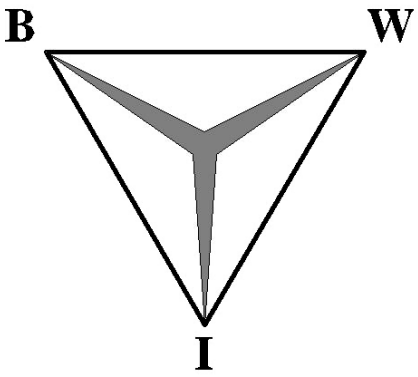
New Capital Accord Basle II

Using LDA Approach for
Measuring Operational Risk?



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Preface

The paper that lies before you is the final result of a literature study that forms a compulsory element of the study Business Mathematics and Informatics at the Faculty of Sciences at the Vrije Universiteit in Amsterdam.

One of the main topics in banks is modelling operational risk. After the adoption of the Basle II Accord, banks are obliged to take operational risk into account, when setting aside capital for its overall risks. In this paper I will give an overview of the methodology currently available for measuring reserved capital for operational risk.

I would like to thank my supervisor Menno Dobber for his time, advice and patience. Furthermore, I have to thank my friend Serdar for helping me finding this interesting subject.

Willem Yu
January 2005

Executive summary

The Basel Committee on banking supervision has recognized that managing Operational Risk is becoming an important feature of sound risk management practice in modern financial markets. Although, this phenomenon is not new in banking industries it has only come into the spotlights these few years. One of the most important functions of banks is to attract deposits and to make loans. In order to perform the latter, banks must hold equity as a buffer to prevent bankruptcy that could possibly be caused by bad realizations of return on the loan portfolio. Since holding equity is very costly, banks are striving to keep this amount to the minimum and as low as possible.

After the adoption of the Basle II accord modeling of operational risk has become a major concern to the financial industry. This framework is supported by the 3 pillars of Basle.

- Pillar 1- minimum capital requirements: This pillar describes the capital requirements for credit risk, market risk and operational risk.
- Pillar 2- supervisory approach: This pillar aims to encourage banks to develop better methods to measure the risks.
- Pillar 3- disclosure: The 3rd pillar sets out disclosure requirements and recommendations.

Pillar 1 of this framework incorporates a new capital charge for operational risk with a choice of approaches. These are the Basic Indicator, Standardized Approaches and the Advanced Measurement Approaches (AMA).

The Basic indicator approach uses the average of a "3 years Gross Income of banks multiplied with a straight percentage" to calculate the reserved capital for operational risk. This method calculates the most capital for operational risk. The Standardized approach uses the same methods as the Basic Indicator approach; the difference is that the standardized approach divides the banks activity into 8 business lines.

The Advanced Measurement Approach is the most sophisticated set of approaches currently available. These set of approaches do not use Gross Income, but loss data to model the losses. The AMA approach can be divided into 3 sub approaches: the Scorecard Approach, the Internal Measurement Approach and the Loss Distribution Approach.

The methodology behind the Scorecard Approach is that it uses the drivers of the losses to predict the loss amount. These drivers can be combined into a score, which can represent the altitude of the loss.

The Internal Measurement approach (IMA) calculates the total capital for operational risk assuming that there is a direct relationship between the expected loss and the unexpected loss. First the expected losses will be determined. After this, the total capital for operational risk will be calculated by multiplying the expected loss with a factor.

The main topic of this paper is Using a Loss Distribution Approach (LDA) for Measuring Operational risk; this is one of the most sophisticated methods currently available within the AMA approach. The difference between this method and the scorecard approach is that it does not uses drivers to model operational losses. Unlike the IMA approach, the LDA approach does not assume that there is a direct relationship between the expected and the unexpected losses. It simply estimates the capital charge for operational risk by using several steps.

For the LDA approach one must determine a loss frequency distribution and a loss severity distribution. The loss frequency distribution represents the arrival of the loss events. The loss severity distribution represents the altitude of the loss amount for a certain loss event. Both

distributions will be used to model an aggregated loss distribution by using the Monte Carlo simulation technique.

This paper gives an overview of the methodology for measuring operational risk, but its main focus is the LDA approach.

Contents

1 Introduction

The Basel Committee on banking supervision has recognized that managing operational risk is becoming an important feature of sound risk management practice in modern financial markets. Operational risks are enterprise wide and inherent in any business. It is more pronounced in industries like nuclear power plants, chemical industries and as has been seen lately in the *banking industry*. Although, this phenomenon is not new in banking industries it has only come into the spotlights these few years.

One of the most important functions of banks is to attract deposits and to make loans. In order to perform the latter, banks must hold equity as a buffer to prevent bankruptcy that could possibly be caused by bad realizations of return on the loan portfolio. Since holding equity is very costly, banks are striving to keep this amount to the minimum and as low as possible. The reserved amount will be referred as the regulatory capital.

The Basel Committee published the Basle 1988 accord; according to this accord the regulatory capital must satisfy certain conditions. The regulatory capital, which is held by all banks, must be at least 8% according to the BIS ratio (Banks of International Settlements ratio). This percentage (8%) indicates the solvency of all banks.

After the adoption of the Basle II accord banks are subjected to changes in the calculation of the regulatory capital. Besides calculating the capital for credit and market risk exposure another element is incorporated to the regulatory capital, the operational risk.

The Main topic of this paper is “Using a Loss Distribution Approach for Measuring Operational Risk”. This is a method that calculates the reserved capital to cover losses that are caused by operational risk events, within the scope of the New Capital Accord.

First one will read about the Basel Accord of 1988 in paragraph 1.1 and follows up with The New Capital Accord, Basel II in paragraph 1.2. In paragraph 1.3 the three pillars, known as the three principals of Basel II, will be explained.

In Chapter 2 one will about the BIS II – ratio, a percentage to determine the solvency of a bank. The BIS II – ratio includes all risks, which are in the scope of pillar I from The New Capital Accord, Basle II.

In Chapter 3 one will read the description of Operational risk, which has been determined by the Basel Committee.

Chapter 4 will discuss several methods to determine the Operational risk, such as: Basic Indicator Approach, Standardized Approach and the Advanced Measurement Approach (AMA).

The AMA approach is a more sophisticated approach. This includes several sub approaches, such as the Scorecard approach, Internal Measurement Approach and of course the “Loss Distribution Approach”. These will be explained in Chapter 5.

In Chapter 6, a detailed description of “Loss Distribution Approach” will be described. This includes several steps to implement this approach, such as using statistical method to measure operational risks.

1.1 The Basle Capital Accord of 1988

The Basle Committee on Banking Supervision published the 1988 Basle Accord after following the difficulties of the bank's markets during the 1980's. The purpose of this Accord is to improve the stability of financial markets by setting a floor for reserved capital held by the world's largest banks, this will be referred to as the "Regulatory Capital" or "Solvency", *The standard for the Regulatory Capital was based on a single risk measure, known as corporate risk exposure. All risks are calculated with a one-size fit all approach for all banks.*

The 1988 Accord has proven its effectiveness in stabilizing the markets over the last decades. Unfortunately, the situations changes through time, as a result the market also changes. Apparently there was a mismatch between the risks that were taken on by banks and the capital they retained. These mismatches were showing the deficiencies of the Basle 1988 Accord.

Because of this, the Basle Committee released a "*consultative paper*" that outlines the deficiencies of the 1988 Accord. The document describes a more risk-sensitive framework for determining capital adequacy with a purpose of improving the soundness of the financial system. Comments were received on this paper. So adjustments were made. In January 2001 the Basle Committee released a "*second consultation paper*", setting out the details on a new accord. The supervision has set far-reaching proposals for revising the original Accord to align the minimum capital requirements more closely with the *actual risks* faced by banks, this will be know as the new Basle Accord. More of this will be explained in paragraph 1.2.

1.2 The new Basle Accord

On April 2003 the Basel Committee released a "third consultative paper", this document is the foundation of the New Capital Accord, Basel II. Comments on this document were submitted and many valuable improvements have been made. The result of the final improvements is a new framework; this is described in the document "International Convergence of Capital Measurement and Capital Standards" released on June 2004.

The principle changes in the New Basle II Accord are enumerated here below:

1. Banks are granted a greater *flexibility,* to determine the appropriate level of capital to be held in reserve against their risk exposure.
2. However, linked to this flexibility banks must carry a greater *responsibility to have effective and supervised systems* to determine capital requirements.
3. Also carry a greater *responsibility* to their requirements to *disclose their approaches and processes,* which are applied to measure the required capital.

These principles are incorporated into the framework of the new approach, which is supported by the 3 pillars of Basle. A description of the 3 pillars will be briefly described in paragraph 1.3.

The Basel Committee was established by the central bank Governors of the Group of "Ten countries" at the end of 1974. The task of the Committee is to formulate "*broad supervisory standard and guidelines*" and "*recommends statements of best practice*" in expectation, that individual authorities will take steps to implement them through detailed arrangements, which are best suited to their own national systems. The Committee does *not possess any formal supranational supervisory authority*, and its conclusions do not, and were never intended to, have legal force.

