MANAGING OPERATIONAL RISK

Practical Strategies to Identify and Mitigate Operational Risk within Financial Institutions

DOUGLAS ROBERTSON

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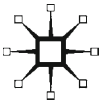

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Softcover reprint of the hardcover 1st edition 2016 978-1-137-44215-4

First published 2016 by
PALGRAVE MACMILLAN

Palgrave Macmillan in the UK is an imprint of Macmillan Publishers Limited, registered in England, company number 785998, of Houndmills, Basingstoke, Hampshire, RG21 6XS.

Palgrave Macmillan in the US is a division of Nature America, Inc., One New York Plaza, Suite 4500, New York, NY 10004-1562.

Palgrave Macmillan is the global academic imprint of the above companies and has companies and representatives throughout the world.

ISBN 978-1-349-56569-6 ISBN 978-1-137-44217-8 (eBook)
DOI 10.1007/978-1-137-44217-8

Distribution in the UK, Europe and the rest of the world is by Palgrave Macmillan®, a division of Macmillan Publishers Limited, registered in England, company number 785998, of Houndmills, Basingstoke, Hampshire RG21 6XS.

Library of Congress Cataloging-in-Publication Data

Robertson, Douglas D.
Managing operational risk : practical strategies to identify and mitigate operational risk within financial institutions / Douglas Robertson.
pages cm
Includes bibliographical references and index.

1. Financial institutions—Risk management. 2. Banks and banking—Risk management. 3. Auditing, Internal. I. Title.

HG173.R57 2015
332.1068′1—dc23 2015019820

A catalogue record for the book is available from the British Library.

To Laura and Mariana

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Acknowledgments

I would like to thank Leila Campoli and Brian Foster for first suggesting that a working paper from an obscure government regulatory agency might have the makings for a book. I would also like to thank Laurie Harting, Bradley Showalter, and Marcus Ballenger of Palgrave Macmillan for patiently helping that transformation take place, and Kristy Lilas and Meenakshi Venkat for excellent editorial assistance. Much of chapter 3 of this book originally appeared as Economics Working Paper 2011–1, March 2011, US Office of the Comptroller of the Currency (OCC). I would like to thank Oliver Berndt, Mike Carhill, Mark Levonian, Rebecca Miller, David Nebhut, Morey Rothberg, Desiree Schaan, Sherrill Shaffer, Kostas Tzioumis, Gary Whalen, and seminar participants at the Eastern Finance Association and Southern Finance Association for helpful comments and suggestions on that working paper. I wrote this book while employed as a Senior Financial Economist and Lead Expert for Regulatory Analysis at the OCC. I would like to thank Roger Tufts for comments on the manuscript. The views expressed in this book are solely those of the author and do not necessarily reflect those of the OCC or the US Department of the Treasury.

Acronyms

ABS	Asset-Backed Securities
AIG	American International Group
AMA	Advanced Measurement Approaches
AML	Anti–Money Laundering
ARM	Adjustable Rate Mortgage
BSA	Bank Secrecy Act
CDO	Collateralized Debt Obligations
CDS	Credit Default Swaps
DMAIC	Defining, Measuring, Analyzing, Improving, and Controlling
DTI	Debt-to-Income
EIC	Examiner-in-Charge
FDIC	Federal Deposit Insurance Corporation
FICO	Fair Isaac Corporation
GAO	Government Accountability Office
ISDA	International Swaps and Derivatives Association
LTV	Loan-to-Value
MRA	Matters Requiring Attention
NRSRO	Nationally Recognized Statistical Rating Organization
OCC	Office of the Comptroller of the Currency
OFAC	Office of Foreign Assets Control
P&L	Profit and Loss
RMBS	Residential Mortgage-Backed Securities
SAR	Suspicious Activity Report
SCP	Synthetic Credit Portfolio
SEC	Securities and Exchange Commission

SIV	Structured Investment Vehicle
SPV	Special-purpose Vehicle
TALF	Term Asset-Backed Securities Loan Facility
UOM	Units of Measure
VaR	Value-at-Risk

1
Introduction to Operational Risk

The working definition of "operational risk" among financial institutions is the risk of loss from inadequate or failed internal processes, people, and systems or from external events.[1] Practically speaking, operational risk is the risk of loss from problems such as human error, system failures, and bad weather—to name a few of the many almost-inherent business complications that qualify as operational risks. Operational risk is just a relatively new term for some very old risks like fraud and embezzlement, and some newer risks like cybercrime and computer system failures.

Operational risks come in many forms and can cause losses of almost any size. The losses can be insignificantly small or large enough to destroy an institution almost overnight. Just as the term "operational risk" is relatively new, the methods and strategies for managing it are similarly new and still developing. To date, these operational risk management strategies have primarily involved measuring past operational risks and allocating capital to meet minimum regulatory capital requirements and, if possible, purchasing insurance or some other risk-transfer product. The objective of this book is to introduce and encourage the use of a third tool to identify, manage, and control operational risk, namely, quality assurance inspections. There is nothing new about the quality assurance

inspection methods themselves—they come directly from the auditor's well-worn toolkit—but their incorporation into the playbook for managing operational risk would open a crucial new front in the escalating battle against costly, destabilizing, and often destructive operational risks.

Any organization can apply quality inspection methods to any operational risk, with the likely exception of external events such as earthquakes and floods. Whereas contingency planning and drills are generally the best means for managing the risks posed by external events, quality inspection methods are more applicable to the other three sources of operational risk: processes, people, and systems. Processes, people, and systems are also inputs into an organization's production process, which yields products or services. If those three inputs are working well, then the quality of the final product or service will usually be the best the organization has to offer. If any of these inputs are performing inadequately, that is, they pose an operational risk, then the quality of the final product or service is likely to suffer, which in turn could damage the institution's reputation and profitability and thereby weaken its long-term outlook.

In this book, we examine several instances of operational failures in financial institutions that had severe consequences for the institutions involved. Because financial markets inextricably link many financial institutions to one another, we'll see how operational risks within one institution can quickly affect entire financial markets and even the regulatory agencies responsible for overseeing those institutions and markets. Our first example of such an infectious operational risk, which we consider in detail in chapter 3, originated in the US mortgage market in the early 2000s and led to the sequence of events that became the Great Recession. What was the operational risk that initiated the avalanche of losses that created

a crisis in credit markets and rapidly spilled into the broader US and global economies? It was an operational risk known as bad lending, but before we explore that operational risk in detail and explain why it is an operational risk problem rather than a credit risk problem, we need some additional background information on operational risks in general: the various types of operational risks, their characteristics, and the three fundamental ways to manage them.

Types and characteristics of operational risk

Although the specific operational risks with which any financial institution must contend will usually differ from one institution to the next, the operational risks across institutions are generally similar. Because a complete list of potential operational risks would be enormous and constantly growing longer as new products and product platforms emerge in the financial sector, a necessary first step in operational risk management is to sort operational risks into several broad categories. In addition to organizing an unwieldy area of risk management, categorizing operational risks will also help with subsequent risk measurement and resource allocation decisions.

There are several ways to think about categorizing operational risks. One way financial institutions often categorize operational risks is by sorting them according to the frequency and severity of losses attributed to the risk. It is common to subdivide both frequency and severity into low and high subcategories, which produces a simple 2-by-2 matrix, as shown in table 1.1. Distinguishing between low and high losses causes the operational risks to fall into one of four frequency/severity categories: low-frequency and low-severity risks, low-frequency and high-severity risks, high-frequency

Table 1.1 A 2-by-2 Operational Risk Matrix

		Severity of Loss	
		Low	High
Frequency of Loss	Low	Least Concern	High Concern
	High	High Concern	Greatest Concern

Source: Author.

and low-severity risks, and high-frequency and high-severity risks. As the degrees of concern shown in table 1.1 suggest, operational risks of low severity and frequency are generally of little concern to an institution. If, however, a business line introduces operational risks that are high frequency and high severity, then most institutions may want to avoid that business line.

Although the high and low distinction may be a useful simplification, it is important to remember that the frequency and severity categories actually reflect much broader and more continuous spectrums. For instance, the frequency spectrum can be subdivided into annual, monthly, weekly, daily, and even hourly categories. Indeed, as Michael Lewis, the author of several books illuminating the complex inner workings of financial markets, informs us, for high-frequency trading activities, the relevant frequency spectrum now extends into nanoseconds.[2] Similarly, the severity spectrum reflects dollar amounts of each loss, so operational risk managers could subdivide loss severity ranges into specific dollar amounts, for example, less than $10, $10–$100, $100–$1,000, and so on. Combining specific dollar amounts with specific frequencies would immediately help operational risk managers convey additional information about the extent of a particular operational risk exposure. For instance, consider the additional information conveyed in describing an operational risk as

leading to losses of less than $10 several times per month compared to saying an operational risk is a low-frequency/low-severity risk. Being specific about the dollar amounts associated with risks can help each institution determine the difference between low severity and high severity and show that what might be a low-severity event for a large bank could be a high-severity event for a small bank.

Regulatory reporting requirements for operational risks in the United States currently only apply to large banks. These reporting requirements look at seven loss-amount categories ranging from less than $10,000 to $1 billion or more.[3] This level of detail, of course, would result in a matrix that is much larger than a 2-by-2 matrix, so for discussion purposes the low/high distinction is useful.

In addition to classifications based on frequency and severity, we can also distinguish operational risks in terms of whether they originate internally or externally and whether the risk reflects an action that is intentional or unintentional. The author and professor Christopher Marshall has written an extremely useful overview of how financial institutions can measure and manage operational risks.[4] Much of this book applies the fundamental approach to identifying operational risk that Marshall describes. In discussing different characteristics of operational risks, Marshall also points out that another important distinction is whether the operational risk is controllable or uncontrollable. According to Marshall, an operational risk is controllable if an organization is able to prevent a loss or mitigate the risk. The proactive risk mitigation strategies described in chapters 3 and 4 are especially applicable to an institution's internal controllable operational risks. Whether those internal and controllable operational risks are intentional or unintentional is of less importance, and the frequency and severity of the operational risks will depend a great deal on the rigor with which

the financial institution applies those risk mitigation strategies. Overall, where a particular operational risk falls in terms of these various categories will often determine the appropriate risk management approach, the appropriate number of resources to dedicate to resolving the problem, and, therefore, the ultimate outcome for the institution.

Catastrophic operational risks

From a management perspective, perhaps one of the most important categorical distinctions for operational risks is between potentially catastrophic and noncatastrophic risks. A catastrophic operational risk is one that exposes the company to a loss so severe that it threatens the viability of the entire company. Many operational risks result in operational failures that occur on a small scale every day, that is, they are high frequency but low severity, and financial institutions tend to be familiar with these risks and are able to manage them with little or no incident. Occasionally, however, operational risks that lead to losses of $1 billion or more can explode onto the scene with dramatic and devastating effect. Many of these more dramatic and highly publicized examples of operational risk involve losses related to unauthorized trading. For example, unauthorized trading led to losses of approximately $1.3 billion by Barings Bank in 1995, $2.6 billion by Sumitomo Corporation in 1996, over $7 billion by Société Générale in 2008, and $2 billion by UBS in 2011. Trading losses were also responsible for JPMorgan Chase's $6 billion loss related to the London Whale events.

In an effort to help banks and their supervisors establish procedures for coping with operational risk, the Basel Committee on Banking Supervision (Basel Committee) created another means of categorizing operational risks by establishing seven broad types of operational risks for data-collection purposes.

Table 1.2 Operational Loss-Event Types

Event-Type Category	Definition
Internal Fraud	Losses resulting from an act involving at least one internal party of a type intended to defraud, misappropriate property, or circumvent regulations, the law, or company policy, excluding diversity- and discrimination-type events
External Fraud	Losses resulting from an act by a third party of a type intended to defraud, misappropriate property, or circumvent the law
Employment Practices and Workplace Safety	Losses resulting from an act inconsistent with employment, health, or safety laws or agreements, payment of personal injury claims, or payment arising from diversity- and discrimination-type events
Clients, Products, and Business Practices	Losses arising from the nature or design of a product or from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements)
Damage to Physical Assets	Losses resulting from the loss of or damage to physical assets from natural disaster or other events
Business Disruption and System Failures	Losses resulting from disruption of business or system failures
Execution, Delivery, and Process Management	Losses resulting from failed transaction processing or process management or losses arising from relations with trade counterparties and vendors

Source: Definitions from "Risk-Based Capital Standards: Advanced Capital Adequacy Framework—Basel II," *Federal Register*, Vol. 72, No. 235, Friday, December 7, 2007, 69402–3.

These seven operational risk event types, shown in table 1.2, include internal and external fraud, business products and practices, and business disruptions.

The operational risk categories established by the Basel Committee are useful for tracking operational risk events within and across organizations. Consistent measures allow for comparisons across organizations, which helps banking supervisors monitor a dynamic problem in a constantly changing financial marketplace. Comparable historical operational risk data also help senior bank management put their own operational risk experiences into context vis-à-vis their peers.

To better understand the types of operational risk and the characteristics of losses associated with it, the Basel Committee conducted a loss data collection exercise for operational risk in 2008.[5] This study surveyed operational risk losses over several years from 121 banks in 17 countries. Together, these banks reported 10.6 million operational risk events resulting in over $94 billion in losses. Because the banks surveyed often only reported losses over a certain dollar threshold, these already-large numbers for just 121 banks reflect truncated data, thus understating the total operational losses at these institutions and vastly understating global operational losses in the financial sector.

In spite of its shortcomings related to truncated data collection, the loss data collection exercise makes important contributions to our basic understanding of operational risk. In terms of frequency and severity, the report suggests that within financial institutions, retail banking, retail brokerage, and trading and sales are the three business lines with the greatest number of reported operational losses. The report also indicates that retail banking, corporate finance, and trading and sales are the three business lines with the largest annual losses. The aggregate number of events and the extent of the losses across the different countries participating in

the exercise show that operational risk is a frequent and global problem that can result in losses ranging from very small to devastatingly large. Thus, it is not surprising to find that operational risk has joined the pantheon of critical risks that financial institutions must manage well in order to survive. This risk pantheon now includes credit risk, market risk, interest rate risk, liquidity risk, enterprise risk, reputation risk, and operational risk, among others.

While operational risk shares this business-critical status with other risks, it also presents unique characteristics that make managing operational risk uniquely challenging. In particular, if left uncorrected, an operational failure can start to generate other risks, such as credit risk and market risk. The relationship between operational risk and credit risk played a major role in the 2007–2009 mortgage-backed securities crisis. Because operational risk relates to system failures, a failure in a bank's underwriting system can effectively automate the creation of unexpected credit risk. Similarly, a failure in a bank's trading system, including the failure to detect unauthorized trading, can lead to the creation of unexpected market risk. For the most part, the reverse is not true. Whereas operational risk can create credit risk, the presence of credit risk will generally not produce operational risk, though it is possible for a large credit loss to cause cutbacks and shortcuts that could in turn create new operational risks.

The dynamic nature of operational risk poses other challenges as well. Again, because operational risk includes failed or inadequate systems, when a financial institution introduces a new system for a new product or service, it also introduces a new potential operational risk associated with that new system. If left uncorrected, what may start off as small losses associated with that product or service can accumulate and result in potentially large or even catastrophic losses.

This tendency for some operational risks to accumulate into catastrophic losses is another characteristic that makes the proper management of operational risk such an important function for a financial institution's risk management team. While the amount of credit risk is generally limited to the amount of the credit exposure, operational risks typically lack such a natural upper limit. For example, data-processing errors could result in errors of a few pennies or in substantially larger losses. For instance, the Basel Committee's 2008 loss data collection scenario exercise reports that the maximum loss amount linked to a data-entry error in payment and settlement was €330 million, or roughly $520 million.

Operational risk is a pervasive problem that can ruin any institution, large or small, bank or nonbank. While this book focuses on operational risk within financial institutions, operational risk managers in any organization should pay attention to operational failures occurring in other businesses to incorporate valuable lessons. For instance, operational problems in the retail sector related to hacking and identity theft are but one step removed from the payment system and financial institutions.

Operational risk is a problem for financial institutions of all sizes. Although the size of an operational risk exposure is usually related to firm size, the presence of an exposure to operational risk is generally linked to a business activity rather than being a function of a firm's size. Thus, small banks are subject to the same operational risks as large banks if they engage in the same business activities. Strategic decisions to avoid particular business lines will accordingly limit a small bank's exposure to certain operational risks. For instance, according to year-end 2013 data from the Federal Deposit Insurance Corporation (FDIC), most small banks in the United States do not hold derivatives or engage in securitization activities.

Only 15 percent of FDIC-insured institutions with total assets under $1 billion reported holding derivatives, whereas 93 percent of banks with assets greater than $10 billion reported derivatives. Only 1 percent of small banks reported securitization activity, compared to 31 percent of the large banks.[6] Thus, smaller banks tend to face few operational risks from trading derivatives or engaging in securitization activities.

Although limited activities will similarly limit small banks' exposure to operational risks associated with those activities, there are still plenty of operational risks that threaten banks of any size. Recall that the Basel Committee's 2008 loss data collection exercise indicated that retail banking ranked first among business lines for the frequency of operational losses and the total number of operational losses. Retail banking, of course, is usually the principal business of small banks. A 2003 Joint Forum report also points out that increasing institutional complexity can foster operational risk, and automation just replaces one set of operational risks associated with human error with another set of operational risks associated with system errors and system failures.[7]

While the operational risks that threaten small banks also threaten large banks, large banks typically encounter additional operational risks because of their size, their broad range of activities, and their complexity. Because operational risk involves failed processes, people, or systems, the more people, processes, and systems an institution employs, the greater the potential for operational risks. Similarly, because complex systems behave and can fail in complex ways, as an institution becomes more complex, exposure to operational risk tends to increase with that complexity.

Increased institutional size and complexity not only increase the exposure to operational risk of the institutions themselves, they also increase the operational risk exposure

of the government agencies charged with their supervision. In the case of banking, because maintaining the safety and soundness of supervised institutions is one of the mission goals of bank regulatory agencies, failure to identify operational risks that ultimately undermine bank safety and soundness is also of great concern to the regulatory agency, especially with respect to catastrophic operational failures. As we explore in chapter 5, problems at two banks that caught the attention of the United States Senate Permanent Subcommittee on Investigations, JPMorgan Chase and HSBC, are two relatively recent examples of operational failures at banks that also exposed operational problems at the regulatory agency responsible for their supervision. Operational risk threatens any organization with people and systems, which, of course includes government agencies, so banks and bank regulators must actively manage operational risk within their respective organizations.

Bank size and complexity are two important factors contributing to increased operational risks, but other factors contribute as well. Marshall cites several factors that are making operational risk an increasing threat and thus helping operational risk receive greater attention from financial institutions and their regulatory supervisors. He points out that operations are changing within an institution more frequently because of (1) changing markets, (2) changing products and services, (3) changing technologies and techniques, and (4) more frequent external events. Marshall's list of contributing factors from 2001 continues to be relevant today. Changing markets continue to reflect not only ongoing globalization, but also increasing competition from the generally less-regulated shadow banking system. A system that may be less regulated is certainly no less susceptible to operational risk, as we'll see clearly in chapter 3. In a study from the Wharton School in Philadelphia and the Hartford Insurance Group, David Cummins, Christopher Lewis, and Ran Wei describe how losses

from operational risks affect the market value of banks and insurers. They echo Marshall and suggest several additional factors that have increased the prevalence of operational risk.[8] They suggest that beyond the growing size and complexity of individual institutions, which they see as growing out of the consolidation of the banking industry, globalization, increased reliance on computer systems and e-banking, and expansion of interbank activities have all increased operational risks and the attention operational risk management receives.

The expansion of interbank activity not only increases operational risks because of the added complexity typically associated with those arrangements, but also increases correlation across institutions and thus systemic risk problems tied to operational risk. In the absence of interbank activity, a catastrophic operational failure at one institution would affect only that institution. In the presence of interbank activity, however, a catastrophic loss at one institution could transmit at least a portion of that loss to other banks participating in the shared activity where the loss occurred. For example, the fallout from the catastrophic trading loss that led to the failure of Barings Bank was almost exclusively limited to Barings itself. In contrast, the operational failures connected to the securitization of subprime mortgages sent catastrophic shockwaves throughout the financial sector and deep into the broader macroeconomic environment.

The fallout from an operational failure can spread from one financial institution to another through shared activities and through shared assets. Activities such as asset securitization, investing in tranches, buying protection, and selling protection provide a means to transfer risk rather than eliminate it. Consequently, these risk-transfer mechanisms tend to spread the exposure to operational risk throughout the financial system. As pointed out in the report by the Joint Forum in 2003,

risk transfer across financial sectors merely raises a new set of supervisory issues tied to monitoring and managing dynamic operational risks.[9] These supervisory issues include ensuring sound management of the entities taking on the risk, and monitoring for the possibility of increasing risk concentrations at these institutions. Such concerns announced in 2003 almost perfectly anticipated the collapse of the insurance company American International Group (AIG) five years later. Although the collapse of AIG is usually thought of as a failure to manage credit risk, lack of adequate systems to accurately measure any risk is, in turn, an operational risk.

The first example of a catastrophic operational risk studied here involves bad lending and related problems in the securitization production chain that directly contributed to the severity of the subprime financial crisis. The crisis that began in the US subprime mortgage market in late 2006 was in part a consequence of cascading operational failures linked to the securitization process. In that crisis, operational risks, including negligent underwriting standards, mortgage fraud, and failed due diligence, combined with modern finance to initiate a catastrophic crisis in financial markets and a painful recession. For example, the operational risks we follow through the securitization process in chapter 3 include inadequate or failed verification of loan application information, misrepresentation, and inadequate internal controls.

Operational risk management procedures

As with any risk, properly addressing operational risk requires a risk-management process consisting of several steps, from identification of the potential problem to actively removing or reducing the threat.[10] The first step in any risk-management process is simply recognizing that there may be a risk. For many credit risks, market risks, and operational risks that take

familiar shapes, such as settlement errors or forgery, this first step is often as easy as making a list of known risks. Simply making a list of past operational losses can help an organization develop a preliminary list of operational risks that should be of concern to the organization, if only because these risks have caused losses in the past.

Unlike other risks, however, thoroughly completing even this first risk-identification step may prove elusive because some operational risks can arise from unexpected sources and new operational risks can emerge over time. For instance, the catastrophic operational failures that grew out of the process for underwriting subprime mortgages involved the relatively new business lines of underwriting and securitizing subprime mortgages. Although a risk manager might be more apt to associate mortgage underwriting with potential credit risk—which is the probability that a borrower will default on a loan—pervasive lapses in the basic underwriting process, such as dubious appraisals or exaggerated income, will generally lead to bad lending, which is a particularly dangerous and potentially catastrophic operational risk that ends up producing credit risk as quickly as it generates new loans.[11] New business lines and new technologies can also add to the list of potential operational risks that may emerge over time. For instance, operational risks associated with mobile pay platforms are likely to emerge as this new technology gains wider use.

The second step in the risk-management process is measuring or assessing the potential impact of each operational risk. Accomplishing this step also involves considerable challenges. While the second step appears to require the seemingly straightforward task of matching potential losses to the list of operational risks developed in the first step, the range of potential losses for many operational risks is so wide that

identifying a reasonable estimate of an institution's overall exposure to operational risk is likely to be both difficult and discouraging. Fortunately, just collecting thorough data on past operational losses along with thoughtful consideration of possible emerging risks makes for a good start toward completing the second step. Also, because an institution can return to the first two steps to make modifications at any time, moving on to the third step in our risk-management process helps get past some of the difficulties encountered in the second, or measurement, phase.

The third step in managing operational risk is deciding what actions to take to actually manage an institution's exposure to operational risk. An institution may choose from four options when determining how to contend with operational risk. (1) It may plan to hold sufficient capital to meet minimum regulatory capital requirements for operational risk plus additional capital, if necessary, to meet the institution's internal capital requirement for operational risk. (2) It may elect to transfer all or a portion of its operational risk exposure through insurance, if such insurance is available, or via other risk-transfer mechanisms such as hedging or outsourcing. (3) It may take a proactive approach to the identification and mitigation of operational risks, primarily through quality assurance and internal audit activities, in an effort to limit the frequency and/or severity of particular operational risks. (4) It may decide to exit the particular business line entirely, which has its own costs because of lost income opportunities and decreased competitiveness in complementary markets.

If an institution doesn't choose the fourth option, it will typically use some combination of the first three options to manage its operational risk exposure. If the institution is a regulated financial institution such as a bank, it will have to hold enough capital against operational risk to meet the

minimum capital standards established by its supervisory agency. Beyond this required minimum that currently applies to only a few financial institutions in the United States, emphasizing or limiting the use of a particular option will play a crucial role in an institution's operational risk management process. Chapter 2 describes the first three options in more detail and discusses why an institution may elect to emphasize or deemphasize a particular option and the possible ramifications of such a decision.

Regardless of how an institution decides to manage its operational risks, the first step of the risk-management process is identifying the operational risks to which the institution is exposed. Because specific operational risks are closely linked to particular business lines, an institution's operational risk exposure will greatly depend on its lines of business. And while any institution has processes, people, and systems and thus is exposed to operational risk, this book focuses on financial institutions, and thus the particular set of operational risks for a financial institution will depend on whether it is a bank, a securities firm, an insurance company, or other financial company.

This first chapter has provided a brief introduction to operational risk. In addition to defining operational risk from the perspective of financial institutions, we have identified many of its unique characteristics and discussed ways to categorize operational risks. We have also acknowledged several factors that have contributed to the growing importance of and dangers posed by operational risk. In chapter 2, we identify what options are available to financial institutions to help them combat and control operational risk.

2
Operational Risk Management Practices

In this chapter, we discuss the three pillars of operational risk management: capital allocation, transfer of operational risk through insurance, and proactive mitigation of operational risk through product inspection and quality control. Thorough operational risk management will generally involve all three pillars. While the first two pillars are fairly well understood and have been the subject of attention from the Basel Committee and other regulatory bodies, the third pillar is equally important though less familiar to those tasked with operational risk management. Regardless of which pillar an institution elects to rely on for operational risks in general or for a particular operational risk, the procedure to begin managing operational risk is the same.

Approaches to managing operational risk

As mentioned in chapter 1, properly addressing operational risk requires a financial institution to implement a thorough risk-management system consisting of several steps. These steps include identifying the risk, quantifying the risk to the extent possible, and then determining the best approach to take to contain the risk, which may involve some combination of holding capital, transferring all or part of the risk,

or actively mitigating the risk. Of course, an organization that must contend with an operational risk in a specific line of business also has the option of avoiding the line of business that is creating the risk, or simply accepting the risk as a cost of doing business—that is, do nothing about it. This latter option happens to be the default option for all risks the institution fails to identify. While using this default option, whether by choice or through ignorance, may be acceptable for low-frequency, low-severity risks, it could prove very costly or even fatal to an institution for even one catastrophic operational risk event.

Once a financial institution elects to undertake a particular line of business, then it has three ways to manage and mitigate the operational risks that accompany that line of business. The institution may (1) hold capital to absorb losses from operational failures, (2) purchase insurance or adopt some other risk-transfer strategy, or (3) attempt to identify and correct operational hazards that are increasing operational risk. In this chapter, we briefly discuss these approaches to operational risk management, including current capital rules as they apply to different financial institutions. A particular application of the third approach, proactive risk containment that includes sampling and inspection methodologies, is the focus of chapters 3 and 4.

Capital

Although operational risk has always been a part of doing business, specifically accounting for operational risk is a relatively new undertaking for financial institutions. Prior to the initial proposal of the Basel II capital rules in 2004, financial institutions did not have any specific regulation-based capital requirements tied to operational risk. Although banks have always had to manage operational risk and account for

operational losses related to problems such as fraud and payment system errors, prior to the introduction of the Basel II framework there was no specific capital regulation that mandated a particular capital charge for operational risk.

With the introduction of the Basel II framework, the Basel Committee, and by association, its member countries, acknowledged the need for an explicit capital allocation for operational risk. Recognizing that an explicit operational risk capital requirement was new, and thus that banks differed considerably in the development of their operational risk measurement systems, the Basel Committee approved three different methodologies for calculating the operational risk capital charge. The three approaches were the Basic Indicator Approach, the Standardized Approach, and the Advanced Measurement Approaches. In October 2014, the Basel Committee issued for comment a proposal to replace the two simpler options—the Basic Indicator Approach and the Standardized Approach—with one new Business Indicator Approach.[1]

Basic indicator and standardized approaches

As adopted in 2006, the Basic Indicator Approach required banks to hold capital for operational risk as a fixed percentage of the bank's annual gross income averaged over three years. The Basel Committee set the fixed percentage banks were to use in the capital formula at 15 percent. Thus, under the Basic Indicator Approach, an institution's capital allocation for operational risk is simply equal to 15 percent of the firm's average annual gross income measured over the past three years, assuming that the gross income was positive in each of those years. Under this formula, the capital calculation ignored the gross income in any year it was negative, and if necessary, the bank's supervisor could make appropriate adjustments to

the operational risk capital charge under its general supervisory authority. Clearly, and by construction, the capital requirement for operational risk using the Basic Indicator Approach is completely dependent on a bank's gross income and, consequently, is independent of everything else, including a bank's activities and its risk-mitigation activities, if any.

The second Basel-approved approach, the Standardized Approach, also determines the amount of operational risk capital as a fixed percentage of gross income, but at a more granular, that is, business line, level. The Standardized Approach divided bank activities into eight business lines and applied a fixed percentage to the gross income generated by each business line. The overall operational risk amount was then the sum of the operational risk capital charge over the eight business lines. Whereas the Basic Indicator Approach applied a fixed percentage of 15 percent to total gross income, the fixed percentage under the Standardized Approach varied from 12 percent to 18 percent, depending on the business line.[2]

Table 2.1 Components of the 2006 Standardized Approach Methodology

Business Lines	**Fixed Percentage of Gross Income**
Corporate finance	18%
Trading and sales	18%
Retail banking	12%
Commercial banking	15%
Payment and settlement	18%
Agency services	15%
Asset management	12%
Retail brokerage	12%

Source: Basel Committee on Banking Supervision, *Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework—Comprehensive Version*, 147.

Table 2.1 shows the business lines and corresponding fixed percentages under the Standardized Approach.

By recognizing that operational risk may vary across business lines, the Standardized Approach is somewhat more risk sensitive than the Basic Indicator Approach. Both approaches, however, use gross income as the sole determinant of an institution's operational risk capital requirement, and thus both approaches assume that gross income is an adequate indicator of an institution's exposure to operational risk. The sudden contraction of gross income during the subprime financial crisis, and hence the shrinking operational risk requirements using the Basic Indicator Approach and the Standardized Approach, called into question the validity of this assumption. Consequently, the Basel Committee undertook a review of these two simpler approaches, and in October 2014, issued for comment a single new approach called the Business Indicator Approach to replace the two simpler approaches.

