

CHAPTER ONE

OpRisk in Perspective

1.1 Brief History

Operational risk (OpRisk) is the youngest of the three major risk branches, the others being market and credit risks. The term OpRisk started to be used after the Barings event in 1995, when a rogue trader caused the collapse of a venerable institution by placing bets in the Asian markets and keeping these contracts out of sight of management. At the time, these losses could be classified neither as market nor as credit risks and the term OpRisk started to be used in the industry to define situations where such losses could arise. It took quite some time until this definition was abandoned and a proper definition was established for OpRisk. In these early days, OpRisk had a negative definition as “every risk that is not market and credit”, which was not very helpful to assess and manage this risk. Looking back at the history of risk management research, we observe that early academics found the same issue of classifying risk in general, as Crockford (1982) noticed: “*Research into risk management immediately encounters some basic problems of definition. There is still no general agreement on where the boundaries of the subject lie, and a satisfactory definition of risk management is notoriously difficult to formulate*”.

Before delving into the brief history of OpRisk it might be useful to first understand how risk management is evolving and where OpRisk fits in this evolution. Risk in general is a relatively new area that began to be studied only after World War II. The concept of risk management came from the insurance industry and this was clear in the early days’ definitions. According to Crockford (1982) the term “risk management”, in its earliest incarnations, “*encompassed primarily those activities performed to prevent accidental loss*”. In one of the first textbooks on risk, Mehr and Hedges (1963) used a definition that reflected this close identification with insurance: “[T]he management of those risks for which the organization, principles and techniques appropriate to insurance management is useful”. Almost 20 years later, Bannister and Bawcutt (1981) defined risk management as “*the identification, measurement and economic control of risks that threaten the assets and earnings of a business or other enterprise*”, which is much closer to the definition used in the financial industry in the twenty-first century.

The association of risk management and insurance came from the regular use of insurance by individuals and corporations to protect themselves against these “accidental losses”. It is interesting to see that even early authors on the subject made a case for the separation between risk management and risk-takers (the businesses). Crockford (1982) wrote that “*operational*

convenience continues to dictate that pure and speculative risks should be handled by different functions within a company, even though theory may argue for them being managed as one”.

New tools for managing risks started to emerge in the 1950s, in addition to insurance, when many types of insurance coverage became very costly and incomplete; or certainly this “incompletion” started to be better noticed as risk management was beginning to evolve. Several business risks were either impossible or too expensive to insure. Contingent planning activities, an embryo of what is today called Business Continuity Planning (BCP), were developed, and various risk prevention or self-prevention activities and self-insurance instruments against some losses were put in place. Coverage for work-related illnesses and accidents also started to be offered during the 1960s. The 1960s were when a more formal, organized scholarly interest started to blossom in academia on issues related to risk. The first academic journal to show “risk” in their title was the *Journal of Risk and Insurance* in 1964. This journal was actually titled *Journal of Insurance* until then. Other specialized journals followed including *Risk Management*—published by the Risk and Insurance Management Society (RIMS), a professional association of risk managers founded in 1950 and the *Geneva Papers on Risk and Insurance*, published by the Geneva Association since 1976.

Risk management had its major breakthrough as the use of financial derivatives by investors became more spread out. Before the 1970s, derivatives were basically used for commodities and agricultural products; however, in the 1970s but more strongly in the 1980s, the use of derivatives to manage and hedge risks began. In the 1980s, companies began to consider financial risk management of “risk portfolios”. Financial risk management has become complementary to pure risk management for many companies. Most financial institutions, particularly investment banks, intensified their market and credit risk management activities during the 1980s. Given this enhanced activity and a number of major losses, it was no surprise that more intense scrutiny drew international regulatory attention. Governance of risk management became essential and the first risk management positions were created within organizations.

A sort of “risk management revolution” was sparked in the 1980s by a number of macroeconomic events that were present during this decade as, for example, fixed currency parities disappeared, the price of commodities became much more volatile, and the price fluctuations of many financial assets like interest rates, stock markets, exchange rates, etc. became much more volatile. This volatility, and the many headline losses that succeeded, revolutionized the concept of financial risk management as most financial institutions had such assets in their balance sheets and managing these risks became a priority for senior management and board of directors. At the same time, the definition of risk management became broader. Risk management decisions became financial decisions that had to be evaluated based on their effect on a firm or portfolio value, rather than on how well they cover certain risks. This change in definition applies particularly to large public corporations, due to the risk these bring to the overall financial system.

These exposures to financial derivatives brought new challenges with regard to risk assessment. Quantifying the risk exposures, given the complexity of these assets, was (and still remains) quite complex and there were no generally accepted models to do so. The first and most popular model to quantify market risks was the famous “Black & Scholes” developed by Black and Scholes (1973) in which an explicit formula for pricing a derivative was proposed—in this case, an equity derivative. The model was so revolutionary that the major finance journals refused to publish it at first. It was finally published in the *Journal of Political Economy* in 1973. An extension of this article was later published by Merton in the *Bell Journal of Economics and Management Science* (Merton, 1973). The impact of the article in the financial industry

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was significant and the risk coverage of derivatives grew quickly, expanding to many distinct assets like interest rate swaps, currencies, etc.