1.3 The three pillars- main elements of the new Accord

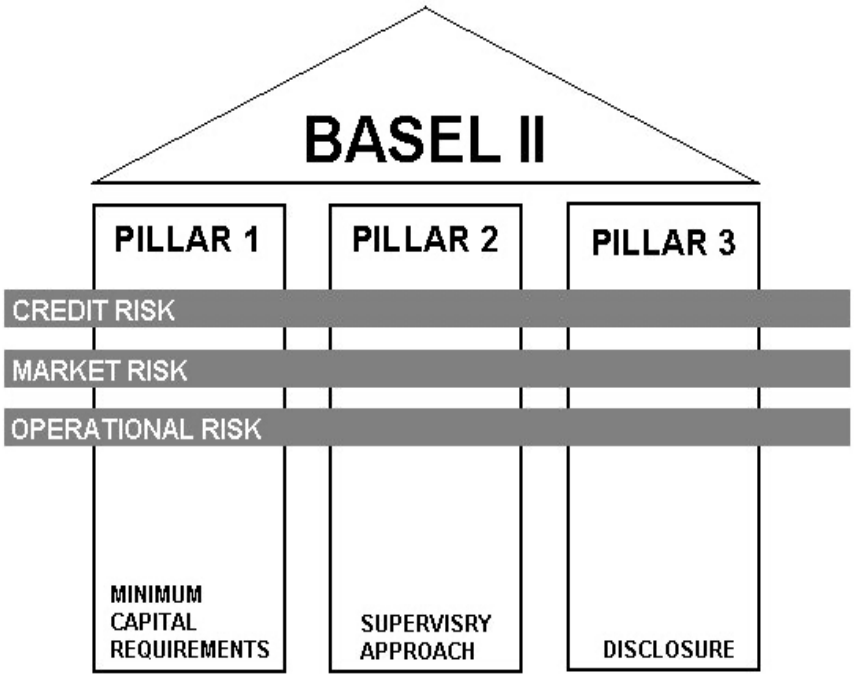

Figure 1. The structure of Basel II

Figure 1 is a graphical representation of the New Capital Accord, Basle II. The Framework of the new accord is supported by the three pillars of Basle II.

The three pillars are described as follow:

- Pillar 1- minimum capital requirements: This pillar describes the capital requirements for credit risk, market risk and operational risk.
- Pillar 2- supervisory approach: This pillar aims to encourage banks to develop better methods to measure the risks.
- Pillar 3- disclosure: The 3rd pillar sets out disclosure requirements and recommendations.

1.3.1 Pillar 1- Minimum capital requirements

There are three kinds of risks which are within the reach of the first pillar, namely: credit risk, market and the operational risk.

Credit risk: This is the risk of a loss for the bank due to the financial failure of a second party (company) to meet its contractual debt obligations towards the bank. Basel II distinguishes two kinds of methods to measure credit risk:

- The standardized Approach.
- The Internal rating based (IRB) approach, this can be divided into two approaches:
  - The Foundation Internal Rating Based Approach
  - The Advanced Internal Rating Based Approach

The Internal rating based approach is more sophisticate than The Standardized Approach. The Advanced Internal Rating Approach is the most sophisticated approach within the IRB methods.

Market risk: This is the risk of a loss, due to the day to day potential of an investor to experience losses from fluctuations in securities prices. There are two methods to measure market risk, within the framework of Basle II.

- The Standardized Approach
- The Internal Models Approach

Operational risk: According to the Basle committee, this is the risk of loss due to the inadequate or failed internal processes, people and system, or from external event. This can be summarized as everything that is not a result of credit and market risk. There are three approaches to measure operational risk.

- The Basic Indicator Approach (BIA)
- The Standardized Approach (TSA)
- The Advanced Measurement Approach (AMA)

The AMA approach is the most sophisticated approach currently available. There are several methods within the AMA approach. One of them is the Loss Distribution Approach, which is also the main topic of this paper.

An overview of the methods for risk management within the scope of the revised framework is shown is table 2.

Pillar 1			
Risk type	**Credit risk**	**Market risk**	**Operational risk**
Methods:	Standardized Approach	Standardized Approach	Basic Indicator Approach
	Foundation Internal Rating Based Approach	Internal Models Approach	Standardized Approach
	Advanced Internal Rating Based Approach		**Advanced Measurement Approach**

Table 2. Impact of the Basle II, within Pillar 1.

1.3.2 Pillar 2- Supervisory Approach

The second pillar of Basle II is the supervisory review process. The supervisory review process requires supervisors to ensure that each bank has sound internal processes in place to assess the adequacy of its capital based on a thorough evaluation of its risks. This framework encourage the bank's management to develop an internal capital assessment process and setting targets for capital that commensurate with the bank's particular risk profile and control environment.

Supervisors are responsible for evaluating how well banks are assessing their capital adequacy needs relative to their risks. Internal processes of the bank would be subject to supervisory review and intervention. The role of the supervisors in Holland is fulfilled by *"De Nederlandsche Bank".*

1.3.3 Pillar 3- Disclosure

The third pillar of the new framework is disclosure, which sets a floor to support market discipline through enhanced disclosure by banks. The main idea is to ensure that market participants can get a better understanding of banks risks profiles and the adequacy of their capital position by effective disclosure. The new framework sets out disclosure requirements and recommendations in several areas, including the way a bank calculates its capital adequacy and its risk assessment methods. These requirements apply to all banks.

2 The development of the BIS II-ratio

According to pillar I of the New Capital Accord Basel II, banks must satisfy certain criteria to calculate the regulatory capital. Banks must have a certain level of solvency. The solvency is an indicator of the degree in which a bank can satisfy its financial obligations. The higher the solvency, the better a bank can meet its financial obligations. The solvency is expressed in percentages. A calculation of this percentage is written in the New Basle Accord, This will be referred as the BIS II – ratio. The BIS II –ratio indicates the altitude of the banks reserved capital to cover all risks (credit, market and operational risks) in a percentage. A detailed description of this ratio will be described in paragraph 2.1.

2.1 The BIS II ratio

The BIS II- ratio is calculated with formula 1. In the numerator, one can see tier 1, tier 2 and tier 3 capitals. In the denominator one can see several components, which represents the reserved capital.

$$\text{BIS II - ratio} = \frac{Tier1 + Tier2 + Tier3}{RWA + 12.5 * C_{mr} + 12.5 * C_{or}} \qquad (1)$$

The components, which are included in the BIS II – ratio are generally described as following:

- RWA= Risk Weighted Assets. These are the added up assets, weighed with the associated risk percentage. The RWA are stipulated at calculating the capital seizure for credit risk.
- Tier1 = A term used to describe the capital adequacy of a bank. Tier I capital is core capital; this includes equity capital and disclosed reserves.
- Tier2 = A term used to describe the capital adequacy of a bank. Tier II capital is secondary bank capital that includes items such as undisclosed reserves, general loss reserves, subordinated debt of five years.
- Tier3= A term used to describe the capital adequacy of a bank. This is the subordinated term debt of a maximum of two years.
- C_{mr} = Capital requirements for market risk.
- C_{or} = Capital requirements for operational risk.

2.2 The BIS I (1988) - ratio

The BIS II -ratio was developed from the BIS ratio. This ratio was firstly introduced in the Basle Accord in 1988, this will be referred as the BIS I (1988) –ratio. Initially this ratio only took credit risk into account. The requirements were that the capital seizure had to be at least 8% of the risk weight asset. To calculate the risk weight asset, banks multiply several assets with the associated risk percentages, which are prescribed by the Basel committee. The capital seizures are to be covered by the tier 1 and tier 2 capitals. The BIS I (1988) – ratio is calculated wit formula 2:

$$\text{BIS I (1988) - ratio} = \frac{Tier1 + Tier2}{RWA} \qquad (2)$$

The description of the elements which are included by the “BIS I (1988) – ratio” is written in paragraph 2.1.

Note that formula 2 does not take credit risk into account. This element was taken into the ratio in 1996.

2.3 The BIS I (1996) – ratio

In 1996, another ratio was applied, this will be referred as the BIS I (1996) – ratio. Because market risk was not taken into account in the old Basle Accord of 1988, so an extra element was taken into the formula. As a result the capital seizure for market risk is incorporated into the denominator of the BIS I (1988) ratio. The numerator was extended with the tier 3 capital to cover the market risk. For more details, one will be referred to formula 3.

$$\text{BIS I (1996) – ratio} = \frac{Tier1 + Tier2 + Tier3}{RWA + 12.5 * C_{mr}} \qquad (3)$$

The description of the elements which are included by the "BIS I (1996) – ratio" is written in paragraph 2.1.

The development of the BIS II –ratio (see formula 1) is a step-by-step process through many years. Many adjustments were made through the years. Such as, the risk weight assets (RWA) must also to be calculated differently. The Basel committee has provided new percentages to calculate the RWA. But the most crucial change to the ratio is that the capital seizure for operational risk has been incorporated into the denominator. Causing the denominator to be bigger or (smaller, also depends on the other credit and market risks), while the criterion remains 8% for the total capital. Furthermore, banks must be able to allocate less capital to the stronger credits while more capital will be required for weaker credits. The side effect of this New Accord is that it will affect the banks return on individual relationships and can be expected to lead to a change in their behavior to some clients and facilities. Generally the most difficult task in risk management is managing operational risk, due to the lack of experience dealing with this matter. Next to it, operational risk is an ill defined concept and therefore this makes the task more difficult for risk managers. The concept of operational risk will be explained in Chapter 3.

3 Operational Risk

In Chapter 2 one reads about the elements which are incorporated into the BIS II – ratio to indicate the solvency of the bank. One of those elements is the $C_{or,}$ the capital seizure that must be calculated to cover the possible loss caused by operational risk events. In this chapter a detailed description of operational risk will be outlined.