The business indicator approach

After reviewing the appropriateness of gross income as the proxy for exposure to operational risk, the Basel Committee determined that gross income alone is not a reliable indicator for determining capital requirements for operational risk. In their review, the Basel Committee noted that the principal problem with gross income is that it may fall, and thus imply a decreasing minimum requirement for operational risk capital, precisely when the situation calls for increasing capital for operational risk. The Basel Committee notes that the problems banks encountered during the financial crisis, both systemic and bank-specific problems, lowered gross income and operational risk capital regardless of what was occurring in the bank's operational risk domain. The Basel Committee also noted that there is no fixed relationship between a bank's size and its operational risk, which is an assumption underlying

the use of gross income as a proxy for risk in the Basic Indicator and Standardized approaches.

In light of these problems with gross income as the sole determinant of capital requirements for operational risk for a large number of institutions, the Basel Committee signaled its intention to replace the Basic Indicator Approach and the Standardized Approach with a new Business Indicator Approach. As proposed, the Business Indicator Approach, which the Basel Committee refers to as the revised Standardized Approach, discards the single proxy, gross-income formulas in favor of a capital calculation that considers three income components (albeit ones that are closely related to gross income) to determine the minimum capital requirement: an interest component, a services component, and a financial component. Under the Basel Committee proposal, the Business Indicator is equal to the sum of the three components, where the interest component is the absolute value of net interest income; the services component is equal to the sum of fee income, fee expense, other operating income, and other operating expense; and the financial component is the sum of the absolute values of net profit and loss on the bank's trading and banking books. The Business Indicator Approach then applies a graduated percentage to the Business Indicator amount as the indicator increases. Table 2.2 shows the proposed size buckets in euros and converted to dollars for the Business Indicator and the corresponding capital coefficient.

The 2014 Basel Committee proposal would effectively eliminate the Basic Indicator Approach and introduce two changes relative to the current Standardized Approach. The Business Indicator Approach (1) would replace gross income in the Standardized Approach with the Business Indicator variable, and (2) it would replace the business-line-based percentages with size-based percentages. While the use of size-based

Table 2.2 Proposed Size Categories and Percentages of the 2014 Business Indicator Approach

Business Indicator Amount		Percentage of Business Indicator
(€ millions)	**($ millions, €1 = $1.25)**	
0–100	0–125	10%
100–1,000	125–1,250	13%
1,000–3,000	1,250–3,750	17%
3,000–30,000	3,750–37,500	22%
> 30,000	> 37,500	30%

Source: Basel Committee on Banking Supervision, *Operational risk—Revisions to the simpler approaches—Consultative Document*, 13; € conversion is author's calculation.

Table 2.3 Income Components of 2006 Basic Indicator and 2014 Business Indicator

Income Component	Basic Indicator Approach: Gross Income	Business Indicator Approach
Interest	Net interest income	Absolute value of net interest income
Services	Net noninterest income	Fee income + Fee expense + Other operating income + Other operating expense
Financial	Not applicable	Absolute value of net profit and loss on the trading book + Absolute value of net profit and loss on the banking book

Source: Basel Committee on Banking Supervision, *Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework—Comprehensive Version*, 145; and Basel Committee on Banking Supervision, *Operational risk—Revisions to the simpler approaches—Consultative Document*, 8.

percentages is a completely new feature, the Business Indicator in the proposed approach is an expanded income measure that is somewhat similar to gross income. Table 2.3 compares the income components of gross income with the income components of the Business Indicator.

Because it adds several items to gross income, the Business Indicator will typically be greater than the gross income measure used in the old approach, which implies that the capital requirement will usually be greater under the new approach. For instance, by taking the absolute value of net interest income, the interest component of the Business Indicator will always be greater than or equal to the interest component of the old approach. Under the old approach, a loss would decrease gross income, which would decrease the capital requirement. Because the new Business Indicator approach takes the absolute value of several income components, which converts a loss into a positive number, losses will add to the capital requirement rather than reducing it. Similarly, the new financial component of the Business Indicator, which uses the absolute value of net profit and loss on the bank's trading and banking books, will always be zero or a positive number, and this implies that the Business Indicator requirement will always be at least as great as the old Basic Indicator approach, and it will usually be greater except in the rare circumstance when net profit and loss on both the trading book and banking book are zero. The services component of the Business Indicator approach, which includes gross fee income and expenses and gross other operating income and expenses rather than net noninterest income under the old approaches, will also tend to increase the capital requirement in the new approach relative to the old approaches.

In describing their reasons for recommending changes to the two simpler operational risk capital calculation methodologies,

the Basel Committee revealed some findings regarding the banking industry's initial efforts at introducing an explicit capital charge for operational risk. The Committee indicated that operational risk capital levels were already inadequate by 2009, according to data collected by the Committee, and were used in an operational risk capital-at-risk model developed by the Committee that estimates operational risk capital requirements based on a bank's internal loss data. The Committee's analysis also indicated that business lines used in the old Standardized Approach do not differ statistically in terms of riskiness, and that operational risk did increase with size, but in a nonlinear fashion. These initial results suggested that the simpler approach to calculating capital for operational risk could do away with business-line distinctions and just apply higher requirements as the Business Indicator measure of income increases. The new Business Indicator Approach incorporates these changes.

Estimates of capital requirements under the old Basic Indicator Approach and the new Business Indicator Approach provide a measure of Basel Committee expectations for minimum operational risk capital amounts before and after the financial crisis. Table 2.4 shows rough estimates of the operational risk capital requirement under the old Basic Indicator Approach and the new Business Indicator Approach for US financial institutions of various sizes. Year-end 2013 data from quarterly Call Reports filed by US banks and thrifts provide the underlying income data used to construct the estimates.[3]

As shown in table 2.4, new minimum operational risk capital requirements under the new Business Indicator Approach could increase from roughly 250 percent to roughly 600 percent, depending on the size of the institution. In the smallest size category, within which the median bank size is approximately $148 million in total assets, the estimated capital

Table 2.4 Estimated Operational Risk Capital Requirements, All FDIC-insured Institutions, Dec. 31, 2013 ($ in thousands)

Bank Size Category	Median Asset Size	Median Gross Income	Median Business Indicator	Median Old Basic Indicator Approach	Median New Business Indicator Approach
Under $1 bil.	$148,000	$1,700	$7,000	$250	$740
$1 bil.–$10 bil.	$1,840,000	$24,000	$93,000	$3,700	$9,300
$10 bil.–$50 bil.	$18,100,000	$300,000	$895,000	$46,000	$113,000
$50 bil.–$250 bil.	$100,000,000	$1,500,000	$4,900,000	$230,000	$847,000
Over $250 bil.	$1,400,000,000	$20,700,000	$70,600,000	$3,100,000	$17,900,000

Source: Asset and income data from Quarterly Consolidated Reports of Condition and Income (Call Reports), otherwise author's calculations; figures are rounded.

requirement would increase from approximately $250,000 under the old approach to approximately $740,000 under the new approach, an increase of close to 300 percent. Among the largest banks, those with over $250 billion in assets, the estimated capital requirement would increase from roughly $3.1 billion to $17.9 billion under the new approach, an increase of nearly 600 percent. Table 2.4 provides banks of any size with a rough idea of what their capital requirements might be using the new Business Indicator Approach. Although the largest increase under the new Business Indicator Approach would be for those institutions with total assets of $250 billion or more, the Basel Committee expects (and US regulations require) that the largest institutions use the Advanced Measurement Approaches (AMA) to determine their capital requirements for operational risk. The AMA is the third alternative in the Basel Committee's 2006 framework.

The advanced measurement approaches

In their 2006 framework, which came to be known as Basel II, the Basel Committee indicated that they expected internationally active banks to use the AMA to calculate minimum operational risk capital requirements. The AMA relies on the bank's internal operational risk measurement system to determine appropriate capital charges. In addition to the development of an internal operational risk model, the AMA requires active involvement from the bank's board of directors and senior management, and adherence to the qualitative and quantitative standards summarized below:[4]

Basel Committee AMA Qualitative Standards

1. A bank must have an independent operational risk management function to design and implement the bank's operational risk framework.

2. The internal operational risk measurement system must be closely integrated into the day-to-day risk management processes of the bank.
3. There must be regular reporting of operational risk exposures and loss experience to business unit management, senior management, and the board of directors.
4. The operational risk management system must be well documented.
5. Internal and/or external auditors must perform regular reviews of the operational risk management processes and measurement systems.
6. The validation of the operational risk measurement system must verify that the internal validation processes are operating satisfactorily, and that data flows associated with the risk measurement system are transparent and accessible.

The Basel Committee also establishes certain quantitative standards for AMA banks:

Basel Committee AMA Quantitative Standards

1. The operational risk measurement system must cover the full scope of the definition of operational risk.
2. The regulatory capital requirement must equal the sum of expected loss and unexpected loss.
3. The risk measurement system must be able to capture the major drivers of operational risk affecting the tail of the distribution of the loss estimates.
4. The bank must sum the risk measures for different operational risk estimates for purposes of calculating the regulatory minimum capital requirement.
5. Any operational risk measurement system must include the use of internal data, relevant external data, scenario analysis, and factors reflecting the business environment and internal control systems.

6. The bank must have a credible, transparent, well-documented, and verifiable approach for weighting internal data, external data, scenario analysis, and business environment and control systems in its overall operational risk measurement system.

These standards establish the essential framework for use of the AMA by banks that are internationally active or particularly vulnerable to operational risk. As with all Basel Committee recommendations, each country applies the Basel framework separately, and this separate implementation with variation across countries applies as well to the Basel Committee's operational risk framework described above. The operational risk framework was part of the overall Basel II capital framework finalized in 2006, which also included several approaches for calculating minimum capital requirements for credit risk.

The United States implemented Basel II in December 2007, electing to require only large and internationally active banks to use the Basel II internal model approaches for both credit risk and operational risk. Thus, with respect to operational risk, the United States requires banks with total consolidated assets of $250 billion or more or with consolidated foreign exposures of $10 billion or more to use the AMA. As of late 2014, these size thresholds applied to roughly 30 out of nearly 6,600 FDIC-insured institutions. The other 6,570 or so institutions do not have an explicit minimum capital requirement for operational risk. Instead, most banks in the United States continue to be subject to capital rules that include an implicit requirement that a bank's capital be sufficient to meet all hazards the bank may encounter, including operational risk.

Although the US implementation of the Basel II capital standards does not require an explicit capital calculation for most US banks, this regulatory exception does not mean that these banks are immune to operational risk. If anything, the absence

of explicit capital requirements may increase their vulnerability to operational risk if the lack of a capital rule diminishes the importance of operational risk in the eyes of the institution's senior management and board of directors. Because operational risk poses a threat to all banks, even banks that do not have an explicit capital requirement may want to fit the qualitative and quantitative standards of the AMA to their own institutions to the best of their ability. The AMA, though still evolving, has the potential to represent the best practices of the banking industry with respect to the measurement and management of capital requirements for operational risk.

For the most part, the US implementation of the AMA mirrors the Basel Committee's framework. Banks subject to the AMA requirement use internal measurement systems to calculate their minimum capital requirement for operational risk. The internal operational risk measurement systems also have to meet conditions similar to the qualitative and quantitative standards set out by the Basel Committee. Beyond these general standards, however, both the dynamic nature of operational risk and the newness of the advanced measurement methodologies present banks with extraordinary risk-management challenges.

The AMA avoids prescribing specific methodologies or models, and permits banks to develop their internal operational risk measurement function within certain bounds. While banks have considerable flexibility with respect to model development, the AMA does establish expectations in five system design areas meant to steer banks toward developing an appropriate and comprehensive internal operational risk management model. The five AMA design areas are: (1) operational risk management processes, (2) operational risk data and assessment systems, (3) operational risk quantification systems, (4) data management and maintenance, and (5) control, oversight, and validation mechanisms.[5]

The AMA qualification standards require that an operational risk management process adequately identify and report on a bank's operational risk information. In particular, the standards for operational risk management processes require that a bank have an independent operational risk management function that designs, implements, and oversees the bank's operational risk data, assessment, and quantification systems. The management process should also identify, measure, monitor, and control operational risk in bank products, activities, processes, and systems. Finally, the management process should report operational risk information, including exposures and operational losses, to bank management and the bank's board of directors.

A bank's data and assessment systems collect information on operational risks, create an operational risk database, and analyze the database. The AMA qualification standards for these systems require that the systems capture the bank's operational risk exposures that are consistent with the bank's activities and processes. The data systems must incorporate four data elements: (1) internal operational loss event data, (2) external operational loss event data, (3) scenario analysis, and (4) business environment and internal control factors.

The AMA qualification standards then require a bank's operational risk quantification system to weight the four data elements and estimate the bank's operational risk exposure for a confidence level of 99.9 percent. The risk-based capital requirement for operational risk is then the bank's operational risk exposure minus eligible operational risk offsets. If the bank has qualifying operational risk mitigants, such as qualifying insurance, then the capital requirement is equal to the greater of (a) the bank's operational risk exposure adjusted for qualifying mitigants minus eligible operational risk offsets, such as eligible reserves, or (b) 80 percent of the difference between the unadjusted operational risk exposure and

its eligible operational risk offsets, which means that qualifying operational risk mitigants can only reduce the unadjusted operational risk capital requirement by 20 percent.

The AMA systems are also subject to data management and maintenance requirements as well as several control, oversight, and validation requirements. These control requirements assign specific responsibilities related to operational risk management to the bank's senior management and the board of directors. The bank's AMA systems must also undergo stress tests and an annual independent internal audit that assesses the effectiveness of system controls.

Meeting the AMA qualifying requirements is, and will likely remain for the foreseeable future, a considerable challenge. This is especially true for the bank's operational risk data and assessment systems, which must incorporate and assess internal and external operational loss event data along with scenario analysis and business environment and internal control factors. The applied methods and practices banks use in their data and assessment systems are sophisticated and deserving of their own book. Fortunately, several books do exist to help guide risk-management practitioners through the relatively new and unsettled territory of the AMA.[6]

Supervisory agency guidance

Bank supervisory agencies also issue general guidance to help financial institutions meet their regulatory requirements, including operational risk AMA requirements. Supervisory agencies have the advantage of observing the implementation process and methods used across all supervised institutions, which enables them to identify both common problems and potential solutions. The Basel Committee has published periodic updates on what it has been able to identify as sound practices for operational risk management and

information on what banks are actually doing in the AMA domain. Meanwhile, US banking agencies issued updated guidance on AMA implementation issues in 2011 and 2014.[7]

The new supervisory guidance continues to give banks flexibility regarding their AMA quantification systems. Rather than dictate models and tools for operational risk measurement and management programs, supervisory guidance provides assistance in establishing or improving a bank's overall operational risk-management function, which in turn is responsible for all aspects of the bank's operational risk-measurement and risk-management activities, including the quantification systems. For instance, the 2011 banking agency guidance discusses issues related to the governance of the operational risk-management function, various matters involving the use of the four required data elements (internal and external data, scenario analysis, and business environment and internal control factors), and guidance for the independent review of a bank's AMA systems, including system validation and internal audit.

As banks implementing the AMA continue to develop more experience with the advanced approaches and encounter specific difficulties, they can benefit from supervisory agency guidance on how best to proceed. Again, without dictating specific models or methods, the banking agencies' 2014 supervisory guidance responds to the banks' needs by providing information on supervisory expectations for data, modeling, and model risk management. In particular, the 2014 guidance focuses on "frequently encountered issues relating to data, units of measure (UOM), model selection and fitting, diversification, and model risk management."[8] To assist with problems banks are encountering, the 2014 guidance addresses such specific challenges as dealing with extreme events, excluding internal data, determining loss amounts, aggregating losses,

model selection and estimation in both the frequency and severity domains, and model risk management. While leaving many modeling details to the banks, the guidance does, as its name implies, help guide banks around emerging obstacles in the evolving operational risk management arena.[9]

Determining the appropriate capital charge for operational risk is a relatively new, complex, and open-ended undertaking for financial institutions. As discussed earlier, even the simpler Basic Indicator and Standardized approaches are undergoing revisions, and are likely to continue undergoing revisions in the future. Indeed, it is almost certain that any capital calculation for operational risk, including the AMA, will continue to change as risk measurement and management continue to evolve along with the underlying operational risks themselves, much as the capital calculations for credit risk and market risk undergo periodic revisions by the Basel Committee and its member jurisdictions.

As is the case in the United States, even if the majority of banks are not subject to formal operational risk capital requirements, all banking institutions are still exposed to operational risk. By limiting the applicability of specific regulation-based operational risk capital standards to just a few large US. banks, the lack of capital requirements for all other banks serves to increase the importance of the other two options for managing operational risk: risk transfer and risk mitigation.

Risk transfer

Risk transfer is the process of mitigating an institution's exposure to operational risk through the purchase of insurance or some other form of exposure protection. Clearly, for a risk transfer to take place, insurance must be available to the bank for protection from the particular operational risk. While such insurance may be available for certain operational risks, such

as physical damage to assets, insurance is often not available for a broad range of operational risks.

The AMA capital calculation formula described in the previous section does allow insurance purchases to offset the operational risk capital charge to a limited extent, but insurance can only offset a maximum of 20 percent of the total operational risk capital charge and it must meet certain conditions spelled out in the AMA rule. These necessary conditions include the requirements that the insurance company providing the protection must be unaffiliated with the bank and financially sound, the initial term of the policy must be at least one year, the notice period for policy cancellation must be at least 90 days, the policy cannot include any exclusions or limitations if a supervisory action or bank failure occurs, and the policy must apply to an explicit operational risk exposure of the bank.

Banks may transfer operational risk to insurance companies through insurance, or to some other third party through swaps or derivative transactions. In 2003, the Joint Forum, which is a Bank for International Settlements organization, published a report on operational risk transfer across financial sectors, that is, across banks, insurance companies, and securities firms.[10] In addition to identifying supervisory issues related to risk management and intragroup risk transfers, the Joint Forum study points out that organizations have rather limited options when confronting operational risks in general. As mentioned in chapter 1, financial institutions can avoid an operational risk altogether by not engaging in the business activity associated with the risk. This approach, of course, involves a loss of its own—the loss of the foregone business—and a profit-maximizing institution should generally only elect this option if the expected losses associated with the business are greater than the expected profits. Institutions

can also accept the inherent operational risk and pursue the business activity. If they pursue the business, then they can try to transfer the risk by selling the business or the asset produced or by purchasing insurance. They can also retain the asset and the risk, in which case they should try to mitigate the risk. With credit risk, for instance, risk mitigation may involve ensuring that the firm maintains strong, conservative underwriting standards. With operational risk, firms can also mitigate risk with an active inspection and internal audit program.

The Joint Forum report

As the Joint Forum discusses in its 2003 report, banks have to manage and minimize operational risk through internal controls and systems. By preventing some losses caused by operational risks, internal control systems help pay for themselves. Although this book focuses on operational risk within the banking sector, operational risk management is an important undertaking at other financial institutions such as securities firms and insurance companies. According to the Joint Forum report, securities firms typically manage operational risk by monitoring processes, especially those related to back office operations. Securities firms divide their operational risk management responsibilities between business units and the chief financial officer. The resulting combination of centralized and decentralized operational risk oversight may introduce some practices that could be beneficial to other financial institutions, such as banks and insurance companies.

According to the Joint Forum report, insurance companies often focus much of their operational risk management efforts on the manual processes associated with policy underwriting and claims processing.[11] In the United States, capital requirements for life insurance companies include a capital charge

for business risk, which effectively includes operational risk. The capital calculation for property and casualty insurers does not include a specific capital charge for operational risk, but instead includes implicit charges for it.

The Basel Committee gave some structure to operational risk management by separating operational risk into seven loss-event categories. These seven loss-event types include (1) internal fraud, (2) external fraud, (3) employment practices and workplace safety, (4) clients, products, and business practices, (5) damage to physical assets, (6) business disruption and system failures, and (7) execution, delivery, and process management. Table 1.2, referenced in chapter 1, reflects the detailed loss-event-type classification table provided in Annex 3 of the 2003 Joint Forum report on operational risk transfer across financial sectors. Annex 3 also shows the definition of the loss event type as well as several examples. As the Joint Forum report points out, however, operational risks do not necessarily fall neatly into one of these loss-event types, and certain operational risks may overlap two or more event types. The categorization, however, is a useful starting point for operational risk management.

Purchasing insurance is one operational risk mitigation technique. Firms are often interested in transferring tail risk, that is, low-frequency/high-severity operational risks. All banks also have an important operational risk management tool beyond risk transfer and minimum capital requirements for operational risk, namely, risk-mitigation efforts that they can conduct within the business line or through inspections and audits undertaken by the bank's internal audit function. We will discuss these risk-mitigation and audit functions next.

Operational risk and statistical quality control

Capital allocation and risk-transfer mechanisms are two of the three means by which an institution can manage its exposure

to operational risk. The third component of any operational risk management strategy should be a risk-mitigation program based on audits and statistical quality control. Of the three operational risk management components, the audit component is the most proactive. Capital allocation in general and the AMA in particular are effective tools for determining appropriate capital apportionment for operational risk, but out of necessity these tools look to past experience to estimate a future capital need. Risk-transfer mechanisms require estimates of current operational risk exposures and provide an option for sharing this risk with an insurer in exchange for payments of an insurance premium. The audit component of operational risk management, which is the subject of the remainder of this book, attempts to identify, analyze, and correct operational risks. Through this corrective intervention, the audit and quality control functions attempt to prevent current operational risks from becoming expensive operational failures in the future. If effective, these audit and quality control procedures take a proactive approach that will also help an organization lower its future operational risk capital charges by lowering the frequency and severity of actual operational losses.

Internal audits

Audits are already an integral piece of the bank supervision process. Various laws and regulations establish minimum requirements for internal and external audit programs at most banks. According to the Comptroller's 2003 Handbook on Internal and External Audits, internal or external audit requirements exist for fiduciary activities, Bank Secrecy Act (BSA) compliance, safety and soundness standards, US Securities and Exchange Commission (SEC) regulations for publicly held companies, and annual audit and reporting requirements for banks

with at least $500 million in total assets. As the Comptroller's Handbook states, "Well-planned, properly structured auditing programs are essential to effective risk management and adequate internal control systems."[12] A study of the determinants of operational losses in US financial institutions between 1980 and 2005 by business and management professors Anna Chernobai, Philippe Jorion, and Fan Yu attributes most of these operational losses to internal control breakdowns.[13]

Reflecting the critical function that auditing plays in the operation of a financial institution, regulations assign the ultimate responsibility for establishing, overseeing, and maintaining the audit function to the bank's board of directors. The Comptroller's Handbook sets three fundamental objectives for the audit function:

1. Effectively test and monitor internal controls,
2. Ensure the reliability of the bank's financial statements and reporting, and
3. Satisfy statutory, regulatory, and supervisory requirements.

Furthermore, the Handbook tasks the bank's board of directors with ensuring that the bank's audit program identifies the following potential problems:

1. Inaccurate, incomplete, or unauthorized transactions;
2. Deficiencies in the safeguarding of assets;
3. Unreliable financial and regulatory reporting;
4. Violations of laws or regulations; and
5. Deviations from the institution's policies and procedures.[14]

With this focus on activities such as transactions, reporting, and policies and procedures, many operational risks readily fall under the purview of these audit program expectations.

In addition to instituting audit requirements within the United States, the Basel Committee also has minimum expectations regarding banks' internal audit functions. In June 2012, the Basel Committee published its supervisory guidance on the internal audit function in banks. The purpose of the guidance is to help supervisory agencies assess the effectiveness of a bank's internal audit function, and it states that "[a] strong internal control system, including an independent and effective internal audit function, is part of sound corporate governance."[15] The Basel Committee also points out the important relationship between the bank's audit function and the bank's internal controls: "An internal audit function provides vital assurance to a bank's board of directors and senior management (and bank supervisors) as to the quality of the bank's internal control system."[16] It is this internal control system, which we discuss in the remainder of this book, that provides critical quality control oversight for the institution, and the institution's internal audit function is the most appropriate group to perform this oversight role.

As the Basel Committee makes clear, internal audit is responsible for "[e]very activity (including outsourced activities) and every entity of the bank."[17] Thus, by association, the audit function is largely responsible for assessing the bank's entire portfolio of operational risks. With good reason, the bank may wish to focus internal audit activities first in those areas where operational failures are most severe or most frequent. Eventually, however, the bank should use the audit function to ensure that the bank is pursuing quality control efforts throughout the organization, and it is through these proactive quality control efforts that the bank can work to reduce or eliminate some operational risks.

The Basel Committee tasks the internal audit function with the responsibility for an independent assessment of the effectiveness of the bank's internal control, risk management, and

governance systems and processes. And in turn, the bank's supervisors should communicate with the bank's internal audit function "to (i) discuss the risk areas identified by both parties, (ii) understand the risk mitigation measures taken by the bank, and (iii) understand weaknesses identified and monitor the bank's responses to these weaknesses."[18] Together, meeting these responsibilities lays the foundation for an ongoing quality control exercise that seeks to protect the bank, and in so doing identifies, analyzes, and takes steps to reduce or eliminate operational risks.

The role of the regulatory examination

In addition to the bank's internal audit function, the financial institution's regulatory agency, through its examination function, acts as a type of auditor. Capital requirements, liquidity requirements, extensive reporting requirements, and regular examinations are a few of the many areas of regulatory oversight with which financial institutions must comply. While most financial institutions would be happy to discuss the costly burden of regulation, a few financial institutions may be willing to acknowledge that, along with the costs of regulation, there are some benefits. In addition to the broad social benefits of having supervised financial institutions help ensure that banks are complying with laws and regulations, the regulated institution itself benefits from having a special type of independent auditor. The regulatory agency, by taking on this role of quasi-auditor, provides a critical function, helping to promote the safety and soundness of the financial institution.

The regulatory agency establishes rules and regulations to govern the safe and sound operation of a financial institution and provides guidance to the bank regarding the supervisor's expectations for what the bank should do to meet those minimum requirements. To enforce these rules and regulations, the

regulatory agency conducts regular examinations of the financial institutions it supervises. Should the examination reveal shortcomings at the financial institution, the regulatory agency has an arsenal of actions of graduating stringency that it can apply to get the institution to correct its problems. These regulatory actions range from the flagging of a concern, generally through a Supervisory Letter or a Matters Requiring Attention (MRA) notice in the examiner's official Report of Examination, to informal and formal enforcement actions, such as Commitment Letters and Cease and Desist Orders, respectively.[19]

As part of the examination process, the regulatory agency will assess the adequacy of a bank's overall audit function and its internal control systems. In conducting the assessment, examiners will consider various elements of the bank's internal audit program, including its mission statement, risk assessments of significant business activities, audit work programs, audit reports, and audit sampling methods and techniques. The regulatory agency plays an important role in fostering an active and effective internal audit program that in turn can play a key role in identifying risks that may threaten the bank, both operational and other risks.

Both regulatory oversight and the threat of severe losses from catastrophic operational failures provide institutions with strong incentives to use their internal audit and internal control systems to proactively search for operational risks. This proactive approach entails monitoring known operational risks; identifying new operational risks through product quality assessments; and subsequently taking the necessary steps to improve the people, systems, or processes that are creating the operational risks. By adopting proactive measures aimed at either decreasing the likelihood that a particular operational loss will occur or limiting the severity of an operational loss that does occur, the bank will reduce losses from operational

risks and thereby lower future capital requirements that are a function of those past losses.

We turn now in chapters 3 and 4 to describe these proactive efforts and suggest how a financial institution can use them to identify and control most internal and controllable operational risks. In chapter 3, we start with one such proactive measure aimed at limiting operational risks associated with bad lending and asset securitization. More generally, van den Brink and Marshall provide thorough discussions of the breadth of operational risks and the various approaches to managing operational risk. Marshall, in particular, provides a helpful outline of a six-step operational risk management process, within which the inspection process described in chapters 3 and 4 fits nicely. Marshall's risk-management process is as follows:

Step 1: Define the scope and objectives of the firm's operational risk management program.
Step 2: Identify critical operational risks.
Step 3: Estimate risks.
Step 4: Analyze risks, including the aggregate effect of losses.
Step 5: Implement management actions.
Step 6: Monitor risks and report findings to management.

Marshall's process covers the firm's overall operational risk management program, and is similar to the statistical quality control procedures described in the exceptional and thorough textbook on statistical quality control by Douglas Montgomery, professor of industrial engineering and statistics, which we will be applying in later chapters.[20] First, however, we look at how operational risk management and statistical quality control come together by examining the catastrophic operational failures that arose from bad lending associated with the subprime mortgage crisis.

3
Mortgage Mayhem

Financial institutions may use several methodologies to mitigate at least one type of especially pernicious operational risk: bad lending. Marshall includes bad lending in a list of potential catastrophic losses that can threaten the viability of a company.[1] Not only did bad lending associated with subprime mortgages drive many lenders out of business, but also linkages through the securitization market threatened the viability of many global financial markets.

The methodologies described in this chapter and applied to bad lending are applicable to what Marshall describes as "controllable" operational risks. Bad lending is a controllable operational risk, and as a potential catastrophic risk, it is a controllable catastrophic operational risk, which suggests that the benefits of controlling this risk through mitigation procedures may be well worth the costs. As Marshall points out, efforts to mitigate operational risks will be more productive if those mitigation efforts reduce the likelihood of high-frequency events or the severity of high-impact events. For financial institutions, bad lending will almost always result in a high-impact event, and no bad lending event makes this clearer than the subprime lending crisis.

The death of Barings Bank in 1991 provides a good example of how we had come to view a typical catastrophic operational

risk event prior to the subprime crisis. An isolated incident—in the case of Barings, a $1.3 billion loss attributed to unauthorized trading—proved to be catastrophic for the institution and led to bankruptcy. This billion-dollar event resulted in the demise of Barings, but it was a relatively contained crisis from the perspective of the broader financial market. Published studies of the effects of operational risk losses by Cummins, Lewis, and Wei, mentioned in chapter 1, and by economists Patrick de Fontnouvelle, Virginia Dejesus-Rueff, John Jordan, and Eric Rosengren discuss several other relatively contained operational risk events, including losses by Daiwa Bank in 1995 and by Allied Irish Banks in 2002.[2]

The Barings collapse, though devastating to Barings, was largely an internal and contained event. In contrast, what the world witnessed from the spring of 2006 through the fall of 2008 was a cascade of operational risk events in which an operational failure at one institution or in one market exposed an operational failure at another institution, which in turn triggered yet another operational failure in an unnerving and destabilizing sequence of accumulating catastrophes. The natural reaction of credit market players who find themselves treading in a minefield of unfolding risk is to stand still, which is precisely what they did in October 2008, bringing the world's credit markets to a near standstill.

