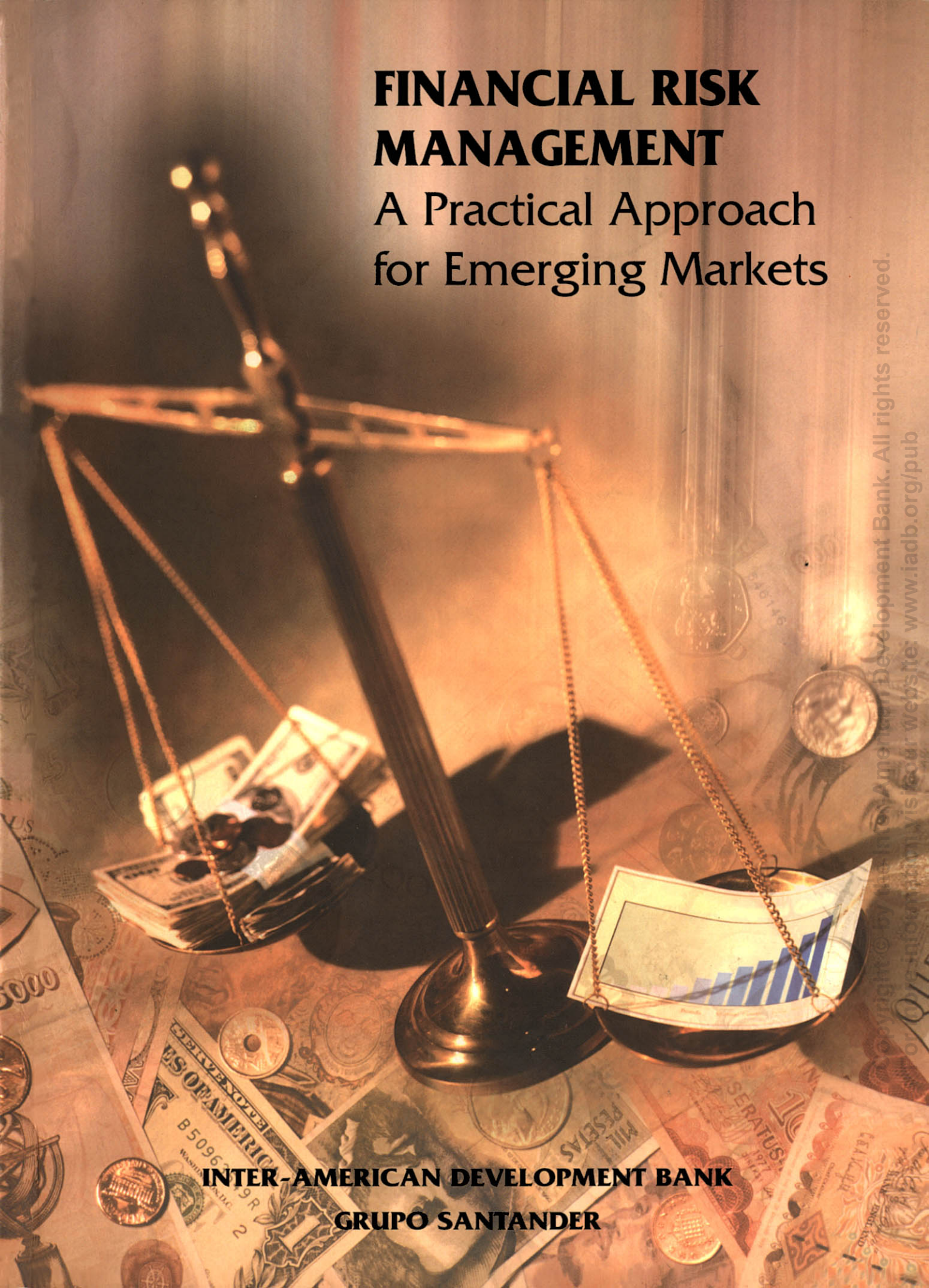
FINANCIAL RISK MANAGEMENT

A Practical Approach for Emerging Markets



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FINANCIAL RISK MANAGEMENT

A Practical Approach for Emerging Markets

José A. Soler Ramos, Kim B. Staking, Alfonso Ayuso Calle, Paulina Beato, Emilio Botín O'Shea, Miguel Escrig Meliá and Bernardo Falero Carrasco

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Foreword

During the last two decades, economic reform and modernization in Latin America and the Caribbean have strengthened the region's financial markets and institutions. The IDB believes that this improvement is closely related to the ability of entities in that market to manage their risk portfolios given the volatility of external private financing. The IDB is proposing a new approach to risk management that consists of adapting international practices that have been shown effective in promoting economic growth and well-being. This book is part of that approach.

This book offers a new approach to risk management at financial institutions and is the result of cooperation with the Santander group. It provides basic guidelines for use in making decisions about the level of risk a financial institution is willing to assume and the information systems needed to track and monitor the risks associated with financial transactions. The concept of "capital at risk" is central to the modern risk management of financial entities that operate in volatile markets. The book offers guidelines for calculating capital at risk in illiquid emerging markets, and includes procedures for insuring that a financial entity will have the capital needed to offset risk and decrease its vulnerability.

The procedures and guidelines in this book are aimed at all levels of management, from the Board of Directors and senior management to the operating and legal departments. The approach presented requires that all decisions be made through systematic, consistent evaluation of risk. This approach is not the only way to calculate and control risk. Each financial entity must develop guidelines and procedures that are suited to its characteristics, but they must involve the entire organization and include careful and systematic analysis of the value at risk.

By publishing this book, we are providing financial entities, the regulators and supervisors of these entities with a risk management system adapted to the specific needs of emerging markets and used by an internationally known financial institution. Our hope is to begin a process that enables all financial institutions in the region to develop responsible, credible, and appropriate risk management systems. I believe that this will promote stability and efficiency in the financial systems of the region.

Enrique V. Iglesias, President
Inter-American Development Bank

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Introduction

This purpose of this manual is to assist financial institutions in Latin America and the Caribbean in implementing a systematic, objective, and consistent model for financial risk management that enables them to evaluate and control the creation of value in the different businesses in which they operate.

The book covers financial risk management issues, mainly market and credit risk, but also operational and legal risk. It specifically analyzes the issues related to risk management in Latin America and the Caribbean and proposes practical solutions.

The book is applicable mainly to financial entities and the financial departments of companies. Only financial risk is discussed here, although a general framework is discussed for handling other types of risk. Risk management as related to the activities of non-financial companies (production, storage, and supply risk) is not discussed here. The business risks related to financial matters at financial entities are covered, but not the risks related to aspects such as which businesses to enter (wholesale banking, investment banking, etc.), management styles, expansion plans, and others.

The manual gradually and systematically outlines a financial risk management system for Latin American and Caribbean entities. Its purpose is to help the entities earn a return on the investments that they must make to manage their financial risk properly and to avoid errors, which increase costs and prevent optimization of systems implemented. This will help them move ahead quickly on the path already underway by many United States and European companies, many of which are active in Latin America today.

We have tried to cover all topics that are relevant to financial risk management in sufficient depth to add value for the entities for whom this book was written, and have tried to make the concepts easy to understand. More complex technical issues are discussed in special appendices. We hope that the manual can be used by Latin American and Caribbean entities as a reference work for training its personnel in all matters related to financial risk management.

The financial risk management examples contained in the book can provide guidance, but should not be considered absolute rules. The specific decisions made by each entity about specific items—organizational structure, methodologies, procedures, controls, systems, etc.—related to financial risk management will depend on their specific situation and the actual characteristics of their environment. To make appropriate decisions, the entities must have personnel who are qualified and sufficiently experienced in risk management issues.

The book is divided into thirteen chapters and four basic subject areas. The first section (chapters 1 and 2) discusses general aspects of risk management. Chapter 1 introduces the general philosophy of risk management, its scope and the reasons why it adds value to an entity, thereby justifying the investment required to implement risk management. The purpose of establishing a general framework is to keep entities from committing errors that can make all future work useless. Chapter 2 discusses issues related to organizational structure and functions in risk management. It proposes a structural model intended to provide integral support to financial risk management and defines the functions of the different areas of the entity and relationships between them.