As risk management started to grow as a discipline, regulation also began to get more complex to catch up with new tools and techniques. It is not a stretch to say that financial institutions have always been regulated one way or another given the risk they bring to the financial system. Regulation was mostly on a country-by-country basis and very uneven, allowing arbitrages. As financial institutions became more globalized, the need for more symmetric regulation that could level the way institutions would be supervised and regulated increased worldwide. The G10, the group of 10 most industrialized countries, started meetings in the city of Basel in Switzerland under the auspices of the Bank for International Settlements (BIS). The so-called Basel Committee on Banking Supervision or Basel Committee was established by the central bank governors of the group of 10 countries at the end of 1974, and continues to meet regularly four times a year. It has four main working groups, which also meet regularly.

The Basel Committee does not possess any formal supranational supervisory authority, and its conclusions cannot, and were never intended to, have legal force. Rather, it formulates broad supervisory standards and guidelines and recommends statements of best practice in the expectation that individual authorities will take steps to implement them through detailed arrangements, statutory or otherwise, which are best suited to their own national systems. In this way, the Committee encourages convergence toward common approaches and common standards without attempting detailed standardization of member countries' supervisory techniques.

The Committee reports to the central bank governors and heads of supervision of its member countries. It seeks their endorsement for its major initiatives. These decisions cover a very wide range of financial issues. One important objective of the Committee's work has been to close gaps in international supervisory coverage in pursuit of two basic principles: that no foreign banking establishment should escape supervision; and that supervision should be adequate. To achieve this, the Committee has issued a long series of documents since 1975 that guide regulators worldwide on best practices that can be found on the website: www.bis.org/bcbs/publications.htm.

The first major outcome of these meetings was the Basel Accord, now called Basel I, signed in 1988 (see BCBS, 1988). This first accord was limited to credit risk only and required each bank to set aside a capital reserve of 8%, the so-called Cooke ratio, of the value of the securities representing the credit risk in their portfolio. The accord also extended the definition of capital to create reserves encompassing more than bank equity, which were namely:

- **Tier 1 (core capital)**, consisting of common stock, holding in subsidiaries, and some reserves disclosed to the regulatory body;
- **Tier 2 (supplementary capital)**, made up of hybrid capital instruments, subordinated debts with terms to maturity greater than 5 years, other securities, other reserves.

The Basel I Accord left behind one important risk component, which was market risk. In the meantime, JP Morgan released publicly its market risk methodology called Risk Metrics (JP Morgan, 1996), and the popularization of market risk measurement became widespread in the early 1990s. Reacting to that, in 1996 the Basel Committee issued the market risk amendment (BCBS, 1996), which included market risk in the regulatory framework. The acceptance of more sophisticated models like Value at Risk (VaR) as regulatory capital was a significant milestone in risk management. However, this initial rule had a number of limitations as it did

not allow diversification, that is, the total VaR of the firm would be the sum of the VaR for all assets without allowing for correlation between these risks.

As the global financial markets became increasingly interconnected and sophisticated as well as financial products, like credit derivatives, it soon became clear to the Basel Committee that a new regulatory framework was needed. In June 1999, the Committee issued a proposal for a revised Capital Adequacy Framework. The proposed capital framework consisted of the following three pillars:

- **Pillar 1.** Minimum capital requirements, which seek to refine the standardized rules set forth in the 1988 Accord;
- **Pillar 2.** Supervisory review of an institution’s internal assessment process and capital adequacy;
- **Pillar 3.** Market discipline focused on effective use of disclosure to strengthen market discipline as a complement to supervisory efforts.

Following extensive interaction with banks, industry groups, and supervisory authorities that are not members of the Committee, the revised framework (referred to as Basel II) BCBS (2004) was issued on June 26, 2004; the comprehensive version was published as BCBS (2006). This text serves as a basis for national rule-making and for banks to complete their preparations for the new framework’s implementation.

With Basel II, there also came for the first time the inclusion of OpRisk into the regulatory framework. The OpRisk situation was different from the one faced by market and credit risks. For those risks, regulators were looking at the best practice in the industry and issuing regulation mirroring these. The progress in OpRisk during the late 1990s and early 2000s was very slow. Some very large global banks like Lehman Brothers did not have an OpRisk department until 2004, so the regulators were issuing rules without the benefit of seeing how these rules would work in practice. This was a challenge for the industry.

In order to address these challenges, the Basel Committee allowed a few options for banks to assess capital. The framework outlined and presented three methods for calculating OpRisk capital charges in a continuum of increasing sophistication and risk sensitivity: (i) the Basic Indicator Approach (BIA); (ii) the Standardized Approach (SA); and (iii) Advanced Measurement Approaches (AMA). Internationally active banks and banks with significant OpRisk exposures (e.g., specialized processing banks) are expected to use an approach that is more sophisticated than the BIA and that is appropriate for the risk profile of the institution.

Many models have been suggested for modeling OpRisk under Basel II; for an overview, see Chernobai *et al.* (2007, chapter 4), Allen *et al.* (2005), and Shevchenko (2011, Section 1.5). Fundamentally there are two different approaches used to model OpRisk:

- The top–down approach; and
- The bottom–up approach.

The top–down approach quantifies OpRisk without attempting to identify the events or causes of losses while the bottom–up approach quantifies OpRisk on a microlevel as it is based on identified internal events. The top–down approach includes the Risk Indicator models that rely on a number of operational risk exposure indicators to track OpRisks and the Scenario Analysis and Stress Testing Models that are estimated based on the what-if scenarios. The bottom–up approaches include actuarial-type models (referred to as the Loss Distribution

Approach) that model frequency and severity of OpRisk losses. In this book we provide a detailed quantitative discussion on a range of models some of which are appropriate for top-down modelling whilst others are directly applicable to bottom-up frameworks.