In this chapter we follow the sequence of operational failures that brought the financial markets to such a standstill. Tracing this sequence of events shows how an operational risk in the mortgage industry that is probably as old as mortgages themselves—mortgage fraud—exposed operational failures by mortgage originators, mortgage bundlers, credit-rating agencies, asset managers, investors, and ultimately regulatory agencies. We examine how linkages among these credit market players allowed operational failures that began in the

mortgage industry to infect the broader asset-backed securities market, the commercial paper market, and the credit-default swap market. Mounting losses from these numerous operational failures rapidly depleted capital, undermined confidence even more quickly, and soon led to apoplectic credit markets that temporarily paralyzed a broad range of financial instruments, requiring dramatic rescues by the US Department of the Treasury and the Federal Reserve that went well beyond more traditional bank bailouts.

Sampling loan data

Looking toward the future, we also examine some relatively simple steps to take to mitigate and manage these operational risks. While neither complex nor prohibitively expensive, the sampling methodology, which we borrow from the auditor's toolkit and apply to loan originations, requires a substantial investment of human capital to gather sufficient loan-level information to verify asset quality.[3] Indeed, while the Basel II capital framework is making important strides in determining the amount of regulatory capital necessary to provide a buffer against operational risk, human capital, used to ensure the quality of assets underlying asset-backed securities, is an equally important form of capital necessary for the management of operational risk.

We first present the timeline of events that began in the mortgage market and rapidly brought the world's credit markets to their knees. We then describe the sequence of operational failures and linkages through securitization that allowed the chain reaction to transmit trouble so broadly and so quickly. Next, we introduce the sampling methodology that lenders, securitizers, credit-rating agencies, investors, and regulators should have been applying to loan originations destined for the securitization network. We also describe how sampling

can inhibit future operational failures and establish a quality assurance system that should dramatically limit the likelihood of another sequential and systemic failure of the sort that began in 2006.

The subprime crisis, born in part out of operational risk, began and ended quite differently from the Barings episode. Unlike the extreme but singular incident that brought down Barings, in the subprime crisis, operational risk in the mortgage industry manifested itself as multiple lapses, modest in size but pervasive in extent, that accumulated to enormous proportions and crushed many mortgage players, crippled many others, and triggered further operational crises in the adjacent mortgage-backed securities market.

What were these modest but pervasive operational failures in the mortgage industry? News reports provide shocking revelations regarding mortgage underwriting standards across the industry that stumbled well beyond laxity into the arena of criminality.[4] Appraisal fraud, "liar loans," intimidation and retribution toward underwriters, and computer programs that steered customers into loans that were more expensive for the borrowers and more profitable for the originators are all just pieces of the anecdotal evidence of serious problems in the mortgage industry described in these media reports.[5] But each piece of anecdotal evidence points to a realized operational risk, that is, an operational failure.

Subprime problems begin to emerge

In 2006, the first indication that underwriting problems, accompanied by rising interest rates and stalling home prices, might lead to repayment problems began to appear. Delinquencies in subprime mortgages began to increase in the third and fourth quarters of 2006. Although the overall subprime delinquency rate of 12.6 percent in the third quarter of 2006 was less than

it had been as recently as the fourth quarter of 2002, attention focused on the 13.2 percent delinquency rate among subprime adjustable-rate mortgages (ARMs).[6] Concern centered on ARMs for several reasons: ARMs accounted for approximately 30 percent of all mortgage originations, and interest rates were rising, which meant that more delinquencies on ARMs were likely as interest rates reset higher. The Federal Reserve had increased the federal funds rate 25 basis points to 5.25 percent on June 29, 2006, and it would keep the funds rate at that level for the remainder of 2006. The delinquency rate on subprime ARMs increased to 14.4 percent in the fourth quarter of 2006. By the fourth quarter of 2007, the delinquency rate on these mortgages would increase to 20.0 percent, that is, one delinquency for every five subprime ARMs.

Weakening home prices exacerbated problems in the mortgage market. From the fourth quarter of 2005 to the first quarter of 2006, the median price of a home in the United States fell 4.1 percent.[7] With interest rates rising and home prices falling, the ingredients for making easy money in the residential real estate market disappeared, and mortgage market problems soon began to make their way into newspaper headlines.[8] Ownit Mortgage Solutions, a wholesale mortgage lender specializing in 100 percent financing of subprime mortgages, filed for bankruptcy on December 28, 2006. Mortgage Lenders Network USA Inc., another large subprime lender, went into bankruptcy on February 5, 2007. At the beginning of March 2007, New Century Financial Corporation, the second-largest subprime lender in 2006, with $51.6 billion in subprime loan originations, announced that its lenders were withdrawing the funding it relied upon for its mortgage lending operations. As a consequence, New Century announced that it was no longer accepting loan applications, and it filed for bankruptcy a month later. On August 2, 2007, American Home Mortgage Investment Corporation, the twelfth-largest residential mortgage originator

in 2006, also filed for bankruptcy. The first dominos, the subprime mortgage originators, had toppled.

In a Barings-like situation, the realization of losses because of operational failures in mortgage underwriting would have led to the collapse of individual mortgage originators like New Century and American Home Mortgage Investment Corporation, but the problems largely would have ended there. Unfortunately, in the crisis that was just beginning to unfold, spillovers from mortgage problems spread quickly because asset securitization and other financial market innovations, such as collateralized debt obligations (CDOs) and credit default swaps (CDSs), had helped place poorly underwritten subprime mortgages or their derivatives into investment portfolios around the globe. Amplifying the problem, CDOs and CDSs allowed other investors to speculate on subprime mortgage-backed securities.

Linkages through securitization

Securitization was the linchpin that linked institutions and investors in a network that spread subprime problems throughout the financial system. News coverage about bankruptcy filings of subprime mortgage lenders generally identified the bankrupt companies' major creditors, and many of these creditors soon made their own way into the headlines. These creditors included such major commercial and investment banks as Merrill Lynch, JPMorgan Chase & Co., Credit Suisse First Boston, and Countrywide Financial Corporation. Mortgage Lenders Network USA listed approximately 5,000 creditors in its bankruptcy filing. Bond houses, including Bear Stearns & Co., Lehman Brothers Holdings, Morgan Stanley, and Merrill Lynch, also owned stakes in some subprime lenders to ensure a steady flow of mortgages for pooling into securities.[9] The vast securitization network that had developed around the

mortgage market began to pull everyone into the subprime mortgage maelstrom that had started to churn. Operational failures in quality assurance during mortgage origination and securitization as well as failures in due diligence by credit-rating agencies and investors soon amplified a mortgage market problem into a global problem and devastating financial crisis.

Because of their own operational failures in due diligence, financial institutions outside the mortgage industry soon felt the ripple effects from the sudden collapse of the subprime mortgage market. Among the first casualties after mortgage originators were two hedge funds operated by the investment bank Bear Stearns. In July 2007, the Bear Stearns High-Grade Structured Credit Fund and the Bear Stearns High-Grade Structured Credit Enhanced Leveraged Fund filed for bankruptcy after losing essentially all of their investors' capital. But they were not alone. On August 9, 2007, BNP Paribas, a major French bank, announced that it was suspending three investment funds that invested in subprime mortgage debt. If financial markets needed further confirmation that there were serious problems in mortgages, they received it a week later when Countrywide Financial, the largest residential mortgage originator in the United States in 2006, with $455.6 billion in originations, drew down its entire $11.5 billion line of credit from a group of banks. Typically, a company draws down its credit line to increase short-term liquidity, and Countrywide's large drawdown suggested that it had concerns about near-term liquidity or anticipated having difficulty accessing capital markets.

Late in 2007, losses from mortgage-related activities began to show up on the income statements of major commercial and investment banks. In October, Merrill Lynch announced losses of $8.4 billion, and two weeks later Citigroup announced that

mortgage-related write-downs would total between $8 billion and $11 billion. The resignation of the chief executive officers of Merrill Lynch and Citigroup accompanied each of these announcements of major losses.

In early 2008, under growing pressure from mounting losses and plunging asset values, several large commercial banks and investment banks in the United States began to weaken. In January 2008, Bank of America announced that it would pay $4 billion to acquire Countrywide Financial. In March 2008, JPMorgan Chase announced that it would be acquiring most of the assets of the investment bank Bear Stearns for $2 a share, though the transaction was eventually consummated at approximately $9 a share; this was still dramatically below the 52-week high of $133 per share. In July 2008, IndyMac Bank entered into receivership with the FDIC, an event accompanied by the unnerving sight of uninsured depositors waiting in line outside the closed institution.[10]

The widening scope of the financial crisis exposed additional financial linkages, many created through securitization, and additional markets began to topple. In February 2008, responding to concerns about the soundness of monoline insurers, the International Swaps and Derivatives Association (ISDA) published a list of the obligations of monoline insurers.[11] Eventually this list would include over 13,000 deals with initial principal amounts of more than $1 trillion. Problems for monoline insurers began with their exposure to mortgage-backed debt guarantees, but the loss of confidence in the monoline insurers destroyed investor confidence in and hence appetite for any debt instrument guaranteed by the bond insurers. The market for auction-rate securities quickly evaporated, and auction-rate security investors who thought they had bought cash-equivalent instruments found that they were holding illiquid debt. The demise of auction-rate

securities almost immediately created problems for other assets, such as student loans that had been bundled into auction-rate securities. The disappearance of these supposedly cash-equivalent assets also made liquidity problems worse as investors stuck with auction-rate securities had to scramble for increasingly scarce sources of cash and liquidity.

September 2008, one of the worst months in the history of US financial markets, began with the takeover of mortgage giants Fannie Mae and Freddie Mac by the US government on September 7. Roughly a week later, on September 15, the investment bank Lehman Brothers declared bankruptcy. The following day, the federal government stepped in to save the insurance company AIG with a loan of $85 billion, and AIG's predicament exposed potentially dire problems in the massive CDS market. Among those making claims for Lehman Brothers assets were JPMorgan Chase, Credit Suisse, and GE Capital Corporation. But these large creditors were joined by smaller investors like Arapahoe County, Colorado.[12]

Losses tied to the Lehman Brothers bankruptcy also drove the net asset value of at least one money market mutual fund below a dollar, implying losses to investors in that supposedly cash-equivalent money market mutual fund. With global credit market confidence in shambles, on September 19, the Federal Reserve Board announced that it was creating a special liquidity facility to effectively support asset-backed commercial paper and money market mutual funds. By the end of September, the two surviving large investment banks, Morgan Stanley and Goldman Sachs, converted into bank-holding companies. The FDIC seized Washington Mutual, the largest thrift institution in the United States, and announced that Citigroup would acquire the banking assets of Wachovia Corporation—although Wells Fargo eventually purchased all of Wachovia's assets.

Dissipation of the credit markets continued into October 2008. Difficulties in the commercial paper market continued even after President Bush signed the Emergency Economic Stabilization Act of 2008 into law on October 3. On October 7, the Federal Reserve announced it was taking the extraordinary step of direct lending to the commercial paper market through the creation of a Commercial Paper Funding Facility. On October 14, using funds made available by the Emergency Economic Stabilization Act, the Treasury Department injected $250 billion in capital into major US financial institutions, including Bank of America, Citibank, JPMorgan Chase, and Wells Fargo. A week later, the Federal Reserve announced the creation of the Money Market Investor Funding Facility to provide up to $540 billion to buy assets from money market mutual funds in an effort to restore confidence in that critical market with over $3 trillion in assets.[13]

By the end of 2008, the Federal Reserve Board and the Treasury Department had implemented several more rescue operations. The Federal Reserve had lowered the Fed Funds rate below 1 percent and created the Term Asset-Backed Securities Loan Facility (TALF) to lend up to $200 billion to holders of AAA-rated securities backed by consumer and small business loans. Together, the Federal Reserve and the Treasury Department had expanded their financial support of AIG and implemented a rescue plan for Citigroup. On December 1, the National Bureau of Economic Research declared that the recession had begun in December 2007. And as if all of these financial problems were not enough, on December 13, 2008, more undetected fraud, in this case a $50 billion pyramid or "Ponzi" scheme perpetrated by investment adviser Bernard Madoff, came to light.

Table 3.1 shows an outline of the structure of the mortgage securitization market that also sets the stage for the domino

Table 3.1 Operational Risk Linkages in the Mortgage Market

Institution Type	Operational Risks	Vertical Linkages	Horizontal Linkages
A. Mortgage Originator	Underwriting, Property Appraisal, Document Evaluation	Mortgage Bundler	Other Loan Originations
B. Mortgage Bundler	Due Diligence of Mortgage Originators	Bond Insurers and Credit-Rating Agencies	Other Bundles
C. Bond Insurers and Credit-Rating Agencies	Due Diligence of Mortgage Originators and Mortgage Bundlers	Investment Managers	Other Bonds and Other Rated Securities
D. Investment Managers	Due Diligence of Mortgage Originators, Mortgage Bundlers, Bond Insurers, and Credit-Rating Agencies	Investors	Other Investments
E. Investors	Due Diligence of Mortgage Originators, Mortgage Bundlers, Bond Insurers, Credit-Rating Agencies, and Investment Managers	Creditors	Other Credits

Source: Author.

effect that began with operational failures in subprime mortgage originations and ended with the near collapse of the world's credit markets. Vertical linkages transmitted operational failures in mortgage originations all the way through the mortgage securitization process to investors. But just as important for the financial meltdown of 2007–2009 are the horizontal linkages that transmitted the shock waves from the mortgage market implosion across markets for other financial instruments and eventually throughout the world's financial system. Table 3.2 repeats table 3.1, but populates it with some of the financial market participants discussed in the description of the financial crisis timeline.

Contributing to the spillover problem, as the mortgage meltdown sequence showed us, operational risks within the financial system can be cumulative. Thus, as shown in table 3.1, credit-rating agencies and bond insurers are exposed to the operational risks of the mortgage originators with whom they deal, and investors are exposed to the operational risks of the entire securitization structure. A staff report from the Federal Reserve Bank of New York by Adam Ashcraft and Til Schuermann, a Bank for International Settlements study by Ingo Fender and Janet Mitchell, and a management company research report by Gotham Partners Management Company reveal how linkages that form through the securitization process can transform operational risk from an idiosyncratic problem into a systemic problem.[14] In describing the steps taken to securitize subprime mortgages, Ashcraft and Schuermann reveal the parties that became intertwined through securitization and, because they are one and the same, reveal the parties that each committed an operational failure that eventually allowed the chain reaction of operational failures to continue through them and engulf the world's financial markets. Similarly, in describing business and accounting problems at the monoline insurer the Municipal

Table 3.2 Populated Operational Risk Linkages in the Mortgage Market

Institution Type	Operational Risks	Vertical Linkages	Horizontal Linkages
A. Mortgage Originators: New Century, IndyMac	Underwriting, Property Appraisal, Document Evaluation	Fannie Mae, Bear Stearns, Goldman Sachs, JPMorgan Chase	Other Loan Originations
B. Mortgage Bundlers: Fannie Mae, Bear Stearns, Goldman Sachs, Merrill Lynch, JPMorgan Chase, Cheyne Capital Management	Due Diligence of New Century, IndyMac	Ambac, MBIA, S&P, Moody's	SIVs, Auction-Rate Securities, Asset-Backed Commercial Paper
C. Bond Insurers and Credit-Rating Agencies: Ambac, MBIA, S&P, Moody's, Fitch	Due Diligence of New Century, IndyMac, Fannie Mae, Bear Stearns, Goldman Sachs, Merrill Lynch, JPMorgan Chase, Cheyne Capital Management	Investment Managers	Auction-Rate Securities, Mortgage-Backed Securities, Asset-Backed Securities, Other Rated Securities, CDOs, CDSs

Continued

Table 3.2 Continued

Institution Type	Operational Risks	Vertical Linkages	Horizontal Linkages
D. Investment Managers	Due Diligence of New Century, IndyMac, Fannie Mae, Bear Stearns, Goldman Sachs, Merrill Lynch, JPMorgan Chase, Cheyne Capital Management, Ambac, MBIA, S&P, Moody's, Fitch	Investors	Other Investments
E. Investors	Due Diligence of New Century, IndyMac, Fannie Mae, Bear Stearns, Goldman Sachs, Merrill Lynch, JPMorgan Chase, Cheyne Capital Management, Ambac, MBIA, S&P, Moody's, Fitch, and Investment Managers	Creditors	Other Credits

Source: Author.

Bond Insurance Association (MBIA), Gotham Partners shows us the linkages that connect insurance companies and investors to the asset-backed commercial paper market that shrank substantially in September 2008.

As Ashcraft and Schuermann describe, securitization involves many players. These players include the original borrower, the loan originator, a warehouse lender, the security issuer, the security servicer, credit-rating agencies, asset managers, and, finally, the ultimate investor.[15] Participants become exposed to operational risk anywhere within the securitization process preceding their contact with the security. Thus, the security issuer is exposed to operational risk created by the borrower or loan originator, and the investor is exposed to the operational risk of the entire securitization process.

Operational failures by participants who have already contributed to the securitization process affect any subsequent participant of that process. Although this might seem to create an overwhelming operational risk hazard for the ultimate investor in any securitized product, breaking the chain of these operational failures only requires proper due diligence with respect to the immediately preceding securitization participant, as long as that due diligence includes an operational risk report.[16] Just as an operational failure anywhere in the securitization process can trigger cascading failures throughout the process, due diligence that effectively identifies operational failures helps to limit or eliminate subsequent spillovers.

Operational failures can spread across credit markets horizontally as well as vertically. Gotham Partners' analysis of MBIA suggests that model failures, supposedly off-balance-sheet special-purpose vehicles (SPVs) issuing commercial paper, and questionable credit ratings can lead to catastrophic problems for one firm that can quickly paralyze entire markets. As Gotham Partners points out in its analysis, asset quality

problems emerging for MBIA's SPVs likely meant that investors would not want to buy commercial paper backed by these assets. Similar problems likely contributed to the near paralysis of the asset-backed commercial paper market in 2008 that necessitated the Federal Reserve's stepping in to guarantee most asset-backed commercial paper to prop up that market and the money market mutual funds that invest in it.

Although the accumulation of operational risk problems is what proved to be so devastating to credit markets, the benefits from operational risk mitigation are also cumulative. Thus, proper operational risk mitigation undertaken by mortgage bundlers helps protect the entire securitization chain. Should bundlers fail to properly address operational risk, intermediaries, such as credit-rating agencies that undertake efforts to ensure asset quality, can still protect other market participants further down the securitization chain. The procedures to institute operational risk mitigation essentially involve quality assurance steps at the mortgage origination and bundling levels and due diligence regarding those quality assurance procedures by the other links in the securitization chain.

Before describing the risk mitigation techniques, however, in the next section we discuss how operational risk affected financial institutions involved in the mortgage mess. Because of the massive financial rescue the crisis required, the federal government and, ultimately, American taxpayers bore some of the losses from these operational risks. Institutional investors, owning many "toxic" securities, had their own operational failures that led them to purchase the problematic assets, but it was their awakening to credit losses that led them to abandon many of the tainted credit markets; this action subsequently required the Federal Reserve to create special lending facilities to save these markets from complete collapse. After we show the operational risk exposure of these market players, we show the relatively simple but absolutely necessary asset

qualification steps securitizers should take to confront some of the unique operational risks found in structured finance.

Operational risks behind the mortgage mess

Subprime mortgages in and of themselves are not bad things. Properly underwritten, a subprime mortgage provides valuable access to credit for individuals and families with blemishes on their credit histories or with limited credit histories that result in low credit scores. Of course, being properly underwritten is the essential element necessary to make subprime lending beneficial to borrower and lender. Unfortunately, the US economy has witnessed the devastating consequences of poorly underwritten subprime mortgages that ended in delinquencies and foreclosures. But what are the specific operational risks that allowed the subprime mess to happen, and how can we prevent such a disaster from happening again and restore confidence in the mortgage-backed securities market?

The financial crisis began with subprime mortgages, but the operational risks that made those subprime loans so toxic have the potential to exist with any loan. Underwriting, property appraisal, and document evaluation were the problematic operational risks in subprime mortgage origination. Ironically, subprime market participants and their regulators knew of the presence of these operational risks, but everybody failed to notice actual problems until it was too late. As early as March 5, 1999, more than six years before the start of the subprime crisis, the federal banking agencies had issued interagency guidance on subprime lending.[17] They defined subprime lending "as extending credit to borrowers who exhibit characteristics indicating a significantly higher risk of default than traditional bank lending customers."

Studied now, the 1999 "Interagency Guidance on Subprime Lending" reads like a prophecy from Cassandra. In advising on loan purchase evaluation, the guidance warns,

> For instance, some lenders who sell subprime loans charge borrowers high up-front fees, which are usually financed into the loan. This provides incentive for originators to produce a high volume of loans with little emphasis on quality, to the detriment of a potential purchaser. Further, subprime loans, especially those purchased from outside the institution's lending area, are at special risk for fraud or misrepresentation (i.e., the quality of the loan may be less than the loan documents indicate).

With respect to consumer protection, the prophetic guidance continues,

> Higher fees and interest rates combined with compensation incentives can foster predatory pricing or discriminatory "steering" of borrowers to subprime products for reasons other than the borrower's underlying creditworthiness.

On model risk, loan review, and monitoring, the guidance states,

> Models driven by the volume and severity of historical losses experienced during an economic expansion may have little relevance in an economic slowdown, particularly in the subprime market.

And referring to securitization and sale hazards, the guidance foretells the coming destruction, simply and accurately:

> Investors can quickly lose their appetite for risk in an economic downturn or when financial markets become volatile. As a result, institutions that have originated, but have not yet sold, pools of subprime loans may be forced to sell the pools at deep discounts. If an institution lacks adequate personnel, risk management procedures, or capital support to hold subprime loans originally intended for sale, these loans may strain an institution's liquidity, asset quality, earnings, and capital.

Eight years later, each of these warnings would essentially reappear in media reports but as descriptions of the subprime meltdown rather than as warnings.[18]

Given this evidence that bankers and their regulators knew the risks of subprime lending well and accurately, how could

the subprime crisis happen?[19] Although many factors, including rising interest rates and declining home prices, contributed to the start of the crisis, several regulatory gaps also played an important role. First, the federal banking agencies did not regulate some of the principal participants in the subprime lending market. Ownit Mortgage Solutions, Mortgage Lenders Network USA Inc., and New Century Financial Corporation were finance companies and not regulated by any of the federal banking agencies.[20] Though it would have been in their long-term best interests to adhere to the guidance from the banking agencies, these unregulated mortgage lenders did not have to and were free from the threat of enforcement actions by the agencies. Second, for the subprime participants such as IndyMac Bank and Countrywide Financial that performed poorly and were regulated by one of the banking agencies, the financial institution failed to follow guidance and the relevant banking agency failed to compel the institution to adequately comply with guidance.

Regulatory gaps

While the fee structures described in the subprime guidance eliminated the originator's incentive to maintain minimal underwriting standards, regulatory shortcomings are harder to explain. Part of the problem may have been inexperience contending with operational risk in the securitization market. Before the introduction of the Basel II capital rules, regulatory capital rules for banks did not require an explicit capital charge for operational risk. Even with Basel II, the explicit capital requirement for operational risk only applies to institutions adopting the Basel II advanced approaches. As pointed out in chapter 1, however, almost every bank has had experience dealing with such operational risks as mortgage fraud. The origins of this financial crisis had more to do with poor

due diligence and shoddy underwriting that became standard practice at many institutions, especially at institutions that intended to sell their mortgages,[21] than it did with inexperience concerning operational risk.

Furthermore, for regulated banks subject to minimum regulatory capital requirements, an explicit capital charge for operational risk may not have done much good. That is because regulatory capital rules and economic capital models take a mostly passive approach to handling operational risk. Based on historical experience, the institution holds financial capital in an amount sufficient to accommodate losses from a broad range of risks, including operational risk. If the subprime financial crisis teaches us one thing, it is that the threat from operational risks demands a much more aggressive and active response than just holding financial capital. The search for and identification of a potential operational failure stemming from fraud and deceit generally require a considerable expenditure of human capital as well to uncover the problem.

Originating quality mortgages

The first step in confronting these operational risks is to identify them before they become operational failures. In the case of subprime mortgages, or any mortgage, banks, bank regulatory agencies, and mortgage institutions like Fannie Mae and Freddie Mac are well aware of the steps necessary to originate a quality mortgage. Fannie Mae published a guide, "Originating Quality Mortgages," intended for lenders that want to sell mortgage loans to Fannie Mae. The Comptroller of the Currency includes a booklet on "Real Estate Loans (Section 213)" in the Comptroller's Handbook with detailed examination procedures. These guides provide a valuable blueprint for assessing the fertility of the environment for

operational risks in mortgage originations. Regulated mortgage originators should continue to use these guides, and nonbanks should begin to apply these guidelines if they are not doing so already. But more importantly, mortgage bundlers, bond insurers, and credit-rating agencies should step into a more active quality assurance role.

Fannie Mae's "Originating Quality Mortgages" provides an adequate template for quality assurance procedures for any loan origination by any loan originator.[22] Its procedures include developing a written quality assurance plan, designating a quality assurance manager separate from the origination function, documenting results from the financial institution's quality assurance process, and conducting a review of a sample of mortgages to monitor the quality of its mortgage production. Any institution that implements and adheres to these procedures has an excellent foundation for operational risk mitigation in originating loans. Because of the vertical linkages created by securitization, however, mortgage bundlers, bond insurers, and credit-rating agencies should independently repeat the sample review portion of the quality assurance process. Potential conflicts for the quality assurance manager, regardless of whether the quality assurance process is conducted internally or outsourced, make it necessary for other links in the securitization chain to conduct a review of a sample of loans from the institution preceding them in the securitization chain as part of their due diligence.[23]

Operational risk sampling methodology

Sample design

Of course, with over 10 million mortgage applications for home purchases in 2006 and millions of mortgages making their way into mortgage-backed securities every year, it is not

feasible to inspect every mortgage. Borrowing from the auditor's toolkit, however, we can draw a test sample from any portfolio and, through reverification of several loan items, estimate the credit quality of the portfolio relative to its advertised quality. Furthermore, repeating the sampling procedure over time provides valuable information on trends in portfolio quality.

Several sampling methods are feasible for sampling asset portfolios, and the most appropriate method depends on the purpose of the inspection and who is conducting the sample inspection. Author Arthur Wilburn provides an excellent and thorough discussion of the various methods that are most appropriate for use in audit sampling. These sampling methods include random sampling, judgment sampling, discovery sampling, and flexible sampling.[24]

Our objective to infer population characteristics from our sample suggests that simple random sampling is the best method with which to begin our operational risk inspection program. The first step of our inspection method, as applied to a portfolio of securitized mortgages, takes a simple random sample of the mortgages, obtains a new appraisal on each property, and verifies the borrower's income, debt, and Fair Isaac Corporation (FICO) score at the time of the loan application.[25] As part of the sample review, the sample inspector should request a review appraisal by an appraiser unaffiliated with the original appraiser; verification of income, using IRS Form 4506T to request a transcript of the borrower's tax return; and a new credit report to verify the borrower's liabilities and credit score.

Although we use mortgages in describing our inspection methodology, the methodology can be applied to any asset group and should be applied to all securitized assets. Sampling and verifying property value, debt, and income allow us to

calculate sample estimates for loan-to-value (LTV) and debt-to-income (DTI) ratios and FICO scores. We then compare our sample estimates with the original declared values of these scores and ratios as shown in the prospectus of the mortgage-backed security.

Each entity issuing an asset-backed security must file a prospectus with the SEC. The prospectus provides potential investors and credit-rating agencies with information on the asset pool backing the security. The prospectus includes information on the principal balances of the loans, the number of loans in the pool, average interest rates, LTV ratios, FICO credit scores, and interest rate caps— to name a few of the reported data items. The prospectus provides data in the aggregate and for a large number of different categories, such as fixed-rate loans, adjustable-rate loans, credit scores, and property types. A prospectus, which typically can be as long as 300 pages for a single security, contains an impressive amount of data regarding the asset pool. Regrettably, all of this prospectus information is unverified, and this proved to be the Achilles' heel of the securitization channel, where operational risk took up residence and, in the future, where inspection sampling to verify loan-level information can do the most good.

Three items in the prospectus are of interest from an operational risk sampling perspective. As we saw earlier in chapter 3, the mortgage meltdown resulted from, to put it bluntly, originators cramming garbage into the securitization conduit—the operational risks that apply to loan originations most often affected inaccurate appraisal values, overstated income, and understated debt. Thus, we are interested in the following reported values from the prospectus: the weighted-average original LTV ratio, the weighted-average DTI ratio, and, to a lesser extent, the weighted-average original FICO score.

Independent verification of property value and the borrower's income and liabilities for a random sample allow us to construct unbiased estimates of the mean LTV ratio and the mean DTI ratio for the entire pool of mortgages. We can then compare these unbiased estimates with the values for each ratio reported in the prospectus to determine an estimate of the LTV and DTI errors for the mortgage pool as a whole. The estimated LTV and DTI ratios in turn may convey information regarding default probabilities and loss given default.[26] It is also feasible to use an indicator variable to identify the presence of an error above some specified percentage, but as our objective is to assess the accuracy of values reported in the prospectus, we focus on verifying the specific value of our variables of interest.

In gathering the information on the sample of mortgages, we could also develop estimates for the mean appraisal error, income error, and liabilities error in the mortgage pool. By tracking information on appraisers and originators across different mortgage pools, we can use these error estimates to grade individual appraisers and originators. This may be of help later if an inspection suggests that sample stratification and discovery sampling may be informative, but we defer this topic to future research.

We now demonstrate our sampling methodology using a mortgage-backed security. Table 3.3 presents data on the mortgages underlying a mortgage-backed security issued by Goldman Sachs in 2006, GSAMP 2006-NC2.[27] The aggregate pool of mortgages for this security is our population. Column A of table 3.3 shows the reported population value for several variables as reported in the prospectus. Columns B through D list estimates for these variables based on samples of 50, 100, and 200 mortgages, respectively.

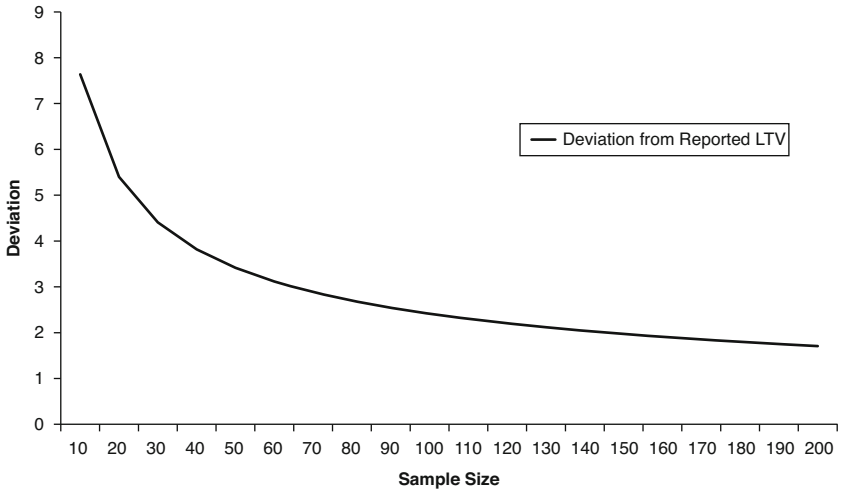
With the *t*-statistic that we use later to compare sample means with reported means, we show how the tolerance limit

Table 3.3 Universe and Sample Data for GSAMP 2006-NC2 (*p* Values in Parentheses for Comparison of Sample and Universe Means)

Variable	(A) Universe (Prospectus)	(B) Sample Size 50	(C) Sample Size 100	(D) Sample Size 200
Total Principal Balance	$881,499,701	$9,730,857	$20,278,243	$42,519,321
Number of Mortgages	3,949	50	100	200
Weighted-Average (WA) Original FICO	626	631.8 (0.3792)	626.5 (0.9306)	625.1 (0.8176)
WA Combined LTV with Silent Seconds	80.34%	81.01% (0.5115)	80.27% (0.9274)	81.25% (0.1937)
WA DTI Ratio at Origination	41.78%	40.30% (0.1812)	41.15% (0.4488)	41.15% (0.3420)

Source: Author, except prospectus information.