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The second section of the book (chapters 3 through 8) presents the principles of financial risk management and control. Chapter 3 discusses market risk management and control. It discusses how to determine the market risks to which an entity is exposed and offers alternatives for defining market risk limits and control procedures. Certain market risk management techniques are also reviewed. Chapter 4 is a discussion of quantitative methods and market risk management in the commercial banking business (corporate, retail, etc.), as compared to some of the methods traditionally used for this purpose. Chapter 5 discusses credit risk management and control, and analyzes the main issues entities must keep in mind when measuring, controlling and managing credit risk. Various concepts related to credit risk management and control are introduced (such as credit exposure, credit provision, credit capital at risk, return on risk-adjusted capital, and credit position), as well as the fundamental elements of credit risk in the commercial banking business. The purpose is to define the similarities with treasury credit risk, and there is an in depth discussion of credit risk management and control in the treasury business. Chapter 6 outlines the scope of operational risk and develops basic policies and procedures that an entity could establish to control operational risk in the treasury. Chapter 7 defines the scope of legal risk and its implications for an entity. It also includes guidelines to control legal risk and treasury transactions, by discussing the situations and defining the controls that entities need to establish in order to mitigate legal risk. At the end of the chapter, legal issues specific to Latin America and the Caribbean for four areas related to treasury transactions are discussed: currency transactions, derivatives and master agreements, netting, and collateral. Chapter 8 discusses a risk management information system and provides specific criteria regarding information needed by the various areas of the organization for evaluation, control, and decision-making purposes as regards the financial risks to be assumed by company. Issues related to external distribution of risk management information are also discussed.

The third section of the book (chapters 9 through 11) covers risk measurement methodologies. Chapter 9 develops the risk/return measurement calculations discussed in chapter 3, which are needed to manage and control market risk. Two calculation approaches are compared: analytical and numerical. The behavior and measurements of risk associated with an asset are studied analytically; this case is then generalized to a portfolio and is compared with the results obtained through a numerical model based on Monte Carlo and historical simulations. Chapter 10 presents an approach for markets in Latin America and the Caribbean. Various alternatives are discussed for dealing with the issues associated with risk management and control in emerging markets and, specifically, in Latin America and the Caribbean. The chapter is divided into three large sections: crisis risk, specific products, and illiquid markets. Chapter 11 is dedicated to credit risk measurement methodologies. It outlines how to calculate three basic parameters related to treasury credit risk management and control: credit provision, credit capital at risk, and return on risk-adjusted capital.

The final section of the book (chapters 12 and 13) discusses the human and material resources needed to implement risk management. Chapter 12 discusses the critical points and phases that an entity must consider when defining and implementing a risk management and control information system structure. Chapter 13 outlines criteria for developing a risk management training plan.

All four sections of the book will be of interest to those responsible for the risk management function. For other readers, certain sections will be of more interest than others and the value added will depend on that person's specific responsibilities.

- For senior management, the first two sections will be of the most interest, because they discuss strategic and tactical issues related to financial risk management and control.

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- Personnel in the risk management and control areas who are more involved in technical issues must be responsible for analyzing and implementing the methodologies discussed in the second and third sections of the manual.
- Personnel in the systems and training areas (human resources) will find proposals in the fourth section of the manual that may be of use to them when dealing with the areas of risk management and control for which they are responsible.

The book points out that there are a number of international standards regarding the issue of financial risk management. All entities should know the scope and content of the standards in detail. The manual provides an overview of the recommendations of three international standards that are considered typical. The standards selected are those of the Group of Thirty (G30), the Derivatives Policy Group (DPG), and the Basle Committee on International Bank Supervision at the Bank for International Settlements (BIS). At the end of some chapters, the recommendations of these three groups with respect to the issues discussed in that chapter are provided. The recommendations of the G30 and the DPG are particularly aimed at entities that trade derivatives. However, most of these recommendations are applicable to transactions with other instruments, and should be considered when managing and controlling financial risks.

This manual was prepared in conjunction with a project to implement financial risk management at two Latin American entities (Banco Santander Chile and Banco Santander Peru). Once implementation has been completed, a document will be published discussing the scope, objectives, critical points and results achieved. That document will be a supplement to this manual and will allow entities to learn about and analyze two actual occurrences of implementation of a financial risk management model.

The authors

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Chapter 1

The Scope and Value of Risk Management

What Is Risk Management?

This first chapter develops a philosophy of risk management, defines its scope, and explains how risk management adds value to a company. While it may appear to be a theoretical exercise, it is worth reflecting on the nature of risk management because in the early stages of establishing a risk management framework, it is easy to make mistakes that could adversely affect the entire process.

Companies exist to offer products or services to society. To do this, a company invests capital, assumes a number of risks, and by managing them effectively is able to earn a profit. From this perspective, risk management is a fundamental part of the strategic and decision-making process of a company, and therefore contributes to the creation of value across all levels of an organization—especially to the shareholder, but also to the users of the goods and services (customers), to other stakeholders in the company (lenders and other creditors, management, employees, the government, etc.), and to other entities that serve these groups or to society in general. Risk management thus contributes to the efficiency of the economic system (financial analysts, potential investors, regulatory and governmental bodies, rating agencies, etc.). The creation of value for groups that are not shareholders tends to translate into increased value for those that are shareholders through profits and share prices.

Senior management must lead the process of risk management. They must be involved in the implementation, requiring that all decisions be made, monitored, and evaluated *a posteriori* according to risk-reward criteria. This process begins with those decisions that are most strategically important. Within this framework, risk management consists of:

- Definition of the criteria for accepting the risks that the company will manage, based on its business activities, profitability, and creditworthiness (or credit rating) goals. The maximum acceptable level of risk must be related to the total amount of capital that the company is willing to risk, both as a whole and in each of its businesses.
- Analysis and evaluation of all risks existing at any given time (for the entire entity as well as on a disaggregated basis by business unit).
- Decision-making related to new transactions and changes in the overall risk-reward profile of the entity, according to its expectations regarding business conditions and market opportunities.
- Performance evaluation that links revenue sources to the risks assumed.
- Provision of the inputs needed to achieve all of the above, including:
  - Organizational plans.
  - Policies and procedures.
  - Risk measurement criteria and methodologies.

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- Information systems.
- Controls.
- Incentives.
- Personnel training.
- Access to markets and instruments.
- Communication of pertinent information to all parties (both in internal and external).

As is evident, investment in risk management activities is essential to the proper definition and implementation of a company's strategy and the conduct of day-to-day business. Likewise, although participation by all parts of the company is required, a special risk management function that supports senior management and the relevant units in all of the aforementioned activities, must often be created. The objectives of the risk management area include:

- Ensure an effective risk-reward balance.
- Guarantee that the absolute level of risk assumed is in line with the creditworthiness goal (desired credit rating) and within the limits defined by the governing bodies of the company.

Chapter 2 (Organizational Structure) defines the activities of this risk management unit in more detail.

Occasionally, companies make mistakes in the implementation of risk management. There are three main types of errors:

1. Limiting the risk management function, especially reducing its scope to the control of risk or to the development of methodologies applicable to fairly new products such as financial derivatives.
2. Failing to define risk management responsibilities within the organizational structure (because the different aspects of risk management are unclear), resulting in the creation of multiple units that attempt to manage risk—each concentrating on one of its aspects (control, usefulness to the treasury department, performance evaluation, etc.)—but effectively colliding with each other.
3. Applying the principles of management, control, and performance evaluation inconsistently across the various areas or businesses of the company, or even denying the existence of risk in some areas.

Some of these errors are illustrated below with real-life examples.

As an example of the first type of error, risk management is simply conceived of as a control based on some measurement method. Control is viewed as necessary only when required by regulatory agencies, or when relying solely on the honesty of the company's employees and management is not allowed. Control is deemed to be an unavoidable cost, and investments in risk management are as limited as possible, because they are not going to provide any benefit other than avoiding unpleasant surprises.

Its identification as an internal control or auditing activity also leads to risk management being perceived as something that can get in the way of business growth, until, paradoxically, it must be abandoned in crisis situations in order to concentrate on profit generation and problem solving. The potential benefits of risk management in making good decisions and evaluating performance are lost, along with the opportunity to set operating criteria and install the information systems necessary to support the business, especially in times of crisis.