3.1 What is operational risk?

What is operational risk? There is no definition that is an “acceptable and recognized” explanation for Operational risk, as this is yet to evolve. However, we can describe OR generally as follow. It ranges from narrow definition of covering operational breakdowns in processes to broad definitions, which capture all risks that are not credit or market risks. Figure 3 shows the operational risk within the Pillar 1 of The New Capital Accord, Basel II.

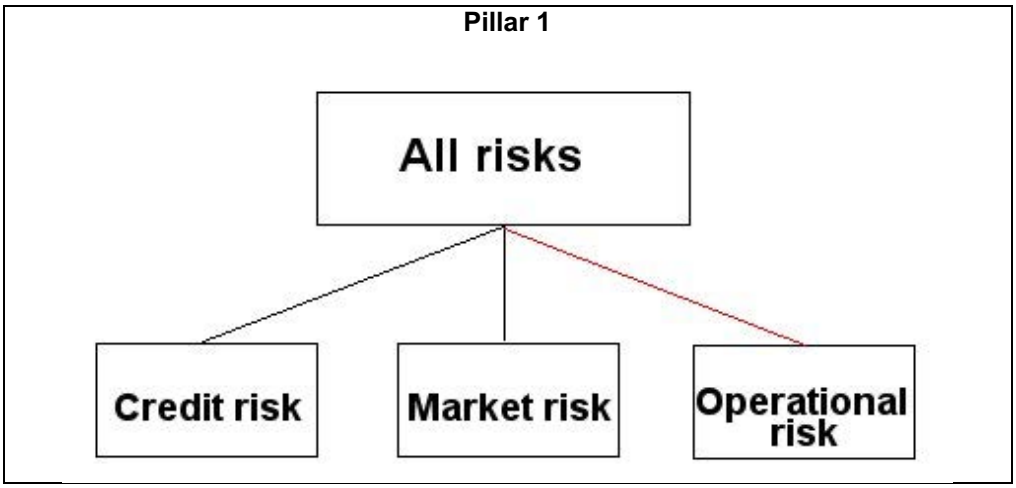

Figure 3: Operational risk within pillar 1 of the New Capital Accord, Basel II.

For banking industries, the *Basle Committee* has adopted a common industry definition of operational risk, *OR can be described as the "risk of loss, resulting from inadequate or failed internal processes, people and systems, or from external events."*

This definition includes legal risk, which is the risk of loss resulting from failure to comply with laws as well as prudent ethical standards and contractual obligations. It also includes the exposure to litigation from all aspects of an institution’s activities. The definition does *not* include strategic or reputation risks.

3.2 Operational risk loss

In this paragraph a new term, “*operational risk loss*”, will be introduced and discussed. What is an operational risk loss? Operational risk loss is the loss, which has been created by operational risk events. There are several losses that are created by operational risks. These can be characterized by seven event factors, which are recorded in the institution’s financial statements consistent with Generally Accepted Accounting Principles (GAAP).

- **Internal fraud**- Losses due to acts of a type intended to defraud, misappropriated property or circumvent regulations, the laws or company policy, excluding diversity/discrimination events, *which involves at least an internal party.*
- **External fraud**- Losses due to acts of a type intended to defraud, misappropriate property or circumvent the laws, *by a third party.*
- **Employment practices and workplace safety**- Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity / discrimination events.
- **Clients, products, and business practices**- Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.
- **Damage to physical assets** – Losses arising from loss or damage to physical assets from natural disaster or other events.
- **Business disruption and system failures** - Losses arising from disruption of business or system failures..
- **Execution, delivery, and process management** - Losses from failed transaction processing or process management, from relations with trade counterparties and vendors

A detailed loss event type classification is to be seen in appendix B.

In the recent years it has significant been proven that the operational risks are caused by events, which are mentioned here above. Besides this, banks must also increase attention to social, ethical and environmental issues; issues that can result in operational risk loss. So, the scope of operational risk management has extended in monitoring and managing these risks as well.

3.3 Loss data for operational losses

Measuring operational risk to determine the capital seizure comes with a great challenge, collecting loss data. An operational risk is more difficult to measure than market or credit risk, due to the non-availability of objective data, redundant data and the lack of knowledge of what to measure. Operational risk, is an ill-defined "inside measurement", related to the measures of internal performance, such as: internal audit ratings, volume, turnover, error rates and income volatility, interaction of people, processes, methodologies, technology systems, business terminology and even culture. The uncertainty about which factors are important arises from the absence of a direct relationship between the risk factors usually identified and the size and frequency of losses.

The data requirements for measuring market risk are pretty straightforward, such as: prices, volatility and other external data. These are packaged with significant history in large databases easily accessible and measurable. Similarly, credit risk relies on the assessment and analysis of historic and factual data, which is easily available in most core banking systems. Operational risk events are in contrarily hard to detect. Nevertheless, banks are still taking disciplined and proactive approach for these data collection procedures.

4 Measuring operational risk

In Chapter 3 one reads about the definition of operational risk that has been defined by the Basle Committee. Chapter 4 will describe several methods to measure the operational risk. There are several ways for banks to measure operational risk within the framework that has been outlined by to the Basle Committee. The following methods are described in the “International Convergence of Capital Measurement and Capital Standards, June 2004”. In this document a framework that is outlined to present three methods for calculating operational risk capital charges in a continuum of increasing sophistication and risk sensitivity. In addition to this the requirements to apply these methods are described as well. The measurement methodologies are:

1. The Basic Indicator Approach (BIA)
2. The standardized Approach (TSA)
3. The Advanced Measurement Approach (AMA)

Banks are encouraged to move along the spectrum of available approaches, which are enumerated here above in the order of the difficulty of adoption. The first two approaches are easier to adopt than the AMA approach. The AMA approach requires a large database of loss data. In contrarily, the BIA and the TSA do not use operational loss data. Figure 4 shows a graphical representation of the methods to calculate the capital reservation for operational risk losses.

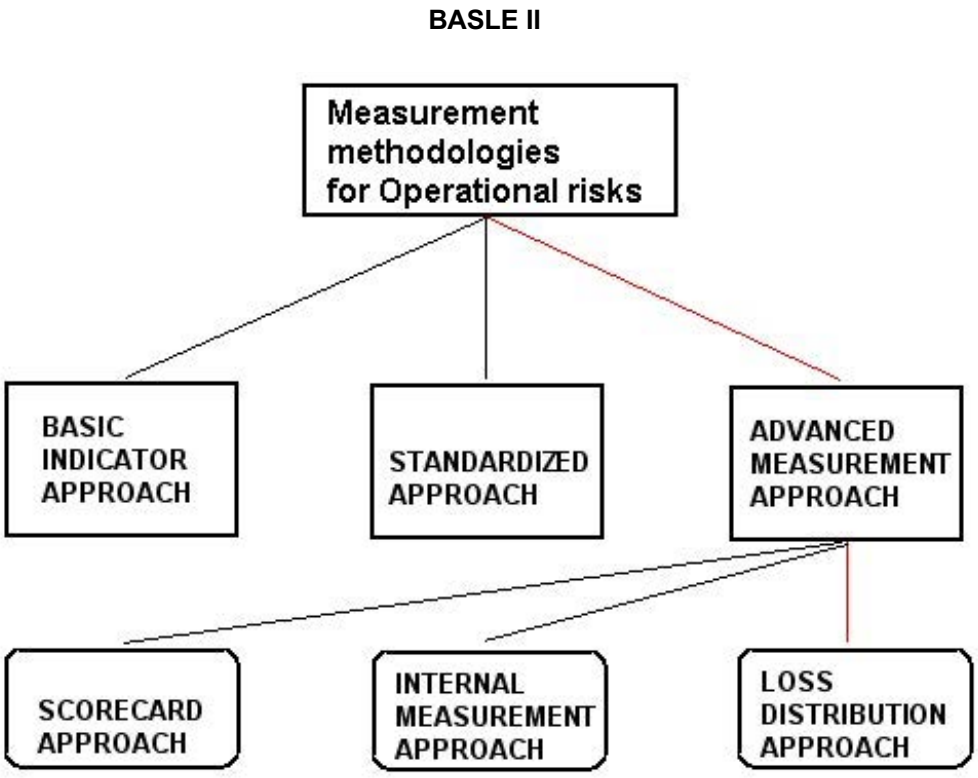

Figure 4: The structure of several operational risk measurement methodologies

Internationally active banks and banks with significant operational risk exposures are expected to use an approach that is more sophisticated than the Basic Indicator Approach, which must be

appropriate for the risk profile of the concerned institution. In addition to this, without the supervisors approval banks are not allowed to choose a simpler approach once it has been approved that a more advanced approach has to be applied. However, if a supervisor determines that a bank's advanced approach no longer meets the qualifying criteria, it may require the bank to revert to a simpler approach for some or all of its operations, until it meets the conditions specified by the supervisor for returning to a more advanced approach.

The basic indicator approach will be discussed in paragraph 4.1 and the standardized approach will be discussed in paragraph 4.2. For more information about the advanced measurement approach, please read Chapter 5.

4.1 The Basic Indicator approach

The Basic Indicator Approach is the simplest, but it will charge the most capital generally. It's based on a straight percentage of gross income, which includes net interest income and net non-interest income but excludes extraordinary or irregular items. While this approach may roughly capture the scale of an institution's operations, it surely has only the most questionable link to the risk of an expected loss due to internal or external events.

Banks that uses the Basic Indicator Approach must hold capital for operational risk *equal to the average over the previous three years of a fixed percentage (denoted alpha) 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 charge may be expressed as follow:

$$K_{\text{BIA}} = \frac{\sum_{i=1}^{n} (GI_i * \alpha)}{n} \qquad (4)$$

Where:

K_{BIA} = The capital charged under the Basic Indicator Approach.