Figure 3.1 Tolerance Limit to LTV Deviation as Sample Size Increases, alpha = .05



for deviations from the reported means falls as sample size increases. Figure 3.1 shows, for a significance level of 0.05, that the tolerance limit for deviations from the reported LTV drops quickly, from over 7 with a sample size of 10 to just over 2 with a sample size of 100 and just under 2 with a sample size of 200. In other words, if the sample size is 10, then the sample LTV would have to be nearly 8 percentage points higher than the reported LTV before the test could reject the null hypothesis that the sample LTV and the reported LTV are equal. If the sample size is 100, then LTV deviations of roughly 2.4 percentage points lead to rejection of the null hypothesis. Although, as table 3.3 and figure 3.1 show, a random sample of as few as 50 mortgages provides both a reasonable approximation to the population and a reasonable trade-off between tolerance limits and sample size, we elect to use 100 mortgages randomly selected for our inspection. The *p* values shown in table 3.3 inform us that our sample means do not, in any of the samples, differ significantly from the reported population mean.

If we were performing the actual inspection, we would draw a random sample of 100 mortgages from the pool and request new appraisals and verifications of borrower debt and income, as discussed at the beginning of this section. Unfortunately, we can only simulate an inspection and report the results of the simulation. Using LoanPerformance data on the underlying mortgages, we are able to explore how differences in appraisal values would affect reported LTV ratios. Again, in the simulation we have to be content with this single variable, as the LoanPerformance data do not report the underlying information on debt and income. We could manipulate the DTI ratio as we do the appraisal value, but because the methodology and effects would be the same, we limit our discussion to the results pertaining to LTV ratios.

When looking at a specific security, we randomly select 100 mortgages from all loans underlying that security. After verifying the appraisal value, borrower debt, and borrower income, we are able to calculate sample means and confidence intervals for our LTV and DTI ratios. We can also calculate weighted sample means and corresponding confidence intervals to match the weighted-average information disclosed in the prospectus. For example, we compute the weighted sample mean for the LTV ratio as

$$\hat{\bar{y}} = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \tag{3.1}$$

where y_i is the LTV ratio for mortgage *i,* w_i is the weight for mortgage *i* calculated as the closing balance of mortgage *i,* and *n* is the size of the sample. We then calculate the confidence limits for the mean as

$$\hat{\bar{y}} \pm StdErr(\hat{\bar{y}}) * t_{df,\alpha/2} \tag{3.2}$$

where *StdErr* is the standard error of the sample estimate of the mean, and $t_{df,\alpha/2}$ is the *t*–statistic for degrees of freedom, *df,* and confidence coefficient α. We then use a *t*-test to compare the sample means with the means reported in the prospectus,

$$t = \frac{\hat{\bar{y}} - \mu}{s/\sqrt{n}} \tag{3.3}$$

where μ is the mean reported in the prospectus, *s* is the sample standard deviation, and *n* is the sample size.

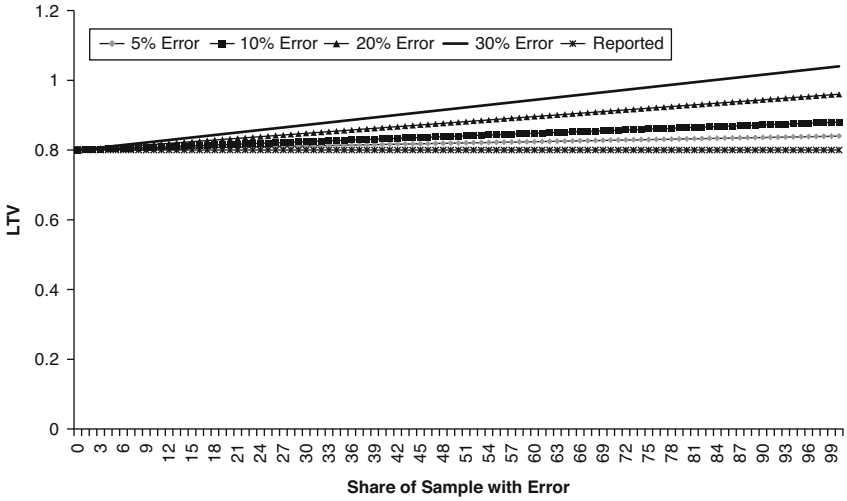
Dissecting equation 3.3 shows how sampling and the *t*-test allow us to identify systematic bias in a pool of mortgages. In

the numerator, if the new appraisals underlying the sample LTV are consistently lower than the original appraisals, then the sample LTV ($\hat{\bar{y}}$) tends to be greater than the reported LTV *(μ)* and the numerator increases. In the denominator, the *t*-test uses the sample standard deviation, which measures deviations from the sample mean rather than deviations from the reported mean. Large deviations within the sample increase *s,* making the *t*-statistic smaller and making it less likely to reject the null hypothesis that the means are equal. Thus, results that reject the null hypothesis provide strong evidence that there is systematic bias in the pool.[28]

Each of our three variables of interest—the LTV ratio, FICO scores, and the DTI ratio—are subject to some uncertainty. For instance, the very nature of appraisals, that is, estimating the value of a home based on comparable but not identical home sales, introduces uncertainty into LTV ratios. Uncertainty, however, is not bias. Uncertainty suggests that appraisal errors, or honest differences in appraised values, are relatively evenly distributed around zero. Thus, it would not be surprising to find new appraisals that are 5 percent or even 10 percent above or below the original appraisal. Such general uncertainty associated with each of our variables tends to have offsetting effects in our sample and would not necessarily lead us to reject the null hypothesis of equal means. Our *t*-test can accommodate the general uncertainty associated with our variables of interest while identifying the presence of systematic bias.

Figure 3.2 demonstrates how bias in a variable of interest affects the mean as the error rate increases. Figure 3.2 shows the hypothetical situation in which all loans in a pool have equal weight and equal LTVs of 80 percent. Each line in figure 3.2 traces the new LTV ratio for a given appraisal error as the share of the population with the error increases. Thus, following the line for a 5 percent appraisal error, if each new

Figure 3.2 Effect of Appraisal Errors on LTV Ratio



appraisal reports a value that is 5 percent lower, the new LTV slowly rises from the reported value of 80 percent to approximately 84 percent. Similarly, with a 20 percent appraisal error, the new LTV rises more quickly as it approaches 100 percent if all the new appraisals are 20 percent lower than the original appraisals.

To illustrate how our sampling methodology would work, we demonstrate by randomly drawing a sample of 100 mortgages from the pool, GSAMP 2006-NC2. As mentioned before, in an actual inspection, we would then calculate the sample means and confidence limits after verifying, in this case, the appraisal values. In our simulations, however, we have to be content with manipulating the data artificially and then investigating how effective sampling is at detecting the change. To show how poor asset quality can affect the sample estimates in our simulation, we first randomly "infect" part of our population with fixed appraisal errors: we assign a new appraisal that is less than the original appraisal. We illustrate the effect of overstated collateral values by gradually increasing the appraisal error and the share

Table 3.4 LTV Ratio Simulation Sample Means and Confidence Limits, GSAMP 2006-NC2 (3,949 Mortgages)

Sample	*n*	Percent Infected (number infected)	Appraisal Error Rate	Errors Found	True Mean	Sample Mean	Lower 95% Limit	Upper 95% Limit
Universe	3,949	0	0	NA	78.60	NA	NA	NA
1	100	0	0	NA	78.60	78.29	76.48	80.10
2	100	10% (395)	10%	7	79.45	79.04	77.20	80.89
3	100	20% (790)	20%	16	82.33	81.54	79.12	83.96
4	100	30% (1185)	30%	31	88.59	89.20	85.01	93.39
5	100	50% (1875)	50%	46	115.75	114.46	104.99	123.94

Source: Author.

of the population we infect with the simulated error. Thus, to start, we randomly infect 10 percent of our population with a 10 percent error rate, then 20 percent of our population with a 20 percent error rate, 30 percent of our population with a 30 percent error rate, and 50 percent of our population with a 50 percent error rate. After infecting our population, we then draw a new random sample of 100 mortgages and estimate our sample means and confidence limits. Table 3.4 reports the results from our simulations.

The results shown in table 3.4 have two implications. First, as the infection and error rates increase, the 95 percent confidence interval for the LTV ratio gradually moves away from the population mean of 78.60 percent.[29] At a 20 percent infection rate with 20 percent error severity, the confidence interval no longer includes the reported mean, and a *t*-test with a 95 percent confidence level rejects the hypothesis that the sample mean is equal to the reported value of the mean, as

Table 3.5 *t*-Tests, LTV Ratio Simulation Sample Means, and Reported Mean, GSAMP 2006-NC2 (3,949 Mortgages)

Sample	*n*	Percent Infected	Appraisal Error Rate	Sample Mean	*p* Value, Sample Mean Equals Reported Mean
Universe	3,949	0	0	78.60	NA
1	100	0	0	78.29	0.7583
2	100	10%	10%	79.04	0.6660
3	100	20%	20%	81.54	0.0219
4	100	30%	30%	89.20	< 0.0001
5	100	50%	50%	114.46	< 0.0001

Source: Author.

shown in table 3.5. Second, the sample mean continues to closely track the true mean of the infected population, and *t*-tests do not reject the hypothesis that the two values are equal. Table 3.4 also shows that the number of errors found in the sample is relatively consistent with the population infection rate.[30]

The information in table 3.4 indicates the potential power of an asset-inspection program using a simple random sample of 100 mortgages. Applied here to a mortgage-backed security, this method is applicable to any asset-backed security. Clearly, a sample LTV ratio that differs significantly from the reported LTV ratio should raise red flags for bundlers, credit-rating agencies, investors, and regulatory agencies.

From the perspective of mitigating operational risk, it is important that sampling occur before issuing a security. Sampling, however, can also provide information on the health of a security after issuance. Using information on actual losses incurred with GSAMP 2006-NC2 as reported by LoanPerformance with its January 2009 data, we can construct an updated LTV ratio as the ratio of the original loan

balance to the difference between the original appraisal and the amount of the loss. If there is no loss, then this ex post LTV is equal to the reported LTV. The January 2009 LTV for our sample of 100 mortgages is 93.68 percent with a 95 percent confidence interval between 82.24 percent and 105.11 percent, well above the reported LTV of 78.60. These results reflect the weakness in GSAMP 2006-NC2 that had already occurred by January 2009 as a consequence of multiple factors, including the deterioration of the housing market.

Reporting inspection results

Reporting the results of the inspection is just as important as the actual sampling and verification of the underlying assets. Because of vertical and horizontal linkages, information from the sampling report strengthens the entire financial market. Individual investors and investment managers may have the most to gain from operational risk reporting because they are the participants who ultimately purchase a potentially toxic security. Sampling allows the disclosure of operational risk reports for the lender, third-party originators, mortgage brokers, and correspondents.

Table 3.6 shows a template for an operational risk inspection report. Table 3.7 populates the template using information from one of our simulation samples. Several fields in the template include information from the prospectus about the portfolio. The portfolio description section should list basic identifying information about the portfolio. The reports should also include reported values related to the inspection variables along with the source for those values, which in our case is the prospectus.

The inspector then populates the remaining fields based on the sample results. In addition to identifying the specific variables that the inspection is testing with the sample,

Table 3.6 Sample Inspection Report Example

Sample Inspection Report					
Portfolio Description					
Definition of Critical Events					
Reported Values (Source)					
WA LTV					
WA DTI					
WA FICO					
Sample Values (Sample Size = n)					
Inspection Variables					
Variable	Critical Events Found	Reported—Verified Mean	Reported—Verified Minimum	Reported—Verified Maximum	Reported—Verified Range
Property Appraisal					
Borrower Income					
Borrower Debt					
Borrower FICO					
Derived Values					
Variable	Sample Median	Sample Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit	*p* Value, Sample Mean Equals Reported Mean
WA LTV					
WA DTI					
WA FICO					

Source: Author.

Table 3.7 Sample Inspection Report, Simulation Exercise with 20 Percent Error Infection and Severity Rates

Sample Inspection Report					
Portfolio Description	GSAMP 2006-NC2, a pool of 3,949 first- and second-lien 1-to-4-family home mortgages with a total principal balance of $881,499,701				
Definition of Critical Events	Verified Appraisal Value < 0.85 * Reported Appraisal Value Verified Income < 0.85 * Reported Income Verified Debt > 1.15 * Reported Debt Verified FICO < 0.85 * Reported FICO				
Reported Values (Source: Prospectus)					
WA LTV	80.34%				
WA DTI	41.78%				
WA FICO	626				
Sample Values (Sample Size = 100)					
Inspection Variables					
Variable	Critical Events Found	Reported—Verified Mean	Reported—Verified Minimum	Reported—Verified Maximum	Reported—Verified Range
Property Appraisal	16	$13,031	$0	$182,000	$182,000
Borrower Income	NA	NA	NA	NA	NA
Borrower Debt	NA	NA	NA	NA	NA
Borrower FICO	NA	NA	NA	NA	NA
Derived Values					
Variable	Sample Median	Sample Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit	*p* Value, Sample Mean Equals Reported Mean
WA LTV	79.96%	81.54%	79.12%	83.96%	0.0219
WA DTI	NA	NA	NA	NA	NA
WA FICO	NA	NA	NA	NA	NA

Source: Author.

the inspector should define critical events for each of those inspection variables. For instance, it is highly likely that the original appraisal and the verified appraisal will differ by thousands of dollars. Thus, it is more appropriate to define a critical event, or serious error, as something more substantial. Inspector experience and knowledge help to define critical events, which should be consistent across similar portfolios. The definitions for critical events themselves provide information to potential investors, giving them a sense of the precision that typically accompanies a particular portfolio. Note that critical events are one-sided, reflecting their role as risk indicators. Verified income that is substantially higher than reported income is not likely to increase the risk of the portfolio, for example.

For each of the inspection variables, the report should indicate the number of critical events found in the verified sample and information regarding the overall (critical and noncritical) differences between reported and verified values. The minimum and maximum values along with the mean give an indication of the extent to which the errors are distributed around zero. For instance, in our simulation, we only reduced the value of property relative to the original appraisal. This results in a minimum appraisal difference of zero, which means that all appraisal errors overstated the value of the property. Such a problem would most likely be a cause for great concern among potential investors.

Finally, the inspection report then presents the derived variables for the sample. After verifying the appraisal value, the inspector constructs a new weighted-average sample mean, determines the 95 percent confidence interval, and tests whether the sample mean is significantly different from the reported value. We also include the sample median because a comparison of the mean and the median suggests the degree

and direction of skewness in the sample. The completed inspection report should then become part of the portfolio, accompanying the prospectus for perusal by potential investors.

Who should conduct operational risk inspections?

Although any institution that is contemplating investing in a portfolio of loans should be inclined to conduct inspections as described in this section, we believe that the maximum universal benefit from the inspections ensues if nationally recognized statistical rating organizations (NRSROs) incorporate such inspections into their rating process and the SEC mandates and supervises the sampling procedure as part of its supervision of NRSROs. Regulated banks and loan originators securitizing through Fannie Mae and Freddie Mac should already sample their mortgages and other loans as part of the regulatory examination process or quality assurance process. To our knowledge, however, these examinations do not produce the type of risk report we advocate. Thus, regulated banks and bank regulators may wish to incorporate inspections and reports similar to those described above into their examination procedures. These reports would be of great value to any institution's chief risk officer.

Investors owning securitized assets and those that securitize assets stand to gain considerably from our sample inspection reports, but it is not feasible for them to conduct the inspections themselves because of data access and conflict-of-interest issues, respectively. Thus, it falls to the rating agencies and monoline insurers to conduct these inspections because of their ability to get access to underlying loan-level information on the securities they rate or insure, respectively. Furthermore, we do not see how a rating agency could have accurately rated any asset-backed security without verifying the accuracy of loan-level data.

One of the problems the subprime financial crisis exposed was the fundamental weakness in how rating agencies rated

asset-backed securities. This fundamental weakness was the reliance on historical data regarding comparable assets. The rating process can continue to use historical data to estimate transition and default probabilities, but it should conduct inspections as we describe in order to verify that the current vintage of assets is indeed comparable to the historical vintages. To appreciate the critical importance of this simple verification step, just consider the damage that might have been avoided if the rating agencies had tested the comparability of subprime mortgage securities issued in 2003 against those issued in 2006.[31]

Although bankers and bank examiners inspect samples of mortgages as part of their internal or regulatory examination procedures, they may wish to adopt the sampling inspection methodology with data verification and reporting as just described to complement the implementation of operational risk efforts being introduced in conjunction with Basel II regulatory capital requirements.[32] The sample inspection report shown in tables 3.6 and 3.7 should serve as a useful tool for chief risk officers, senior bank management, bank directors, and bank regulators.

Sample inspections conducted by credit-rating agencies would also extend critical oversight to nonbanks that seek access to global credit markets through the securitization channel. Any nonbank seeking to securitize assets it originates would have to pass the rating agencies' inspection verifying comparable asset quality. To appreciate the importance of this step, recall the story of New Century at the start of the financial crisis. If the rating agencies had detected the toxicity of New Century's mortgages sooner and limited its access to the securitization channel, New Century's operational failures in underwriting could have left us with a story similar to the Barings debacle rather than the cascading failures that came in the wake of New Century's collapse. New Century's failures

would have cost them dearly and they likely would have ended in failure. Like Barings, however, it would have been another operational risk tragedy with terrible consequences for those responsible but with consequences limited to those responsible.[33]

The economic crisis that began in the US subprime mortgage market in late 2006 was a consequence of cascading operational failures. Old operational risks, such as mortgage fraud and lack of due diligence, combined with modern financial players, such as nonbanks and financial engineers assembling asset-backed securities, to initiate a nearly catastrophic crisis in financial markets and a painful recession that became the longest on record since the Great Depression.[34] Operational failures in the credit-rating process by credit-rating agencies and monoline insurers and operational failures in due diligence by investors allowed toxic assets to permeate throughout global credit markets. When the first domino fell in the subprime market, it exposed these other operational failures along with their accompanying losses in a chain-reaction that radiated along vertical and horizontal market linkages until it had greatly undermined confidence in the world's credit markets. Dramatic guarantees and capital injections by the Treasury Department, the Federal Reserve, other central banks, and the FDIC rescued the world's credit markets from almost complete paralysis and began the process of restoring confidence in global financial markets.

To avoid a repetition of such a crisis born of operational risk and to help restore confidence in the securitization market, in this chapter we've proposed an asset inspection methodology that employs simple random sampling and direct verification of loan-level information. We've described how this sampling and confirmation procedure can verify critical asset quality information reported in a security's prospectus

and demonstrated this procedure with a simulation exercise applied to a mortgage-backed security, GSAMP 2006-NC2. We've provided a rough template for reporting the results from the sampling inspection, which should then become part of the security's prospectus. The information in this inspection report is of great use to investors, loan originators, and bank regulators, but it is of essential importance for credit-rating agencies and monoline insurers. The credit-rating agencies should incorporate the inspection report into their rating process as a means of verifying that the security they are rating is comparable in quality to the securities they are using to model historical default risk.

It is vital that the credit-rating agencies, or their proxies, become involved in sampling inspections, because failures by the credit-rating agencies expose the entire securitization market to a potential crisis of confidence. Investors rely heavily on the credit-rating agencies for an assessment of the riskiness of a particular asset. Widespread mistakes in credit ratings strike a blow to the credibility of the rating agencies and lead reasonable investors to question the validity of any credit rating. In such a scenario, investors would likely abandon most rated securities and flock to US government securities, which, of course, is exactly what happened in 2008. So critical is the need for sampling of structured finance products that, should the credit-rating agencies fail to adopt such a methodology voluntarily, the SEC may want to consider making it a condition for granting NRSRO designation for an agency rating structured-finance products.[35] In chapter 4, we discuss some of the positive steps that the SEC and NRSROs have taken since the financial crisis with respect to asset quality assurance.

It almost certainly did not help confidence in the financial markets that the two Bear Stearns hedge funds that imploded in June 2007 included "high-grade" in the fund's

name. In addition to raising the possibility that other "high-grade" investments might not be so high grade after all, the failure of the Bear Stearns funds exposed other concerns, namely, the speed with which the funds collapsed, that Bear Stearns was a major player in the mortgage securities market, and the obvious failure or absence of effective risk management.[36] These concerns would certainly rattle any risk-sensitive institutional investor. They may have contributed to problems in the auction-rate securities market, which began slowing in August 2007 and stopped completely in February 2008. Similar risk assessment failures could also allow insurance companies, such as AIG, to write $656 billion in credit insurance on structured finance products with only $54 billion in resources to pay those claims.[37]

The sampling methodology has the potential to expose liar loans and mortgage fraud, and it effectively applies quality assurance supervision to nonbanks seeking access to the securitization channel. In addition to providing a current assessment of the quality of assets underlying an asset-backed security, the sampling inspection report should increase confidence in the securitization market.

4
Operational Risk Monitoring and Control

The sampling and verification methodology is really just an application of conventional risk-assessment and quality control practices to mortgage lending and the mortgage securitization process. Looking back, a risk assessment that could have limited or even prevented the subprime mortgage crisis would have involved recognizing that bad subprime lending is a potentially catastrophic operational risk and that following the loan-quality inspection steps described in chapter 3 could have educated the market regarding the quality of the mortgages it was originating. Looking forward, a risk assessment that can limit or even prevent future lending crises involves recognizing that bad lending of any sort, performed on a large enough scale, is a potentially catastrophic operational risk.

Recognizing the threat of bad lending is just the first step in preventing a lending crisis. Conducting a rigorous loan-quality inspection and reporting process is a necessary second step. Following the procedure outlined in chapter 3, the loan-quality control process will verify several loan-level attributes of a random sample of loans. The mean and variance from this sample allow us to infer important credit-risk characteristics for the entire pool of loans. Significant differences between the inferred population characteristics and the reported characteristics identify loan pools with potential

problems and the location of particular problems in the loan underwriting process. For instance, the mortgage inspection methodology described in chapter 3 examines the LTV ratio, the DTI ratio, and the borrower's credit score. Marked differences between reported and verified LTV would suggest that there are significant problems in the property appraisal segment of the mortgage underwriting process. Similarly, marked differences between reported and sample DTI ratios would indicate problems in the debt and income verification segments of the underwriting process.

LTV, DTI, and credit scores are critical characteristics for other loans as well, such as auto loans, commercial real-estate loans (mortgages), and student loans. While all three measures are of value in assessing the quality of auto loans and mortgages, student loans may lack an LTV ratio because of the difficulty in assigning a dollar value to an education. Measures of debt, income, and credit scores are the same across all loan types. The market value of any physical asset, such as real estate or a vehicle, is the appropriate measure to determine value for LTV purposes. This is true at origination and to determine current LTV.

As was the case with the subprime mortgage crisis, securitization is a crucial factor in determining the potential extent of the damage that can result from bad lending in any asset category. If a lending institution holds all of its originated loans in its own portfolio, bad lending could still be a potentially catastrophic operational risk, but only for that lending institution. When a loan originator transfers a bad loan into an asset-backed security (ABS), the exposure to potential catastrophe associated with that loan transfers to the ABS owner. Furthermore, because of the nature of the securitization process and liability, various risk exposures transfer to the ABS issuer and the servicer in addition to the ultimate investor.

Post–financial crisis regulatory changes

Because the subprime financial crisis exposed the extensive risk linkages that securitization creates, the legislative and regulatory response to the financial crisis touched on several aspects of the mortgage origination and general asset securitization process in an attempt to fix what had caused such extensive damage. Foremost among these responses to the financial crisis are the Basel III capital and liquidity framework issued by the Basel Committee and the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act), which President Obama signed into law on July 21, 2010.

Whereas the Basel III framework focuses on determining appropriate levels of capital and liquidity within financial institutions, various Dodd-Frank Act provisions applied to mortgages in particular and ABS markets more generally. The Dodd-Frank Act mortgage reforms include new property appraisal expectations, new mortgage standards, and requirements regarding a financial institution's responsibilities to determine a borrower's ability to repay. Provisions directed at the ABS market include risk-retention requirements for issuers of ABSs and new requirements for credit-rating agencies to become NRSROs.

In response to Dodd-Frank Act ABS statutes, the SEC adopted several rules that relate directly to the asset-inspection process outlined in chapter 3. Most relevant among these rules is the ABS disclosure and registration rule finalized by the SEC in August 2014. This rule requires issuers to make available to investors an extensive list of loan-level characteristics for five types of assets: residential mortgages, commercial mortgages, automobile loans and leases, and ABSs made up of debt securities. The rule also requires asset-level information for resecuritizations of ABSs, in which an ABS issuer packages a group of previously issued ABSs into a new tradable security.[1]

As explained in chapter 3, it is precisely this sort of loan-level information that is necessary for an effective asset-inspection program, and access to this information helps determine who can conduct the quality assurance inspection. Returning to table 3.1 in chapter 3, which shows the vertical and horizontal linkages created during the securitization process, we can think of this table as an event tree for operational risks associated with bad lending and the securitization process. An event tree traces the parties that could be affected by the occurrence of some event, which in our case is the systematic extension of bad loans.[2] Because of securitization, the event tree for bad lending extends from the loan originator through the ABS issuer and the rating agency to the ultimate investor. The disclosures now required by the ABS disclosure and registration rule allow some quality assurance inspection by the ultimate investor. Borrower privacy considerations, however, dictate that much of the quality assurance inspection effort should still occur earlier in the securitization process, as the description of the inspection process in chapter 3 suggested.

The ABS disclosure and registration rule does provide the ABS investor with extensive information about the assets underlying the security, but most of the information necessary for a quality assurance program is not made available by the new rule and generally should not be made available to the ABS investor. Recall from chapter 3 that to verify the LTV ratio, the DTI ratio, and the borrower's credit score for a mortgage, the following five pieces of information are necessary: the original loan amount, the address of the property to determine appraisal value, the borrower's income, and the borrower's total outstanding debt and credit score from the borrower's credit report. Similarly, for an auto loan, the following seven pieces of information are necessary: the original loan amount, the make, model, and year of the auto to determine appraisal value, the borrower's income,

and the borrower's outstanding debt and credit score from a credit report. To be able to verify asset value for a mortgage, the investor would need to know the address of the property. To be able to verify information from a credit report and income information from the IRS, an ABS investor would need to know personal borrower information such as a Social Security number. Whereas there may or may not be a privacy problem with revealing the address of a mortgaged property, there are clearly prohibitive privacy considerations that would prevent sharing Social Security numbers with ABS investors.

The SEC acknowledged these privacy concerns when they determined the final list of loan-level information required by the disclosure rule. As they state in the final rule, "[w]e are revising the required disclosures contained in the proposal to address the risk of parties being able to re-identify obligors and the associated privacy concerns."[3] Of the various pieces of loan-level information just mentioned as being necessary for quality assurance inspections, under the new ABS disclosure rule, ABS investors would only be able to verify LTV ratios for automobile loans and leases. Of course, even this verification would require the investor to make an assumption about the car's mileage to estimate the value of a car from its blue-book value.

Although the SEC's new ABS disclosure rule provides important information to help the ABS investor determine the riskiness of a particular security, for the most part, the quality assurance function remains out of reach for the ultimate ABS investor. This limitation is an operational risk created by the securitization process itself. The new ABS disclosure rule does enable investors to asses the riskiness of a security based on reported asset-level information, but quality-assurance due diligence involves the more intensive step of verifying reported loan-level data.

Quality-assurance due diligence or a quality assurance inspection specifically requires access to personal borrower information. The SEC disclosure rule appropriately limits access to personal borrower information, which implies that the quality assurance inspection should take place earlier in the securitization process. Given the importance of establishing confidence in the securitization process, it may be appropriate for both credit-rating agencies and loan originators to conduct quality assurance inspections and disclose the results of those inspections.

As with any risk-management decision, loan originators and investors could avoid operational risks associated with the securitization process by avoiding the securitization process altogether. This, of course, would be a mistake. Securitization is an important financial market innovation. Securitization allows specialization in loan underwriting and loan servicing. It also provides a means to transfer credit and interest-rate risk to investors willing to accept those risks. The large pool of underlying assets generally makes those risks more palatable to investors through diversification across loan and borrower characteristics. Securitization also increases access to credit opportunities for some borrowers, especially riskier borrowers, and it increases access to investment opportunities for investors. Thus, given these benefits of securitization, the risk-management objective should be to improve the securitization process rather than doing away with it.

Another option to limit exposure to operational risk from either bad lending or securitization would be to limit or prohibit certain types of loans or loans to certain borrowers, such as subprime loans. While some types of loans may warrant outright prohibition, such loans tend to be predatory in nature and beyond the borrower's ability to pay, even at origination. An outright ban on a subprime loan for instance, would in general be an inappropriate response to operational risk in the

subprime loan origination process. Such a ban would restrict access to credit for subprime borrowers, many of whom may be good candidates for credit. Rather than an outright ban on loans to subprime borrowers, the appropriate response to prevent subprime lending from becoming bad lending is quality assurance verification of the underwriting process, which would approve of properly underwritten subprime loans and reject poorly underwritten subprime loans.

The SEC's ABS Disclosure and Registration rule puts some of this power to recognize, and thus limit, bad lending in the hands of the investor. With respect to residential mortgage-backed securities (RMBS), the new disclosure rule stipulates that over 250 items of loan-level information accompany the issuance of a RMBS. The SEC disclosure rule also requires a large number of loan-level data elements for commercial mortgages, automobile loans and leases, debt securities, and re-securitizations.

Quality assurance inspections

The SEC disclosure rule helps determine the institutions that are best suited to perform quality assurance inspections. By limiting our loan verification activities to the following five variables—(1) loan amount at origination, (2) value of underlying asset at origination, (3) borrower's debt at origination, (4) borrower's income at origination, and (5) the borrower's credit score—we would be able to verify the LTV ratio, the DTI ratio, and the borrower's credit score, all at origination. Table 4.1 shows these five variables of interest and the participants along the securitization chain that typically would have ready access to all the information required to verify the reported values for each variable.