1.2 Risk-Based Capital Ratios for Banks

Until the late 1970s, banks in most countries were in general highly regulated and protected entities. This protection was largely a result of the bitter memories of the Great Depression in the US as well as the role that high (or hyper) inflation played in the political developments in Europe in the 1930s, and banks arguably play a significant part in the spreading of inflation. Due to these memories, the activities banks were allowed to undertake were tightly restricted by national regulators and, in return, banks were mostly protected from competitive forces. This cozy relationship was intended to ensure stability of the banking system, and it succeeded in its goals throughout the reconstruction and growth phases, which followed World War II. This agreement held well until the collapse of Bretton Woods¹ (Eichengreen, 2008) in the 1970s. The resulting strain in the banking system was enormous. Banks suddenly were faced with an increasingly volatile environment, but at the same time had very inelastic pricing control over their assets and liabilities, which were subject not just to government regulation but also to protective cartel-like arrangements. The only solution seen by national authorities at this time was to ease regulations on banks. As the banking sector was not used to competitive pressures, the result of the deregulation was that banks started to take too much risk in search of large pay-offs. Suddenly banks were overlending to Latin American countries (and other emerging markets); overpaying for expansion (e.g., buying competitors looking for geographic expansion), etc. With the crisis in Latin America in the 1980s, these countries could not repay their debts and banks were once again in trouble. Given that the problems were mostly cross-boundary as the less regulated banks became more international, the only way to address this situation was at the international level and the Basel Committee was consequently established under the auspices of the BIS.

In 1988, the Basel Committee decided to introduce an internationally accepted capital measurement system commonly referred to as Basel I, (BCBS, 1988). This framework was replaced by a significantly more complex capital adequacy framework commonly known as Basel II (BCBS, 2004) and, more recently, the Basel Committee issued the Basel III Accord (BCBS, 2011, 2013), which will add more capital requirements to banks. Table 1.1 shows a summary of key takeaways of the Basel Accords.

Basel I primarily focuses on credit risk and developed a system of risk-weighting of assets. Assets of banks were classified and grouped in five categories according to credit risk, carrying risk weights of 0% for the safest, most liquid assets (e.g., cash, bullion, home country debt like Treasuries) to 100% (e.g., most corporate debt). Banks with an international presence were required to at least hold capital equal to 8% of their risk-weighted assets (RWA). The concept of RWA was kept in all Accords with changes on the weights and in the composition of assets by category. An example of how risk-weighting works can be seen in Table 1.2. In this example, the sum of the assets of this bank is \$1015; however, applying the risk-weighting rule established in Basel I, the RWA is actually \$675.

¹The Bretton Woods agreement was established in the summer of 1944 and put in place a system of exchange and interest rate stability which ensured that banks could easily manage their exposures.

TABLE 1.1 Basel framework general summary

Accord	Year	Key points
Basel I	1988	Introduces minimal capital requirement for the banking book. Introduces tier concept for capital requirement. Incorporates trading book into the framework later on through the Market Risk Amendment (MRA).
Basel II	2004	Allows usage of internal models and inputs in risk measurement. Introduces operational risk.
Basel II/III	2010	Increases capital requirement for trading book, with significant increase for correlation trading and securitizations.
Basel III	2010	Motivated by the great financial crisis of 2008, increases capital requirements, introduces leverage constraints and minimum liquidity and funding requirements.

TABLE 1.2 Example of risk-weighted assets calculation under Basel I

Risk-weight (%)	Asset	Amount (\$)	RWA (\$)
0	Cash	10	0
	Treasury bills	50	0
	Long-term treasury securities	100	0
20	Municipal bonds	20	4
	Items in collection	20	4
50	Residential mortgages	300	150
100	AA+ rated loan	20	20
	Commercial loans, AAA- rated	55	55
	Commercial loans, BB- rated	200	200
	Sovereign loans B- rated	200	200
	Fixed assets	50	50
Not rated	Reserve for loan losses	(10)	(10)
Total		1015	675

Since Basel I, a bank’s capital also started to be classified into Tier 1 and Tier 2. Tier 1 capital is considered the primary capital or “core capital”; Tier 2 capital is the supplementary capital. The total capital that a bank holds is defined as the sum of Tier 1 and Tier 2 capitals. Table 1.3 provides a more detailed view of the components of each tier of capital. The key component of Tier 1 capital is the common shareholders equity. This item is so important that a number of banks also report the so-called Tier 1 Common Equity in which only common shareholder equity is considered as Tier 1. As shown in Table 1.3, the Basel Committee made capital requirement much stricter in the latest Basel Accords by changing the definition of some of the current items but also by sending a couple of items to Tier 2 (e.g., trust preferred securities and remaining noncontrolling interest), making it more difficult for banks to comply with these new capital rules.