GI = Gross income, where positive, over the previous three years.

n = Number of the previous three years for which gross income is positive.

α = 15% (which is set by the committee, relating the industry wide level of required capital to the industry wide level of the indicator).

GI, the Gross income, will be defined as net interest income plus net non-interest income, as is defined by national supervisors and/or national accounting standards. The intention is that this measure should:

- Be gross of any provisions (e.g. for unpaid interest);
- Be gross of operating expenses, including fees paid to outsourcing service providers; (In contrast to fees paid for services that are outsourced, fees received by banks that provide outsourcing services shall be included in the definition of gross income);
- Exclude realized profits/losses from the sale of securities in the banking book; (Realized profits/losses from securities classified as "held to maturity" and "available for sale", which typically constitute items of the banking book (e.g. under certain accounting standards), are also excluded from the definition of gross income);
- Exclude extraordinary or irregular items as well as income derived from insurance.

For the Basic Indicator Approach, there are no criteria specified which banks has to satisfy. However banks that use this approach are encouraged to comply with the Committee's guidance on "Sound Practices for the Management and Supervision of Operational Risk, February 2003" [8].

4.2 The Standardized Approach

The concept for applying the Standardized Approach is basically the same as the Basic Indicator Approach. The main difference between the two is that "The Standardized Approach" must divide the bank's business operations into 8 business lines: corporate finance, trading & sales, retail banking, commercial banking, payment & settlement, agency services, asset management, and retail brokerage.

Within each business line, gross income is a broad indicator that serves as an approximated scale for the business operations and thus the likely scale of operational risk exposure within each of these business lines. The capital charge for each business line is calculated by multiplying gross income by a factor (denoted beta) assigned to that business line. Beta serves as a proxy for the industry-wide relationship between the operational risk loss experience for a given business line and the aggregate level of gross income for that business line. The Beta factors are displayed in table 5.

Business Lines	Beta Factors
Corporate finance ($ß_1$)	18%
Trading and sales ($ß_2$)	18%
Retail Banking ($ß_3$)	12%
Commercial Banking ($ß_4$)	15%
Payment and Settlement ($ß_5$)	18%
Agency Services ($ß_6$)	15%
Asset Management ($ß_7$)	12%
Retail Brokerage ($ß_8$)	12%

Table 5. Percentage of the relative weighting of the business lines

In the Standardized Approach, the gross income is measured for each business line, not the whole institution. For example: in corporate finance, the indicator is the gross income generated in the corporate finance business line.

Furthermore, the total capital charge will be calculated with the three-year average of "the simple summation of the regulatory capital charges" for each of the business lines in each of those three years where the gross income is non-zero. However, where the aggregate capital charge across all business lines within a given year is negative, then the input to the numerator for that year will be zero.

The calculation of the Standardized Approach to determine the total capital charge is as follows:

$$K_{\text{TSA}} = \frac{\sum_{j}^{3} \max\left[\left(\sum_{i}^{8}\left(GI_i * \beta_i\right)\right),\ 0\right]}{3} \qquad (5)$$

K_{TSA} = The capital charge under the Standardized Approach.

GI_i = Annual gross income in a given year, as defined above in the Basic Indicator Approach, for each of the eight business lines.

β_i = A fixed percentage, *set by the Committee*, relating the level of required capital to the level of the gross income for each of the eight business lines.

For using the Standardized Approach, there are certain criteria specified which banks has to satisfy, these are defined in the document: "International Convergence of Capital Measurement and Capital Standards, June 2004", in paragraph 660- 663.

4.3 The Advanced Measurement Approach

As one can see, the gross income is the basis for calculating a capital charge for both the Basic Indicator and Standardized Approaches. In practice, these two approaches calculate the most capital charges, compared to the Advanced Measurement Approach.

The Advanced Measurement Approach (AMA) is the last approach. This approach charges the least amount of capital; also this approach is comparatively more sophisticated. However, going by the sophistication of the AMA from the perspective of the cost beneficial factor, it will perhaps be wrong to conclude that it is thus far the best approach, for some banks. Consider that only large banks have the financial power to implement this approach and also make it profitable. The AMA, however, offers the greatest possibility to reduce capital requirements. It includes three approaches, namely the internal measurement approach (IMA), the scorecard approach and the Loss Distribution Approach. Read Chapter 5 for more details about the AMA Approach.

5 The advanced measurement approach (AMA)

The Advanced measurement approach is the most sophisticated approach currently available, presented by the Basle Committee. Under the Advanced Measurement Approaches, the calculation of the regulatory capital requirements for operational risk is based on a bank's internal risk measurement system. A bank must satisfy several criteria set out by the committee before they are permitted to use the Advanced Measurement Approach (AMA). However, within these criteria, banks are not provided with specification on distributional assumptions to generate the operational risk measure. So, banks are flexible to use any distribution to calculate the potential loss.

Furthermore, on the application of these types of approaches several types of trade activities and several types of events are distinguished. These trade activities, which are referred as the 8 business lines in paragraph 4.2, can be subdivided into sections. Within these sections several activities are grouped together. The mapping process is one the requirements which is set out by the Basle Committee.

The difference between the AMA method and other methods is that many data are collected. Also, banks develop several methods to analyze these data to determine a reasonable amount for the regulatory capital. There are currently three sub methods available for the Advanced Measurement Approach.

The measurement methodologies
The Basel Committee has identified three sub approaches to determine capital allocation for operational risk. They are:

1. Scorecard Approach
2. Internal Measurement Approach
3. The Loss Distribution Approach

Before we discuss the methods mentioned here above, one will read about collecting operational loss data and how to process losses into different types of trade activities and different types of events, which is a necessity when a bank applies the Advanced Measurement Approach.

5.1 Operational loss data

Many industry participants are aiming for a meaningful risk measurement approach, by collecting operational loss data. The operational loss data will be registered in a database; this will be referred as the ***Loss Database***. The fundamental premise of collecting operational loss data is that each firm's operational loss is a reflection of its expected operational risk exposure. However, the challenge of measuring operational loss is the calculation of the unexpected loss. Unexpected operational losses are losses that have occurred, but they are not registered in the database. In fact, they are for the most part unknown.

There are certain key questions to be asked, when dealing with the collection of operational loss data.
1). How do you know which data to collect?
2). How to register the loss events?

Before these questions are answered first one will read about the importance of the Loss Database for the LDA approach.

5.1.1 What is loss data?

Operational loss databases are essentially a collection of stories. These stories can constitute the high-frequency/low-severity events. Events with high-frequency/low-severity are for example: processing errors in a high-volume business. These types of operational losses are expected, as they are easier to be detected. Calculating capital for these expected events will be as easy as examining the historical data. Bank can even budget them as an expected cost of doing business. It is only the larger than expected losses that create downside volatility in a bank's earnings and they are the high-severity incidents of major fraud and error that make newspaper headlines and which are archived in the media's databases. Even when the high-severity events are detected, it is hard to tell the size of the financial damage that has been caused. Most of the time, the actual losses will be known weeks or months after the first moment of observation. These rare events that threaten the solvency of institution will be referred as unexpected losses. But, how do you measure an operational risk event that has not been detected yet? These types of events must also be taken into account, when calculating the capital. More of this subject will be described later in this chapter.

The most important part of a loss database is without doubt the integrity of data. Whether a bank builds its own database or buys a commercial variety, it is important that the processes and systems must assure good quality. Because working with bad data can result in false stories, which is more dangerous than receiving no data at all. However, collecting operational loss data is a difficult task and it can only be achieved with good data collection processes. The risk profile of the risks is unique in every financial institution and with its own environment. So, one must also take into account that even with the possession of perfect data collection processes, there will be some areas of the business that may never generate sufficient internal data to permit a comprehensive understanding of the risk profile.

5.1.2 Internal loss data

Internal loss data are loss data, which are located in the banks internal sources. The tracking of internal loss data is a prerequisite for the development and the functioning of operational risk measurement methods. Internal loss data is important for tying a bank's risk estimates to its actual loss experience.
To qualify for regulatory capital purposes, a bank's internal loss collection processes must meet the following standards, which are outlined by the Basle Committee [3]:

- ***Map its historical internal loss data into relevant categories and business lines.*** Loss data must be mapped into the relevant business line and event type. This subject will be described in paragraph 5.2. Objective criteria for allocating losses into the specified business lines and event types must be documented.
- ***Capture all material activities and exposures from all appropriate sub-systems and geographic location***. A bank's internal loss data must be comprehensive in that it captures material activities and exposures form all appropriate sub-systems and geographic location. Also, when any activities and exposures are excluded individually and in combination, banks must justify that this would not have any material impact on the overall risk estimates. Furthermore, a threshold must be held to for internal data collection, for example €10000. The appropriate threshold can vary between banks and even between business lines and event types within a bank.
- ***Date of event and recoveries of gross loss amounts.*** In addition to gross loss amounts, banks must also collect information about the data of events and recoveries of gross loss amounts, as well some descriptive information about the drivers and causes of the loss event.
- ***Assigning loss data in a centralized function or activity that are spanned to more than one business line as well as from related event over time.***
- ***Several operational risk losses will not be subject to operational risk charges.*** Operational risk losses that are related to credit risk and have historically been included

in banks credit risk database (e.g. collateral management failures) will continue to be treated as credit risk for the purpose of calculating minimum regulatory capital under this framework. Therefore, such losses will not be subject to the operational risk charge. Nevertheless, banks must identify all material operational risk, including those related to credit risk, as set out in paragraph 644 of [3].