As table 4.1 indicates, the ability to verify loan-level information tends to deteriorate as one moves farther away from the origination process. Whereas the loan originator clearly has

Table 4.1 Access to Loan-Level Information for Verification

Institution	Loan Amount	Asset Value	Borrower's Outstanding Debt	Borrower's Income	Borrower's Credit Score
Loan Originator	Yes	Yes	Yes	Yes	Yes
ABS Sponsor	Yes	Yes	Yes	Yes	Yes
Rating Agency	Yes	?	?	?	?
Investor	Yes	?	No	No	No

Source: Author.

access to all relevant information about the borrower and the underlying asset, and should be verifying the accuracy of this information on an ongoing basis, the other participants in the securitization chain are completely dependent on the willingness and ability of preceding securitization participants to share that loan-level verification information. Thus, the ability of the ABS sponsor to verify the LTV, the DTI, and the credit score for each loan depends on the originator's willingness to share this information. Typically, any ABS sponsor would require access to the information as a basic condition of being willing to include the asset in the sponsor's pool of assets being securitized. It is worth emphasizing again that the information necessary for verification is personal information such as the borrower's Social Security number so that the institution can compare reported DTI and credit score information to the information reported by the original source, such as the borrower's credit report.

Moving one step further along the securitization chain to the credit-rating agency, table 4.1 shows that a rating agency's ability to verify loan information depends on the ABS sponsor's willingness or obligation to share the necessary information. As mentioned in chapter 3, this willingness to share information

with the credit-rating agency was a problem during the run-up to the financial crisis. In recognition of the importance of providing information to foster the ability of institutions and investors to perform thorough due diligence, the SEC also issued new rules in 2011 and 2014, designed to enhance issuer review of assets in ABS offerings. The 2011 rule, "Issuer Review of Assets in Offerings of Asset-backed Securities," rather than requiring issuers to directly share loan-level information with investors, required issuers to review the assets underlying any ABS it is issuing. The 2011 rule also required the ABS issuer to share information about its review with investors, including information about what the issuer found during the review. In a similar vein, the 2014 credit-rating agency reform rule adopted new disclosure requirements for credit-rating agencies, that is, NRSROs, which also require that ABS issuers and underwriters disclose the findings and conclusions of any third-party due diligence report they obtain.

These new SEC rules provide important information to NRSROs and investors. As described in the SEC's press release accompanying the 2014 rule, the new disclosures will help investors conduct due diligence to "better assess the credit risk of asset-backed securities."[4] Although the new rules enhance the ability of investors to assess the credit risk of ABSs, it is not entirely clear that the required disclosures will provide the information necessary to verify reported information, which is the only way to fully assess the underlying operational risk that may exist within the lender's loan origination process. For this reason, table 4.1 shows question marks with respect to the ability of credit-rating agencies to verify the loan-level information that they would need to be able to identify operational failures associated with bad lending.

Table 4.1 also shows that the investors who ultimately purchase ABSs typically do not have access to the detailed

information necessary for verifying reported information. As mentioned earlier, legitimate borrower-privacy concerns justify restricting ABS investor access to this level of information. Beyond privacy concerns, simple efficiency considerations suggest that the dispersed group of ABS investors should not be the ones responsible for verifying that the underlying assets in any ABS are the product of bad lending. Instead, a loan originator with a desire to maximize profit over the long term has the greatest incentive to conduct the loan inspection, and conveniently has ready access to the necessary information. Long-term profit maximization of the lender and cost-minimization of the inspection program both imply that the loan originator should overcome the inherent conflicts of interest and conduct the loan-inspection program. Of all the subsequent participants in the securitization chain, the ABS issuer is in the second-best position to conduct the loan-inspection program and in the best position to verify that the loan originator has an excellent loan-inspection program.

By placing the onus for conducting a reliable loan-inspection program on the loan originator, the true nature of the loan-inspection program as a critical component of the originator's overall quality assurance program becomes more apparent. The inspection and reporting process described in chapter 3 is roughly an application to loan underwriting of the quality control procedures described in detail in Douglas Montgomery's textbook on statistical quality control.[5] By roughly applying the quality control procedures described by Montgomery to the loan origination process, we can see that loan inspection and verification are the most appropriate ways to control operational risk in the underwriting process and that the loan originator is the only participant in the securitization chain that has the ability to influence all aspects of the quality control efforts needed to limit bad lending.

The DMAIC procedure

As Montgomery points out, the five steps in the general approach to the quality improvement procedure are defining, measuring, analyzing, improving, and controlling (DMAIC) the quality problem and its solution. Although Montgomery's discussion of the procedure relates to solving a particular quality control problem within one organization, we can generalize the procedure to allow us to consider how multiple institutions affected by a common problem might contribute to the quality control solution. Working on a common problem across different institutions is the challenge we encounter when dealing with the problem of bad lending and the securitization process.

The DMAIC procedure described in Montgomery and worked through in chapters 3 and 4 is similar to the procedures recommended by other operational risk management experts. For instance, the DMAIC steps are echoed in the operational risk remediation process suggested by Marshall, who identifies a similar six-step process to correct operational risk problems:[6]

1. Define the scope and objectives of the firm's operational risk management program.
2. Identify critical operational risks.
3. Estimate risks.
4. Analyze risks, including the aggregate effect of losses.
5. Implement management actions.
6. Monitor risks and report findings to management.

The defining step

The defining step in the DMAIC procedure involves identifying an opportunity to address a quality control issue. Generally, information about a potential quality control problem might

come from customer complaints or product failures. In the context of bad lending and the potential securitization of bad loans, the brutal arrival of the subprime financial crisis alerted the world to the problem of having poor-quality loans as the underlying collateral in a security. Applying the defining stage to this problem suggests that identifying the quality control problem could be stated as, "What is the quality of the loans in my investment portfolio?"

Here we must make an important distinction in what "quality" means in this particular operational risk example. Generally, the quality of a loan would mean its credit risk: the probability of the borrower defaulting on the loan's required payments. To answer this question for a mortgage, for example, we would then ask about the LTV ratio, the DTI ratio, and the borrower's credit score. Each of these variables has implications for the credit risk of the loan. In our operational risk context, however, quality refers to the quality of the underlying loan information, such as property value and borrower income, that pertains to credit risk. Thus, in our mortgage example, our quality question becomes, "Is the relevant credit-risk information reported for the loan accurate?"

Identifying the quality control problem in this way allows us to see that the question applies broadly to any loan in any institution's portfolio. The loan originator can ask this question about the loans it is originating and holding or distributing, and the ABS investor can ask this same question about the underlying loans in any ABS.

The measurement step

The measurement step in the quality control procedure involves evaluating the current state of the process creating the product. In our lending context, this would mean understanding the current loan underwriting procedure, including

the content and source of various informational inputs into the loan. Montgomery even identifies this input information using an auto loan as an example.[7] He points out that the input information for an auto loan would include the loan application with the customer information along with the borrower's credit score, the car type, the car price, and the loan amount. To be consistent with our bad-lending example, we would add that the customer information Montgomery mentions should also include information that would allow a quality control team to verify the accuracy of reported debt and income information.

Montgomery mentions that sampling is often part of the measuring step, which he indicates is one approach to collecting current data. As described in the residential mortgage-backed security example in chapter 3, a random sample of mortgages allows us to make inferences about the population of mortgages under consideration. Thus, in the case of quality control for bad lending, the measurement step consists of collecting all relevant information for verification purposes on a sample of originated loans.

The analysis step

In the analysis step, the quality control team uses data collected in the measurement step to identify the causes of quality problems in the production process. Montgomery points out that the analysis involves identifying two types of causes: (1) common causes, which are part of the production process, and (2) assignable causes, which are problems with external origins. Montgomery's example of a common cause is poor training, and his example of an assignable cause is tool failure on a machine. Translating common and assignable causes to the bad lending example, a common cause of quality failures in loan origination could be poor training of a loan officer,

whereas an example of an assignable cause could be inaccurate financial information reported by the borrower. We'll explore further examples of common and assignable causes when we consider specific lending examples later in this chapter.

Among the tools used in the analysis step are statistical hypothesis testing, model simulation, and control charts. We worked through a statistical hypothesis testing example in chapter 3 when we simulated appraisal errors in a sample of mortgage-backed securities. Montgomery also identifies an analysis tool called failure modes and effects analysis, which looks at the likelihood of a problem occurring, the ability to detect a failure, and the severity of a failure. This type of failure analysis is similar to the frequency/severity dichotomy discussed in our review of types of operational risks in chapter 2.

The improvement step

The fourth step in the quality control procedure is the improvement step, which identifies specific changes that can be made to the process to improve performance by reducing or eliminating quality problems. Pilot tests are one way of introducing process improvements. In our residential mortgage-backed security simulation example, faulty property appraisals created the loan-quality problems undermining the performance of the security. Improving appraisal quality might involve establishing higher appraisal standards or avoiding certain appraisers if the analysis step traces the quality control problem to particular appraisers.

The control step

The final step in the DMAIC procedure is the control step. The control step establishes a process-control plan to ensure that the institution maintains the quality improvement measures

Table 4.2 Institutional Ability to Implement Quality Control Elements

Institution	Define	Measure	Analyze	Improve	Control
Loan Originator	Yes	Yes	Yes	Yes	Yes
ABS Sponsor	Yes	Yes	Yes	No	No
Rating Agency	Yes	?	?	No	No
Investor	Yes	?	No	No	No

Source: Author.

taken in the previous step and that the quality improvements are effective. The process-control plan that corrects bad lending would likely include a schedule for periodic sampling of loans for inspection to ensure that quality problems do not slip back into the underwriting process.

Table 4.2 shows the five DMAIC quality control steps along with the participants in the securitization chain that are able to execute each step. As we move through the securitization process from loan originator to ABS investor, the participant becomes less able to fully implement the quality control and improvement measures. At the far end of the securitization process, the ultimate investor in the ABS has the ability to define the quality control problem, and depending on the sophistication of the investor and data availability, may have some ability to measure and analyze the loan quality characteristics. In contrast, at the beginning of the securitization process, the loan originator has access to the necessary data and control over the loan origination process, which gives it the ability and the long-term incentive to actively implement all five steps of the quality control process. However, the ABS sponsor, who should have unrestricted access to the necessary verification data, and hence is able to measure and analyze the quality control problem, has limited opportunity to improve and control the loan origination process.

Similarly, the credit-rating agency, depending on data availability, may be able to undertake the first three steps of the quality control process, but also is limited in its ability to improve and control loan origination.

As the name implies, loans originate with loan originators. Beyond the loan originators, sponsors, credit-rating agencies, and investors are the various links in the supply chain for ABSs. Each participant in the ABS supply chain will have a particular quality control interest. We can think of loan originators as the factory producing loans at the start of the supply chain, and hence in the best position to conduct top-to-bottom loan inspection and information verification. Loan originators are also in the best position to directly implement quality improvements and control those system improvements. The other participants would generally focus on quality as a supply chain management problem and inspect supplier qualifications and, if appropriate, the supplier's own quality assurance efforts.

Applying statistical quality control to operational risk

We now illustrate how an ABS participant could apply the DMAIC quality control procedure to test for loan-quality problems stemming from operational risks in its loan acquisition process. Financial institutions can apply the DMAIC procedure to contend with a wide variety of operational risks, but we will limit our exposition of the procedure to our current bad-lending example. Although statistical quality control may not be able to help with operational risks from external sources, such as earthquakes and external fraud, the process we will now work through applies to many other types of operational risk.

We begin our exposition by looking for lending problems at the institutions closest to the underwriting process, the loan

originators. Recall from our discussion of the financial crisis timeline in chapter 3 that for mortgage originators such as New Century Financial Corporation, Countrywide Financial, and IndyMac Bancorp, operational risks in the institution's underwriting process led to catastrophic operational failures. Each of these companies went from a prosperous company with high market capitalization and thousands of employees to bankruptcy in a few short months. While some of their problems may have been created by simple old-fashioned credit risk, applying the DMAIC procedure allows us an opportunity to identify operational risks that may have emerged in the institution's loan underwriting process. Identifying and then correcting and controlling the operational risk in the system would make coping with the credit-risk component of the problem a more manageable proposition.

For our exposition of the application of the DMAIC procedure to identify potential operational risks in an institution's loan origination process, we can consider the task of two operational risk officers in a mortgage underwriter specializing in subprime mortgage originations. Although we might have to project ourselves back in time to 2005 to find such an institution, as we'll see, looking at subprime auto loans as our next example will allow us to return to the present.

The operational risk officers at our subprime mortgage underwriter could begin their search for potential problems in their institution by selecting a category of operational risks from table 1.2. Because we are interested in identifying and correcting potential problems in our loan origination process, we would select the category of Clients, Products, and Business Practices to address the possibility that there may be flaws in the nature or design of the product, that is, subprime mortgages, that could lead to unexpected operational losses. Thus, our operational risk officers begin the DMAIC procedure at step 1 by defining their project: Does our underwriting

process produce a subprime mortgage that meets or exceeds our quality standards?

Although a quality subprime mortgage may sound like an oxymoron, it is not, and it is precisely this distinction that will allow us to separate out the operational risk associated with quality assurance from the credit risk associated with subprime lending. As Montgomery points out, there are many dimensions to quality, such as performance, reliability, durability, conformance to standards, and aesthetics, to name a few. Conformance to standards and performance are the two quality dimensions that most readily apply to our subprime mortgage example. While the credit quality of a subprime loan will always be lower than the credit quality of a prime loan, their production standards should be the same, and it is the testing of conformance to these production standards that interests our operational risk officers.

With the potential operational risk problem defined by our operational risk officers, they complete step 1 of the DMAIC procedure by identifying the metrics they will use to measure and analyze the problem along with the appropriate source for that information. There are many loan and borrower characteristics that we could measure, but as we described in chapter 3, we will limit the relevant metrics for our mortgage quality evaluation to the LTV ratio, the DTI ratio, and the borrower's credit score. The information for the LTV components would come from the loan itself for the loan amount and the appraisal report for the property valuation. Information for the DTI ratio and the borrower's credit score would come from the borrower's credit report, income records, and information provided by the borrower during the loan application process. As a final part of this step of the procedure, the operational risk officers would also determine the appropriate dates and scope of the quality inspection program. For instance, the risk

officers could decide to evaluate all mortgage originations over a specified time period.

To begin the measurement step of the procedure, the operational risk officers would identify the key process input and output variables of interest. In our subprime mortgage lending example, we have already identified these key variables. The output variables are the LTV and DTI ratios of the originated mortgages along with the borrower's credit score. The input variables are those sources of information that we just described. Following the inspection procedure described in chapter 3, the operational risk officers would draw a random sample of mortgages from the appropriate pool of mortgages identified at the end of the definition stage of the procedure.

Prior to drawing the inspection sample, the risk officers would take output variable measurements for the entire pool of mortgages under consideration. The risk officers would record the LTVs, DTIs, and credit scores for the entire pool, and they would calculate the weighted average of each to determine the reported average of each output variable for the pool. These reported averages become the baseline for the measurement, and this is the information that would be reported in a prospectus describing this pool of mortgages.

Once we have calculated the relevant output variables for the entire pool of mortgages, that is, the population, the risk officers will want to draw a random sample of loans from the pool. In keeping with the example in chapter 3, we'll say that the risk officers draw a random sample of 100 mortgages. The risk officers have some flexibility in determining a particular sample size, and their sample size will depend on the degree of sensitivity with which they wish to identify differences between actual and reported output variables. In selecting a sample size, they will want to keep in mind that as sample size increases, the probability of committing a type II error

goes down for a given difference between the reported and actual variables. Recall that a type I error occurs when one rejects the null hypothesis when the null hypothesis is true, and a type II error occurs when one does not reject the null hypothesis when the null hypothesis is actually false. In our lending example, this means that our operational risk officers would have to determine the extent to which they would be comfortable accepting a pool of loans with LTV ratios that differ substantially from the reported average LTV. If they decide that LTVs may vary considerably because of the inherent variability of the appraisal process, then they can adopt a more favorable stance toward small LTV deviations and be comfortable with a smaller sample size. In general, the operational risk officers can consult operating-characteristic curves described in Montgomery. Consulting operating-characteristic curves may suggest that sample sizes of less than 100 are sufficient for the purposes at hand, but for consistency with our inspection example in chapter 3, we'll say that the sample size is 100, which in general should be more than adequate for our quality inspection.

It is at this stage of the measurement step that our lending quality control procedure differs somewhat from typical quality control measurements taken in other industries. With other products, the output variables would be recorded and we would move on to the analysis step. If those other products were loans, that would mean that we would record the LTV, DTI, and credit scores from our sample of loans and compare those values to the company's established standards. Although this is one way of measuring quality, for our loan-quality inspection we go one step further and verify the input information.

Thus, our measurement step is where the verification of the information reported with the loan application takes place. Ignoring costs for a moment, for the loans selected

by random sample, the operational risk officers would check the loan amount at origination, request an appraisal of the property, verify outstanding debt from the loan application and the credit report, verify the borrower's income from IRS Form 4506T and the loan application, and verify the borrower's credit score from the credit report. With this information in hand, the operational risk officers would be able construct new LTVs, DTIs, and credit scores for each loan in their sample. Using these newly constructed ratios and credit scores, they could then calculate weighted average sample means for each output variable and separately test the null hypothesis that the sample mean of each output variable is equal to the reported mean for the loan population under consideration. This is the testing process described in chapter 3. At the end of the measurement step, the operational risk officers would have the test results for each of the output variables of interest. They would then use the results from these tests as they begin the analysis step of the DMAIC process.

The first thing our operational risk officers will do in the analysis step is use the test statistics from the end of the measurement step to determine which null hypotheses to reject. With respect to our current quality control experiment for subprime mortgages, rejecting the null hypothesis would mean that sampling has unveiled a potential quality problem. Table 3.7, the inspection report from the measurement exercise in chapter 3, is an example of the type of report our operational risk officers could receive from the sampling and testing exercise performed in the measurement step. From table 3.7, the reported p-value of 0.0219 for the null hypothesis that the LTV sample mean is equal to the reported LTV mean suggests that we should reject this null hypothesis using a 5 percent significance level.

In chapter 3, we limited our attention to the LTV ratio to show the mechanics of sample testing because the testing

mechanics would be the same for the other output variables. In the analysis stage, however, we are interested in the test results for all of the output variables because of the information each output variable tells us about the loan origination process. Rejecting the LTV null hypothesis for instance, informs us that there may be a problem with the appraisal process. This of course assumes that the institution is recording the loan amount correctly, so that the problem is in the denominator of the LTV ratio. Similarly, rejecting the DTI null hypothesis of equal means would indicate that there is a potential problem with either the borrower's reported debt or the borrower's reported income, or both. Rejecting the credit score null hypothesis suggests some sort of problem with the way the company records the credit score, assuming that the credit report accurately records the credit score.

This abundance of information regarding the underwriting process is why the quality inspection should at least begin broadly by verifying all components of the output variables. Even though the cost of verifying certain components, such as getting a new property appraisal to verify valuation for the LTV, may be high, collecting enough information to establish a comprehensive baseline should be worth the expenditure in the long run. Furthermore, if the initial inspection does not find any quality problems in a particular output component, then subsequent inspections may be able to reduce the sample size drawn for verification of that component.

The test results from the measurement step will indicate if there is a difference between the sample mean and the expected or reported means. Whether that difference is positive or negative will determine whether the operational risk officers have a quality problem or not. Because our output variables reflect the credit quality of the loan, depending on the variable, significantly lower readings from the sample

would suggest that the quality of the loans may be higher than expected. For instance, lower LTV ratios are generally associated with lower default probabilities. Thus, if the LTV mean from the sample is estimated to be 80 and the reported LTV is 85, even though the means may statistically differ from each other and the operational risk officers may want to know the reasons for the lower LTV, it is not as critical a problem as would be the case if the sample LTV is significantly higher than the reported LTV. For this reason, the measurement stage may wish to focus on one-sided *t* tests. Operational risk officers may wish to concern themselves only when sample LTVs and DTIs are significantly higher than reported values, and when sample credit scores are significantly lower.

Once the test results from the measurement step have flagged areas of potential operational concern, the operational risk officers next use the analysis step to identify what is causing the problem. The first step in the process of identifying what is causing the significant differences is to check the sample data for data-entry errors. The operational risk officers should perform this data-entry check for each output variable. Montgomery points out that one of the problems with inspection is that it is prone to data-entry errors, as the sampling and measurement process tends to be more manual and thus has a propensity for human error to occur. Ironically, this propensity highlights the fact that another potential source of operational risk is the operational risk inspection process itself.

Once the operational risk officers have determined that data entry during the measurement stage is not the source of the problem, they must then identify what is the source of the problem. Among the analysis tools Montgomery suggests, the cause-and-effect diagram is likely to be the most practical for operational risk officers to explore operational risks in the loan origination process. As its name implies, the cause-and-effect

Table 4.3 Cause-and-Effect Diagram for Mortgage Underwriting Quality Analysis

Output Variable	Variable Component	Potential Cause
LTV	Loan	Data-entry error
	Value	Data-entry error
		Appraiser error
		Appraisal process
DTI	Debt	Data-entry error
		Incomplete application
		Debt misreporting
	Income	Data-entry error
		Incomplete application
		Income misreporting
Credit Score	Credit Score	Data-entry error
		Misreporting

Source: Author.

diagram associates identified problems (the effect) with potential causes of the problem. Generally, a quality improvement team consisting of people familiar with the production process is best suited to the task of identifying potential causes. Beginning with the LTV ratio, as with the procedures underlying the data for any ratio, quality problems could be affecting components of the numerator, the denominator, or both. Table 4.3 shows an example of a cause-and-effect diagram for quality analysis of an institution's mortgage underwriting operations. One thing that is immediately obvious from table 4.3 is that simple data-entry errors present a potential problem with each of the output variables.

Because of the numerous data checks that are likely to occur throughout the underwriting process, actual data-entry errors

may not be a common problem, but it is a potential cause that operational risk officers would want to investigate. This is especially true because, if data entry is the source of the problem that leads to the poor test results, then it is a relatively easy and inexpensive problem to correct. Because recording the loan value at origination is the only activity involved in producing the value of the numerator in the LTV ratio, a data-entry check is the only potential cause identified in table 4.3. Of course, even with an action as basic as recording the loan origination amount, there could be a data entry problem if, for instance, there is some inconsistency in whether the data recorded is the amount at origination or the current loan balance. A data-entry problem of this sort may reflect inconsistency or confusion on the part of the individual responsible for data entry as to which amount they are supposed to record. Operator error, which in turn may be linked to inadequate training, is a common cause of data-entry operational risks.

Continuing down the list of potential causes in table 4.3, a quality problem with property valuation, which we simulated in chapter 3, has more potential causes. In addition to the ever-present potential for problems with data entry, problems with property valuation, which reflects a property's appraisal value, could be associated with the appraisal process or the appraiser. Thus, in our table 4.3 cause-and-effect example, if our quality problem is linked to the value component of the LTV ratio, then the operational risk officers would have three potential causes to explore: data-entry errors, appraiser error, and appraisal process problems. Appraisal process problems could include faulty appraisal models, which could be a problem if the appraisal process uses automated valuation models, or problems associated with a lack of appraisal independence, which was a noted problem during the financial crisis.[8] Appraiser error could reflect something unintentional

such as inexperience or lack of familiarity with the property's characteristics, which could result in the selection of inappropriate comparable home sales, or intentional, such as providing a high valuation to please the loan underwriter with an aim toward securing future business.

Regardless of the number of potential causes that the operational risk officers have to investigate, the analysis stage of the DMAIC process consists of just this sort of investigation. Similar investigations would take place if the measurement step also revealed problems with the DTI ratio and the credit score. As shown in table 4.3, problems with the credit score, which is a relatively straightforward data-recording procedure like recording the loan origination amount, are likely limited to data entry or misreporting problems.

Problems in the debt and income components of the DTI ratio have a wider array of potential causes, much like the more numerous potential causes of property valuation problems. Because both debt and income require thorough and accurate reporting by the borrower and thorough documentation by the originator, there are multiple sources of potential problems in processes that assemble the DTI ratio. In addition to the usual data-entry problems, putting together an accurate and consistent DTI ratio requires applying a consistent definition of debt and a consistent definition of income. The DTI ratio generally reflects the ratio of monthly debt payments to monthly gross income, but slight variations in what is counted as debt and what is counted as income could cause considerable variation in the resulting DTI.

Overall, the analysis step would involve comparing reported data to the information verified during the measurement step across multiple variables. Over time, the list of potential causes shown in table 4.3 is very likely to change. These changes may occur because of changes in the loan origination

process itself or in the information the operational risk officers deem important as they gain experience with each business line inspected. There may also be an iterative element to the cause-and-effect analysis. For instance, if the investigation of mortgage quality problems points consistently toward errors in reported income, the operational risk team may wish to try to isolate the causes further by determining whether the borrower or the loan officer is doing the misreporting. If the misreporting is by the loan officer, then that could mean that some internal fraud is taking place or that the mortgage origination process is asking the loan officer to request the wrong information, two possible causes with two dramatically different implications for subsequent actions to improve the faulty process.

Implementing the improvement step

The improvement step is where the financial institution takes corrective action. Montgomery describes the role of the out-of-control action plan, which is a flowchart of activities that the institution needs to perform to identify and correct a problem once the measurement and analysis steps flag a potential problem. As Montgomery points out, an important determination the institution must make before embarking on its action plan, however, is whether the variation in quality reflects natural variability, or what Montgomery and others refer to as "assignable causes": for example, variation caused by broken processes, operator errors, or defective inputs. As its name implies, natural variability is just the background variability that is likely to accompany any measurement. In the case of the LTV ratio, we would expect a fair amount of natural variability to occur during the appraisal process. The very nature of the property appraisal process, which involves matching similar properties with recent sales data to make

transaction price comparisons, will generate some variation around the true value of the property.

In a recent Federal Reserve Bank of Philadelphia article, economist Leonard Nakamura discusses problems with appraisal bias and points out several potential sources of appraisal variation.[9] One potential source of variation that Nakamura identifies is thin markets, that is, there may be only a few house sales nearby, which means that selected home sales may not be closely comparable, and having relatively few price comparisons tends to increase the variance (a typical small sample problem). A second source of appraisal variation may be that, as mentioned earlier, all parties to the transaction may not want an independent and unbiased appraisal. Also, most homes have unique characteristics, which may make finding comparable home sales difficult, and may contribute to appraisal variation in much the same way as the limited comparable home sales information in thin markets. A fourth source of appraisal variation is foreclosures. Nakamura cites a National Bureau of Economic Research study by John Campbell, Stefano Giglio, and Parag Pathak, which estimates that foreclosed homes in Massachusetts sold for 28 percent less than they would have otherwise.[10] If appraisers include foreclosures in their comparable home sales, then the resulting appraisal may undervalue a comparable home that is not part of a foreclosure.

Given the natural variability that may occur with an output variable, part of the improvement stage's action plan is to determine the threshold for taking action to improve product quality. Because there is probably little that an institution can do about natural variability, action plans focus on correcting assignable causes of variation, which are the operational risks present in a process. In the case of lending, an assignable cause of variation such as operator error could be a data-entry

error if the mistake is unintentional or fraud if the mistake is intentional.

In addition to considering natural variability, there are several other elements that can help an institution determine appropriate action-triggering thresholds for its output variables. One such element is the overall result of the inspection report from the measurement stage of the DMAIC process. If the inspection report indicates a potential problem with just one output variable, the level of concern from the operational risk officers will be much lower than if the inspection report indicates problems in multiple output variables. In our mortgage origination example, for instance, test results that lead to just the rejection of the null hypothesis of equal means for the LTV ratio comparing the sample mean to the reported mean at the 5 percent level of significance may not be a cause for concern, given what we know about the natural variability that may exist in the appraisal process. If those test results, however, reject the null hypothesis of equal means for the LTV ratio, the DTI ratio, and the credit score, then the operational risk officers should be more concerned that there are general quality problems in the mortgage underwriting process.

Another element that can affect the determination of action thresholds is the distribution of problems around the mean. In chapter 3, we discussed the appropriateness of tracking critical events. In the case of LTV ratios, we suggested that such a critical event could be a deviation of the verified appraisal value from the reported appraisal value of 15 percent or more. Because mortgages with lower LTVs are less risky than mortgages with higher LTVs, operational risk officers may only wish to concern themselves when the sample LTV means are higher than reported LTV means. In determining thresholds for appraisals, however, inspection reports should include information about the size of the deviation and about the sign of the deviation,

that is, whether the verified appraisal is above or below the reported appraisal. If the appraisal deviations are the result of natural variability, then the deviations from the reported value should be randomly distributed above and below zero. If this is the case and the inspection report shows that most appraisal deviations are less than 10 percent and half are above zero and half are below zero, then the operational risk officers can credit these differences to natural variability and elect to indicate no need for action in their action plan. If, however, the inspection report shows that most of the appraisal deviations are less than 10 percent, but all of the verified appraisals are below the reported appraisal, then such a result would suggest an upward bias in the appraisals, and the operational risk officers may wish to take some action, such as changing appraisers or adjusting the appraisals to account for the estimated bias.

Another element that will help determine an action threshold is the stated tolerance limit of the ultimate customer. In the case of mortgage lending, the ultimate customer could be the financial institution itself, if the institution plans to hold the mortgage in its portfolio, or the ultimate customer could be an institutional investor, such as a pension fund, if the originator intends to sell the loan into the mortgage pool of a mortgage-backed security. Thus, the tolerance limit could be wide if it reflects the tolerance of a large lender that plans to hold the mortgage in its own portfolio until maturity and believes that there is a great deal of natural variability in the mortgage underwriting process. It may be more likely, however, for the customer to have a more limited view of natural variability and expect little deviation between what the originator initially reports and what the inspection report subsequently verifies.

A combination of these elements will help determine the thresholds for an institution's action plan. We have gone

into some detail regarding the specific elements and considerations that could affect LTV thresholds, but the process would be similar for the DTI and credit score variables. Because the various components of these variables should use consistent definitions for debt, income, and credit score, there should be little natural variability, and thus the tolerance limits for deviations between reported and verified values of DTI and credit scores should be quite low. Thus, taking natural variability and other factors into account, the operational risk officers would establish appropriate action-triggering thresholds. As we will explain further when we discuss the control stage of the DMAIC process, these tolerance thresholds may change over time.