Another important contribution from Basel I is the concept of capital ratios that remains until today. Basically, a bank needs to assert its capital requirements based on the formula:

$$\text{Capital ratio} = \frac{\text{Eligible capital}}{\text{RWA}}. \quad (1.1)$$

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TABLE 1.3 Tiered capital definition under Basel II and Basel III

Tier	Capital requirement under Basel II	Basel III capital requirement
Tier 1	(+) Common shareholders equity (+) Partial noncontrolling interest (NCI) (–) Certain deferred tax assets (DTA) (–) Goodwill and intangibles (–) Debt valuation adjustments (DVA) (–) Other deductions = Tier 1 common (+) Perpetual preferred stock (+) Trust preferred securities (+) Remaining NCI = Tier 1 capital	(+) Common shareholders equity (+) Partial noncontrolling interest (NCI)* (–) Certain deferred tax assets (DTA)* (–) Goodwill and intangibles (–) Debt valuation adjustments (DVA) (–) Other deductions* = Tier 1 common (+) Perpetual preferred stock = Tier 1 capital
Tier 2	(+) Subordinated debt (+) Allowance for loan loss reserves	(+) Trust preferred securities* (+) Remaining NCI* (+) Subordinated debt (+) Allowance for loan loss reserves

Basel III changes are indicated by *.

TABLE 1.4 Example of capital ratios in some large European banks in 2012

	UBS	Credit Suisse	Deutsche Bank
Tier 1 capital	40,982	43,547	50,483
Total capital	48,498	49,936	57,015
RWA total	192,505	224,296	333,849
RWA market risk	21,173	29,366	53,058
RWA credit risk	105,807	143,679	229,196
RWA OpRisk	53,277	45,125	51,595
Other risks	6,248	6,126	—
Tier 1 capital ratio	21.3%	19.4%	15.1%
Total capital ratio	25.2%	22.3%	17.1%

Source: Banks annual reports. Figures are in Swiss Francs (CHF) millions for UBS and Credit Suisse and in Euros millions for Deutsche Bank.

Therefore, to find its Tier 1 capital ratio a bank would have to calculate its RWA based on the current Basel rules and also retrieve the elements that compose Tier 1 capital from its balance sheet. Dividing the Tier 1 capital by the RWA would provide the Tier 1 capital ratio. In order to make this process very clear, we show examples on how to calculate each of the steps. Table 1.2 shows an example of RWA calculation using only credit risk-weightings; Table 1.3 provides an overview of capital requirement definitions on the balance sheet; and Table 1.4 shows a real-life example of capital ratios in a few Large European banks that are Basel II approved and, therefore, have to show their capital breakdown.

Basel II discussions started in the late 1990s and ended with the publication of the second Accord, or “Basel II” in 2004 (BCBS, 2004). Basel II was implemented in an era where banks posted record profits and the global macroeconomic scenario did not show many clouds on

TABLE 1.5 New capital charges on Basel III

Capital conservation buffer	Countercyclical capital buffer
2.5% added to the minimum ratios	Up to 2.5% added to the minimum ratios
To be built up in good times and available in period of stress	Declared by any country that is experiencing overheated credit markets—preannouncement of decision by up to 12 months
Inclusion in target capital ratios by end of transition period (2018)	Can be relaxed when the market “cools down” again—takes effect immediately with announcement
Restriction on distributions (dividends, share buybacks, and bonuses) if the full buffer requirement is not met	Restriction on distributions (dividends, share buybacks, and bonuses) if the buffer requirement is not met

TABLE 1.6 Minimum capital requirements

Type of capital	Before Basel III(%)	Basel III(%)	Capital conservation buffer (%)	Countercyclical capital buffer (%)	Total Basel III(%)
Common Equity Tier 1	2	4.5	2.5	0–2.5	9.5
Tier 1	4	6	2.5	0–2.5	11
Total risk-based capital	8	8	2.5	0–2.5	13

Source: BCBS (2013).

the horizon. In this Accord, banks were allowed to use their own internal models to calculate regulatory capital for market, credit, and also operational risk, which was introduced in this Accord. The overall idea of Basel II was that banks would be able to reduce their capital requirements by adopting internal models and following the strict qualification criteria.

In order to calculate the RWA in market and operational risks, where the risk-weighting asset in the example of Table 1.2 would obviously not apply, banks would have to convert the outcomes of their internal models, calculated at the 99.9% quantile, and divide this number by 8% (or multiply by 12.5). Reverse engineering these numbers from Table 1.4, i.e. calculating operational risk capital as RWA OpRisk divided by 12.5, we can see that the operational risk capital at UBS in 2012 was CHF 4264 million, Credit Suisse was CHF 3610 million, and Deutsche Bank was €4127 million.

Unlike Basel I and Basel II, Basel III was motivated by the great banking crisis in 2008 and this motivation made this 3-rd version of the Accord primarily focussed on addressing concerns about a run on the bank risks (i.e., liquidity issues on customers withdrawing resources from a bank due to lack of confidence in its financial health), consequently requiring differing levels of reserves for different forms of bank deposits and other borrowings. Therefore, contrary to what might be expected by its name, Basel III rules do not, for the most part, supersede the guidelines established in Basel I and Basel II but work alongside them. The main changes in the Basel III framework are shown in Table 1.5 and are mostly related to the creation of new capital buffers to ensure banks are enough capitalized in the next crisis.