- ***Market risk related operational risk would be subjected to operational risk.*** Operational risk losses that are related to market risk are treated as operational risk for the purpose of calculating minimum regulatory capital, and therefore will be subjected to the operational risk capital charge.

Furthermore, for measuring operational risk capital banks must also use external sources.

5.1.3 External loss data

External data are used to capture relevant operational loss events. These can help to consider infrequent, potentially severe losses. External data should include data on the actual loss amount, information on the scale of business operations where the event occurred, information on the causes and circumstances of the loss events. To put it briefly, all information that would help in assessing the relevance of the loss event for banks.

5.1.4 Collecting Loss data

A clear data collection policy is an essential element for robust collection of loss data. This policy should clearly articulate what data is to be collected, as well as standards, roles and responsibilities for its collection. However, when collecting operational loss data for the AMA approach one must know the definition of an "operational risk loss". This narrow definition must make it easier to get a consistent and objective measurement of losses. See the following definition:

"*An operational risk loss is the amount charged to the profit & loss statement net of recoveries in accordance with General Accepted Accounting Principles (GAAP), in the resolution of the operational risk event".*

In other words this definition implies that we are only capturing the out of pocket loss, revenue reversals and asset write-downs as formal operational losses. Furthermore, other information related to the event will be registered as well.

Assuming the definition mirrors the Basle Committee definition, the following data should be **at least** considered for collection, as they may be helpful, or indeed essential, in modeling loss distributions and improving operational risk management.

An example that shows the relevant elements of registering operational loss data is shown in table 6. This table is derived from the document "An LDA- Based Advanced Measurement Approach for the Measurement of Operational Risk, May 2003".

Data of operational loss events

1.	Date(s) of event occurrence
2.	Date(s) of event discovery
3.	Date(s) of event write-off
4.	County(ies) of event occurrence
5.	Organizational entity(ies) in which the loss is booked
6.	Legal vehicle(s) and country(ies) in which the loss is booked
7.	Regulatory and internal lines of business (level 2) which bear the loss
8.	Event category (level2)
9.	Amounts(s) of the loss(es) (local currency)

10.	Exchange rate(s) and/or exchange rate data(s) (if not the reporting currency)
11.	Recovery amount(s) and recovery date(s) end exchange rate and/or exchange rate date(s)
12.	Type of recovery (e.g. insurance, customers, counterparty, other)
13.	Indication as to whether the loss is associated with a credit or market risk loss (needed to avoid double counting), and if so, the amount attribute to the operational risk event
14.	Indication as to whether the loss related to a larger event (e.g. is this one loss in a larger disaster?)
15.	Description of the event describing root cause(s) and failed/missing controls
16.	General ledger account number to which the loss was booked
17.	Person and organization to contact for follow-up

Table 6: Shows which kinds of elements to collect when registering operational loss events.

In addition to element 14, one must consider that, there may be events that unfold over time, and also events with multiple effects. An example of the former is an event where an employee steals several times over a period of month or years. In this case, individual losses may be discovered and written off at different times as the investigation continues. An example of the latter: an earthquake destroys buildings affecting several bank businesses. In designing an operational risk loss data collection process, a provision must be made to link these related losses together.

Other issues

To determine which kinds of information is required for each loss, one must also set a data collection threshold, and below this threshold no losses will be collected. This threshold can differ in every bank, because this is a matter of the banks personal view of an operational loss. Some banks see loss amounts above 10000 Euro, as an operational loss and some bank do not. So it will be likely that different thresholds will be adopted [2].

Furthermore, when registering the losses, one should consider also registering issues that are not operational losses:" near misses and opportunity cost". Near misses and opportunity cost are normally excluded as an operational loss, unless it is recognized by GAAP. The definition of near misses and opportunities cost are written here below.

- Near misses: An operational risk event that could have but did not result in a loss. For example: payment system downtime out of hours.
- Opportunity Costs**:** Income that would have been earned in the absence of an operational risk event.

Both are not operational losses, but it can reveal a part of the banks true operational risk, even when it didn't occur.

In the next paragraph one will read about how the operational risk loss events will be processed for further analyses, which is prerequisite for using the AMA approach.

5.2 How to process operational losses?

5.2.1 Mapping losses to trade activity

The operational losses will be mapped to certain trade activities and certain event types. Within two of the methods of the Advanced Measurement Approach, the Internal Measurement Approach and the Loss Distribution Approach, one must map these losses as detailed as possible into the trade activities. We can obtain several trade activities by subdividing the 8 business lines into several sections. Hereby, within these subdivided section, several trade activities will be grouped together.

Mapping of business lines

Business Unit	Business lines		Activity Groups
	Level 1	Level 2	
INVESTMENT BANKING	Corporate Finance	Corporate Finance	Mergers and Acquisitions, Underwriting, Privatisations, Securitisation, Research, Debt (Government, High Yield) Equity, Syndications, IPO, Secondary Private Placements
		Municipal/Government Finance	
		Merchant Banking	
		Advisory Services	
	Trading & Sales	Sales	Fixed Income, equity, foreign exchanges, commodities, credit, funding, own position securities, lending and repos, brokerage, debt, prime brokerage
		Market Making	
		Proprietary Positions	
		Treasury	
BANKING	Retail Banking	Retail Banking	Retail lending and deposits, banking services, trust and estates
		Private Banking	Private lending and deposits, banking services, trust and estates, investment advice
		Card Services	Merchant/Commercial/Corporate cards, private labels and retail
	Commercial Banking	Commercial Banking	Project finance, real estate, export finance, trade finance, factoring, leasing, lends, guarantees, bills of exchange
	Payment and Settlement[1]	External Clients	Payments and collections, funds transfer, clearing and settlement
	Agency Services	Custody	Escrow, Depository Receipts, Securities lending (Customers) Corporate actions
		Corporate Agency	Issuer and paying agents
		Corporate Trust	
OTHERS	Asset Management	Discretionary Fund Management	Pooled, segregated, retail, institutional, closed, open, private equity
		Non-Discretionary Fund Management	Pooled, segregated, retail, institutional, closed, open
	Retail Brokerage	Retail Brokerage	Execution and full service

Table 7: The mapping of business lines

Table 7 shows the 8 business lines, which are divided into detailed subsections. In these subsections one can see the related activity groups.

5.2.2 Mapping losses to loss events

After attributing the operational losses to a trade activity, one must also map these to a loss event. There are several loss event types, such as: 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. These events are specified in appendix B. To classify an operational loss to these types of events, one must follow the decision tree, which is developed by the Basel Committee (see figure 8).

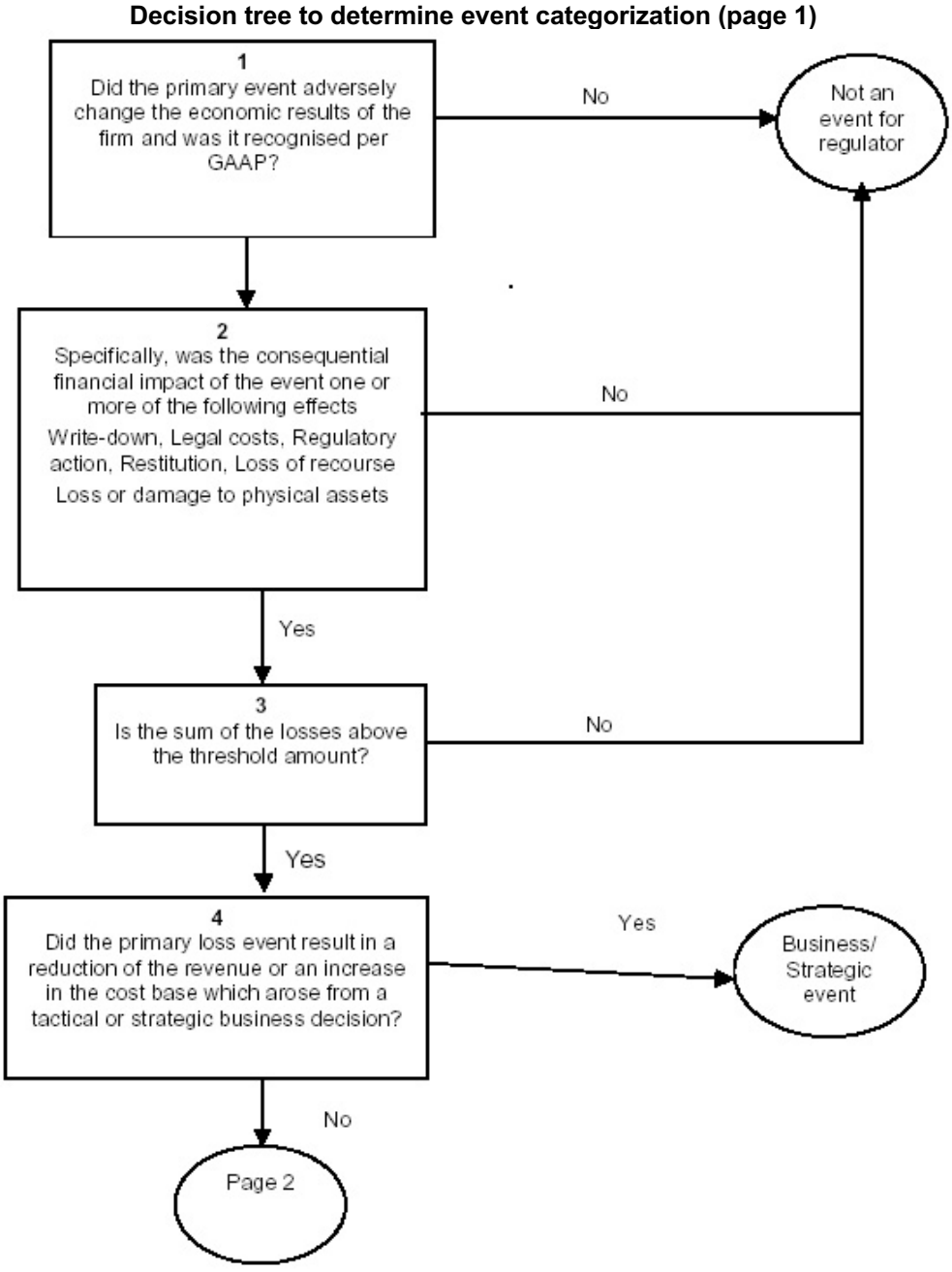

Figure 8a: The decision tree to determine event categorization (page 1)

