP report*, 3. Denver: Panorama Consulting Group. For link see http://Panorama-Consulting.com/resource-center/2014-erp-report/.
27. Walton, Richard E. 1989. *Up and running: Integrating information technology and the organization*, 205–218. Boston: Harvard Business School Press.
28. The section is based on Ross, *Introduction to supply chain management technologies*, 356–381.
29. Walton, Richard E. 1989. *Up and running: Integrating information technology and the organization*, 154–155. Boston: Harvard Business School Press.

INDEX

D.F. Ross, *Distribution Planning and Control: Managing in the Era of Supply Chain Management*,
DOI 10.1007/978-1-4899-7578-2,