Once the operational risk officers have established appropriate thresholds, the next step in the improvement phase of the process is to identify the specific cause of the problem. During the measurement stage, the operational risk officers collected additional information about various components of the output variables. With the LTV ratio, for instance, in addition to information about the loan amount and the appraised value of the property, the operational risk officers would want to include the name of the loan officer approving the loan and the name of the appraiser and appraisal company. If there are misreporting problems with the loan amount, then action should be taken with regard to data entry or the loan officer. Such action may be as simple as retraining, if the mistakes are careless and unintentional, or disciplinary, if the mistakes are intentional. This applies to appraisal errors as well. If the originator uses a variety of appraisers and the quality problems are evenly distributed across different appraisers, then the appropriate action may be to adjust the appraised value upward or downward by some fixed percentage, as suggested by Nakamura. If,

however, quality problems are concentrated in one or two appraisers, then the quality-improving action may be to stop using those appraisers. The operational risk officers would first want to verify that the appraisal process is independent, and that the appraisers were not being influenced by the loan officer, a complaint that appraisers raised with the Financial Crisis Inquiry Commission.[11] If the appraiser isn't being influenced by the underwriter, then the appropriate action to take may be to drop that appraiser from the institution's list of approved appraisers or adjust consistently overoptimistic appraisals downward by an estimate of the amount of upward bias.

Corrective action with respect to the DTI and credit score components will generally focus on improving data-reporting processes. If the operational risk officers track the quality problem to data-entry errors, then they may wish to recommend retraining of the individuals responsible for data entry, or inserting a step to check for data-entry errors into the underwriting and reporting process. If the quality problems reflect inconsistent definitions of what counts as debt or income, then the corrective action may be to introduce a checklist into the underwriting procedure that would help ensure that borrowers provide, and loan officers collect, all relevant debt and income information.

Implementing the control step

The operational risk quality control process moves into the control step when the institution has taken all appropriate action, quality has improved, and the institution wishes to maintain the new, higher-quality process. For the most part, the control step involves a periodic repetition of the measurement and analysis steps of the DMAIC procedure. Continuing with our lending example, this will involve periodic resampling

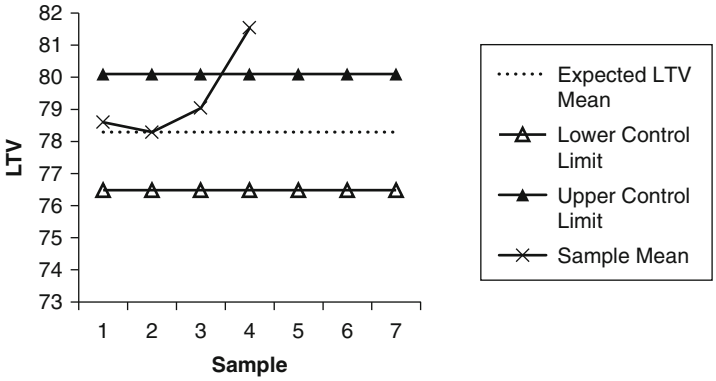
of originated loans along with verification of data and testing whether the verified data differs significantly from the reported data. Control charts and other statistical tools will be useful in helping the institution monitor and maintain control over product quality.

Cost factors, such as the cost of sampling and information verification, will affect the institution's decision as to how frequently they should draw samples and conduct quality verification tests. High sampling and verification costs will tend to make the institution prefer smaller and less-frequent samples. Offsetting these cost considerations, however, are the internal and external costs of an operational failure caused by poor product quality. Just as the cost of sampling and information verification push a firm in the direction of less-frequent sampling, internal and external failure costs push it back in the direction of more-frequent sampling. The institution's reputation, the attitude of senior management toward quality, the market, and the firm's regulatory constraints will all factor into the institution's decision regarding all quality control efforts,that is, the levels of both initial and monitoring activities.

The past experience of a particular product may also influence an institution's attitude toward ongoing quality monitoring and control efforts. For instance, lessons learned in the ABS market during the financial crisis should help convince all participants of the value of ongoing quality control for loans destined for the securitization pipeline. Because most securitization deals include buyback provisions, which means that the loan originators must buy back any loan that does not meet certain minimum performance standards, loan originators will ultimately bear the cost of poor-quality loans.

As Montgomery describes, the control step involves the operational risk officers completing their involvement in the

Figure 4.1 Sample Control Chart for LTV Mean



production improvement process by providing those with ongoing responsibility for the product with a process control plan. The process control plan will typically reference sample and test results from the DMAIC procedure and include a system for monitoring the improved production efforts. The production team will then follow the process control plan, which will include ongoing auditing requirements, and track and report audit results to the institution's senior management.

Control charts are a particularly useful tool for the control step within financial institutions. Montgomery provides a detailed description of control charts with respect to statistical quality control in general, but for financial institutions and monitoring the quality of the underwriting process in particular, control charts on the output variables should be sufficient. As Montgomery explains, a general model of a control chart consists of a center line, an upper control limit, and a lower control limit. In practice, for control charts for output means, the center line reflects the expected value, or mean, of the output variable, and the upper and lower control limits are some multiple of the standard deviation of the variable above and below the center line, respectively.

Control charts can mimic the hypothesis testing boundaries set in the initial measurement stage of the DMAIC process. For instance, figure 4.1 shows a possible control chart for the mortgage portfolio used in chapter 3, that is, GSAMP 2006-NC2. Calibrating the control chart with data from the first drawn sample from table 3.4 in chapter 3, we could construct the control chart using the sample mean of 78.29 and the lower and upper 95 percent confidence limits of 76.48 and 80.10, respectively. Figure 4.1 then records the first four sample mean observations from table 3.5. As figure 4.1 indicates, when the fourth sample yields an LTV estimate of 81.54 compared to the expected mean of 78.29, the control chart suggests that the process is out-of-control, and the operational risk officers should repeat the DMAIC procedure to establish control over the process.

The complete DMAIC procedure provides additional guidance as to which institutions in the securitization chain are able to implement a complete quality control program. A complete quality control and improvement procedure would begin with the define stage and end with the control stage after the institution has identified and corrected the production problems that created the quality problems. The loan originator has the power, the necessary information, and the proper incentive to implement a thorough quality control program. As we have seen, the loan originator has complete control over the loan origination process. During the loan application process it collects all the relevant information that feeds into the output variables, and it has the incentive and the means to correct systemic flaws in the loan production process that generate poor-quality loans. Again, it is worth repeating that by poor-quality loans, we do not mean poor credit quality, but rather loans with underlying information that does not match reported information.

The next participant in the securitization chain is the ABS sponsor. Because the ABS sponsor has a supply-chain-management responsibility regarding the loans it includes in its ABS, any ABS sponsor should have access to all the documents it would need to verify the information about any loan in its ABS pool. Thus, the ABS sponsor should be able to complete the define, measure, and analyze steps of the DMAIC process. Because it lacks direct control over the actual underwriting process for loan originations, however, its influence on the improvement and control steps of the process is limited to the indirect influence a purchaser could have on one of its suppliers. Depending on the competitiveness of both the loan origination and the ABS securitization markets, this indirect influence could be powerful or weak. A large ABS sponsor would tend to have greater influence over a relatively small loan originator, just as a large retailer like Walmart would have a great deal of influence over a small supplier. Refusing to accept a loan unless the originator takes the necessary steps to improve loan quality could be enough to induce the originator to take those steps, provided that the ABS sponsor has enough market power.

Next in the securitization chain, the credit-rating agencies are much the same as ABS sponsors. Because their reputations depend on the quality of their ratings (as we witnessed in the wake of the subprime financial crisis), to protect their reputations, credit-rating agencies should be able to get access to the same documents as the ABS sponsor and be able to verify the same information. If this is the case, then like the ABS sponsors, the credit-rating agencies can define, measure, and analyze quality problems and attempt to influence the improvement and control steps of the originator by bringing pressure on both errant ABS sponsors and errant loan originators. If, for some reason, credit-rating agencies do not have

access to the necessary documents, then they are only able to define the potential quality problem and they would be unable to measure and analyze the problem. They could still try to apply pressure to influence the quality control procedures of the ABS sponsors and loan originators, but if they are not strong enough to get access to the information they would need to protect their own reputations, then they are almost surely not strong enough to have much influence over the quality control decisions of the sponsors and originators.

Last in the securitization chain, ABS investors are probably least capable of performing the thorough data-verification procedures necessary to ensure loan underwriting quality. As we discussed earlier in this chapter, legitimate privacy concerns place limitations on certain types of borrower information that ABS investors should have access to, and without access to this information, investors are not able to verify the accuracy of the reported information. Such a verification effort would also be costly for investors, and extremely inefficient if each investor has to undertake an inspection program to verify loan data. Given the data restrictions that investors face, it is reasonable to expect investors to limit their due diligence to making sure that either the credit rating agency, the ABS sponsor, or the loan originator is performing the appropriate loan-information inspection program. Investors can accomplish this due diligence task by reading the inspection reports that the quality control program should produce for senior management and outside investors.

Applicability to other operational risks and DMAIC reporting

Before discussing the importance of quality control program reporting, however, it is worth pointing out that financial institutions may use the statistical quality control program

we've described with a variety of operational risks. For expository purposes, we've focused on a particular type of potentially catastrophic operational risk, namely, bad lending. Chapters 3 and 4 have focused on mortgage lending in particular. The quality control procedures described, however, apply readily to underwriting and origination processes for other types of loans, and they also apply more generally to other types of operational risk affecting other bank activities.

Mortgages provide an excellent example for working through the DMAIC procedures. As we have seen, mortgages have several significant output variables (namely, LTV, DTI, and credit scores) with underlying systems and procedures where operational problems could easily take root. As we look first to solving operational problems with other types of loans, we can determine how readily the quality control procedures used with mortgages transfer to these other loans. Two of the output variables that we inspected and tested with mortgages, the DTI and the credit score, are variables that are associated with the borrower. Thus, any time a loan is made, at a minimum, the loan originator can inspect and verify these two output variables. The third output variable, the LTV ratio, is associated with the asset backing the loan. In the case of loans for physical assets like homes, cars, and boats, the LTV is readily available and the loan originator can copy the full DMAIC procedure described for mortgages and apply it to loans collateralized by other physical assets.

Some loans, especially certain consumer loans, may not be collateralized by physical assets, and hence, coming up with an LTV ratio for the loan may be difficult. With student loans for instance, it will always be difficult to place a value on the education the student is purchasing with the loan, so we typically do not associate LTV ratios with student loans. Depending on the age of the student, DTI ratios and even credit scores

may be difficult to find, making the quality of student loans one of the more difficult to verify. Nevertheless, even institutions originating student loans can apply the DMAIC procedure to the DTI and the credit score to see what information is available on a particular pool of student loans. Limited information may just require some creativity on the part of the DMAIC team. For instance, if a simple DTI ratio may not be appropriate because the borrower is just entering college, the operational risk team could estimate a ratio of debt to projected income (a DTPI ratio) for the borrower. As a benchmark for hypothesis testing and subsequent control chart monitoring, the student loan DMAIC team could use the DTI ratio of 43 percent sanctioned by the Consumer Financial Protection Bureau's ability-to-pay standards. Generally, if there is a loan output variable that is germane to the likelihood that a borrower will be able to make timely payments to repay the loan, then the DMAIC team should be interested in verifying this output information.

Moving away from loans and looking at other bank products and activities, the DMAIC procedure remains the same even though the output variables of interest will change. For instance, trading may be another important activity for a particular bank. As we know from the introduction and studies cited there, trading can also be a major source of operational risks, and potentially catastrophic operational risks to boot. Although trading is very different from lending, there are still systems, processes, and people that generate output variables of interest in the course of trading, and it is these output variables that operational risk officers and the DMAIC team should focus on. With lending, we saw that two of our output variables of interest are linked directly to the borrower. With trading, we trade a borrower for a counterparty, and thus we readily see that operational risk officers could be concerned

with verifying counterparty information. With lending, the concern focused on DTI and credit scores. With trading, attention might focus on a counterparty's ability to honor the trade (something similar to the DTI) and the counterparty's credit rating (something similar to the credit score).

In general, if a product has some characteristic that is easily measurable, then we can associate a particular output variable with that product characteristic. If that product characteristic is not easily measurable, but if the institution can note its presence or absence, then the institution can count how often a product is missing a certain attribute. Montgomery provides additional detail regarding how the DMAIC procedure applies to this product attribute testing, but let it suffice here to say that the DMAIC procedure itself is the same.

Regardless of whether the product characteristic of interest is an attribute or a measurable variable, the DMAIC procedure allows us to test the quality of the underlying business operations that are creating the product. While those operations may be functioning properly, losses may still occur, but those losses should be attributable to credit risk in the case of lending and counterparty credit risk or market risk in the case of trading, and not to operational risk. To make this determination and assign the loss to its proper risk category, the institution's senior management should initiate and take active interest in the quality control program, which can test for product-quality shortcomings that indicate the presence of operational risk. Without an active and ongoing quality control program, an institution will certainly not be able to prevent existing operational problems from leading to operational failures. Moreover, after the failures occur, the absence of a quality control program may make it difficult to assign a cause to the failure and hence determine whether the institution could have done anything to prevent it or could do

anything in the future to prevent it from happening again. After a catastrophic failure, however, a forensic team may be assigned the task of determining the cause of the failure, and their methods of identifying root causes align closely with the define, measure, and analyze steps of the DMAIC procedure.

To prevent the situation where a forensic team is responsible for identifying what went wrong with an institution after its failure, the senior management of that institution should ensure that they have an active quality inspection program in place for each of their major business activities. Operational risk and quality control experts (for example, Marshall and Montgomery) consistently emphasize the absolute necessity of establishing senior management as the driving force behind operational risk and quality control programs. Without the backing of senior management, an institution may be able to accomplish the define, measure, and analyze steps of the DMAIC procedure, but the critical steps of improvement and control cannot get done without an executive blessing.

Of course, it is entirely in the best interests of senior management to be thoroughly involved in the quality control process and attentive to quality control reports. The operational risk literature is rife with examples of catastrophic failures resulting from operational problems. Under the single assumption that senior executives of an institution have as their primary objective maintaining the long-term viability of the institution, then these executives would want to apply at least some effort toward quality control and they should be willing to expend considerable effort as long as the cost of the quality control program does not exceed the expected profit from the product. If inspection costs are this high, then we are back to the case described earlier in the book, in which the executive decision should be one to avoid that particular business line altogether. If quality control costs are below this threshold,

then executives would generally improve long-term institutional value by taking steps to prevent catastrophic operational failures, and by doing so, generally improve their long-term personal wealth to the extent it is linked to the institution's continued existence.

To see why this is the case for executives, consider any of the mortgage originators that failed during the subprime crisis. For example, New Century Financial was a publicly traded company with thousands of employees and a market capitalization of roughly $1 billion at its peak.[12] In other words, the owners of New Century had $1 billion at stake in the company, and they were about to lose more than 90 percent of its value. Although some of the loss is attributable to credit risk, which asserted itself as the housing market and interest rate environment changed in early 2006, we know from subsequent media reports mentioned in chapter 3 that some of the losses were attributable to serious operational failures in the loan origination process. Would a statistical quality control program have helped identify operational problems at New Century in time to prevent its catastrophic failure? We'll never know for sure of course, but I suspect that the answer is "yes."

If senior management and employees alike had a great deal to lose if New Century failed and catastrophic operational risks contributed to its failure, what prevented senior management from taking steps to correct these operational problems? For one possible answer to this question, we can turn again to the interagency guidance on subprime lending issued in 1999. Recall that this guidance warned about high upfront fees and that these fees combined with compensation incentives could foster predatory pricing or steering of borrowers into subprime products. In general, firms can be undone by their own shortsighted incentive compensation schemes if those schemes

reward employees based on the number of units produced without regard to quality. Employees compensated in such a manor will have a strong incentive to hide quality problems from executive management. When a firm is producing a high-quality product, the top producer in the firm is a valuable asset to the firm. When, however, a firm is producing a defective product, the firm's top producer is actually harming the company. Because of this ever-present potential for misaligned incentives regarding product quality and employee compensation, product quality must always be a fundamental objective of an institution's most senior management.

Institutional management has the resources to monitor and improve product quality, and among regulated financial institutions, it also has some potential allies in accomplishing this objective. As we discussed in chapter 2, senior management has the internal audit department to act as its operational risk and quality control officers. As mentioned by Montgomery, eventually the quality control efforts should revert to those responsible for the particular business line, but internal audit, especially those trained in statistical quality control, will want to play a central role in the institution's enterprise-wide quality control program.

In addition to support from the internal audit department, supervised financial institutions may also receive external help from the examination, inspection, and audit functions performed by the institution's primary regulator. Ideally, examination efforts by an institution's supervisory agency would simply verify that the institution is taking all the steps necessary to ensure that it is operating in a safe and sound manner. These examination efforts generally include actual product inspection, but if an institution is in regulatory compliance, then external inspection should not find anything amiss. If an institution is not in regulatory compliance, however,

then the regulatory inspection that identifies a problem adds value to the institution and senior management by bringing those shortcomings to the attention of the board of directors. While some of the identified shortcomings may seem relatively minor to the institution, it is difficult to know how often catastrophic failures begin as minor problems. If some catastrophic failures do begin as minor problems, then identifying even minor problems provides a potentially significant benefit to the institution.

Regulatory oversight often provides value to a regulated institution by complementing the institution's internal audit process. However, institutional management must also contend with the fact that its external auditors, including its regulatory agency, also have to cope with potential operational failures that may result in the regulator making mistakes by missing compliance and other operational shortcomings. As we discuss in the next chapter, operational risk is a risk that can affect any institution with people, systems, and processes—in other words, any institution, including government agencies. Thus, senior management, while benefiting from the contribution external auditing may make to their organization by identifying problems that the institution's internal auditors missed, remains ultimately responsible for and most affected by operational risks and quality control problems.

5
Regulatory Agencies and Operational Risk

At the beginning of this book, we defined operational risk as the risk of loss from inadequate or failed internal processes, people, and systems or from external events. While the Basel Committee on Bank Supervision developed this definition for financial institutions—banks in particular—the fact is that any institution with people, systems, and internal processes is exposed to operational risk. Because every institution has people, systems, and processes, every institution, including regulatory agencies, must contend with operational risk. Although regulatory agencies may suffer financial losses from some operational risks that lead to higher-than-expected budget expenditures, we are concerned here with the operational risks involving inadequate or failed internal processes or systems that could lead a regulatory agency to provide inadequate supervision of the institutions it regulates.

Operational risks at regulatory agencies vary by type, frequency, and severity, just as they do at financial institutions. The principal activities of financial regulators are to examine regulated institutions and oversee regulated markets, and these supervisory activities often involve the collection of confidential supervisory information. Thus, some of the more serious operational risk exposures for regulatory agencies include inadvertently disclosing confidential supervisory information,

inadequate examination of a regulated institution, and inadequate oversight of a regulated market. Certainly, many of the operational failures that occur at regulatory agencies are both low in frequency and low in severity. Like operational risk anywhere, however, unnoticed or uncorrected operational risks at regulatory agencies can lead to catastrophic operational failures that may impact the regulated institutions, the regulated market, and even the regulatory agency itself.

For example, the Office of Federal Housing Enterprise Oversight and the Office of Thrift Supervision are former regulators that closed in the wake of catastrophic failures at their supervised financial institutions during the subprime financial crisis. It is important to be clear that these regulatory agencies did not cause the catastrophic failures at the institutions they supervised. As we discussed at the end of chapter 4, the senior management and owners of a firm are ultimately responsible for the activities and product quality of their institutions, and thus are ultimately responsible for the firm's survival. Regulatory agencies, however, do bear some responsibility to the extent that their own operational failures prevent them from identifying problems at the regulated institutions and requiring corrective action in time to prevent widespread failure.

Operational failures at a regulatory agency are particularly dangerous because they can potentially affect all institutions under the agency's supervision. Thus, if examiners do not identify a potential problem at one institution because of a systematic problem in the regulatory examination procedure, then examiners and the regulatory agency will generally not be able to identify similar problems in other institutions, and the operational risk may become a systemic problem. Conversely, the regulatory examination procedures may be adequate, but the execution of those procedures by a particular examination team may be the problem. As with most operational risks linked to particular individuals, the corrective action typically

will include improved training. For operational risks linked to the agency's examination procedures and systems, the agency would have to correct or enhance its examination procedures.

Just as catastrophic operational failures at individual financial institutions often create enough problems to attract public attention, so too do severe operational failures at regulatory agencies. To examine the types of operational risks with which regulatory agencies must struggle, we offer the examples of two recent problems at financial institutions that exposed related operational risks at regulatory agencies. The operational problems at these two banks were severe enough to draw congressional scrutiny for both the banks and the bank regulator.

Anti–money laundering and HSBC

In July 2012, the United States Senate Permanent Subcommittee on Investigations (the Subcommittee) released its report titled, "U.S. Vulnerabilities to Money Laundering, Drugs, and Terrorist Financing: HSBC Case History."[1] In the introduction to its report, the Subcommittee examined the anti–money laundering (AML) and terrorist financing vulnerabilities created when a global bank uses its US affiliate to provide high-risk affiliates and clients access to the US financial system. These vulnerabilities put other US financial institutions and the US financial system at risk. Acknowledging the pivotal role that regulatory agencies play in protecting the US financial system, the Subcommittee's investigation also "examined the regulatory failures that allowed these and other AML problems to fester for years."[2]

To investigate AML vulnerabilities, the Subcommittee selected HSBC as a case study because of its large size and "because of its weak AML program."[3] HSBC, which is one of the world's largest financial institutions, has its headquarters in London and owns a US affiliate—HSBC Bank USA National Association—which holds a national bank charter. Its primary regulator is the OCC, which supervises national banks and federally chartered

savings institutions. By examining HSBC's AML shortcomings and the regulatory failures at the OCC, the Subcommittee's report allows us to explore the operational risks at both institutions, the steps each institution could take to reduce these and similar operational risks, and the consequences of not tackling these operational risks when they first appear.

The operational risks at HSBC that are the focus of the Subcommittee's investigation are those associated with the institution's AML program. To see that any institution's AML shortcomings qualify as operational risks, we need only note that the AML program itself consists entirely of procedures, systems, and people tasked with verifying that various transactions are not facilitating money laundering. The Subcommittee reviewed over a million documents and identified the following five outstanding AML issues at HSBC:[4]

1. Opening US correspondent accounts for high-risk affiliates without conducting due diligence;
2. Facilitating transactions that hinder US efforts to stop terrorists, drug traffickers, rogue jurisdictions, and others from using the US financial system;
3. Providing US correspondent services to banks with links to terrorism;
4. Clearing bulk US dollar travelers checks despite signs of suspicious activity;
5. Offering high-risk bearer share corporate accounts.

These are serious AML shortcomings that most likely allowed money laundering and terrorist financing access to the US financial system. The report also notes that avoiding such problems requires "an effective AML program, with written standards, knowledgeable and adequate staff, the infrastructure needed to monitor account and wire transfer activity for suspicious transactions, effective AML training, and a compliance culture that values obtaining accurate client information."[5] The report

points out that there are four minimum statutory requirements for a bank's AML program: (1) AML internal controls, (2) an AML compliance officer, (3) AML training, and (4) independent testing of the effectiveness of its AML program. A US financial institution's primary regulator examines the institution for precisely these elements of an effective AML program.

As OCC testimony provided during Subcommittee hearings makes clear, the OCC monitors compliance with AML regulations through its regular examination cycle.[6] During this cycle, the OCC examines community banks either every 12 or 18 months and large and midsize banks at least every 12 months. The OCC's AML examination procedures include a review of the bank's risk assessment and AML compliance programs, which includes an assessment of the bank's internal controls, training programs, independent testing, and Bank Secrecy Act (BSA) officer independence and qualifications.

As was apparent from OCC testimony, OCC procedures ensured that its examiners conducted thorough AML examinations of its banks on a regular basis and of HSBC in particular on an annual basis. Nevertheless, the Subcommittee report determined that the OCC was "exercising ineffective AML oversight."[7] In other words, the OCC's AML processes, people, or systems failed or proved inadequate in this particular instance, which is the very definition of operational risk. What were the OCC's operational failures?

Before outlining the operational failures described by the Subcommittee, it is critical to note that such operational failures are by no means unique to the OCC. In fact, as mentioned earlier, operational risks and subsequent operational failures exist in any organization, and this is true of all regulatory agencies, other government agencies, not-for-profit organizations, and for-profit companies, both public and private. For expository purposes, however, we examine two cases of operational failure at the OCC because of the public record made available about

the problems through the Subcommittee's report and subsequent hearings. Furthermore, the occurrence of operational failures at any organization does not automatically imply that the organization is fundamentally flawed. Operational risk is ever present in any organization. On occasion the processes, people, or systems involved will prove to be inadequate, and mistakes will be made or financial losses will occur. Although the organization's reputation will almost always suffer in the wake of an operational failure (reputation may not suffer when the cause is an external event), the only operational failure that would indicate a fundamental flaw in an organization is the absence of a process to learn from and correct operational failures when they occur. In other words, repeated identical operational failures would be an indication of serious and potentially catastrophic senior executive and board-level operational deficiencies at an organization. Corrective action taken by the OCC after its two very public operational failures indicates that the OCC does not suffer from this fundamental flaw.[8]

How then, did operational risks at the OCC manifest themselves with respect to AML exams? The Subcommittee report describes HSBC's serious and ongoing AML problems. The report identifies six problems at HSBC and one problem at the OCC. The Subcommittee's findings are:[9]

1. Longstanding severe AML deficiencies at HSBC,
2. Taking on high-risk affiliates,
3. Circumventing the US Treasury Department's Office of Foreign Assets Control (OFAC) prohibitions,
4. Disregarding terrorist links,
5. Clearing suspicious bulk travelers checks,
6. Offering bearer share accounts, and
7. Allowing AML problems to fester for years.

Recognizing that AML deficiencies are similar to other quality control problems, we can treat HSBC's AML problems as

we would any other operational risk and attempt to apply the DMAIC procedure to the problems. To accomplish this, we would want to use what Montgomery and others refer to as "attribute testing." Attributes are nonnumerical quality characteristics, such as the number of mistakes in a loan application. One obvious analogous application of attribute testing to the problems at HSBC would have been to simply count the number of AML examination deficiencies at the institution. For instance, the Subcommittee report cites an HSBC backlog of 17,000 alerts that HSBC had not reviewed and late or missing Suspicious Activity Reports (SARs). Recognizing that an unreviewed alert or a missing SAR is a quality defect in the institution's AML processes, we could then count the number of defects in each AML process.

Following the methodology for using control charts with attributes as described in Montgomery, if we treat each unit as a Bernoulli random variable,[10] then the mean number of defects per unit is equal to np and the variance in the number of defects per unit is $np(1–p)$, where n is the size of the sample selected and p is the probability that a unit will be defective. If the institution knows the probability that a unit will be defective, then this probability would form the center line in a control chart tracking the number of defects and the baseline for the null hypothesis against which to test subsequent samples. Such a known probability of defects could represent some industry standard established by experience or tolerance. Usually, however, the true probability of defects is not known, and the institution must establish this probability that a unit will be defective through initial sampling. If this is the case, then, following Montgomery, the estimate of the probability that a unit will be defective is equal to:

$$\hat{p}_i = \frac{D_i}{n}, \tag{5.1}$$

where D_i is the number of defective units in sample i of sample size n. To determine the baseline estimate of the probability that

a unit is defective, the institution would then take some number m of preliminary samples and determine the average as:

$$\bar{p} = \frac{\sum_{i=1}^{m} D_i}{mn} = \frac{\sum_{i=1}^{m} \hat{p}_i}{m}, \tag{5.2}$$

Then for subsequent samples, say $m + 1$, we could test the null hypothesis: $\bar{p} = \hat{p}_{m+1}$.

We could also begin a control chart with center $\bar{p}$, and upper and lower control limits set at:

$$control\,limits = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \tag{5.3}$$

At this point, we could work through the HSBC AML problems one by one and learn how to apply attribute testing to each problem. In this chapter, however, we want to move the focus of quality testing from the regulated institution to the regulatory agency. As it turns out, the quality control methodologies using attributes are roughly the same at the regulatory agency as they would be at the bank. Thus, by working through an attribute testing example at the regulatory agency, we can see how the bank could use that same methodology internally to identify and improve operational risks in its AML processes. Because regulatory agency operational risk exists in any examination processes or systems rather than just the AML examination process, we can generalize the regulatory quality control procedures we learn in the context of AML exams at the OCC to any examination process at any regulatory agency.

As a first step, however, with the help of information revealed in the Subcommittee's report, we can study how to improve the management of operational risk at regulatory agencies by working through the example of operational risk problems connected to the AML examination process at the OCC. To do this, recall that the first step in the DMAIC procedure is to define the

problem. The Subcommittee report will help us identify the basic nature of the AML examination problems that arose within the OCC. We can deduce from the Subcommittee's report that the AML problems at the OCC were not a complete lack of awareness of AML deficiencies at HSBC. The Subcommittee report indicates that between 2005 and 2010, the OCC conducted 43 AML examinations and identified at least 83 AML MRAs. If the OCC examinations had not uncovered any AML deficiencies at HSBC during those 43 examinations, then our quality control process would have likely focused on the OCC's AML examination procedures to try to determine why they were missing repeated and significant AML deficiencies. This was not the problem, however. Instead, the OCC's quality control problem was that the examination reporting procedures did not communicate the seriousness of repeated and significant AML deficiencies reflected in the 83 MRAs to the OCC's senior management, the bank's board of directors through informal enforcement actions, and potentially to the general public through formal enforcement actions. This miscommunication occurred in turn because the OCC did not have a quality control monitoring system in place that could indicate that AML systems at HSBC were in fact "out of control."

Thus, in defining our quality control question for the OCC, we ask, why did the identification of 83 MRAs by examiners over a five-year period not trigger greater regulatory scrutiny and insistence that HSBC correct its AML deficiencies? As this is a quality control question about potential operational risks in the OCC's examination process, we must first understand that process and the role of MRAs.[11]

The OCC generally conducts a full-scope onsite examination of national banks at least once a year.[12] Whereas the OCC conducts most examinations with a temporary visit by an examination team, the OCC's largest and most complex banks are part of a continuous examination program, with a team of examiners assigned to the bank full-time. HSBC is part of the OCC's

continuous examination program for large banks. The head of the large-bank examination team is the EIC, and the EIC develops an annual supervisory strategy for the bank, which is the work plan for examining the bank.

The principal output of the examination is the report of examination, or supervisory letter, which the OCC distributes to the bank's board of directors at least once each examination cycle. The report of examination "conveys the overall condition and risk profile of the bank, and summarizes examination activities and findings during the supervisory cycle."[13] It contains conclusions on assigned ratings, discusses deficient risk management practices, and details corrective action committed to by the board of directors or management. Overall, the report of examination "is usually a summary of examiners' conclusions about the bank's condition drawn from the results of supervisory activities throughout the 12-month cycle."[14] Including updates through October 2014, the typical report of examination consists of mandatory core pages, optional core pages, and supplemental pages. Among the mandatory core pages are the Examination Conclusions and Comments, MRAs, Narratives discussing the supervisory Uniform Financial Institutions Rating System, or "CAMELS" rating that addresses the institution's capital adequacy, asset quality, management, earnings, liquidity, and sensitivity to market risk, a Risk Assessment Summary, and Schedules. The EIC may include optional core pages to further support examination findings and supplemental pages to support mandatory core page analysis.