Decision tree to determine event categorization (page 2)

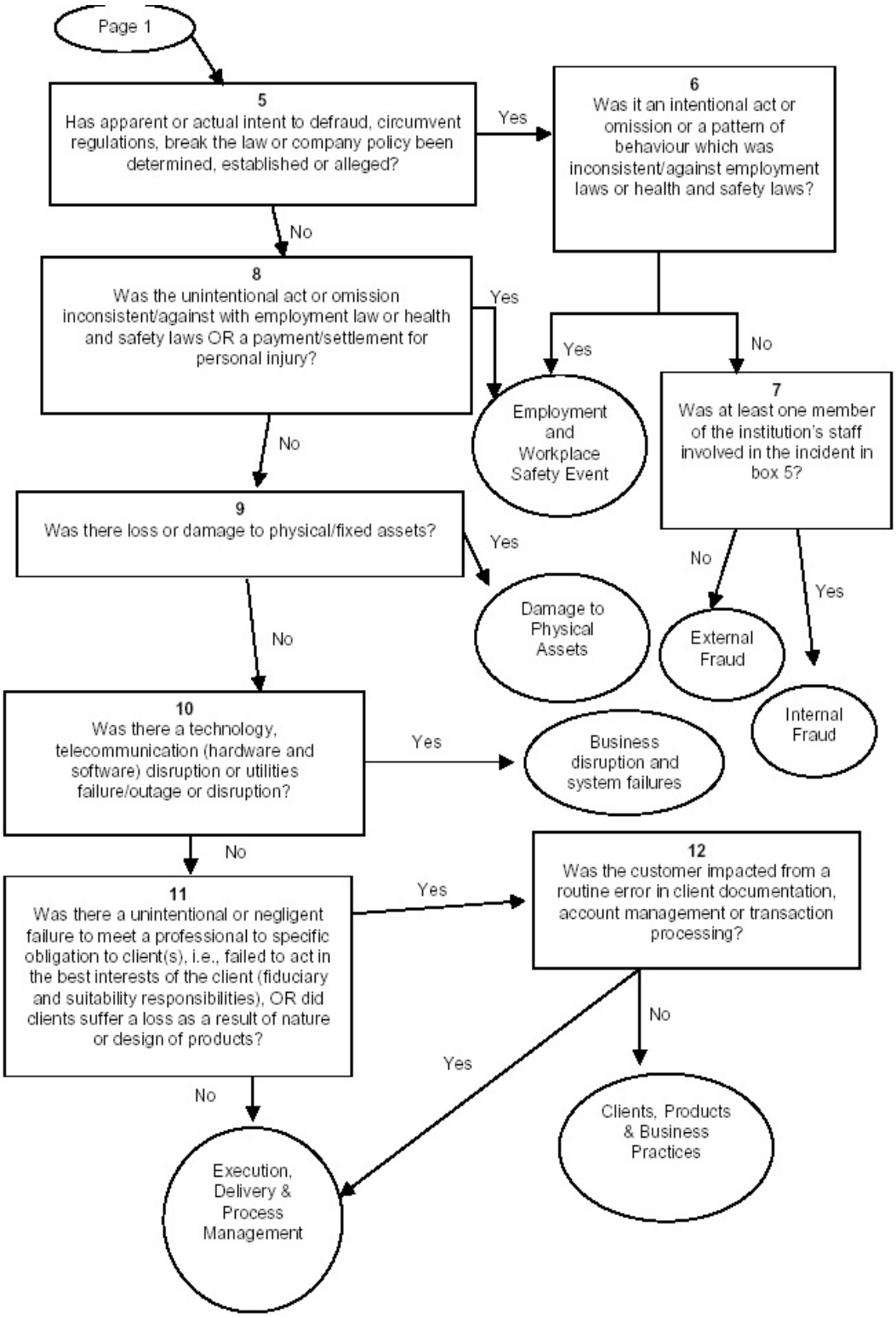

Figure 8b: The decision tree to determine event categorization (page 2)

After the mapping requirements are accomplished, the AMA approach can be adapted to the operational risk loss data. These methods will be described in the following paragraphs.

5.3 Scorecard Approach

In the scorecard approach, banks initially determine a level of operational risk capital at the firm's business line and over time these amounts will be modified according to the Scorecard. Banks aims to improve the risk control environment that will reduce both the frequency and severity of future operational risk losses. By identifying a number of risk indicators for particular risk types within business lines, one can captures the underlying risk profile of the various business lines. These risk indicators represents indirectly the altitude of the operational risk. A combination of risk indicator will be combined into a score, to allocate the altitude of the operational risk. After a certain time, the performance of these indicators will be assessed. Based on these assessments one can decide which point must still be improved. Also, based on the scorecard, one can analyze what was effectively the indirect influence of the indicators on eventual operational risk losses.

Where the Scorecard approach differs from other approaches (Internal Measurement Approach and Loss Distribution Approach) is that it relies less exclusively on historical loss data in determining capital amounts. Instead of this, after the size of the regulatory capital is determined, its overall size and its allocation across business lines will be modified on a qualitative basis. However, historical operational risk loss data must be used to validate the results of scorecards.

5.4 Internal Measurement Approach

The Internal Measurement Approach provides discretion to individual banks in the use of internal loss data. In this approach banks estimate the operational risk capital based on the measurement of the total expected losses. The IMA approach assumes a fixed, direct relationship between expected loss (the mean of the loss distribution) and the unexpected loss (the tail of the distribution).

The relationship can be linear; this implies that the capital charge is a simple multiplication of the expected loss with a fixed number. Or non-linear, implying that total capital charge will be a more complex function of expected losses.

The IMA approach calculates the capital charge based on a framework that divides a bank's operational risk exposure into a series of business lines and events, described in paragraph 5.2. In such a framework separate expected losses are calculated for each business line and event type combination. Such an approach, calculates the expected losses generally by estimating the loss frequency and the size of the amount for various business line and event combination by using internal loss data and, where appropriate, relevant external loss data, along with a measure of the scale of business activities for the particular business line in question.

While these elements can be specified in a variety of ways, in general they can be described as follow:

- PE: The probability that an operational risk event occurs over some future horizon.
- LGE: The average loss given that an event occurs.
- EI: An exposure indicator that is intended to capture the scale of the bank's activities in a particular business line.

The EI exposure indicator is specified by the supervisor for each type of business line an event combination. EI is a proxy for the size or amount of risk of each business line's operational risk [5].

The Expected loss (EL) for each business line and event combination will be calculated with the following formula:

$$EL = EI * PE * LGE \qquad (6)$$

Combining these parameters, the IMA capital charge for each business line i and event type j combination K_{ij} would be:

$$K_{ij} = \gamma_{ij} * EI_{ij} * PE_{ij} * LGE_{ij} = \gamma_{ij} * EL_{ij} \qquad (7)$$

In this formula we expect a linear relationship between expected losses and the tail of the distribution. The parameter γ_{ij} translates the estimates of expected losses, EL for the business line and event type combination into a capital charge. The γ_{ij} for each business line and event type combination would be specified by the supervisor.

5.5 Loss Distribution Approach

Under the loss distribution approach, the banks estimate for each business line/ event type, the probability distribution functions of the single event impact and the event frequency, for the next one year using its internal data. And it computes the probability distribution function of the cumulative operational risk loss. The capital charge is based on the sum of all operational risk for each business line/event type.

However, during the application of this approach correlation effect are not considered in this method. The advantage is this approach is that it can possibly increase the risk sensitivity. This method differs from the Internal Measurement Approach (IMA) in two important aspects. It aims to assess expected loss and unexpected loss directly and *without* making an assumption about the relationship between the expected loss and the unexpected loss. So, there is no need for the supervisor to determine a multiplication factor (gamma) under this approach. Also the bank itself determines the structure of business lines and event types. For more details about this approach, one will be referred to Chapter 6.

6 Using LDA-based AMA approach

Once loss data are collected, it must be sorted and filtered for any irrelevancy, before one can start to measure the probability of an operational loss and the potential size of an operational loss. The LDA approach involves modeling **the *loss severity*** and ***the loss frequency*** separately and than combining these distributions via Monte Carlo simulations or other statistical techniques to form an aggregated loss distribution for each loss type/business line combination, for a given time horizon.

The main issue is to fit the distribution of observed total loss points to a curve of total loss occurrences. It is this curve that will allow extrapolation from data points to determine the likely amount of total maximum losses or minimum capital required at any given percentile. The biggest challenge when dealing with fitting the distribution, is selecting the distribution that fits the tail of the observed data for 99.9% confidence interval.