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Sometimes risk management is conceived of as a set of statistical methodologies that are particularly useful for measuring the risks of complicated products, especially financial derivatives. From this perspective, there is no need for risk management as long as there are no new lines of business or products. As a result, the majority of the benefits of risk management, including the control function, are lost. Concentrating on methodological developments (which are necessary) hides the fact that many traditional areas of business are exposed to risks that are difficult to quantify (such as mortgage prepayment options) and that their correct quantification would produce more efficient pricing and hedging policies for the company.

The second type of error in implementing risk management is related to organizational failure. These problems arise when the risk management mission is not clearly defined and the related activities are not programmed. Not surprisingly, these problems emerge when risk management is defined purely in terms of control. The realities of day-to-day business begin to demand additional risk management activities, which begin to be undertaken by specific support groups established by individual business units (as is frequently the case with the treasury function). Given the benefits that may accrue to these different groups, they will likely attempt to develop risk management projects simultaneously yet separately in areas such as financial management, treasury, controller's, internal audit, etc. This obviously results in duplication of efforts and higher costs, and even so, no one area normally has enough resources to give its project a global character and complete it successfully. In addition, friction arises between different departments, which argue over who is in charge and fight to make their methodology or information system the standard.

In other cases, duplication occurs because some large units of a company want to avoid interference from a centralized department in their activities. This can encourage individual groups to develop their own risk management approach and practices. Opposition can emerge because of fear that improved control by a central department could close certain holes that formerly allowed management to make decisions without limitations. In general, however, the managers of business units recognize the need for external control. In fact, the main opposition comes from the fear that returns would be compared in a uniform manner across units, which could, for example, reveal a high level of risk assumed in a particular area.

All these situations demonstrate the need for senior management involvement from the outset in order to properly focus efforts and define responsibilities, especially considering that the new risk management program will affect the whole entity.

Among mistakes of the third type (lack of uniformity in applying risk management principles), those that involve simple denial of the existence of risk stand out. This denial is sometimes implicit. For example, a bank may be opposed to beginning to trade interest rate options because it considers such trading highly speculative, while at the same time it is giving its customers the option to prepay their fixed-rate mortgages for a certain fee. Likewise, great effort may be dedicated to managing the position and risk of a foreign exchange trader so that his/her position could never cause a loss larger than US$ 100,000, while at the same time no effort is made to quantify the foreign exchange risk of an investment in a foreign company whose value is more than US$ 500,000 greater than the dollar financing obtained to make the purchase.[1] In both situations, the risks of trading activities are recognized, but other risks of a more structural nature are not.

On other occasions, such as in evaluating the performance of the business units, if profits are high, their return is considered to be satisfactory and no additional analysis is done. On the other hand, if profits are low, emphasis is placed on the fact that they were obtained taking little risk, and that they are expected to be stable. In fact, it is important to distinguish profits

[1] We are not defending the need to completely eliminate foreign exchange risks originated in foreign investments, but rather the need to quantify and manage them.

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obtained in high-risk activities from those that are stable and low-risk. This distinction needs to be made consistently, systematically, and objectively.

The sections of this chapter are intended to help avoid these types of mistakes. The scope of risk management will be described, with a list of all the tasks that it encompasses, to avoid limiting ourselves to any single task (control, development of methodology, etc.). To understand risk management, it is necessary to first define the concept of risk. The second section is dedicated to how to measure risk. The third section defines the scope of risk management and the objectives of each of its components. We pose seventeen specific questions, the systematic resolution of which will prevent the inconsistent application of risk management principles. Using these principles, we will be able to understand why risk management requires the organizational structure as presented in Chapter 2.

Having determined the scope of risk management, the penultimate section of this chapter justifies the need to establish it as a specific activity that is separated from other management processes, and examines the value that risk management can bring to an entity and its shareholders. Finally, the specific characteristics of risk management in the context of emerging markets are examined.

What Is Risk?

In this section, the concept of risk and its most common measure, Capital-at-Risk, are defined. In addition, risk-adjusted return measures such as RAROC (Return on Risk-Adjusted Capital) are discussed. This will allow us to move ahead to defining the functions of risk management and the value it contributes to a company.

THE CONCEPT OF RISK

Risk means the possibility of experiencing a loss. This book discusses only economic/financial risks, where a loss means a loss of economic value. To characterize risk completely, it would be necessary to consider all possible future scenarios, assign each a probability, and determine their economic consequences. By doing this, the probability of future losses falling, for example, between 5 and 10 million, or any other level, could be determined.

This exhaustive characterization of risk is not practical, because one would have to establish all the possible combinations of variables that could affect the economic value of a portfolio or company (interest rates for different maturities, exchange rates, stock prices, credit spreads over the risk-free rate, etc.). Besides, its usefulness for decision-making would be limited without adequate systematization.

One of the main problems in adequate risk management is how to obtain measurement indicators that appropriately capture all significant risk factors and that are sensitive to market movements. Two main methodologies have been developed:

- Scenario analysis
- Probabilistic techniques

Scenario analysis consists of selecting a few adverse scenarios and estimating the losses resulting from them, generally without taking into account the probability that the scenario will occur. This measurement approach was the first one to be developed. It is still useful and even irreplaceable for analyzing very unlikely but not impossible crisis situations. However, it needs to be combined with other risk measures because it has several deficiencies:

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- The scenarios are selected subjectively. There is no guarantee that all risk analysts will define an adverse case using the same criteria. This prevents achieving the consistency required for comparing levels of risk at different times and between different activities and businesses.
- The probabilities of certain levels of losses are not known. Even if one determined the probability of any given scenario, it would still be necessary to consider all the possible scenarios that would result in similar losses.

More recent methodologies, based on probabilistic techniques, have solved those problems, helping to build tables that capture both the size of each possible loss and the probability that that level will be reached (technically, a loss probability distribution). These methodologies are called Value-At-Risk (VAR) methodologies and enable consistent valuation of risks by use of a common measure. From the possible losses on a table, the VAR technique permits the identification of the loss amount that has a probability of, for example, only 1% of being exceeded.

The concept of Value-At-Risk is especially important, partly because of its increasing use, but also because it allows us to define the amount of capital required to operate a business, which is called the Capital-At-Risk. In the next section of this chapter we will return to this concept.

The discussion in the previous paragraphs reveals a fundamental advance in risk measurement: the inclusion of probability. In order to examine further the definition of risk, we should explore the concept of loss, introducing two principles:

1. Losses must be measured against the present value of the business, portfolio or position.
2. Losses refer to unexpected losses, not to anticipated costs.

The present value of a portfolio or business captures the true worth of the company, and reflects the amount that would be collected or paid out if each operation were sold or discontinued, as well as what it would cost to replace the company if it were disabled (adjusted for transaction costs). Essentially, the present value is the investment that would have to be made today under current market conditions to reproduce future anticipated revenues and payments at the same level of risk. If market conditions, revenue and payment expectations, or the level of risk change, the present value also changes. No other measure of economic value reflects the whole reality, and using any other measure as a basis for estimating losses would lead to incorrect risk measurement.

Let us give a very simplified example. Assume that a bank concentrates its measurement of value on its annual income statement, and consequently measures the risk of each transaction as the maximum decrease (at a 99% confidence level) that that transaction can cause to the income statement. At the beginning of the year, the interest rate for all maturities is 12% and the bank grants a three-year fixed-rate loan. In estimating the risk, the bank assumes at a 99% confidence level that rates will not increase to more than 14%. The risk, measured as the difference between the expected income statement and the adverse scenario is 2%. However, if the rates for all maturities increased to 14%, it is to be expected that these losses would extend to years 2 and 3. In terms of the effect on the present value, the net loss would be greater by an amount equal to the provision that would have to be made today to cover the losses on the 2% for the next three years.

On the other hand, it is important to distinguish the concept of loss from the concept of cost. In order to achieve the revenues sought by every business, it is necessary to incur some costs that reduce net profit. These costs, which are included in the forecasts or budgets along

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with the expected revenues, are not considered part of risk. Risk refers only to deviations from expected profits. A company has suffered a loss when profits have fallen short of initial predictions, but foreseeable production costs should not be considered risks.