In addition to the minimum capital ratios already established in the previous Accords (see Table 1.6), Basel III requires that all banking organizations maintain a “capital conservation buffer” consisting of Tier 1 Common Equity capital in an amount equal to 2.5% of risk-weighted assets in order to avoid restrictions on their ability to make capital distributions and to make certain discretionary bonus payments to executive officers. Thus, the capital conservation

buffer effectively increases the minimum Tier 1 common equity capital, Tier 1 capital, and total capital requirements for US banking organizations to 7.0%, 8.5%, and 10.5%, respectively. Banking organizations with capital levels that fall within the buffer will be forced to limit dividends, share repurchases or redemptions (unless replaced within the same calendar quarter by capital instruments of equal or higher quality), and make discretionary bonus payments. The limits consist of a sliding scale, so that as the buffer decreases, so does the maximum payout as a percentage of the banking organization’s net income over the past four quarters. For large global banks, the capital buffer may be increased during periods of “excessive credit growth” by an incremental “countercyclical capital buffer” of up to 2.5% of risk-weighted assets. In a change from the proposed rules (i.e., presigning the Accord), large global banks would (after completing the “parallel run” process for migrating to the advanced approaches regime) be required to use the lesser of their standardized and advanced approaches risk-based capital ratios as the basis for calculating their capital conservation buffer (and any applicable countercyclical capital buffer). This change will likely increase the capital buffer for at least some large global banks compared to the proposed rules.

Basel III also imposes a Tier 1 minimum leverage ratio of 4.0% for all banking organizations and an additional supplementary Tier 1 leverage ratio of 3.0% for large global banks (BCBS, 2013). The 3.0% supplementary leverage ratio (which, consistent with Basel III schedule, will take effect in January 2018 but be reported beginning in January 2015) incorporates in the denominator certain off-balance sheet exposures that are not included in the standard leverage ratio. Despite significant criticism from the industry, Basel III continues to include in the supplementary leverage ratio derivative exposures based on potential future exposure (without collateral recognition) and 10% of unconditionally cancellable commitments.

1.3 The Basic Indicator and Standardized Approaches for OpRisk

Under the Basel II framework, the simplest method that banks could use to calculate OpRisk capital is the BIA. Banks using the BIA must hold capital for OpRisk equal to the average over the previous 3 years of a fixed percentage (denoted α) of positive annual gross income. Figures for any year in which annual gross income is negative or zero should be excluded from both the numerator and denominator when calculating the average. The capital charge K_{BIA} may be expressed as follows:

$$K_{BIA} = \alpha \frac{1}{n} \sum_{j=1}^3 \max \{ GI(j), 0 \}, \quad n = \sum_{j=1}^3 \mathbb{I}_{\{GI(j) > 0\}}, \quad (1.2)$$

where $GI(j)$, $j = 1, 2, 3$ are the annual gross incomes over the last 3 years; $\mathbb{I}_{\{GI(j) > 0\}}$ is an indicator function that equals 1 if condition in $\{.\}$ is true and 0 otherwise; n is the number of previous years in which income is positive (expected to be three); and $\alpha = 0.15$ (as of 2013) as established by the Committee (BCBS, 2006, pp. 144–145).

Another simple approach to calculate OpRisk capital under the Basel II framework is the SA where, bank activities are divided into eight business lines: Corporate finance, Trading and sales, Retail banking, Commercial banking, Payment and settlement, Agency services, Asset management, and Retail brokerage. Within each business line, gross income is a broad indicator that serves as a proxy for the scale of business operations and thus the likely scale of OpRisk exposure within each of these business lines. The capital charge for each business line

TABLE 1.7 Coefficients β_i for each business line as determined by Basel II in BCBS (2006, p. 147)

Business line	β_i
Corporate finance	0.18
Trading and sales	0.18
Retail banking	0.12
Commercial banking	0.15
Payment and settlements	0.18
Agency services	0.15
Asset management	0.12
Retail brokerage	0.12

is calculated by multiplying gross income by a factor (denoted β) assigned to that business line. The value of β serves as a proxy for the industry-wide relationship between the OpRisk loss experience for a given business line and the aggregate level of gross income for that business line. It should be noted that in the SA gross income is measured for each business line, not the whole institution, that is, in Corporate finance, the indicator is the gross income generated in the Corporate finance business line.

The total capital charge is calculated as the 3-year average of the simple summation of the regulatory capital charges across each of the business lines in each year. In any given year, negative capital charges (resulting from negative gross income) in any business line may offset positive capital charges in other business lines without limit. However, where the aggregate capital charge across all business lines within a given year is negative, the input to the numerator for that year will be zero. The total capital charge K_{TSA} may be expressed as

$$K_{TSA} = \frac{1}{3} \sum_{j=1}^3 \max \left(\sum_{i=1}^8 \beta_i GI_i(j), 0 \right), \quad (1.3)$$

where $GI_i(j)$ is the annual gross income of business line i in year j and β_i a fixed coefficient, set by the Committee, relating the level of required capital to the level of gross income for each of the eight business lines. These details can be found in (BCBS, 2006, pp. 146–147); the values of β_i (as of 2013) are presented in Table 1.7.

1.4 The Advanced Measurement Approach

Under the Basel II AMA for OpRisk, banks are allowed to use their own internal models to estimate capital. A bank intending to use the AMA should demonstrate the accuracy of the internal models within the matrix of Basel II risk cells (eight business lines by seven event types) relevant to the bank. The eight business lines are listed in Table 1.7 and the seven event types are as follows:

- Internal fraud;
- External fraud;
- Employment practices and workplace safety;

- Clients, products, and business practices;
- Damage to physical assets;
- Business disruption and system failures;
- Execution, delivery, and process management.