6.1 The loss frequency distribution

A statistical manner to determine the loss frequency distribution will be discussed here. Our goal is to find the best distribution that can describe the random occurrences of the loss events. By counting the occurrence of the loss events in the loss database one can determine the frequencies of the events. Afterwards one can use statistical methods to fit several distributions on the data of the loss events.
In practice, many banks that use the LDA approach assume that the operational loss frequencies follow a Poisson distribution.
The Poisson distribution is most commonly used to model the number of random occurrences of some phenomenon in a specified unit of space or time. For the LDA approach, it will be used to model the number of loss events in a period. The Poisson distribution has only one parameter, λ_{ij} , which is the mean and the variance of an Poisson distribution. Assuming that the probabilty distribution for every business line and event type combination, different parameters will be applied. In figure 9 one can see the graph of the Poisson distribution.

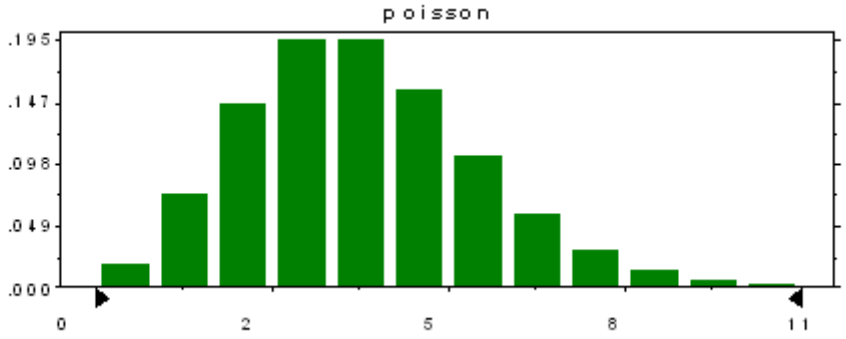

Figure 9: shows the distribution density of Poisson distribution

Figure 9 shows a histogram that is obtained by splitting the range of the data into equal size bins. The number of points from the loss data set that falls into each bin is represented in a percentage.

- Vertical axis: Frequency shown in percentage (counts for each bin).
- Horizontal axis: Number of loss events.

After the determination of the loss frequency distribution one can use the several technique to assess the fit of the data. The probability plot is a graphical technique that plots the data points to the selected distribution. The data will be plotted in such a way that the data points should form approximately a straight line. If the points depart from this straight line, this indicates departures from the specified distribution.

Furthermore, one can use a more sophisticated method to verify the fit of the data, the goodness-of-fit-test. There are several goodness-of-fit-tests, such as the chi-square, Anderson-Darling and Kolmogorov-Smirnoff goodness-of-fit test. The next step for the LDA approach is to determine the loss severity distribution, this will described in paragraph 6.2.

6.2 The loss severity distribution

The loss severity distribution describes the size of the loss amounts for a given event. Dealing with the severity is a lot more complicated than, dealing with the frequency, due to the unpredictable size of high severity events.

There are three kinds of operational severities, which we take into account.

1. Low severity, which occurs more frequently
2. High severity, which occurs sporadically
3. Catastrophic severity, which occurs a few times in decades, i.e. earthquakes.

By fitting the operational severity data, we must take account of the three kinds severities enumerated here above. The main issue here is to choose a distribution that can cover all losses, which can occur in a certain period. Just fitting the historical data into a distribution is not enough, because banks assume that there are a lot of operational risk losses out there, which are not reported. These losses are not registered into the database.

The cause of this is that there exists an uncertainty in the registration of operational risk losses. I.e.:

- Departments within the bank will avoid getting a bad reputation; hence they will try to solve this problem internally.
- Data are missing for some business line and event type (incomplete data)
- Extreme events are hardly represented in the internal database.

As a result, this will cause an uncertainty about the estimated severity for the operational losses. So, during the selection of a distribution to fit the loss severity, it is more likely to choose a fat-tailed distribution to represent the possible loss amount enumerated here above. Hopefully, it will also take the actual losses, which do not occur in the database into account.

There are several fat-tailed distribution candidates, which we can choose from. Several examples are displayed in table 10.

	Distribution	Expression	Parameters
LN	Log-Normal	F (x)= $\Phi\left(\frac{\ln x-\mu}{\sigma}\right)$	$(\mu,\sigma>0)$
GEV	Generalized extreme value	F (x)= $\exp\left(-\left(1+\zeta\frac{x-\sigma}{\beta}\right)_{+}^{-\frac{1}{\zeta}}\right)$	$(\alpha,\beta>0,\zeta)$
GDP	Generalized Pareto	F (x)= 1- $\left(1+\zeta\frac{x-\alpha}{\beta}\right)_{+}^{-\frac{1}{\zeta}}$	$(\alpha,\beta>0,\zeta)$
W	Weibull	F (x)= 1-exp $\left(-\left(\frac{x-\alpha}{\beta}\right)_{+}^{\zeta}\right)$	$(\alpha,\beta>0,\zeta)$

Table 10. Fat tailed distributions.

The selection criterion for the best distribution to fit the loss severity is to select the distribution, which fits the upper tail the most. It means that the best distribution should overestimate extreme risks events, to take the extreme risk events into account in the capital charge.

6.3 The aggregated loss distribution

After the loss frequency distribution and the loss severity distribution are determined, we can combine these 2 distributions with Monte Carlo simulation to calculate the aggregated loss distribution for each business line and event type combination for a given time horizon.

The Monte Carlo simulation works as follow:

1. First we determine the business activity and event type combination we want to simulate.
2. Draw a random sample from the loss frequency distribution (I.e. Poisson distribution, as indicated in paragraph 6.1.)
3. Draw a random sample from the loss severity distribution.
4. Generate the aggregated loss distribution.

An example to describe the steps:
For a given business line and loss type combination we draw from the loss frequency distribution the number of events is 5 (for a given time interval). This value will be used to draw from the loss severity distribution. We might simulate five event samples with the sizes of the loss values 150, 15849, 84654, 1684659 and 1566. These severity samples will be cumulated to generate a point on the aggregated loss distribution. A more detailed description of the Monte Carlo simulation method is described in Appendix A. Figure 11 shows a graphical representation of the result using Monte Carlo simulation.

The Aggregated Loss Distribution

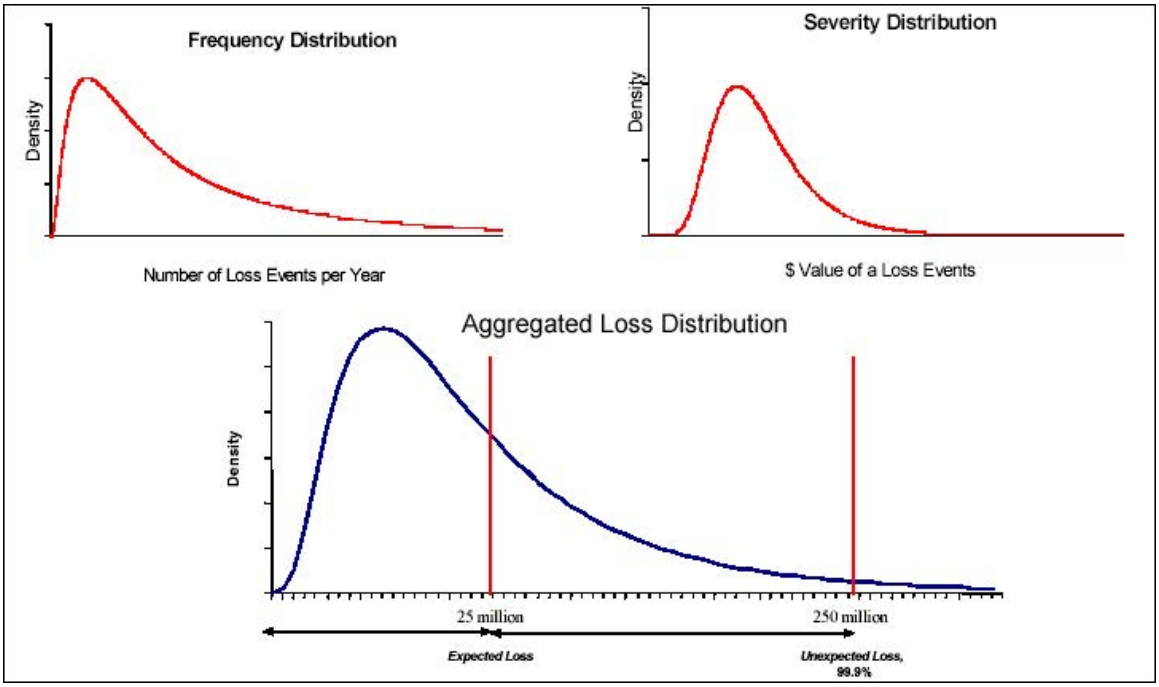

Figure 11: Gives a graphical interpretation of aggregated loss distribution.

The Monte Carlo simulation steps will be repeated for a number of times, until we reach an average amount that represents the underlying Value at Risk of the operational risk. We define Value at Risk (VaR) as the sum of the expected losses (EL) and unexpected losses (UL).

These simulation steps will be executed for all business line and event type combination. The total Value at Risk for operational risk can be represented by summing up all the Value at risk of all business line and event types combination.