As an example, consider a case of great importance to banks: losses on bad debt. This can be treated as an expected cost that is fully recovered in the price of the loans. (If one anticipates a 2% default rate with absolute certainty, the interest rate should be 2 percentage points higher than the risk-free rate, excluding the amount needed to cover other operating costs.) Credit risk exists due to the possibility that the default rate will be higher than anticipated. This possibility should also be taken into account when setting loan rates, but not in the same manner as for anticipated losses. Even though the default rate may rise to 7% in an unforeseen crisis, the loan rates are not increased by a full 7 points, but by 2 points plus some amount, or risk premium, which is determined in the risk management process. In conclusion, the concept of risk applies to unexpected deviations, and is measured against expected profits (revenues – anticipated expenses).

Finally, to classify the types of risk, one normally looks to the nature of the losses, classifying the risk as:

- *Market risk*, which is due to changes in the prices and/or rates prevailing in the financial markets. Market risk is divided further into interest rate, exchange rate, variable rate, commodity, volatility, correlation risks, etc.
- *Credit risk*, which is due to default on contracts as a result of insolvency.
- *Liquidity risk*, which is due to difficulties in financing the operations and growth of the company at a "normal" cost.
- *Business risk*, which is due to a decrease in business volume or margins.
- *Operating risk*, which is due to human error or errors in production or management.
- *Legal risk*, which is due to the legal inability to exercise one's rights, or derives from lack of enforcement of the law.

The classification can also be extended to cover the possible reasons for the loss. The above includes only the most important types of risk. The first four risks are easier to quantify and can be managed actively. The last two risks are more difficult to quantify, but can be minimized and controlled with policies and procedures.

Thus, a risk factor is defined as each of the variables of the business or environment (interest rates for specific maturities, exchange rates, stock indices, prices of individual stocks or commodities, credit ratings of companies, etc.) whose variation is used as a basis for explaining potential economic results. Portfolios of transactions are marked to market, based on the changing values of these factors, which allows us to calculate the sensitivity of portfolio value to movements in these factors.

CAPITAL-AT-RISK AND RORAC

Capital-at-Risk is the level of loss of value of a business (or portfolio of instruments) that would be exceeded in (for example) only 1% of all cases during a predefined time period (such as a year).

The concept of Capital-at-Risk is clearly connected to the role of capital as a mitigator of risk (a "cushion"). On one hand, in a limited liability company, the maximum loss that a shareholder could suffer is the entire capital amount. On the other hand, from the perspective of a creditor, the capital cushion is the maximum loss that the company could suffer before the rights of the lenders would be affected. For that reason, the Capital-at-Risk calculation first

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requires one to decide the level of solvency or credit rating the company wants to have. This credit quality would then determine the confidence level with which a bankruptcy event would be avoided. For example, a company with a AA rating may offer a confidence level of 99.98% that it will not go bankrupt during the next year. Capital-at-Risk is therefore defined as the level of loss that would be reached only in 0.02% of all cases (for a company with a AA rating).

If a new company wants to obtain a AA rating, the proportion of the investment that must be financed with debt can be determined by initially supposing that, for example, debt finances 50%, and by then simulating future scenarios for the company at that debt ratio. If the simulation reveals that the company goes bankrupt in more than 0.02% of cases during the first year, the proportion of debt financing must be reduced, and the initial capital investment of the shareholders must be increased. The amount of equity capital needed to avoid bankruptcy at the desired confidence level equals exactly the Capital-at-Risk. Note that the Capital-at-Risk should not be confused with the initial investment required to form the enterprise, which may be financed partly with debt or with capital (equity capital). However, the Capital-at-Risk calculation determines what proportion of the necessary funds should come from capital contributions, i.e., what the initial capital stock should be.

Once the business is operating, capital available to prevent a bankruptcy equals the value of the business. Only when the market value of the company is zero, do the lenders start suffering losses. This can be seen more clearly when the company is divided into business units. The capital that the company has at its disposal in the event of an unanticipated loss at one of the units is the value for which the other units can be sold. The market value of the company equals the present value of all future cash flows expected by the shareholders. This value is not usually the same as the total of retained earnings and capital injections by shareholders (value of equity capital equal to capital stock plus reserves). The present value is based on expectations while the notional book value is derived from historical accounting results. If available capital is greater than the Capital-at-Risk (needed capital), the creditworthiness of the company is better than the established credit goal. If this is not recognized by the lenders (in the form of lower spreads on loans), the company should consider reducing capital, possibly by repurchasing shares or paying a special dividend. On the other hand, if available capital is less than the Capital-at-Risk, the creditworthiness of the company is not as good as desired, and the capital must be increased to reach the goal.

Finally, we should explain the difference between Value-At-Risk and Capital-At-Risk. Value-At-Risk is based on the same concept as Capital-at-Risk (loss that would only be exceeded in a certain percentage of cases), but different assumptions are used when calculating each. Value-at-Risk is usually calculated for short time horizons (frequently measuring the losses possible in one day), with fairly low confidence levels (between 95% and 99%), and omitting the expected return and financing costs. This calculation must be modified to obtain the Capital-at-Risk (Figure 1-1), which must enable the company to survive for long periods of time, with a very high probability of avoiding bankruptcy, while taking into account all business revenues and costs.[2]

Given that Capital-at-Risk indicates the amount of capital that the company must maintain, it is useful to relate it to the profits that shareholders expect in return for risking this capital. This gives rise to the concept of Return on Risk-Adjusted Capital (RORAC), which is calculated by dividing the after-tax profits to shareholders by the Capital-at-Risk.

[2] Despite the usefulness and importance of the concept of Capital-At-Risk, one should not think that it is the only way to measure risk. In fact, Capital-At-Risk is only one specific item in the loss probability table. Therefore, it is possible that despite having the same Capital-At-Risk, two companies will have different risk-reward profiles. For example, this can happen with Treasury bond option portfolios.

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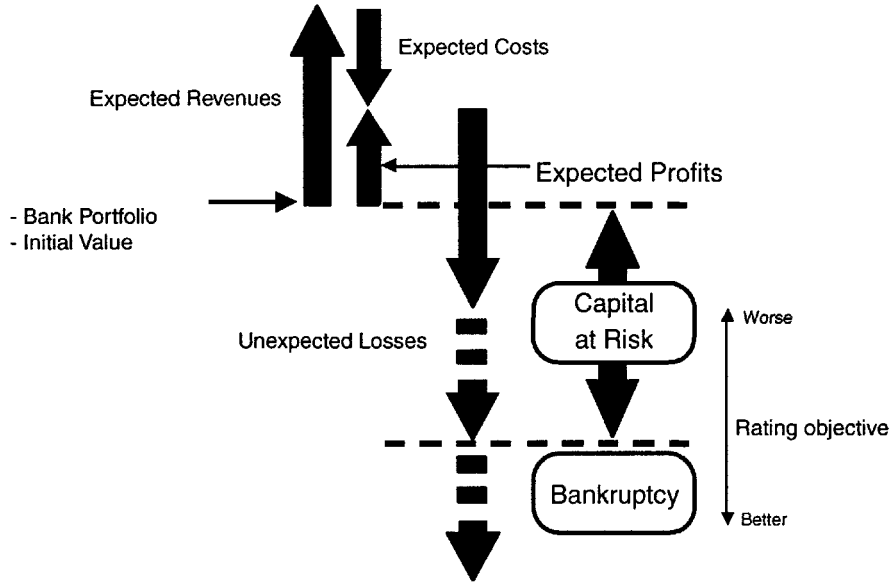
Figure 1-1. Calculation of Capital-at-Risk



Faced with making decisions on financial positions, granting loans, business development, etc., the desired RORAC should be calculated using the expected profits and Capital-at-Risk that result from these activities. Past performance can be evaluated by calculating historical RORAC, based on actual profits during the evaluation period and the capital that had to be maintained to support the risks (i.e., average Capital-at-Risk). It is necessary to have a RORAC objective for both decision-making and evaluation, which makes it possible to separate acceptable results and transactions from those that are unacceptable.

The significance and the implications of Capital-at-Risk and RORAC in the management and control of financial risks will be explored in more detail later in this book.

The Scope of Risk Management

In this section the scope of risk management is defined through 17 questions that companies should pose to themselves during the risk management process. These questions are related to:

- Defining risk appetite
- Analysis and evaluation of existing risks
- Decision-making related to positions
- Performance evaluation
- Implementation
- Communication

Each of these questions is accompanied by an explanation that establishes the basic principles that must be observed in order to arrive at a correct answer.