As imagined, given the early stages of bank frameworks, the range of practice was quite broad. In Europe, the methodological focus of most banks was on using scenario analysis while in the US the focus was on internal and external loss data. Understanding the evolutionary nature of OpRisk management as a developing risk management discipline, the Basel Committee provided significant flexibility to banks in the development of an OpRisk measurement and management system. This flexibility was, and continues to be, a critical feature of the AMA. However, substantial efforts are required by national authorities to ensure sufficient consistency in the application of these features. The Basel II framework envisaged that, over time, the OpRisk discipline will mature and converge toward a narrower band of effective risk management and risk measurement practices. Understanding the current range of observed operational risk management and measurement practices, both within and across geographic regions, contributes significantly to the efforts to establish consistent supervisory expectations. Through the analysis of existing practices, and the publication of papers reporting those practices, the Basel Committee expects the maturation of OpRisk practices and supports supervisors in developing more consistent regulatory expectations.

The initial Basel II proposal (BCBS, 2001, Annex 4) suggested three approaches for AMA:

- Internal Measurement Approach (IMA);
- Score Card Approach (SCA);
- Loss Distribution Approach (LDA).

The latest Basel II document (see BCBS, 2006) does not give any guidance for the AMA approach and allows flexibility.

1.4.1 INTERNAL MEASUREMENT APPROACH

Under the IMA, OpRisk events are divided into business lines $i = 1, 2, \dots$ and event types $j = 1, 2, \dots$; an exposure indicator EL_{ij} is set for each business line/event type combination (risk cell) to capture the scale of the bank's activities in the risk cell; probability P_{ij} that the event will occur over the next year and average loss AL_{ij} are estimated using internal loss data. Then, the capital charge K_{IMA} is calculated as

$$K_{IMA} = \sum_{i,j} \gamma_{ij} EL_{ij} P_{ij} AL_{ij}, \quad (1.4)$$

where γ_{ij} is the conversion factor translating expected loss, $EL_{ij} P_{ij} AL_{ij}$, for business line/event type risk cell into a capital charge; see BCBS (2001, Annex 4).

1.4.2 SCORE CARD APPROACH

Under a scorecard based approach the bank determines an initial level of OpRisk capital at the firm or business line level, and then attempts to modify the calculated amounts over time on the basis of a qualitative ranking or scoring of each risks evolution.

As stated in the Basel working paper on the regulatory treatment of OpRisk (BCBS 2001, p. 35)

“These scorecards are intended to bring a forward-looking component to the capital calculations, that is, to reflect improvements in the risk control environment that will reduce both the frequency and severity of future operational risk losses. The scorecards may be based on actual measures of risk, but more usually identify a number of indicators as proxies for particular risk types within business units/lines. The scorecard will normally be completed by line personnel at regular intervals, often annually, and subject to review by a central risk function”.

The SCA approach calculates the capital charge K_{SCA} as

$$K_{SCA} = \sum_{i,j} \omega_{ij} EI_{ij} RS_{ij}, \quad (1.5)$$

where ω_{ij} is the amount of capital per unit of the indicator of exposure, EI_{ij} is the exposure index from a set for each business line/event type combination (risk cell) and RS_{ij} is the risk factor. Under the SCA, a bank assigns a value to each OpRisk event and compares the different OpRisks according to the values. This method relies on experts’ assessment in the selection of indicators and their weights (see, e.g., Anders and Sandstedt, 2003). There are a number of references discussing in more detail the nature of scorecard based approaches, see for instance Blunden (2003) and Alexander (2003) and the references therein for more details.

As noted in Alexander (2003), scorecards can be highly subjective and the following important issues are still in the process of being better understood:

- The industry has still been unable to develop industry wide standards for the key risk indicators (KRIs) that should be used for each risk type and underpin the development of scorecard methods;
- They may be inherent biases and moral hazards that must be better understood, modelled and managed before scorecard based methods can be considered reliable. To understand this point, typically, given a set of risk indicators, frequency and severity scores are assigned by a business manager or risk expert in the business that ‘owns’ the particular operational risk. Hence, one requires a considered design of the management process in order to avoid subjective biases or moral hazard from occurring in the scoring process;
- In addition to the subjectivity of the scores there is also a second problem that under an AMA approach one should figure out a method to map scorecard data to a loss distribution model. This involves the mapping of the scores subjectively to monetary loss amounts.

For these reasons we don’t elaborate further on scorecard based approaches. In fact we suggest users of scorecard approaches to consider formulating them under a regression based framework such as those developed in Item Response Theory (IRT), see discussions in Linden and Hambleton (1997).

1.4.3 LOSS DISTRIBUTION APPROACH

The LDA approach is based on modelling annual frequency N and severity X_1, X_2, \dots of OpRisk events for a risk cell. Then the annual loss for the j -th risk cell is calculated as aggregation of severities over a 1-year time horizon

$$Z^{(j)} = X_1^{(j)} + X_2^{(j)} + \dots + X_{N^{(j)}}^{(j)} \quad (1.6)$$

and the total loss over all risk cells in a given year is obtained by the following sum over the d risk cells

$$Z = \sum_{j=1}^d Z^{(j)}.$$

Then, the regulatory capital is defined as the 0.999 VaR, which is the quantile of the distribution for the next year’s annual loss Z :

$$\text{VaR}_q[Z] = \inf\{z \in \mathbb{R} : \Pr[Z > z] \leq 1 - q\} \quad (1.7)$$

at the level $q = 0.999$. For economic capital, banks often use quantile levels in the range $q \in [0.9995, 0.9997]$ depending on a bank’s credit rating. The risk cells can be selected at the actual loss generating process level. However, currently, many banks use the LDA for business line/event type risk cells.