After the determination of the Value at risk for the business line and event types combination, one can calculate the Unexpected loss by subtracting the amount of the expected loss from the Value at Risk, for a given α . Note that we calculate the VaR separately for every combination business line and event type. We use the indices i to denote a "given business line and j to denote a given event type".

$$VaR(i,j) = EL(i,j) + UL(i,j) \qquad (8)$$

6.4 Calculating the expected loss

The expected loss $EL(i,j)$ can be calculated with the following distribution:

$$EL(i,j) = E[\upsilon(i,j)] \quad (9)$$

$\upsilon(i,j)$ is the distribution of the total loss for the business line i/event type j between time t and t+ τ . The $EL(i,j)$ is to be calculated by the expected value of the loss $\upsilon(i,j)$.

$$\upsilon(i,j) = \sum_{n=0}^{N(i,j)} \zeta_n(i,j) \quad (10)$$

- $\zeta(i,j)$ = The random variable which represents the altitude of a loss event for "business line i" and "event type j". The **loss severity distribution** of $\zeta(i,j)$ is denoted by $F_{i,j}$.
- N(i,j) = is the number of events for "business line i" and " event type j" between t and t+ τ is random. The corresponding variable N(i,j) has a probability function $p_{i,j}$. Furthermore, the **loss frequency distribution** $P_{i,j}$ for n $\in (0,....\infty)$ will be:

$$P_{i,j}(n) = \sum_{k=0}^{n} p_{i,j}(k) \quad (11)$$

Note: The $E[\upsilon(i,j)]$ can be calculated as following:

$$\begin{aligned} E[\upsilon(i,j)] &= E\left[E[\upsilon(i,j) \mid N(i,j)]\right] \\ &= E[N(i,j)] * E[\zeta(i,j)] \end{aligned} \quad (12)$$

6.5 Calculating the unexpected loss

After the $EL(i,j)$ has been determined, the unexpected loss $UL(i,j)$ can be calculated with formula 13, which can be rewritten as following:

$$UL(i,j,\alpha) = G_{i,j}^{-1}(\alpha) - EL(i,j) = \inf\{x \mid G_{i,j}(x) \geq \alpha\} - E[\upsilon(i,j)] \quad (13)$$

- $UL(i,j,\alpha)$ = The unexpected loss for a business line and event type combination for a given confidence interval represented by α.
- $G_{i,j}^{-1}(\alpha)$ = The inverse of the aggregated loss distribution $G_{i,j}(x)$, where x is the total loss amount. **Note:** $G_{i,j}^{-1}(\alpha) = \inf\{x \mid G_{i,j}(x) \geq \alpha\}$, this is the smallest total loss amount for a business line i and event type j combination, where $G_{ij}(x) \geq \alpha$.
- $EL(i,j)$ = The expected loss amount for a business line and event type combination.

7 Conclusion

In this thesis we discussed several methods to estimate the charged capital for operational risk.

The Loss Distribution Approach has many appealing features since it is expected to be much more risk-sensitive than the Basic Indicator and the Standardized Approach, due to the facts that it uses loss data not gross income to model the capital charge for operational risk.

An alternative AMA approach is the Internal Measurement Approach; this approach only requires banks to estimate the expected losses. Only this method assumes that there is a direct relationship between the expected and the unexpected losses, therefore capital charges are calculated by a multiplication of the expected loss with a factor. The IMA is less risk sensitive than the LDA approach, due to the assumption of a direct relationship between the expected and the unexpected losses.

The Scorecard Approach is preferable when ***managing*** operational risk, due to the fact that the scorecard approach identifies a number of risk indicators, which can indicate the ***cause*** of the underlying risks. The Loss Distribution Approach does not indicate the cause of the underlying risk; it only calculates the capital charge for operational risk.

Unfortunately, only large banks have enough financial power to implement the AMA approach, due to the prerequisite of collecting a large amount of relevant loss data. Perhaps it is preferable to revert to a simpler approach for *small banks* such as the Basic Indicator and the Standardized approach. Both are using Gross Income to calculate the capital charge for operational risk, but these approaches are less risk sensitive and will not reflect the underlying operational risks.

All in all, selection of an approach requires careful consideration in order to balance cost with accuracy, transparency, and potential benefits in minimum regulatory capital. There is no doubt that the AMA approach is preferable for large banks.

The LDA approach is much more risk sensitive, due to the fact that banks can select their own loss severity distribution to (over) estimate the unexpected loss. A fat tailed distribution is preferable. Therefore, banks are granted a **great flexibility** to model the capital charge for operational risks. On the other hand, the LDA approach does not give a better insight into the cause of the risks. By choosing the Scorecard Approach, banks can manage their operational risk by focussing on the drivers of the losses. Perhaps a combination of the LDA approach and the Scorecard Approach is the best solution.

8 Appendices

Appendix A-Monte Carlo Simulation

The Monte Carlo Method has been successfully used in scientific applications for at least 75 years. Monte Carlo Simulation is named after the famous Casino in the Mediterranean Principality of Monaco. However, the use of the name "Monte Carlo" does not mean to imply that the method is either a "gamble" or "risky". It simply refers to the manner in which individual numbers are selected from valid "representative collections of input data" so they can be used in an **iterative calculation** process. These "representative collections of data" are some sort of a "Frequency Distribution" that is converted to a probability distribution.

The Iterative Process
The steps of the iterative calculation used by the Monte Carlo simulation process are as follow:

1. Use the existing data to create a Cumulative Distribution Function for each input variable that will be used by the metric.
2. Create an empty Frequency Distribution Histogram that will be incremented during each iteration.
3. Start the iteration process:
    A. Loop over each input variable used by the metric
        a. Use a random number (generated by a pseudo-random-number generator) between 0 and 1 with the Cumulative Distribution Function to obtain a weighted value for each input variable.
    B. Use the weighted value of all input variables in the metric to calculate a representative answer.
    C. Use the representative answer to determine which bin in the final Frequency Distribution Histogram should be incremented.
    D. Increment the appropriate bin in the Frequency Distribution Histogram by 1.
4. Repeat Step 3 (A, B, C and D) if the final Frequency Distribution Histogram in Step 3.D, is not "smoothly varying" (and therefore complete). A large number of iterations (like 50,000) will ensure that this Frequency Distribution is complete.
5. Normalize the Frequency Distribution Histogram (forming a Discrete Probability Distribution Function) and then create its Discrete Cumulative Distribution Function (or, Discrete Probability Distribution).

The final results from a Monte Carlo simulation include the Discrete Probability Distribution Function and the corresponding Discrete Cumulative Distribution Function. These two discrete functions allow us to extract an amazing amount of relevant and useful information from our Monte Carlo simulation.

Appendix B1 - Detailed Loss type event classification (part 1)

Event-Type Category (Level 1)	Definition	Categories (Level 2)	Activity Examples (Level 3)
Internal fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/ discrimination events, which involves at least one internal party.	Unauthorised Activity	Transactions not reported (intentional) Trans type unauthorised (w/monetary loss) Mismarking of position (intentional)
		Theft and Fraud	Fraud / credit fraud / worthless deposits Theft / extortion / embezzlement / robbery Misappropriation of assets Malicious destruction of assets Forgery Check kiting Smuggling Account take-over / impersonation / etc. Tax non-compliance / evasion (wilful) Bribes / kickbacks Insider trading (not on firm's account)
External fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party	Theft and Fraud	Theft/Robbery Forgery Check kiting
		Systems Security	Hacking damage Theft of information (w/monetary loss)
Employment Practices and Workplace Safety	Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity / discrimination events	Employee Relations	Compensation, benefit, termination issues Organised labour activity
		Safe Environment	General liability (slip and fall, etc.) Employee health & safety rules events Workers compensation
		Diversity & Discrimination	All discrimination types
Clients, Products & Business Practices	Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.	Suitability, Disclosure & Fiduciary	Fiduciary breaches / guideline violations Suitability / disclosure issues (KYC, etc.) Retail consumer disclosure violations Breach of privacy Aggressive sales Account churning Misuse of confidential information Lender Liability
		Improper Business or Market Practices	Antitrust Improper trade / market practices Market manipulation Insider trading (on firm's account) Unlicensed activity Money laundering
		Product Flaws	Product defects (unauthorised, etc.) Model errors

Appendix B2 - Detailed Loss type event classification (part2)

Event-Type Category (Level 1)	Definition	Categories (Level 2)	Activity Examples (Level 3)
		Selection, Sponsorship & Exposure	Failure to investigate client per guidelines Exceeding client exposure limits
		Advisory Activities	Disputes over performance of advisory activities
Damage to Physical Assets	Losses arising from loss or damage to physical assets from natural disaster or other events.	Disasters and other events	Natural disaster losses Human losses from external sources (terrorism, vandalism)
Business disruption and system failures	Losses arising from disruption of business or system failures	Systems	Hardware Software Telecommunications Utility outage / disruptions
Execution, Delivery & Process Management	Losses from failed transaction processing or process management, from relations with trade counterparties and vendors	Transaction Capture, Execution & Maintenance	Miscommunication Data entry, maintenance or loading error Missed deadline or responsibility Model / system misoperation Accounting error / entity attribution error Other task misperformance Delivery failure Collateral management failure Reference Data Maintenance
		Monitoring and Reporting	Failed mandatory reporting obligation Inaccurate external report (loss incurred)
		Customer Intake and Documentation	Client permissions / disclaimers missing Legal documents missing / incomplete
		Customer / Client Account Management	Unapproved access given to accounts Incorrect client records (loss incurred) Negligent loss or damage of client assets
		Trade Counterparties	Non-client counterparty misperformance Misc. non-client counterparty disputes
		Vendors & Suppliers	Outsourcing Vendor disputes

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