MRAs receive their own page in the report of examination. Short of a formal or informal enforcement action, the MRA page "focuses the board's attention on supervisory concerns that require their immediate acknowledgement and oversight."[15] According to the Comptroller's Handbook, as updated on October 23, 2014, MRAs must do the following:

1. Describe the concerns.
2. Identify the root causes of the concerns and contributing factors.
3. Describe potential consequences or effects on the bank from inaction.
4. Describe supervisory expectations for corrective actions.
5. Describe management's commitments to corrective action and include the time frames and the persons responsible for the corrective action.

The Handbook also makes it clear that the bank must have a process for following up on MRAs, and that failure to do so could lead to enforcement actions. Note, of course, that the OCC has updated the Comptroller's Handbook since the Subcommittee's report in 2012, updates that in part reflect issues raised by the Subcommittee.

Table 5.1 summarizes a table in the Subcommittee's report that shows MRAs and recommendations in OCC supervisory letters for HSBC Bank USA from January 2005 through July 2009. As reported by the Subcommittee, the OCC conducted 43 BSA/AML exams, identified 83 MRAs, and made 30 recommendations in supervisory letters to the bank.

We can use this information to show how a regulatory agency could use attribute control charts to help identify quality control problems at institutions they supervise. If we think of an MRA as tagging a nonconformity or defect in the bank's BSA/AML procedures, then we can construct a control chart to monitor those procedures for defects and determine when the bank's BSA/AML procedures are out of control.

Using the information in table 5.1, the mean number of MRAs per BSA examination at HSBC over the time period covered is 1.9. Following the methodology in Montgomery for constructing control charts for nonconformities, which requires the assumption that defects occur according to the Poisson distribution,

Table 5.1 Summary of MRAs and Recommendations in HSBC Supervisory Letters, January 2005–July 2009

BSA Exam Number	Super. Letter Date	Number of MRAs	Number of Recs.	BSA Exam Number	Super. Letter Date	Number of MRAs	Number of Recs.
1	1/26/2005	6	0	23	8/6/2007	0	1
2	6/20/2005	6	0	24	8/21/2007	0	0
3	8/9/2005	0	0	25	8/21/2007	0	0
4	1/17/2006	7	0	26	9/13/2007	5	0
5	1/23/2006	5	0	27	9/21/2007	3	0
6	1/30/2006	4	0	28	9/21/2007	1	0
7	1/31/2006	7	0	29	10/15/2007	0	1
8	4/12/2006	3	0	30	2/11/2008	0	3
9	4/27/2006	0	1	31	4/9/2008	2	1
10	6/14/2006	4	0	32	4/21/2008	3	0
11	7/13/2006	0	3	33	6/2/2008	0	2

12	9/26/2006	3	0	34	7/10/2008	1	0
13	10/19/2006	1	0	35	9/4/2008	2	0
14	12/1/2006	5	0	36	1/20/2009	0	1
15	1/8/2007	0	2	37	1/22/2009	0	0
16	3/8/2007	4	1	38	3/3/2009	0	2
17	3/19/2007	3	0	39	3/18/2009	2	1
18	3/27/2007	3	7	40	3/18/2009	0	1
19	3/29/2007	1	0	41	5/27/2009	0	0
20	5/22/2007	0	0	42	6/24/2009	1	3
21	6/17/2007	0	0	43	7/7/2009	1	0
22	6/20/2007	0	0				

Totals: 43 BSA exams, 83 MRAs, and 30 Recommendations.

Source: US Senate, "HSBC Case History," 380.

the center line of the control chart is equal to the parameter c, which we estimate as the observed average number of nonconformities, or 1.9 using the HSBC data. The upper control limit is then just $(c + 3\sqrt{c})$ and the lower control limit is $(c–3\sqrt{c})$. In this discussion of the HSBC example, the lower limit for the number of defects is below zero, so we will also assume that AML procedures that produce zero defects are in control and just focus on the upper control limit. With c as 1.9, the upper control limit is 6.0, and glancing through table 5.1 would indicate that HSBC's BSA/AML procedures were out of control only four times in 2005 and early 2006, and zero times thereafter.

We know from the Subcommittee report, however, that HSBC's BSA/AML program was not performing adequately, even though our estimated control limits would suggest otherwise. This, of course, just highlights the potential problems that might occur if we set control limits using output from a procedure that is not currently performing according to expectations regarding quality. With respect to control limits for defects, the institution or regulatory agency may be able to establish acceptable standards for the number of defects based on past experience or the institution's tolerance for nonconformities. Note that if the organization sets the center line, c, at zero defects, both the upper and lower control limits also reduce to zero, and the organization would consider such a system out of control any time a defect occurs.

We can use our knowledge that the number of nonconformities from a sample of HSBC examinations (that is, 1.9) may be too high and that zero nonconformities could trigger too many false alarms to consider one MRA as a plausible quality standard for BSA/AML examinations. If we set the standard for exam nonconformities at 1, that becomes our control chart center line, and the upper control limit is equal to 4. Glancing back through table 5.1, it now indicates that the HSBC BSA/AML systems were out of control twice in 2005, six times in

2006, and twice again in 2007. Both HSBC senior executives and OCC managers could have used this information to determine what additional steps to take to correct HSBC's BSA/AML problems. Such heightened management or supervisory efforts would correspond to the analysis, improvement, and control stages of the DMAIC procedure.

To the extent that one MRA is an acceptable baseline for other types of exams, we can extend the MRA quality control methodology beyond BSA/AML exams. Thus, as a general monitoring tool, bank regulatory agencies could use the corresponding upper control limit of four MRAs as a threshold for heightened supervision. If a report of examination includes four or more MRAs, the regulatory agency may wish to use that finding to elevate the level of attention the agency expects the bank's board of directors to devote to the matter, and the level of attention the agency itself will devote to the institution. Such a control chart procedure would be in keeping with one of the recommendations directed toward the OCC that was made by the Subcommittee. The Subcommittee recommended that the OCC should establish a policy to conduct an institution-wide examination and consider the use of enforcement actions whenever examinations identify a certain number of MRAs or legal violations.[16]

Even if the acceptable number of MRAs varies across different exam types or even across institutions because of size or complexity, the general attribute control chart methodology would still apply. For instance, a bank regulatory agency could decide it wants to monitor the number of MRAs over a full 12-month examination cycle rather than on an examination-by-examination basis. For expository purposes, suppose the agency uses past experience to establish that four MRAs over the course of a year is an acceptable standard. With the center line of the attribute control chart set to four MRAs, the upper control limit would equal ten MRAs. If we group the HSBC examination data from table 5.1 by year, such a grouping would show that there

were 12 MRAs in 2005, 39 in 2006, 20 in 2007, 8 in 2008, and 4 in the first half of 2009. Plotting out the control chart would indicate that using the annual MRA standard, HSBC's BSA/AML processes were out of control in 2005, 2006, and 2007.

The attribute control chart methodology applies generally and not just to MRAs and examination reports. We were able to apply this methodology because we treated an MRA as a defect or nonconformity; thus, the attribute methodology would apply equally well to any instance where we can connect an operational risk to the production of a defect or nonconformity. For instance, we could count the number of information items missing from a loan application or the number of data-entry errors in a batch of processed checks as defects in those processes. To see that attribute quality control applies outside of MRAs, we turn now to another high-profile example of operational risk that affected both a supervised institution and its regulatory agency, the case of the London Whale.

The London Whale

In March 2013, the US Senate Permanent Subcommittee on Investigations (the Subcommittee) released its staff report titled, "JPMorgan Chase Whale Trades: A Case History of Derivatives Risks and Abuses."[17] The report describes how a trading portfolio in the Chief Investment Office of JPMorgan Chase and Company lost an estimated $6.2 billion in 2012. Although the $6.2 billion loss itself qualifies as a market risk, the details of the report expose multiple operational failures at both JPMorgan Chase Bank and its primary regulator, the OCC. A subsequent report by the Office of Inspector General of the Board of Governors of the Federal Reserve System indicates that the Chief Investment Office conducted the London Whale trades through the London branch of JPMorgan Chase Bank, N.A., and booked the transactions in an Edge Act corporation subsidiary, which the Federal Reserve System supervises.[18] The Inspector

General's report on the London Whale trades identifies operational problems at the Federal Reserve as well. This connection between operational risks and market risk shows that neglected operational risks can create severe market risks, just as the operational risks described in chapter 3 that were associated with the subprime mortgage crisis created severe credit risks.

Market trades entered into by JPMorgan Chase and Company led to the $6.2 billion loss, but neglected operational risks allowed the exposure to potential losses from those trades to grow unabated. Among the bank's operational risks that the Subcommittee report reveals are (1) mismarking prices in the trading book, which had the effect of reporting smaller losses to senior bank management, (2) disregarding multiple internal risk limits, 3) manipulation of the bank's value-at-risk (VaR) model by adopting a new VaR model that lowered the Synthetic Credit Portfolio's (SCP's) VaR by 50 percent, and (4) omitting performance information in standard reports to the OCC.

The Subcommittee and Federal Reserve Inspector General reports note several lapses at the OCC and the Federal Reserve Bank of New York that qualify as operational risks. As the primary regulator of JPMorgan Chase Bank, the OCC experienced operational failures when it failed to notice signals of increasing risks in reports JPMorgan Chase provided, failed to notice missing risk reports, and failed to follow up with the bank when the Chief Investment Office breached stress loss limits in 2011 and multiple risk limits in 2012. The Federal Reserve Inspector General's report also faulted the Federal Reserve Bank of New York, which was the Federal Reserve Board's delegated supervisor of JPMorgan Chase and Company, for weaknesses in controls for the supervisory planning process and for various shortcomings in executing the Federal Reserve's examination procedures for Edge Act corporations.

As with the AML problems at HSBC, we could apply the DMAIC procedure to work through JPMorgan Chase's

operational problems. In this chapter, however, we are again particularly interested in operational risk at regulatory agencies, so we apply the DMAIC procedures to the operational risks uncovered by the Subcommittee's report on the London Whale trades. The DMAIC procedure may help us discover corrective actions that regulatory agencies could take that would allow them to, as the Subcommittee report suggests, "develop more effective tools to detect and stop unsafe and unsound derivatives trading."[19] JPMorgan Chase and other banks with trading books could then apply similar procedures internally to mitigate operational risks in their trading activities and perhaps prevent the recurrence of similar operational failures.

Part of the problem at regulatory agencies that the Subcommittee's investigation of the London Whale trades revealed was the absence of systematic quality control procedures that serve to alert examiners of potential problems at the supervised entity. Quality control monitoring procedures within a regulatory agency could notify examiners and, if necessary, senior agency management when the quality monitoring system indicates that a production area of the bank is operating out of control. The frequency and severity of these control alerts could then help senior agency management determine when these acknowledged problems may require closer supervision.

These quality control procedures, much like those discussed in the context of HSBC's AML operational risks, are closely related to using product attributes to monitor operational quality. If we think of internal bank risk reports, trade execution and valuation reporting, and risk limit reports as bank products, then we can think of problems with those reports or practices as defects or nonconformities in the product. Once we have associated bank products with identifiable defects, then we are again in the statistical quality control space of monitoring for attributes. Thus, a missing risk report would count as a defect as would a breach of a risk limit.

The Subcommittee report on the London Whale trades identifies multiple instances of inadequate or failed processes, people, or systems, that is, operational risks that occurred inside either JPMorgan Chase or the OCC. Among these failed processes were those related to mismarking prices within the SCP that amounted to deviations in valuation practices from common JPMorgan Chase valuation practices and even the valuation practice within the SCP just prior to the occurrence of large portfolio losses. The report also describes five metrics and trading limits JPMorgan Chase used to manage market risk, all of which the SCP breached between January and March of 2012. The Subcommittee report states that the SCP breached risk limits 330 times between January and April 30, 2012. Other JPMorgan Chase problems identified by the Subcommittee include disregarding concentration limits, lack of disclosure about the SCP to the OCC, and eventually omitting Chief Investment Office performance data in standard reports to the OCC. The Subcommittee report notes that the OCC "failed to notice and follow up on red flags" in reports it did receive.[20]

As with most operational risks, we can apply statistical quality control procedures in an attempt to reduce or eliminate the operational problems cited by the Subcommittee. The first step in using the DMAIC procedure to monitor quality in trading activities and risk reports is to recognize that operational problems such as those described by the Subcommittee report create defects or nonconformities in the bank's products, which we may then measure and analyze as attributes. For instance, according to the Subcommittee report, during the first quarter of 2012, the Chief Investment Office changed how it used market prices to value its credit derivatives. In January of 2012, the Chief Investment Office "typically established the daily value of a credit derivative by marking it at or near the midpoint price in the daily range of prices (bid-ask spread) offered in the marketplace."[21] Later in the first quarter, the Chief Investment

Office "began to assign more favorable prices within the daily price range (bid-ask spread) to its credit derivatives. The more favorable prices enabled the [Chief Investment Office] to report smaller losses in the daily profit/loss (P&L) reports that the SCP filed internally within the bank." If JPMorgan Chase or the OCC decided that selecting credit derivative prices that differ from the daily midpoint affects the quality of the daily P&L reports, then the bank or the OCC or both could count each deviation from midpoint pricing as a defect or nonconformity. The organization could then for the most part follow the defect counting procedure outlined with the HSBC AML example to construct appropriate control charts to monitor quality in the credit derivatives pricing business area.

An alternative approach, which would effectively apply a greater weight to larger deviations in pricing practices, would be to count each dollar in smaller reported losses created by the pricing deviation as a defect. Consider a hypothetical case in which two traders mark their prices for a credit derivative away from the midpoint price. One trader prices just above the midpoint price, which results in a smaller reported loss of $1 million. The other trader prices well away from the midpoint price, which results in a reported loss that is $10 million smaller than if the second trader had used the midpoint price. Using an approach that just counts the deviation from the midpoint price, each pricing deviation would count equally as a nonconformity. Using an approach that counts each dollar of the deviation, the mispricing of the first trader would count for one million defects and the mispricing of the second trader would count as ten million defects. Under either approach, whether the observation of the defect would indicate the system is out of control would depend on the control limits established for the system, but under the second approach, the second trader would be more likely than the first trader to indicate a system is out of control regardless of the control

limits. We can examine how both of these approaches would work using some data provided by the Subcommittee report.

Rather than using information on variations in pricing practices to explore using control charts, we'll work through the control chart example using information in the Subcommittee report on breaches of risk limits. Although the methodology would be the same for the pricing deviations, the Subcommittee report concludes that the credit derivative mispricing was an attempt at hiding losses, which could take an audit to reveal, and this could make it more difficult for the institution or the institution's regulator to detect. Instead of following the audit trail, we'll use the scenario where an institution reports breaches of its risk limits to show how to establish a control chart for trading activities. While we'll be using information on a valuation limit to construct a control chart, the same methodology would apply for control charts to track concentration limit breaches.

We are able to construct a rough control chart using information the Subcommittee report provides on some of the 330 risk limit breaches experienced by the Chief Investment Office in the four-month period between January 1, 2012, and April 30, 2012. Table 5.2 summarizes the risk limit breach data recounted in the Subcommittee report and shows how much the breach amount exceeded the risk limit in dollars and as a percentage of the risk limit. As shown in table 5.2, there were two risk limits, $5 million and $12 million. Even with this limited data, we can illustrate how either JPMorgan Chase or the OCC could have constructed a control chart to better monitor trading activity within the bank.

There are several control chart options available for use with the risk limit data. These options include (1) a simple count of nonconformities, (2) measuring the dollar amount of the breach, and (3) measuring the breach as a percentage of the dollar limit. The first option, counting the nonconformities or defects, would follow the methodology used to count MRAs

Table 5.2 Selected JPMorgan Chase Risk Limit Breaches, 2012

Limit Utilization Amount	Risk Limit	Breach Amount	Breach as % of Risk Limit
CIO Global Credit CSBPV Limits			
$12,476,464	$12,000,000	$476,464	3.97%
$12,795,899		$795,899	6.63%
$14,015,706		$2,015,706	16.80%
$20,551,040		$8,551,040	71.26%
CIO Global Credit CSBPV—Mark-to-Market Limits			
$5,767,816	$5,000,000	$767,816	15.36%
$10,501,916		$5,501,916	110.04%
$10,974,965		$5,974,965	119.50%
$12,096,601		$7,096,601	141.93%
$18,659,019		$13,659,019	273.18%

Source: US Senate, "A Case History of Derivatives Risks and Abuses," 200.

in the HSBC AML example earlier. From that example, we know that if we selected one breach as an acceptable standard, then the upper control limit would be four breaches. The upper control limit would rise as the acceptable standard for number of breaches increases, but presumably for almost any reasonable standard, the 330 breaches recorded in the first four months of 2012 would have exceeded the upper control limit and indicated to the bank or the regulatory agency that the trading area creating the breaches was out of control.

Because the risk-limit breaches provide a dollar amount, building a control chart to monitor the trading activity can go beyond just counting each limit breach as a defect. The second control chart option would count each dollar in excess of the risk limit as a defect. The institution developing the control chart could use historical data to determine a reasonable standard for the dollar amount of a breach and calculate the corresponding upper and lower control limits. This is also the

approach the organization would use if it were tracking breach amounts as a percentage of the risk limit. These approaches could be viable options when the dollar limit is frequently exceeded. Frequent breaches may not be of great concern, but sizable breaches are of concern.

Because any breach of a risk limit could be a cause for concern, counting the dollar amounts of breaches may not be a feasible option for risk-limit control charts. Another, more practical option for risk-limit control charts could be to treat any breach of a risk limit as an indication that the system may be out of control. The bank could use such a system even if it establishes a risk-limit system with tight control limits, which would tend to draw attention to the process more often. To incorporate risk limits into the control chart, we can treat the risk limit as the upper control limit, and any breach of the risk limit would then signal that the system is out of control. Thus, rather than starting with an acceptable centerline standard and determining the upper and lower control limits from this standard, we can start with the upper control limit and determine the corresponding centerline standard. Using the first set of risk limit breaches shown in table 5.2 as an example, the bank set the risk limit at $12 million. Again following Montgomery, the upper control limit is equal to $(c + 3\sqrt{c})$, where c is the centerline standard. Using $12 million dollars as the upper control limit and solving for c, the centerline standard is approximately $5.175 million. We could then construct the lower control limit, but we can dispense with that here because we only consider the system to be out of control when losses exceed the upper control limit. We do not have the data from the Chief Investment Office to see what information the control chart we just constructed would have provided in the days leading up to the breaches of the $12 million risk limits, but the chart may have alerted JPMorgan Chase or the OCC of

approaching problems. As Montgomery points out, individuals monitoring a control chart can determine that a system is out of control before the system breaks a control limit if the data points in the control chart suggest that something could be amiss. Such a signal could occur if there is a bunching of data points increasing toward a control limit or bunching around a control limit.

Attribute control charts have the advantage of allowing risk officers within an institution to monitor potential problems almost anywhere in a financial institution. Variable control charts are extremely useful when a measurement variable is readily available, as we saw with LTV and DTI ratios in the case of mortgage originations. Attributes have the advantage of providing the risk officer a way to apply statistical quality control to situations where quality is of importance, but measuring quality is more elusive. If the risk officer is able to identify a bank product whose quality is diminished because a feature is missing or altered, then the risk officer is able to label that missing feature a defect or nonconformity and begin the process of improving the quality of that product by applying the lessons of statistical quality control to those quality attributes.

In the case of JPMorgan Chase Bank and the OCC as investigated by the US Senate, the findings of fact in the Subcommittee report point to multiple instances of operational risks that affected the quality of activities associated with trading within the bank and the quality of regulatory oversight provided by the OCC. The seven recommendations made by the Subcommittee are all directed at federal regulators. Of these seven recommendations, five allude to improvements in the oversight of trading activities by requiring data, documentation, enhanced procedures, and better tracking and investigation of risk-limit breaches. Statistical quality control procedures can help improve this regulatory oversight.

Monitoring the monitors

Unfortunately, internal audit, external audit, regulatory oversight, and quality control procedures do not guarantee 100 percent success in reducing or eliminating operational risk. As we have seen with the AML problems at HSBC and the London Whale problems at JPMorgan Chase, regulatory agencies must contend with some operational risks of their own. Internal auditing and external auditing also involve processes, systems, and people, and are therefore subject to operational risk as well. For instance, auditing researchers Merle Erickson, Brian Mayhew, and William Felix, Jr., study how audits can fail and thus present their own set of operational risks.[22] They work through an audit failure at Lincoln Savings and Loan in 1987, and identify a set of neglected audit practices that would readily lend themselves to a quality control attribute-style checklist. The study notes that the auditors failed to obtain an understanding of the business of Lincoln Savings and Loan with respect to real-estate dealings and failed to consider buyer and seller motivation for certain real-estate transactions, and how Lincoln Savings and Loan subsequently accounted for those transactions. By counting these audit shortcomings as audit defects or nonconformities, an operational risk officer could subject the external audit itself to statistical quality control scrutiny.

The mere presence of oversight in the form of audit and examination functions can change behavior, thus addressing one of the four principal sources of operational risk: people. Italian researchers Marco Bertoni, Giorgio Brunello, and Lorenzo Rocco study the effect that the presence of an external examiner has on students' standardized test performance in Italian schools.[23] They find evidence of lower test scores when examiners are present, which they attribute to reduced cheating. As with any monitoring activity, the Italian school study points out that subjecting an activity to external examination has costs and benefits. The cost of monitoring includes the time and salary

of the monitors, and these costs increase in direct proportion to their use. That is to say, more frequent and more extensive use of examiners will increase the cost of the monitoring effort. The benefits of monitoring depend on the benefits of reduced cheating and on how effective the monitoring is at reducing cheating. In the context of the Italian schools study, the benefits of reduced cheating (and hence, a more accurate assessment of student performance) include better allocation of education resources. In the context of financial institutions, examinations that improve assessment accuracy of a bank could have the benefit of improved allocation of internal and external capital.

Outside monitors may affect institutional behavior in other ways as well. Management and Information Systems researchers Son Anh Le, Bruce Walters, and Mark Kroll examine the effect that external monitors can have on the relationship between research and development spending and firm performance.[24] If the objectives of firm managers and firm shareholders are misaligned, firm managers may try to maximize their own wealth rather than the wealth of shareholders. External monitors, which in this study consist of independent directors, institutional investors, and securities analysts, may be able to change management's behavior to effectively realign their actions with shareholders' objectives. The study finds evidence of this behavioral change with respect to research and development spending at technology and health care firms. With respect to financial institutions, we know that through the examination and enforcement process, regulatory monitors have the power to effect changes at the financial institutions they supervise. Through their influence on behavior, empowered external monitors such as bank regulatory agencies can help ensure that their supervised institutions provide high-quality financial products that are consistent with safe and sound banking. Furthermore, by guiding their supervised institutions toward the provision of quality products, regulatory agencies could

reduce or eliminate the need for blanket prohibitions against certain bank products or services.

Regulatory agency audits

Some regulatory agencies may not have an active overseer. One of the reasons state and federal legislatures have voted to subject financial institutions to regulatory supervision is that bank supervisors act effectively as independent auditors of their institutions. At present, while the US Congress and the Executive branch may provide effective oversight of bank regulatory agencies, for the most part the supervisory function does not have an independent auditor. Just as regulated institutions generally need regulatory oversight to ensure that processes, people, and systems perform optimally, it may be that regulatory agencies could benefit from independent periodic supervision to ensure that they are functioning optimally. Of course, finding an independent auditor could be a challenge. Such monitoring of the monitor would attempt to ensure that the regulatory agency is providing effective oversight, and as we have seen, quality control monitoring provides an effective way to accomplish this task. It may be that quality control monitoring could reveal that regulatory agencies generally do not have a monitoring system to identify when their examinations indicate that a regulated institution is out of control. Regulatory agencies have the natural advantage that they are collecting information on a large number of institutions and can use this information to establish superior control limits. Either an internal or external review could assess the costs and benefits of adopting a quality control monitoring system.

Monitoring of various procedures and systems at regulatory agencies could extend to the examination process itself. Although an internal audit could accomplish many of the review objectives, for many of the same reasons regulatory agencies generally require external audits of the institutions

they supervise, there are benefits to conducting an independent external audit. Potential outside auditors for bank regulatory agencies could include the agency's own Inspector General's office or an outside agency with extensive audit experience, such as the Government Accountability Office (GAO). The external auditor could conduct occasional duplicate examinations to confirm the conclusions of the first examination and assess the effectiveness of examination procedures.

Resistance to audits

Unfortunately, people within any institution, public or private, tend to react negatively to the idea of an audit of their work. This may be in part because of the negative association many people and institutions have to being the subject of an audit by the IRS. This negative association is understandable given the fact that a poor outcome from an Internal Revenue Service audit could result in required payment of additional taxes and penalties. Generally, audits in the operational risk and quality control context should not involve penalties, although penalties may be necessary when the audit uncovers fraud or intentional abuse.

Resistance to an internal or external operational-risk audit at best reflects a lack of understanding of the role of the operational-risk audit as a first step in improving training for people and correcting inadequate systems and processes, that is, correcting operational risks. At worst, of course, resistance to an internal or external audit could reflect internal fraud, another operational risk that an organization should correct. Acknowledging the negative connotations of the word audit, we can use the term, review, instead. Thus, the appropriate Inspector General's office or the GAO could conduct reviews of examinations performed by regulatory agencies to verify that they are following best practices and utilizing the most effective tools to ensure the safe and sound operation of regulated financial institutions.

Conclusion

In this book, we have described how operational risks can manifest inside any organization, including regulatory agencies that supervise financial institutions, and how they can fester and spill over and affect other organizations, customers, supervisory agencies, and markets in general. We have also shown how any organization can manage many of its operational risks by treating them as quality control problems. By applying the methods described here and discussed thoroughly by Christopher Marshall and especially Douglas Montgomery, an organization may be able to identify, analyze, and eliminate or reduce a particular operational risk before it becomes an operational failure, and potentially a catastrophic operational failure. Every well-meaning individual in an organization has an incentive to manage operational risks in this manner because it protects their job, their organization, and the organization's clients from potentially dangerous processes, people, and systems.

Appendix: Subprime Crisis Timeline*

March 2006—Median home prices fall 4.1 percent from fourth quarter of 2005 to first quarter of 2006.

May 2006—Merit Financial Corporation, a privately held mortgage company, files for bankruptcy.

December 28, 2006—Ownit Mortgage Solutions files for Chapter 11 bankruptcy.

February 5, 2007—Mortgage Lenders Network USA files for Chapter 11 bankruptcy.

March 2, 2007—New Century Financial Corporation, the second-largest subprime lender in 2006 with $51.6 billion in subprime loans, stops accepting new loan applications and files a Form 8-K with the SEC stating that it has $70 million in outstanding margin calls from five lenders and that its lenders are refusing access to financing.

April 3, 2007—New Century Financial Corporation files for Chapter 11 bankruptcy.

June 22, 2007—Bear Stearns announces that it is shoring up its High-Grade Structured Credit Fund with $3.2 billion and seeks help for its High-Grade Structured Credit Enhanced Leveraged Fund. The funds were invested in collateralized debt obligations backed by subprime mortgages.

July 10, 2007—Credit-rating agencies downgrade hundreds of mortgage-backed securities. S&P places 612 US subprime residential mortgage-backed securities, amounting to $7.4 billion in rated securities, on credit watch with negative implications.

July 31, 2007—Bear Stearns High-Grade Structured Credit Fund and the Bear Stearns High-Grade Structured Credit

Enhanced Leveraged Fund file for bankruptcy after losing approximately $1.6 billion in investor capital.

August 2, 2007—American Home Mortgage Investment Corporation, the twelfth-largest residential mortgage originator in 2006 with $58.9 billion in originations, announces it is filing for bankruptcy.

August 9, 2007—BNP Paribas suspends three investment funds that invest in subprime mortgage debt.

August 16, 2007—Countrywide Financial Corporation draws down its entire $11.5 billion credit line from a group of banks.

September 13, 2007—British mortgage lender Northern Rock seeks emergency financial support from the Bank of England.

September 18, 2007—The Federal Reserve begins to lower interest rates.

October 24, 2007—Merrill Lynch announces an $8.4 billion loss and the departure of Chief Executive Officer Stanley O'Neal.

November 4, 2007—Citigroup announces that write-downs will amount to between $8 billion and $11 billion, and Charles Prince resigns as the bank's chief executive officer.

December 10, 2007—The Swiss bank UBS announces a $10 billion write-down for losses tied to mortgage-backed securities.

December 19, 2007—MBIA announces a $30 billion exposure to complex mortgage securities.

January 11, 2008—Bank of America announces that it will pay $4 billion to acquire Countrywide Financial.

February 17, 2008—The British government announces its takeover of Northern Rock.

March 11, 2008—The Federal Reserve Board announces the creation of the Term Securities Lending Facility, which may lend up to $200 billion of Treasury securities against federal agency debt; federal agency residential mortgage-

backed securities; nonagency AAA-rated, private-label, residential mortgage-backed securities; and other securities. The Federal Open Market Committee increases its swap lines (liquidity enhancing reciprocal currency arrangements between central banks) with the European Central Bank and the Swiss National Bank and extends these lines through September 30, 2008.

March 16, 2008—Bear Stearns is reported to be acquired for $2 a share (later revised to approximately $9 a share) by JPMorgan Chase. The Federal Reserve assumes $30 billion in Bear Stearns assets. The Federal Reserve Board establishes the Primary Dealer Credit Facility to extend credit to primary dealers against a broad range of investment-grade securities.

May 2, 2008—The Federal Open Market Committee expands the list of eligible collateral for Term Securities Lending Facility auctions to include AAA-rated, asset-backed securities.

June 5, 2008—S&P downgrades monoline bond insurers AMBAC and MBIA from AAA to AA.

July 11, 2008—IndyMac Bank is placed into receivership by the FDIC.

August 7, 2008—Citigroup and Merrill Lynch agree to buy back $17.3 billion in auction-rate securities.

August 15, 2008—*Financial Times* reports that auction-rate security buybacks top $48 billion.

September 7, 2008—The US government takes over Fannie Mae and Freddie Mac, replacing the management of the companies and providing up to $100 billion in capital for each company.

September 10, 2008—Lehman Brothers posts a $3.9 billion loss.

September 14, 2008—Bank of America buys Merrill Lynch. The Federal Reserve Board announces several initiatives to provide additional support to financial markets, including a significant

broadening of collateral accepted by the Primary Dealer Credit Facility and the Term Securities Lending Facility.

September 15, 2008—Lehman Brothers files for bankruptcy.

September 16, 2008—Moody's and S&P downgrade ratings on AIG's credit. The US government rescues AIG with an $85 billion loan through the Federal Reserve Bank of New York.

September 18, 2008—The SEC issues an emergency order that temporarily prohibits short sales in the securities of approximately 800 financial firms. The Federal Reserve announces the expansion of its swap lines with other central banks to address elevated pressures in funding markets.