The rest of the book explains how to deal with these questions. Market risk is covered in exhaustive detail, and other types of risk (credit, operational, and legal) are partially discussed.

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DEFINING RISK APPETITE

1. What risks should be assumed and managed? Which types? How much?
The entity must specify the businesses, markets and products, and the counterparties with which it can and wishes to operate. The entity must establish the maximum acceptable risk level and relate that level of risk to the capital the company wishes to risk overall and in each of its businesses. In addition, the level of risk must be related to the available capital, in order to ensure an appropriate credit rating for the enterprise.

2. What profit expectations justify accepting the risk of losses at various levels?
The entity must establish a measure that compares profits achieved to the risks assumed, and is uniformly applicable to the different risk-reward profiles of the various businesses of the company. In this context, the firm should establish a return objective on the amount of capital risked. The time horizon for achieving the objectives should be specified while taking into account the business cycle (time needed to generate and measure results, to detect deviations, analyze their causes, decide on and implement corrective measures, evaluate managers, etc.). Before taking a position, the results expected and the risks that would be assumed must be evaluated by comparing them to predefined risk-reward objectives.

3. Which benchmarks should be adopted?
The risk-neutral position (which is nothing more than a position that would be completely unaffected by changes in the environment) must be clearly established, along with the results that would be expected from such a position. Deviations from benchmarks should be examined based on increased profits and associated risks. In addition, the relevant time horizon for decision-making, performance evaluation, and risk measurement must be established.

4. How should global objectives be translated to the individual unit level?
Return targets and risk limits consistent with company objectives and risk appetite should be set for each business unit of the company. In this process, it is essential to consider the effects of risk diversification, which enable total risk to be less than the sum of the risks of the individual business units (large losses do not tend to occur in all businesses at the same time).

ANALYSIS AND EVALUATION OF EXISTING RISKS

5. What is the current position?
The position should be described briefly and in a way that is useful for decision-making. This description should capture all of the factors that affect possible profits and losses (P&L) and quantify their degree of influence, so that the impact of a change in these factors (for example, an increase in a certain interest rate) can be easily calculated. The description should also capture the value of the business and all positions in the financial market positions.

In addition, it is necessary to keep a detailed record of each transaction in order to comply with the requirements and exercise the rights related to the positions (receipts and payments), as well as to excerpt basic summaries for use in decision-making.

6. What is the risk-reward profile?
To characterize this profile, the following must be known:

- The sensitivity of the value of the business and of the financial market positions to market prices/rates and risk factors in general.

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- The expected profit.
- The probability of experiencing losses of a specific predefined magnitude.
- Profits and losses resulting from crises in the market or in the business of the company.

The level of capital that is needed to maintain the activities over a specified time horizon at the target credit rating, as well as the expected return, must be determined.

7. What is the relationship between each individual position and the risk-reward profile?
The impact of marginal changes in the positions on the Profit & Loss profile must be measured, identifying those positions that increase total risk from those that decrease it. This serves as a base for finding alternatives to reduce the risk to predefined levels (essential when established risk limits have been exceeded).

Procedures must be established to minimize risk in situations where one cannot act on each and every risk factor, as, for example, in cases of crisis, illiquidity, hours during which some markets are closed, etc.

8. What view of the market and the business is implicit in the position adopted?
For each actual position, the expectations related to risk factors that made this position appropriate should be explained (with the objective being minimum risk of loss for the expected return). Comparison of the expectations implicit in the positions adopted because of individual opinions will reveal possible inconsistencies in the positions.

DECISION MAKING RELATED TO POSITIONS

9. What opinions are held on the company's business prospects and the financial markets?
It is necessary to predict possible market movements if one is considering taking a position that differs from the predefined risk-neutral position. These predictions must be explicit, and therefore should specify:

- The anticipated values for each of the factors that determine profits and losses (prices, rates, credit ratings, etc.).
- The probability of each possible movement.
- The correlation between the risk factors (the degree to which they move together).

Only when company expectations differ from market expectations does it make sense to take positions based on expected extraordinary profit opportunities compared to the loss risk. Nevertheless, there is still a risk of loss.

The reasons why internal expectations differ from those of other market participants must be explained. On occasion, the reason may be that the company has better information or analytical capabilities, but it is also possible that the company has inferior information due to the difficulty of rapidly accessing information available to other market participants or correctly interpreting data. The latter situation is especially important in the case of niche markets with pronounced peculiarities and local, legal, or regulatory specifications, etc.

In order to determine the significance of the positions, one should keep in mind the level of confidence in internal expectations, and always operate within specified limits that are in line with the company's risk appetite. Thus, the size of speculative positions in relation to the available capital base will be significantly smaller at a commercial bank (to which the public has entrusted a large volume of deposits) than for investment banks, even if both identify the same opportunities in the financial markets with an equal level of confidence in the correctness of their expectations.

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10. What possible business opportunities or new transactions should be accepted?
Before entering into a new transaction, one should examine how the total risk-return profile would change. This is not practical when many relatively small transactions occur. Therefore it is necessary to establish procedures and systems for analysis on a smaller scale. In any case, one must decide which risks introduced by a new transaction are undesirable and should be hedged. One must also establish the price that offsets the risks that will be assumed and managed by the entity.

11. How does one build a portfolio consistent with one's own view and the predefined risk-reward objectives?
Building a portfolio occurs in two stages. In the first stage, the sectors in which one wishes to take credit risk and the markets in which one expects high returns are identified, and the amount of capital to risk in each is determined. In the second stage, one chooses the specific companies and transactions that best reflect particular views related to variations in risk factors (rates, prices, creditworthiness, etc.).

PERFORMANCE EVALUATION

12. What are the results of the decisions taken?
Actual results must be explainable based on positions taken and market movements, or on the behavior of clients.

Profits and losses and return on capital must be broken down by business unit, using consistent measures that enable comparisons. Capital-At-Risk offers the necessary uniformity to be a basis for comparison, and is easy to divide objectively between business units, based on each unit's level of risk and contribution to overall diversification. Capital-At-Risk is also useful for making decisions on which positions to take and which transactions to accept (see questions 10 and 11).

13. How do the results compare to the predefined objectives?
Deviations should be explained by relating them quantitatively to the positions and the risk factors. Comparisons against the objectives should be performed not only at the end of the specified time horizon but also at intermediate points, in order to allow corrective actions to be taken and to analyze whether the objectives will be reached within the pre-defined period or only with certain modifications.

14. What information do the historical results provide for future capital allocation?
Before redirecting the efforts of the company toward certain business sectors that have achieved superior results in the past, the sustainability of these results over the medium or long run should be verified. Equally important is the examination of the effect of diversification on total profits and losses and return on capital; concentrating all activity in one sector, even if it is the most profitable, is very risky.

IMPLEMENTATION

15. What is required to implement risk management?
In order to answer and follow through on the above questions, a number of steps are necessary:

- Data gathering (operations, positions, market rates and prices, etc.)
- Methodology definition

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- Applying the methodologies to obtain the desired information
- Distribution of the information
- Making decisions
- Execution of the decisions
- Evaluation of the results of the decisions

The following decisions need to be made regarding the steps to be taken:

- Who will take the steps? → Organizational structure and qualified teams.
- How and when will they be implemented? → Policies, procedures, and methodologies.
- By what means will they be implemented? → Information systems and access to markets and instruments.
- How will the appropriateness of the process be ensured? → Controls, incentives, and training.

All of this implies an initial economic investment to acquire adequate human and other resources, as well as ongoing operating costs. It is essential to perform a cost-benefit analysis in order to decide the level of detail desired in the implementation of risk management.

COMMUNICATION

16. What internal communication with management and employees should take place?
Assuming that the information flows necessary to the work activities are fully defined during the implementation process (through the Management Information System, or MIS), communication to the employees of the company should center on the creation of a corporate risk management culture, so that employees' analyses and decisions are consistent with the risk management philosophy. Without this change in culture, controls and incentives lose a significant portion of their effectiveness. Senior management must lead the process of change in the corporate culture.

The employees must also be trained in all of the elements of risk management (organizational structure, policies and procedures, methodologies, information systems, markets and instruments, controls, incentives, etc.) so that they will be able to put it into practice.