Remark 1.1 *The LDA is considered to be the most comprehensive approach and is a focus of this book. Hereafter, we consider the LDA model only.*

1.4.4 REQUIREMENTS FOR AMA

The qualifying criteria for using the AMA are quite stringent and, in practice, it takes many years of implementation and regulatory exams to validate the approach. The Basel II Accord states that a bank must meet a number of qualitative standards before it is permitted to use an AMA for OpRisk capital (BCBS, 2006, pp. 150–151). In brief, these are as follows:

- The bank must have an independent OpRisk management function responsible for codifying firm-level policies and procedures concerning OpRisk management and controls; the design and implementation of the firm’s OpRisk measurement methodology; the design and implementation of a risk-reporting system for OpRisk; and developing strategies to identify, measure, monitor, and control/mitigate OpRisk;
- The bank’s internal OpRisk measurement system must be closely integrated into the day-to-day risk management processes. Its output must be an integral part of the process of monitoring and controlling the OpRisk profile. The bank must have techniques for allocating OpRisk capital to major business lines and for creating incentives to improve the management of OpRisk throughout the firm;
- There must be regular reporting of OpRisk exposures and loss experience to business unit management, senior management, and to the board of directors. The bank must have procedures for taking appropriate action according to the information within the management reports;
- The bank’s OpRisk management system must be well documented;
- Internal and/or external auditors must perform regular reviews of the OpRisk management processes and measurement systems;
- The validation of the OpRisk measurement system by external auditors and/or supervisory authorities must include:

- Verifying that the internal validation processes are operating in a satisfactory manner;
- Making sure that data flows and processes associated with the risk measurement system are transparent and accessible.

In addition to these qualitative factors, Basel II also has quite stringent criteria on AMA acceptance based on a series of quantitative standards (BCBS, 2006, pp. 151–152) as follows:

- Any internal OpRisk measurement system must be consistent with the OpRisk defined by the Committee and the loss event types defined in BCBS (2006);
- The risk measure used for capital charge should correspond to the 99.9% confidence level for a 1-year holding period, that is, $\text{VaR}_{0.999}$ defined in (1.7). Supervisors will require the bank to calculate its regulatory capital requirement $\text{VaR}_{0.999}$ as the sum of expected loss (EL) and unexpected loss (UL), unless the bank can demonstrate that it is adequately capturing EL in its internal business practices. To calculate the minimum regulatory capital as UL, the bank must be able to demonstrate to the satisfaction of its national supervisor that it has measured and accounted for its EL exposure. For illustration, see Figure 1.1. Hereafter, for simplicity, we consider the regulatory capital to be the sum of EL and UL, which is the 99.9% VaR;
- A bank’s risk measurement system must be sufficiently “granular” to capture the major drivers of OpRisk affecting the shape of the tail of the loss estimates;
- OpRisk capital charge measures for different risk cells must be added for purposes of calculating the regulatory minimum capital requirement over all risk cells in a bank. However, the bank may be permitted to use internally determined correlations between risk cells, provided it can demonstrate to the satisfaction of the national supervisor that its systems for determining correlations are sound, implemented with integrity, and take into account the uncertainty surrounding any such correlation estimates (particularly in

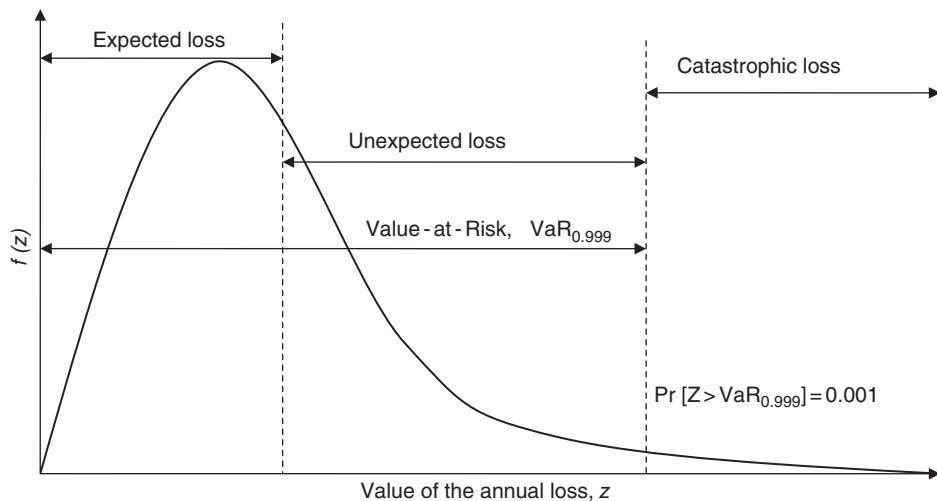


FIGURE 1.1 Illustration of the expected and unexpected losses in the capital requirements at the 99.9% confidence level for a 1-year holding period; $f(z)$ is the probability density function of the annual loss

periods of stress). The bank must validate its correlation assumptions using appropriate quantitative and qualitative techniques;

- OpRisk measurement system must be based on the use of internal data, relevant external data, scenario analysis, and factors reflecting the business environment and internal control systems (BEICF). A bank needs to have a credible, transparent, well-documented and verifiable approach for weighting these fundamental elements in its overall OpRisk measurement system. If the estimates of the 99.9% VaR based primarily on internal and external loss event data are unreliable for business lines with a heavy-tailed loss distribution and a small number of observed losses, then scenario analysis and BEICF may play a more dominant role in the risk measurement system. Conversely, OpRisk loss event data may play a more dominant role in the risk measurement system for business lines where estimates of the 99.9% VaR based primarily on such data are deemed reliable.