September 19, 2008—The Federal Reserve Board announces that it is creating the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility to extend nonrecourse loans to US depository institutions to purchase asset-backed commercial paper from money market mutual funds. The Federal Reserve also announced that the Open Market Trading Desk will begin purchasing short-term debt obligations issued by Fannie Mae, Freddie Mac, and Federal Home Loan Banks.

September 22, 2008—Morgan Stanley and Goldman Sachs convert to commercial banks, and New York State announces it will regulate part of the CDS market.

September 25, 2008—The FDIC seizes Washington Mutual, and its banking assets are sold to JPMorgan Chase for $1.9 billion.

September 29, 2008—The FDIC announces that Citigroup will acquire the banking assets of Wachovia.

September 30, 2008—The SEC and the Financial Accounting Standards Board provide additional guidance on the interpretation of the mark-to-market accounting rule.

October 3, 2008—President George W. Bush signs into law the Emergency Economic Stabilization Act of 2008, creating

the $700 billion Troubled Assets Relief Program (TARP). Wells Fargo makes a higher offer than Citigroup for all of Wachovia's assets, eventually winning the deal.

October 6, 2008—An ISDA auction values Fannie Mae and Freddie Mac debt at 91.51 percent.

October 7, 2008—The Federal Reserve Board announces the creation of the Commercial Paper Funding Facility to purchase three-month unsecured and asset-backed commercial paper from eligible issuers. The FDIC announces an increase in deposit insurance coverage to $250,000 per depositor (per bank).

October 14, 2008—The Treasury Department announces that the TARP will inject $250 billion into US financial institutions. The FDIC expands guarantees to senior debt of all FDIC-insured financial institutions.

October 21, 2008—The Federal Reserve announces the creation of the Money Market Investor Funding Facility to provide up to $540 billion to buy assets from money market mutual funds.

October 29, 2008—The Federal Reserve lowers the Fed Funds rate to 1.0 percent.

November 10, 2008—The Federal Reserve and the Treasury Department announce restructuring and expansion of financial support for AIG.

November 13, 2008—The federal banking agencies announce proposed real estate appraisal and evaluation guidelines.

November 14, 2008—Freddie Mac posts loss of $25.3 billion.

November 17, 2008—Citigroup announces 50,000 job cuts.

November 23, 2008—The Federal Reserve, the Treasury Department, and the FDIC announce a rescue plan for Citigroup, including guarantees against unusually large losses in a $306 billion pool of assets and a capital infusion of $20 billion from the TARP fund.

November 25, 2008—The Federal Reserve announces the creation of the Term Asset-Backed Securities Loan Facility through the Federal Reserve Bank of New York to lend up to $200 billion on a nonrecourse basis to holders of AAA-rated asset-backed securities backed by consumer and small business loans. The Federal Reserve also announces the creation of a program to purchase the direct obligations of Fannie Mae, Freddie Mac, and the Federal Home Loan Banks and mortgage-backed securities backed by Fannie Mae, Freddie Mac, and Ginnie Mae.

December 1, 2008—National Bureau of Economic Research states that recession began in December 2007.

December 13, 2008—A $50 billion pyramid (Ponzi) scheme by Bernard Madoff is revealed.

January 16, 2009—The Treasury Department, the Federal Reserve, and the FDIC provide assistance to Bank of America, including guarantees against unusually large losses in a $118 billion pool of assets and a capital infusion of $20 billion from the TARP fund.

Notes

1 Introduction to Operational Risk

1. See Basel Committee on Banking Supervision, "Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework—Comprehensive Version" (Basel: Bank for International Settlements, June 2006), 144. The Basel Committee on Banking Supervision now consists of senior representatives of bank supervisory authorities and central banks from 28 jurisdictions, including the United States. It was established in 1975, and has played a central role in formulating consistent international capital and liquidity standards for banks. Each member jurisdiction then implements the Basel standard, though generally with varying degrees of national discretion.
2. See Michael Lewis, *Flash Boys* (New York: W.W. Norton, 2014).
3. See Federal Financial Institutions Examination Council (FFIEC) Form 101, Schedule S—Operational Risk, available at www.ffiec.gov.
4. See Christopher Marshall, *Measuring and Managing Operational Risks in Financial Institutions: Tools, Techniques, and other Resources* (Singapore: John Wiley & Sons, 2001), 81.
5. See Basel Committee on Banking Supervision, "Results from the 2008 Loss Data Collection Exercise for Operational Risk" (Basel: Bank for International Settlements, July 2009).
6. See Federal Deposit Insurance Corporation, *Quarterly Banking Profile* (FDIC, Fourth Quarter 2013), tables IV-A, VI-A, and VII-A.
7. The Joint Forum is an international group of supervisors from the banking, insurance, and securities sectors. It was established in 1996 by the Basel Committee on Banking Supervision, the International Organization of Securities Commissions, and the International Association of Insurance Supervisors to address issues common to the three financial sectors. See The Joint Forum, "Operational Risk Transfer across Financial Sectors" (Basel: Bank for International Settlements, August, 2003).
8. See David J. Cummins, Christopher M. Lewis, and Ran Wei, "The Market Value Impact of Operational Loss Events for US Banks and Insurers," *Journal of Banking & Finance* 30, no. 10 (2006): 2605–34.

9. The Joint Forum, "Operational Risk Transfer across Financial Sectors" (Basel: Bank for International Settlements, August, 2003).
10. Both Marshall and another author who has written on operational risk management, Gerrit Jan van den Brink (*Operational Risk: The New Challenge for Banks* [New York: Palgrave, 2002]), provide a thorough discussion of the risk management process applied to operational risks. Professor Douglas Montgomery, in *Introduction to Statistical Quality Control,* 7th ed. (New York: John Wiley & Sons, 2013), on the other hand, provides a detailed discussion of statistical quality control in general, which this book applies to several different types of operational risk. My discussion of the management process for operational risk is similar to both van den Brink's toolkit and Marshall's operational risk management process. Van den Brink describes a risk-management process consisting of the creation of a control environment, the introduction of knowledge management, and the use of a toolkit containing internal policies, procedures, and controls. Marshall uses a six-step risk-management process that is similar in structure to Montgomery, and chapter 3 works through this in more detail.
11. Opinions among analysts studying the subprime financial crisis differ regarding whether losses associated with mortgage defaults during the crisis should count as operational risk or credit risk, and some analysts accept that the losses can reasonably be attributable to both credit risk and operational risk. For our purposes, we need only recognize that operational failures were a significant factor driving those losses.

2 Operational Risk Management Practices

1. For a more detailed description of each approach, see Basel Committee on Bank Supervision, "Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework—Comprehensive Version" (Basel: Bank for International Settlements, June 2006) and Basel Committee on Bank Supervision, "Operational Risk—Revisions to the Simpler Approaches—Consultative Document" (Basel: Bank for International Settlements, October 2014).
2. The 2006 Basel proposal also approved a variant of the Standardized Approach called the Alternative Standardized Approach, which replaced a percentage of gross income with a new percentage of loans and advances for two business lines, retail banking and commercial banking.

3. No estimate is available for the old Standardized Approach because Call Report data does not include income data by business lines, which would be required to construct a Standardized Approach estimate.
4. See Basel Committee on Bank Supervision, "Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework—Comprehensive Version," 150–52.
5. The AMA design standards and their discussion here summarizes the qualification requirements described fully in the final US rule on Basel II; see *Federal Register*, Vol. 72, no. 235 (December 7, 2007): 69407–408.
6. See Christopher Marshall, *Measuring and Managing Operational Risks in Financial Institutions: Tools, Techniques, and other Resources* (Singapore: John Wiley & Sons, 2001), as well as Carol Alexander, ed., *Operational Risk: Regulation, Analysis and Management* (London: Prentice-Hall-Financial Times, 2003); Marcelo G. Cruz, ed., *Operational Risk Modelling and Analysis: Theory and Practice* (London: Risk Books, 2004); Michael K. Ong, ed., *The Basel Handbook: A Guide for Financial Practitioners,* 2nd ed. (London: Risk Books, 2006); and Ellen Davis, ed., *The Advanced Measurement Approach to Operational Risk* (London: Risk Books, 2006).
7. See Basel Committee on Banking Supervision, *Sound Practices for the Management and Supervision of Operational Risk* (Basel: Bank for International Settlements, February 2003); Basel Committee on Banking Supervision, *Review of the Principles for the Sound Management of Operational Risk* (Basel: Bank for International Settlements, October 2014); Basel Committee on Banking Supervision, *Observed Range of Practice in Key Elements of Advanced Measurement Approaches (AMA)* (Basel: Bank for International Settlements, July 2009); Office of the Comptroller of the Currency, "Interagency Guidance on the Advanced Measurement Approaches for Operational Risk," OCC 2011–21 (June 2011); and Board of Governors of the Federal Reserve System, "Supervisory Guidance for Data, Modeling, and Model Risk Management under the Operational Risk Advanced Measurement Approaches," BCC 14–1 (June 2014).
8. See Board of Governors of the Federal Reserve System, "Supervisory Guidance for Data, Modeling, and Model Risk Management under the Operational Risk Advanced Measurement Approaches," 2.
9. Not surprisingly, the AMA also has its critics. See, for instance, an article by Imad A. Moosa, Monash University Professor of Finance, "A Critique of the Advanced Measurement Approach to Regulatory

Capital against Operational Risk" *Journal of Banking Regulation* 9, no. 3 (2008): 151–64. Moosa suggests that one of the incentives for banks to use the AMA is that it will produce lower capital charges than the simpler basic indicator and standardized approaches. A possible counterargument to Moosa perhaps, looks to the broader social justification for the AMA. The social benefit is that the AMA should provide a more risk sensitive capital charge for larger and more complex financial institutions. Furthermore, the information gleaned from the entire AMA implementation and monitoring process should be of considerable value to bank managers and bank regulators, which is especially important for systemically important financial institutions.

10. The Joint Forum, "Operational Risk Transfer across Financial Sectors" (Basel: Basel Committee on Banking Supervision, August 2003). The Joint Forum consists of representatives from the Basel Committee on Banking Supervision, the International Organization of Securities Commissioners (IOSCO), and the International Association of Insurance Supervisors (IAIS).
11. The Joint Forum, "Operational Risk Transfer across Financial Sectors," 5.
12. See Comptroller of the Currency, "Internal and External Audits," *Comptroller's Handbook* (April 2003), 1.
13. Anna Chernobai, Philippe Jorion, and Fan Yu, "The Determinants of Operational Risk in U.S. Financial Institutions," *Journal of Financial and Quantitative Analysis* 46, no. 6 (December 2011): 1683–725.
14. See Comptroller of the Currency, "Internal and External Audits," 4.
15. Basel Committee on Bank Supervision, *The Internal Audit Function in Banks* (Basel: Bank for International Settlements, June 2012), 1.
16. Basel Committee on Bank Supervision, *The Internal Audit Function in Banks*, 1.
17. Basel Committee on Bank Supervision, *The Internal Audit Function in Banks*, 2.
18. Basel Committee on Bank Supervision, *The Internal Audit Function in Banks*, 3.
19. A Commitment Letter is an informal enforcement action. It is a document signed by the bank's board of directors and acknowledged by a regulatory agency official that reflects written commitments to take corrective action in response to problems identified by the agency. A Cease and Desist Order is a formal enforcement action issued by the regulatory agency and imposed on the institution on an involuntary basis that contains restrictions and/or corrective action necessary to

correct deficiencies or violations in the bank. See Comptroller of the Currency, "Enforcement Action Policy," in *Policies & Procedures Manual*, PPM 5310–3 (REV) (September 9, 2011).

20. See Douglas Montgomery, *Introduction to Statistical Quality Control,* 7th ed. (Hoboken, NJ: John Wiley & Sons, Inc., 2013).

3 Mortgage Mayhem

1. Marshall's list of potential catastrophic losses also includes rogue trading, insider fraud, poorly understood derivatives, poorly rolled-out new products, inadequate controls in emerging markets, counterparty failures, natural disasters, and snowballing reputational losses. See Christopher Marshall, *Measuring and Managing Operational Risks in Financial Institutions: Tools, Techniques, and other Resources* (Singapore: John Wiley & Sons, 2001), p. 75.
2. See Patrick de Fontnouvelle, Virginia Dejesus-Rueff, John S. Jordan, and Eric S. Rosengren, "Capital and Risk: New Evidence on Implications of Large Operational Losses," *Journal of Money, Credit, and Banking* 38, no. 7 (2006), 1819–46. Among other studies of the impact of operational risk events, Roland Gillet, Georges Hübner, and Séverine Plunus, "Operational Risk and Reputation in the Financial Industry," *Journal of Banking & Financ* 34, no. 1 (2010), 224–35, examine stock market returns to determine the effect of 154 operational losses at financial companies that occurred between 1990 and 2004. They find that with cases of internal fraud, stock market value fell by more than the value of the operational loss, which they interpret as evidence that the revelation of internal fraud does damage to the firm's reputation. Jay R. Ritter, "Forensic Finance," *Journal of Economic Perspectives* 22 (Summer 2008), 127–47, discusses additional examples of operational risks in financial markets such as late trading in mutual funds and backdating of employee stock options. Elizabeth Klee, "Operational Outages and Aggregate Uncertainty in the Federal Funds Market," *Journal of Banking & Finance* 34, no. 10 (2010), 2386–2402, looks at operational problems in sending Fedwire payments and finds that operational failures can have a measurable effect on the federal funds market.
3. The human capital investment reflects the time and energy of quality assurance and due diligence personnel who, in the case of mortgages, select the sample of mortgages, order reappraisals, verify debt, income, and credit scores, and prepare the sample summary and tests.

4. See, for example, David Streitfeld, "More Home Buyers Stretch Truth, Budgets to Get Loans," *Los Angeles Times* (September 29, 2006); Chris Isidore, "'Liar Loans': Mortgage Woes beyond Subprime," CNNMoney.com (March 19, 2007); the following articles by Gretchen Morgenson: "Inside the Countrywide Lending Spree," *New York Times* (August 26, 2007); "Lender Tells Judge It 'Recreated' Letters," *New York Times* (January 8, 2008); "Lenders Who Sold and Left," *New York Times* (February 3, 2008); "A Road Not Taken by Lenders," *New York Times* (April 6, 2008); "Naked Came the Speculators," *New York Times* (August 10, 2008), and David Streitfeld and Gretchen Morgenson, "Building Flawed American Dreams," *New York Times* (October 19, 2008). An analysis by Fitch Ratings late in 2007 (see M. Diane Pendley, Glenn Costello, and Mary Kelsch, "The Impact of Poor Underwriting Practices and Fraud in Subprime RMBS Performance," *U.S. Residential Mortgage Special Report,* www.fitchratings.com (November 28, 2007)) also identified widespread problems in mortgage underwriting.
5. "Liar loans," also called stated income loans, are loans in which borrowers state their income on the loan application and the loan originator does not verify that stated income with pay stubs, W-2 forms, or some other record of income.
6. Delinquency data is provided by the Mortgage Bankers Association through Haver Analytics. A mortgage is delinquent if it is past due 30 days or more.
7. The median home price is the median sales price of existing single-family homes. The data are drawn from the National Association of Realtors, accessed through Haver Analytics. The S&P/Case–Shiller Home Price Index of existing single-family homes also slowed dramatically between the fourth quarter of 2005 and the first quarter of 2006. After increasing an average of 3.0 percent per quarter from the first quarter of 2002 through the fourth quarter of 2005, the index increased only 0.9 percent during the first quarter of 2006. The quarterly change in the index turned negative in the third quarter of 2006, and remained negative until the second quarter of 2009.
8. The appendix to this book shows a timeline of the major events in the financial market meltdown, beginning with March 2006 and ending with January 2009.
9. See E. Scott Reckard, "Demise of Ownit Mortgage Hits Home," *Los Angeles Times* (January 3, 2007); Bradley Keoun, "Ownit Files for Bankruptcy as

Merrill Seeks to Return Bad Loans," www.Bloomberg.com (January 2, 2007); and Jonathan Stempel, "Mortgage Lenders Network USA Files for Chapter 11," www.reuters.com (February 5, 2007).

10. Although attention focused on the subprime market, losses and concerns about future losses began to undermine market confidence in almost any mortgage-backed security. Structured investment vehicles (SIVs) designed to pool mortgage assets and sell debt backed by the pooled assets found that investors were refusing to buy their debt.
11. Monoline insurers, such as MBIA and Ambac Financial Corporation, provide financial guaranty insurance. They initially insured only municipal bonds, but eventually began to insure asset-backed securities as well.
12. See Jonathan D. Glater and Gretchen Morgenson, "A Fight for a Piece of What's Left," *New York Times* (September 16, 2008).
13. Investment Company Institute, *2010 Investment Company Fact Book,* 50th ed.
14. See Adam B. Ashcraft and Til Schuermann, "Understanding the Securitization of Subprime Mortgage Credit," Federal Reserve Bank of New York, Staff Report 318 (2008); Ingo Fender and Janet Mitchell, "The Future of Securitisation: How to Align Incentives?" *Bank for International Settlements Quarterly Review* (September 2009), 27–43; and Gotham Partners Management Co., "Is MBIA Triple A?" manuscript (December 9, 2002).
15. Whereas Ashcraft and Schuermann describe problems among the different players as information frictions, that is, one party to a transaction with information about an asset passes along the asset to the other party but does not pass along the information about that asset, we believe that many of these frictions reflect manifestations of operational risks. For instance, some of their frictions involve mortgage fraud, predatory lending, inadequate underwriting standards, and failed due diligence by most participants.
16. Of course, even after the mitigation of these operational risks, investors are still exposed to credit and market risks. However, the models used to manage credit and market risks should perform better with operational risks mitigated through due diligence.
17. The federal banking agencies are the Board of Governors of the Federal Reserve System (Federal Reserve), the FDIC, the OCC, and the Office of Thrift Supervision (OTS). The OCC assumed the responsibilities of the OTS per provisions in the Dodd-Frank Act.

The document discussed here is the attachment to OCC Bulletin 1999–10, "Subprime Lending Activities," March 5, 1999 (www.occ.gov/news-issuances/bulletins/1999/bulletin-1999-10.html).

18. For the fulfillment of the perverse incentive and steering warnings, see Morgenson, "Inside the Countrywide Lending Spree." For the realization of the fraud and misrepresentation warning, see Isidore, "'Liar Loans': Mortgage Woes beyond Subprime."
19. Bank regulators were not the only ones aware of subprime risk; prospectuses for securities backed by subprime mortgages typically list risk factors that include less stringent underwriting standards, increased risk of loss from high loan-to-value (LTV) ratios, geographic concentrations, and the possibility that those responsible may not be able to repurchase defective mortgages.
20. Mortgage brokers and finance companies are generally regulated at the state level.
21. The originate-to-sell business model also complicated regulation of subprime lending. Some mortgage originators would tend to abuse the securitization channel to hide shoddy originations. Michael Lewis's book, *The Big Short*: *Inside the Doomsday Machine* (New York: W.W. Norton, 2010), provides vivid descriptions of how institutions gamed the securitization process. A study by Clara Cardone-Riportella, Reyes Samaniego-Medina, and Antonio Trujillo-Ponce, "What Drives Bank Securitisation? The Spanish Experience," *Journal of Banking & Finance* 34, no. 11 (2010), 2639–51 discusses some of the motivating factors behind securitization from the perspective of Spanish banks. They identify an incentive to provide a new source of funding (enhanced liquidity) and an incentive to improve performance measures, such as return on assets and return on equity (enhanced performance), as the forces most likely to be associated with banks that elect to securitize.
22. Fannie Mae's quality assurance guidelines include a random sample of at least 10 percent of the portfolio and a discretionary sample designed to evaluate particular mortgage brokers, employees, appraisers, or mortgage products. Fannie Mae's guide also provides a good list of what mortgage originators should cover in their mortgage reviews. This list includes validating legal and credit documentation, quality of property appraisals, and adherence to underwriting standards and regulatory requirements. While Fannie Mae's list is appropriate for the loan originator, the sampling review by bundlers, insurers, and credit-rating agencies can focus solely on validation of credit documentation and property appraisals. The

stand-alone publication, "Originating Quality Mortgages," is available at www.myclear2close.com/forms/FannieMaeQABestPractices.pdf. Fannie Mae now incorporates the quality assurance material in its publication *Selling Whole Loans to Fannie Mae*, which may be purchased at www.eFannieMae.com.

23. Reporters Vikas Bajaj and Jenny Anderson, "Inquiry Focuses on Withholding of Data on Loans," *New York Times* (January 12, 2008), describe how credit-rating agencies never saw details of exception reports produced by investment banks and due diligence firms that flagged high-risk loans.
24. See Arthur J. Wilburn, *Practical Statistical Sampling for Auditors* (New York: Marcel Dekker, 1984). Besides random sampling, other sampling methods include *judgment sampling*, where an auditor or examiner uses experience and professional judgment to select a sample. This is most appropriate when the independence of the inspector is beyond question and inference to the portfolio outside of the sample is of little or no value. Thus, bank regulators may wish to use judgment sampling in examining particular aspects of a bank's operations or balance sheet. If things go poorly, however, regulators using judgment samples are always susceptible to charges of using poor judgment in deciding what to look for.

    Discovery or hazard sampling is another sampling method. With discovery sampling, which may be most appropriate when trying to find instances of fraud, the inspector defines an intolerable "critical event" and sifts through the sample looking for even one instance of the critical event. If none is found, then the inspector may infer the likelihood that the population from which the sample is drawn has less than a certain number of occurrences of the critical event. Thus, discovery sampling is useful if the inspector is looking for a single instance of a critical event for which there may be little or no tolerance. However, it may be difficult to identify an appropriate threshold to define the critical event, and, once there is a particular threshold, dishonest participants may quickly adapt to operating just under the threshold. Because of this gaming threat, discovery sampling may be most appropriate for irregular or nonsystematic spot checks.

    Flexible sampling, which integrates examiner judgment and prior knowledge with statistical features, seeks to identify material problems. Flexible sampling may be the most appropriate method for auditors to use. However, because of the potential problems we

identified with judgment and discovery sampling, flexible sampling may not be the best sampling method to use when the purpose of the inspection is to assess the reliability of credit quality factors in a large portfolio, which is the principal aim of our operational risk inspection.

25. The tolerance level for critical differences in appraisals will want to take into consideration reasonable fluctuations in property values that occur over time.
26. See Min Qi and Xiaolong Yang, "Loss Given Default of High Loan-to-Value Residential Mortgages," *Journal of Banking & Finance* 33, no. 5 (2009), 788–99, for a discussion of the impact of LTV ratios for residential mortgages on loss given default.
27. This is the security discussed in Ashcraft and Schuermann, "Understanding the Securitization of Subprime Mortgage Credit." LoanPerformance, now a part of CoreLogic, provides loan-level data on mortgage-backed securities, including loan-level data on GSAMP 2006-NC2.
28. For example, in the extreme case when all new appraisals in the sample result in a new LTV that is some constant c points higher than the original, then the sample mean and the numerator in the t-test will be c points higher, but the standard deviation and the denominator will not change. This merely reflects the fact that the addition of a constant will increase the sample mean by that constant but will not change the sample variance or standard deviation.
29. The mean of the combined LTV reported in the prospectus and shown in table 3.3 is 80.34 percent. To run our simulations, we calculated our own LTV as the ratio of the closing balance to the appraisal value reported in the LoanPerformance data. The weighted average of our calculated LTV is 78.60 percent for the population universe, which we use as the "reported" value for our mean comparisons.
30. We also conducted simulations holding the population infection rate at 10 percent while increasing the severity of the appraisal error and simulations holding the severity of the appraisal error at 10 percent while increasing the population infection rate. The sampling inspection seems to be slightly more sensitive to population infection rates than error severity. Holding the error severity constant at 10 percent, the 95 percent confidence interval excluded the reported mean when 30 percent of the population

became infected. The error severity had to be 50 percent for the confidence interval to exclude the reported mean when the infection rate was fixed at 10 percent.

31. Pendley, Costello, and Kelsch, "The Impact of Poor Underwriting Practices and Fraud in Subprime RMBS Performance," conducted an analysis of poorly performing mortgage-backed securities. The analysis included a file review of 45 mortgages with early missed payments that revealed "the appearance of fraud or misrepresentation in almost every file." Despite these findings, surprisingly Fitch dismisses a data re-verification role for itself and prefers to address the problems by assessing underwriting processes and controls during originator reviews.
32. See Davis, *Operational Risk: Practical Approaches to Implementation,* for a thorough presentation of many of the methods large regulated banking organizations are starting to use as part of the implementation of Basel II's Advance Measurement Approaches to operational risk management.
33. Fender and Mitchell, "The Future of Securitisation: How to Align Incentives?" suggests that requiring a retained interest in a securitization could help restore responsibility to and confidence in the securitization market. However, they point out that some sophisticated financial institutions suffered substantial losses on AAA-rated tranches that the institutions themselves had originated. They conclude that retained interests may not align incentives for all securitization transactions, especially if an economic downturn is likely.
34. The National Bureau of Economic Research dates business cycles in the United States. According to the bureau, before the current crisis, the longest contractions after the Great Depression lasted 16 months, from November 1973 to March 1975 and from July 1981 to November 1982. In September 2010, the Bureau announced that the recession trough had occurred in June 2009, terminating the "Great Recession" at 18 months.
35. A study by Anno Stolper, "Regulation of Credit Rating Agencies," *Journal of Banking & Finance* 33, no. 7 (2009), 1266–73, presents a model of credit-rating agency regulation that suggests that regulators can alter credit-rating agency behavior by reducing the future number of approved credit-rating agencies based on relative rating performance.
36. See Gretchen Morgenson, "Fair Game; When Models Misbehave," *New York Times* (June 24, 2007).

37. See Gretchen Morgenson, "Naked Came the Speculators," *New York Times* (August 10, 2008).

4 Operational Risk Monitoring and Control

1. See text of the final rule in *Federal Register*, Vol. 79, no. 185 (September 24, 2014), 57184–346.
2. See Christopher Marshall, *Measuring and Managing Operational Risks in Financial Institutions: Tools, Techniques, and other Resources* (Singapore: John Wiley & Sons, 2001), 248–60, for a discussion of event tree analysis.
3. See *Federal Register*, "Final Rule and Economic Analysis of the Final Rule," Vol. 79, no. 185 (September 24, 2014), 57235, subsection (c).
4. See Securities and Exchange Commission, Press Release 2014–177.
5. See Douglas Montgomery, *Introduction to Statistical Quality Control,* 7th ed. (Hoboken: John Wiley & Sons, Inc. 2013).
6. See Marshall, *Measuring and Managing Operational Risks*, 123–4.
7. See Montgomery, *Introduction to Statistical Quality Control,* 13.
8. The Financial Crisis Inquiry Commission, *The Financial Crisis Inquiry Report* (January 2011), 18.
9. See Leonard Nakamura, "How Much Is That Home Really Worth? Appraisal Bias and House-Price Uncertainty," *Business Review*, Federal Reserve Bank of Philadelphia (First Quarter, 2010): 11–22.
10. See John Campbell, Stefano Giglio, and Parag Pathak, "Forced Sales and House Prices," Working Paper 14866, National Bureau of Economic Research (April 2009).
11. See Financial Crisis Inquiry Commission, *The Financial Crisis Inquiry Report*, 18.
12. See New Century Financial entry in Wikipedia.

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1. See US Senate, Permanent Subcommittee on Investigations, "U.S. Vulnerabilities to Money Laundering, Drugs, and Terrorist Financing: HSBC Case History," Staff Report (July 17, 2012).
2. US Senate, HSBC Case History, 4.
3. US Senate, HSBC Case History, 3.
4. US Senate, HSBC Case History, 3–4.
5. US Senate, HSBC Case History, 4.

6. US Senate, HSBC Case History, 150–68.
7. US Senate, HSBC Case History, 338.
8. For disclosure, the author worked at the OCC while writing this book.
9. US Senate, HSBC Case History, 10–11.
10. We can think of a unit as a Bernoulli random variable if it is a trial or experiment where the outcome can be classified as a success or failure, or in the case of a loan application, conforming or defective. See Sheldon Ross, *Introduction to Probability Models,* 8th ed. (San Diego, CA: Academic Press, 2003), 28–29. It is also assumed that the outcomes or trials are independent of one another.
11. See US Senate, HSBC Case History, 341–59, for a nice summary of the OCC supervision process. For a complete description of the OCC's supervision process, see Comptroller of the Currency, "Bank Supervision Process," Comptroller's Handbook (September 2007, with updates in 2012, 2013, and 2014).
12. The OCC may extend the time between examinations to 18 months if the bank has total assets of less than $500 million, the bank is well capitalized, the bank received a composite and management rating of 1 or 2 under the Uniform Financial Institutions Rating System at its most recent examination, is not subject to a formal enforcement action, has not had a change in control during the preceding 12 months, and is not a newly chartered bank.
13. Comptroller of the Currency, "Bank Supervision Process," 34.
14. Comptroller of the Currency, "Bank Supervision Process," 99. The discussion of the report of examination also summarizes material in this publication, pp. 99–104.
15. Comptroller of the Currency, "Bank Supervision Process," 103.
16. See recommendation number 9, US Senate, HSBC Case History, 12.
17. See US Senate, Permanent Subcommittee on Investigations, "JPMorgan Chase Whale Trades: A Case History of Derivatives Risks and Abuses," Staff Report (March 15, 2013).
18. Office of Inspector General, "The Board Should Enhance Its Supervisory Processes as a Result of Lessons Learned From the Federal Reserve's Supervision of JPMorgan Chase & Company's Chief Investment Office," Board of Governors of the Federal Reserve System, Consumer Financial Protection Bureau, Evaluation Report, 2014-SR-B-017, October 17, 2014.
19. US. Senate, "A Case History of Derivatives Risks and Abuses," 10.

20. US Senate, "A Case History of Derivatives Risks and Abuses," 8.
21. US Senate, "A Case History of Derivatives Risks and Abuses," 5.
22. See Merle Erickson, Brian W. Mayhew, and William L. Felix, Jr., "Why Do Audits Fail? Evidence from Lincoln Savings and Loan," *Journal of Accounting Research* 38. no. 1 (Spring 2000): 165–94.
23. See Marco Bertoni, Giorgio Brunello, and Lorenzo Rocco, "When the Cat Is Near, the Mice Won't Play: The Effect of External Examiners in Italian Schools," *Journal of Public Economics* 104 (2013): 65–77.
24. See Son Anh Le, Bruce Walters, and Mark Kroll, "The Moderating Effects of External Monitors on the Relationship between R&D Spending and Firm Performance," *Journal of Business Research* 59 (2006): 278–87.

Appendix: Subprime Crisis Timeline

*In assembling this timeline, the following resources were helpful: John Engen, "Future Shock," *U.S. Banker*, Vol. 118, no. 9 (2008), 24–29, various media articles cited in the text and the bibliography, the "Subprime crisis impact timeline" from Wikipedia (available at (http://en.wikipedia.org) and "The Financial Crisis" timeline of the Federal Reserve Bank of St. Louis (available at (http://timeline.stlouisfed.org)

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