17. What types of information need to be distributed externally?
The principal goal of external communication is to show all market participants the value added by risk management, so that the value quickly translates into:

- A higher stock price
- A regulatory framework that matches the need for efficient management
- Acknowledgment of credit quality

The information provided should facilitate performance of market participants' specific tasks by facilitating portfolio management by investors, valuation of the company and its prospects by analysts, determination of credit quality by rating agencies; and by establishing a legal framework that favors economic development by eliminating the possibility of fraud and fostering transparency by regulators.

One example of how the development of risk management has contributed to the improvement of the regulatory framework is the Capital Adequacy Directive of the Basle Committee, which favors the use of Value-At-Risk as the basis for establishing capital requirements for

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banks in order for them to bear the risk generated by their capital market activities. If companies achieve a high level of objectivity in measuring and quantifying risk, regulatory agencies can employ the measures used in risk management (for example Value-At-Risk) for their own control purposes, thereby avoiding the need to develop substitutes which put an additional administrative burden on the banks and can impose a framework that is too rigid to adjust to the reality of risk management. Under some regulatory schemes, when a stock portfolio that replicates a particular index is hedged by the sale of futures on the same stock index, capital requirements do not decrease, because the stock position is treated separately from the derivative position. This leads to overcapitalization of the company because the reduction in risk related to the sale of futures is not recognized, as it would be under Value-At-Risk.

The Value of Risk Management

In this section, the value that risk management adds to the company is described. In the first part, the reasons for implementing the approach described above and how it improves the management of the company are discussed. In the second part, the value created by financial risk management is discussed in more detail. This topic remains under intense debate. Although it was first debated in academic circles, it is of great practical interest, partly because some of the functions of risk management might be considered useless in the financial environment, and partly because it sheds light on what should be considered a risk-neutral position (see the third question in the previous section).

THE VALUE OF A GLOBAL APPROACH

Risk management, as outlined above, is clearly necessary to the success of any company, because it consists essentially of making decisions based on future profits, weighing the possibility of unexpected losses, monitoring the implementation of decisions, and evaluating the results of the decisions in a uniform manner adjusted for risk. Nevertheless, given the broadness of this definition, it is logical to ask: is risk management not in fact already performed in any enterprise? Is the additional dedication of human and other resources and senior management time necessary?

In any well-managed company, in fact, risk is already managed:

- The Board and senior management decide which businesses to be in and which strategy to follow.
- During the budgeting process, the expected profits of each business are estimated with the help of its management and the accounting or financial control departments.
- The managers of the business units make their decisions based on the possibility of success and the costs of failure, at least in a subjective manner.
- The results of these decisions are measured afterwards by the accounting department, which also normally compares them to the budget assumptions and itemizes the differences. Frequently this department calculates the return on equity (ROE), and allocates the capital among the units based on criteria related to actual investments or legal requirements (especially in the case of banks).
- Internal and external auditors verify, at a minimum, the value of the transactions performed by the business units and their income statements, thereby controlling managers' behavior.

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So, what does the new risk management approach contribute compared to the old one? Mainly, systematization, objectivity, and uniformity. The new framework does not replace the old but perfects it.

- The correct *systematization* implies rigor in risk-taking and control and performance evaluation, without loss of the flexibility to take advantage of business opportunities. The first factor that contributes to systematization is the establishment of a management information system (MIS), which must capture with predefined frequency the answers to all the questions that arise during the decision-making, control, and risk-reward evaluation processes. Systematization is also a direct result of the explicit definition of policies and procedures and, in general, of all the elements of the risk management implementation process.
- *Objectivity* reduces arbitrariness in risk estimation as a result of new measurement methodologies. Improved objectivity does not reduce the importance of management and expert expectations but facilitates the forecasting process, fundamentally focusing on the estimation of expected returns as a result of variations in the various risk factors. In general, expert knowledge should be exploited in risk measurement as well as in the selection of methodologies, the definition of initial parameters, and the identification of specific risks not adequately captured in the systems. Risk measurement enables the establishment of risk limits, which prevent a manager from causing excessive losses to the company.
- *Uniformity* is desirable both when evaluating managers and businesses and when making business decisions. Only a uniform comparison of the return achieved compared to the risk assumed (quantified by means of uniform measures) allows the identification of those persons and businesses that have contributed to the creation of value, their adequate compensation, and the reorientation of future activities. On the other hand, two managers who have the same return expectations and equal estimates of the risks involved should make the same decision related to its acceptance or rejection. Only then are efforts adequately oriented toward the achievement of company objectives.

The previously mentioned advantages are optimized when all decisions take place within the scope of risk management and are controlled and evaluated frequently. In the financial market environment, opportunities can present themselves quickly and voluminously, so that the risk-reward profile is likely to change rapidly. For that reason, information and management systems must be much faster than those used for budgeting and accounting processes. The new risk framework pays particular attention to the rapid availability of information to management. The high losses that can result from a management structure that cannot keep pace with the business cycle fully justify the material and human investments necessary to stay in step.

THE VALUE OF RISK MANAGEMENT

Once the usefulness of risk management has been accepted, the debate moves on to the question of whether the company should actively manage all risks or only those that are specific to its businesses. Specifically, the extent to which active risk management adds shareholder value has been questioned, with the argument that investors can take financial-market positions based on their own views, thereby enjoying the advantages of diversification. For example, if the profits of the company and thus its value could be negatively affected by depreciation of the dollar with respect to the local currency (which would hinder exports to the United States), shareholders could protect themselves by investing in dollars (or buying a forward contract).

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In this situation, the opinion that financial risk management does not create shareholder value implies that an investor would not pay more for the company's shares just because the company's policy is to protect its future profits from currency risk, because the shareholder could acquire this protection by him or herself.

This line of thinking, which assumes that efficient investors are managing a portfolio of stocks, holds that they need not manage the individual positions of each company separately, but only the net position of the portfolio. In this manner, transaction cost savings would be achieved (commissions for financial transactions) and management time would not be dedicated to taking financial positions. According to this rationale, financial risk management by the company would consist mainly of identifying its positions, communicating them to the shareholders, and avoiding significant deviations from those positions. Risk measurement and control would maintain all of their relevance.

The above approach is based on the assumption that information on the company's position is equally available to investors in and managers of the company, and that there are no secondary consequences from the lack of active position management to the company (other than purely financial costs). This is not the case in practice, because:

- Company managers always have more information about the position of the company than do investors.
- Financial risk management reduces the company's costs (bankruptcy, debt, fiscal, illiquidity, and under-utilization of available capital), which results in higher expected cash flows to shareholders without increased risk.

The only way to ensure equal availability of information on the position at all times to company management and investors would be for the managers to communicate a benchmark position to shareholders and to commit to correcting any significant deviations from that position. This could be impossible in reality for a variety of reasons:

- Public disclosure of the positions could put the company at a disadvantage with respect to competitors. For example, if an airline decides not to hedge fuel costs in local currency, and reports this to the investors, then if there is a steep increase in fuel prices, a competitor that has already hedged itself could start a price war to gain market share, knowing that its rival company is exposed. The mere revelation of currency positions can indicate to competitors the markets in which the company operates or the countries from which it acquires its raw materials.
- The positions used as a benchmark should be related to the financial risks that the business faces, whose estimation is subject to great uncertainty. For example, it would be necessary to determine how the domestic sales of a company would be affected in the event that the depreciation of a neighboring country's currency favored the entry of new competitors. An estimation error could cause great financial damage to investors, who, based on this misinformation, could decide to hedge their foreign exchange risk and hold management legally responsible for communicating the wrong position.
- Financial risks related to the business can change, in which case the benchmark positions would have to be adjusted frequently. For example, a change in the range of products offered by a company that imports its raw materials can change its foreign currency risk.

If, as a consequence of the above, the information that investors have on the company's positions is very limited, it is advisable to retain a large part of financial risk management within the company.

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On the other hand, risk management within the company can add value to shareholders by reducing a number of costs:

- **Bankruptcy costs.** Adequate risk management, which diminishes the probability of bankruptcy, increases expected future cash flows to shareholders by decreasing the expectations of incurring bankruptcy costs. These costs should be interpreted not as a loss in the value of shareholder investment but instead as a portion of the company's value that will not satisfy the rights of the shareholders and the creditors.