Given that these rules are quite stringent and were made without benchmarks, unlike market and credit risks, the range of practice can vary significantly from bank to bank. Even banks based in the same block in Midtown Manhattan, just to be very graphic, can have completely different methodologies and frameworks to measure OpRisk. This is very different from market and credit risks where the measurement frameworks are similar across the banks.

The Basel Committee performs surveys on the range of practices for AMA and then issues reports to divulge the results. These reports describe industry practices for some key areas of the governance, data, and modeling components of an AMA framework identifying emerging effective practices as well as practices that are inconsistent with supervisory expectations. The findings from the latest range of practices report (BCBS, 2009a) based on the 2008 Loss Data Collection Exercise (BCBS, 2009b) include the following:

- The absence of definitions in the Basel II text for “gross loss” or “recoveries” and varying loss data collection practices among AMA banks results in differences in the loss amounts recorded for similar events. This practice may lead to potentially large differences in banks’ respective capital calculations;
- There was a broad range of practices in the use of loss amount as the AMA input. Most of the 42 participating AMA banks (43%) used “gross loss after all recoveries” (except insurance). “Gross loss before any recoveries” was used by 29%. Other loss amounts used by participating banks include “net loss” (14%) and “other definition” (12%);
- Data collection thresholds vary widely across institutions and types of activity. A bank should be aware of the impact that its choice of thresholds has on OpRisk capital computations;
- There is a broad range of practices for when the loss amounts from legal events are used as a direct input into the model quantifying operational capital, which raises questions of transparency and industry consistency in how these OpRisk exposures are quantified for capital purposes;
- There is considerable diversity across banks in the choice of granularity of their models that may be driven as much by modeler’s preferences as by actual differences in OpRisk profiles;
- While it is common for banks to use the Poisson distribution for estimating frequency, there are significant differences in the way banks model severity, including the choice of severity distribution; and

- The combination and weighting of the four elements (internal data, external data, scenario analysis, and BEICF) are significant issues for many banks, given the many possible combination techniques. This is an area where the range of practices is particularly broad both within and across jurisdictions.

1.5 General Remarks and Book Structure

Regulators are trying to close the methodology gap by holding meetings with the industry and they are attempting to incentivize convergence among the different approaches through more individualized guidance. Although some success might be credited to these efforts, there are still considerable challenges and this is where our book *Fundamental Aspects of Operational Risk and Insurance Analytics: A Handbook of Operational Risk* can add value to the industry.

We consider that one of the biggest challenges in OpRisk is to take this risk management branch to the same level that market and credit risk management play. Those two risks are managed proactively and risk managers usually have a say if deals or businesses are approved based on the risk level. OpRisk is mostly kept out of these discussions at this stage and this is an issue as quite a few financial institutions have OpRisk as their dominant exposure. We believe that considerable effort in the industry would have to be put into data collection and modeling improvements, and that is the focus of our work in this book.

Our book can be divided into two parts. The first part (Chapters 1–5) covers the basics, the building blocks, of OpRisk management and measurement. In Chapter 2, there is a broad coverage on the four data elements that need to be used in the OpRisk framework as well as how a risk taxonomy process should be developed. Considerable focus is given to internal loss data and key risk indicators as these would be fundamental in developing a risk-sensitive framework similar to market and credit risks. Subsequently, Chapter 3 shows how OpRisk can be inserted into a firm’s strategic decisions and Chapter 4 shows a model to stress-test OpRisk under the US Comprehensive Capital Analysis and Review (CCAR) program. The basic concepts of probability theory and the basic framework for modeling and measuring OpRisk and how loss aggregation should work are considered in Chapter 5.

In the second part of the book (Chapters 6–18), we cover more special topics in OpRisk measurement. For example, diverse methods to estimate frequency and severity models are discussed. Another very popular issue in this industry is how to select severity models and this is also comprehensively discussed in this part. One of the biggest challenges in OpRisk is that data used in measurement can be very different, so combining them into a single measure is not a trivial task. In this part of the book, we show a number of methods to do so. After the core risk measurement work is done, there are still some issues to address that can potentially mitigate the capital found and also on how to manage risks. We also discuss correlation and dependency modeling as well as insurance and risk transfer tools and methods.

We hope this book can be the basis for a number of discussions in the industry. This book can help novices in the field to learn the building blocks of OpRisk and also suggest new techniques and ideas for those who have been practicing or researching for a while.

Most OpRisk practitioners would say that their focus is always on the tail events as these are the ones that can cause real damage and even force a financial institution into bankruptcy. Realizing this and understanding these tail events and how to model these is a crucial part of OpRisk. Comprehensive treatment of the modeling of heavy-tailed events requires a book-length text and it is a subject covered in the more advanced companion book *Advances in Heavy Tailed Risk Modeling: A Handbook of Operational Risk*, Peters and Shevchenko (2015).