  One of the most significant bankruptcy costs is liquidation costs (legal, losses on liquidation value, severance payments to employees, etc.), which reduce expected recovery by creditors. This makes them demand higher compensation at the time of lending, which reduces the expected return to shareholders.

Another bankruptcy cost stems from a decrease in efficiency due to:

- The diversion of management guidance from those parts of the company that are profitable or generate revenue.
- Lowered employee morale.
- Difficulties in operating normally with suppliers (who require payment guarantees), clients (who are not guaranteed of receiving their products in the future), etc.

All of these problems can occur before bankruptcy is even legally declared.

If bankruptcy costs were ignored, a shareholder would be indifferent to the company's long-term debt obtained through issuance of fixed or floating rate bonds; neither instrument could be said to be better than the other, which is why both instruments exist. The shareholder could control his position with respect to interest rates by buying more or fewer fixed-rate Treasury bonds, according to whether the company has fixed or floating rate debt. However, if company management expects a depression, accompanied by a decrease in interest rates (not yet taken into account by the markets) and lower company sales, it would make sense that they take on floating rate debt, in order to compensate for the lower sales with lower financing costs. Failure to do so would increase the probability of bankruptcy.

- **Cost of debt.** The reduced probability of bankruptcy through management of financial positions diminishes the cost of debt without the need to increase capital. If this improvement in creditworthiness has taken place without additional cost, through the exploitation of the financial positions originating from the dynamics of the business, as in the example in the previous paragraph, shareholder value is clearly improved.

  If the reduced probability of bankruptcy is achieved through hedges with costs (for example, buying options that protect against an increase in interest rates), these costs have to be compared with the savings achieved in the financing.

  Alternatively, the improvement in creditworthiness can be used to increase debt (instead of reducing its cost) and therefore to undertake new projects which also create shareholder value.
- **Fiscal costs.** Another type of cost that can be managed with financial risk management is taxes. For example, suppose that the tax rate depends on the level of profit. If floating rate debt is maintained, an increase in interest rates could make total company profits $100 million before taxes, at which level the tax rate is 30%. If interest rates decrease, profits would increase to $200 million, which would be taxed at 40%. If the rates do not change, profits would be $150 million and the taxes 32%. If these three scenarios are considered equally probable, expected after-tax profits are $97.3 million.

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Table 1-1. Analysis of Fiscal Costs

Interest Rates	Before-Tax Profits	Taxes	After-Tax Profits
Increase	100	30%	70.0
Decrease	200	40%	120.0
Do not vary	150	32%	102.0
Average	150		97.3

Table 1-1 shows that if interest rates could be hedged at current levels, profits after taxes would be $102 million, $4.8 million higher than without hedging ($97.3 million) because pre-tax profits under hedging would be the same as average pre-tax profits without hedging, ($150 million) but would avoid the unfavorable tax impact of unhedged profit variation.

- **Costs of illiquidity.** The lack of liquidity in the capital markets also introduces additional indirect costs, namely opportunity costs resulting from the need to postpone profitable projects because of an inability to obtain the necessary financing, and additional extraordinary costs in certain circumstances.

  The stability of earnings achieved through adequate financial management secures a certain availability of internally generated funds, which can be used to exploit investment opportunities. A greater level of uncertainty regarding profits diminishes the expectations of ability to exploit future investment opportunities. This aspect is critical in less-developed capital markets, where it can be difficult and costly to obtain a sufficient level of financing (with debt or capital) quickly. Another relevant case is that of a company which, for fear of revealing information to the competition, cannot explain clearly which investment project makes the company pursue a capital increase through a public stock offering.

  Sometimes potential investors suspect that company management, acting on the interests of current shareholders, intend to pursue a new stock offering because they believe that the company is overvalued on the Stock Exchange. For that reason, potential investors demand significant discounts on the share price, which are added to the actual issuance costs (underwriting costs, publicity, etc.).
- **Costs of underutilization of capital.** If the company has more capital than investment projects, it would have to return that capital eventually to shareholders through dividends or share repurchases. However, if this excess were only temporary and did not induce creditors to recognize the better credit quality of the company and consequently reduce the costs of capital to the company, the idle capital would still have to be invested, increasing the risk taken by the company in search of returns demanded by the shareholders. In this case, it would be costly to reduce capital only to have to increase capital again within 6 months, for example.

  Financial management allows companies to regulate the level of total risk, determine the capital necessary to cover risk, and then compare risk capital against available capital, making effective decisions.

The previous points should be taken into account when setting a benchmark, which must be:

1. Known by the investors in sufficient detail. This does not mean that the company cannot deviate substantially from the benchmark, but it should put limits on this

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deviation. If there are problems of confidentiality or high variability, the benchmark should be a zero-risk position (equivalent to not having a position in the risk factor) or a risk similar to the sector average.

2. Manageable by investors, who thus need to have access to the necessary markets. If investors lack access, the position should have zero risk (so that its value is not affected by factors beyond the control of investors), or it should be ascertained that the risk is desired by the investors, who otherwise would not be able to include it in their portfolios. For example, owning shares of gold mining companies may be the most efficient way to take advantage of an explosion in the price of this metal (at least for investors that have legal or operating difficulties in buying futures contracts). If the company decided to cover its risk against changes in the price of gold, maintaining only the risk of successfully mining the commodity, it would have destroyed a large part of the value perceived by investors.
3. Contributing to reducing bankruptcy, debt, fiscal, and illiquidity costs. The reduction in the costs of underutilization of capital may justify deviations from the benchmark. In a bank, the regulation of risk capital by the treasury would facilitate the utilization of capital as a liquid asset.

On the other hand, adequate risk management must serve to maintain the external credit rating (imposed by the rating agencies or simply by the banks' internal classifications) in line with creditworthiness as estimated by company management. To achieve that, the company must demonstrate to rating agencies and lenders that it knows the risks and can control them, and that any investment decision is analyzed adequately.

Risk management also helps to demonstrate to regulatory agencies the capacity to develop the business while protecting the interests of third parties (bank depositors, for example), even when the law does not require a specific form of risk management and measurement. When requesting special authorizations from regulatory and government agencies, the rigor of risk management can be a determining factor. Also, in a possible consultative phase before the passage of a new regulation, the sophistication of the entities' risk management tends to be taken into account, in order to concentrate the controls on critical and verifiable magnitudes. As a significant example of this, consider again the directive of the Basle Committee, which allows banks to use their own systems to measure Value-at-Risk in their portfolios and financial Treasury operations. The great advantage of this approach is that the regulators control risk in the same way as management does at the time of rational decision-making, which eliminates restrictions that could be absurd in some circumstances. This type of regulation adds value for:

- The shareholder, by eliminating unnecessary restrictions on the business.
- Company management, which concentrates its attention on the relevant aspects of the business, with fewer distractions.
- Regulatory and rating agencies, which can recognize and control the magnitudes critical for their purposes.
- Society in general, by promoting economic efficiency.

Finally, risk management is useful for companies that are related to the entity and as a consequence incur credit risk (for example a bank that lends to other banks or acts as a counterparty in a foreign exchange forward transaction). These relations can be complicated by the difficulty of evaluating the credit quality of counterparties, by the absence of a credit rating given by a rating agency, or by the simple belief that the entity does not practice systematic risk management. These shortcomings would increase the possibility of an unanticipated loss that would decrease the company's creditworthiness. (Banks that operate on a global scale tend to

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be more sensitive to this type of shortcoming in potential counterparties.) Obviously, restrictions on companies that want to maintain relations with an entity begin to have a negative impact on its activities and profits.

To summarize, the investment companies make to improve risk management can be justified by a variety of reasons:

- Any well-managed company manages its risks, but necessary investments have to be made so that this management is systematic, objective, and uniform.
- A large portion of financial risks must be managed internally by the company and not by investors, especially when company management has more information than investors at all times regarding the position of the company.
- Total, enterprise-wide risk management can contribute to shareholder value, optimize the risk-reward trade-off (i.e. achieve adequate utilization of available capital) of the company and reduce bankruptcy, debt, fiscal, and illiquidity costs.
- Adequate risk management can serve to maintain or improve the external credit rating, as well as to facilitate operations with other firms that bear the credit risk of the company.
- Risk management helps to demonstrate to regulatory and inspection agencies that the company is capable of developing the business while guarding the interests of third parties.

The Emerging Market Environment

Emerging markets have a series of characteristics that require a different risk management approach than that of countries such as the United States and Western Europe. Some of these characteristics affect risk measurement methodologies, while others affect the implementation process.

The instruments traded in the financial markets of emerging markets are in many cases insufficient for the establishment of adequate benchmarks for the valuation of certain transactions. This results from, for example, the lack of quotation of long-term fixed-rate government bonds, which complicates the setting of interest rates on long-term loans to companies or the valuation of previously granted ones.

The lack of benchmarks for valuation also results in a lack of benchmarks for risk estimation (possibility of a loss of value). In cases when a primary benchmark exists, risk estimation remains complicated: the utilization of historical data as a basis for extrapolating future changes in prices is debatable because of the economic and political dynamism particular to countries in this region.

Successful macroeconomic management can result in an exaggeratedly high estimate of current risk, when observing a historical period during which there were significant currency devaluations. If, on the other hand, risk is measured only for a short period, the figures can end up being too low, because the high level of intervention by monetary authorities has resulted in an apparently stable situation that could change at any time. In this situation, risk calculation requires the estimation of the probability of success by governments and monetary authorities, as well as the estimation of the potential fall in financial markets in case of a crisis.

On the other hand, the low trading volume in the markets for many of the instruments creates doubts regarding the validity of the quoted prices as a consensus of the economic and financial agents. These doubts naturally extend to the validity of their fluctuations as reflected in the risk measures.

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In more developed markets the options market offers an alternative avenue for measuring risk, because it provides another way of measuring the level of uncertainty that other economic agents have related to the future prices of the underlying instruments. Option prices depend on this uncertainty (volatility). In an emerging market environment, however, hardly any foreign exchange, interest rate or equity options are traded, so it is difficult to use this reference.

Another additional problem is the existence of numerous products that are more complicated than products in other financial markets, with characteristics difficult to value (for example, Brady bonds).

In the case of credit risk estimation, implicit government guarantees of private companies whose bankruptcy would be especially harmful to the authorities because of their social impact should be taken into account. On the other hand, in certain cases the imposition of currency controls cannot be ruled out. These could prevent companies from satisfying their external debt obligations. For that reason, including country risk (political and economic) in the evaluation of the creditworthiness of companies regarding their external transactions is particularly important.

Given the value that risk management can have in an emerging market context, the importance of systematization, objectivity, and uniformity stands out. Even though the frequency of difficult crises and the development of businesses have stimulated a strong practical approach to risk management, the same factors have complicated its systematization. Other methodological difficulties resulting from the previously mentioned factors have also contributed to this. A new framework, with the application of new methodologies, is a great advancement for companies in emerging markets.

On the other hand, in financial risk management it is especially important to keep in mind the costs of bankruptcy (given the rapid macroeconomic changes in many emerging markets), debt (given the high interest rates and credit risk), and illiquidity (given the level of depth in capital markets).

Finally, investments in information systems have remained at a lower level than in countries with a higher economic standard. In addition, personnel that have good technical qualifications in economics and finance are more scarce in emerging markets. The importance of modern risk management for the efficient operation of the company and the realization that it is truly possible to implement it in emerging market companies should push the entities (public and private) to make necessary investments in material and human resources (with a great emphasis on professional capabilities).

This manual attempts to assist firms operating in an emerging market environment make investments in risk management profitable, avoid mistakes that can increase implementation costs, and obtain the maximum possible benefit from the implemented measures, as numerous American and European companies have done, many of which are currently operating in emerging markets, either directly or through affiliates.

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Chapter 2

Risk Management: Organizational Structure and Functions

Introduction

The main goal of any company is to create value for its shareholders and society in general (to which it offers goods and services). To achieve that goal, the company must manage the resources used and the risks incurred in its business as efficiently as possible. Viewed in this way, risk management becomes a critical factor in the strategy and decision-making process of the company.

Based on this philosophy, risk management should be the main function of any company and all other functions should be structured around it. This means that all areas should be directly or indirectly involved in the risk management function, and that the company's organizational structure should be in total harmony with this philosophy.

From a risk management point of view, the organizational structure can be divided for analytical purposes in two general areas of responsibility:

- Strategic Structure: consists of the Board of Directors and management committees. Their main function is to define and approve the risk management strategy and policies of the entity, as well as to ensure the availability of resources for their proper implementation.
- Operational Structure: consists of the other areas of the company. Their responsibilities include executing the strategy and implementing the policies within their specific areas.

Two-way information flows must exist between these two structures (see Figure 2-1) to ensure efficient risk management throughout the entity:

- The strategic structure must clearly and explicitly communicate the strategy and policies defined to the rest of the organization. It must also create and communicate a risk management corporate culture, which helps to inform and convince the entire organization of the advisability of this style of management.
- The operational structure must inform senior management of everything that is relevant to the execution of the risk management strategy and implementation of the policies, so that the process results in ongoing circulation of information and can be adapted to the needs of the entity and market.

Chapter 8, entitled Risk Management Information System (MIS), shows samples of the reports that the operational structure must provide to the different areas of the strategic

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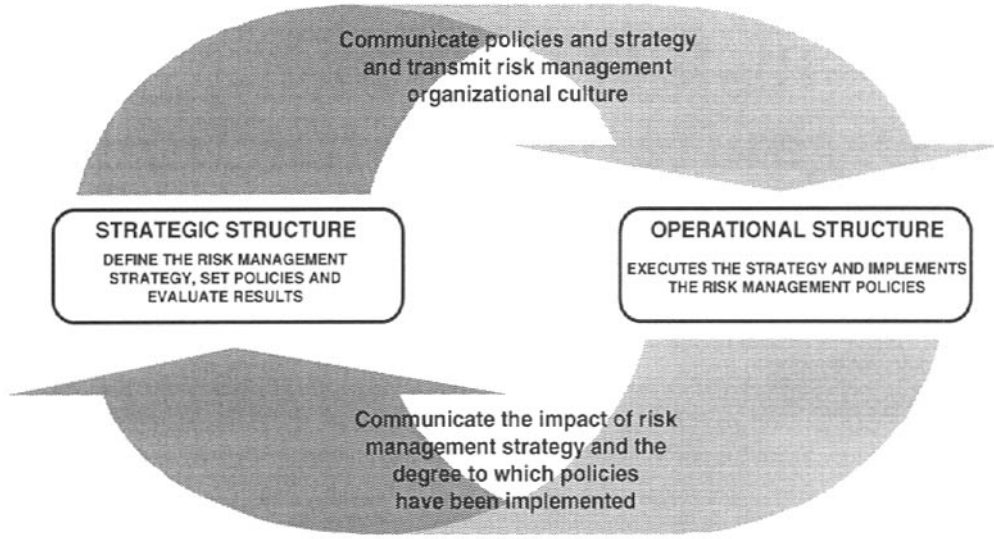
Figure 2-1. Information Flows between the Strategic Structure and the Operational Structure



structure, so that the latter can evaluate and control the existing risks, as well as make decisions regarding them. As we will see, the structure and the level of detail of the reports will vary depending on the area of the strategic structure using them.

In addition to these vertical communication flows, the company must promote and ensure the existence of horizontal communication channels among senior management (strategic structure) and also among the other areas of the organization (operational structure).

An organizational structure model is shown below that is oriented towards supporting the financial risk management function. Although the basics of this model would be applicable to any organization and the management of any kind of risk, this example has been defined for the risk management process of a financial institution or the financial division of a corporation.

Composition and Functions of the Strategic Structure

As mentioned above, the strategic structure (Figure 2-2) consists of the Board of Directors and management committees. The number, composition and functions of the latter will depend on the size, complexity and scope of the entity, as well as the type of business it does. For example, in a large financial institution that operates as a universal bank, the following management committees might exist:

- Executive Committee
- Assets and Liabilities Committee (ALCO)
- Risk Committee: there may be one committee for market risk and one for credit risk
- Business Committee: there may be one for each division (Treasury, Commercial Banking, Wholesale Banking, Investment Banking, Asset Management, etc.).

Table 2-1 summarizes the basic functions that must be assumed by the different strategic structure groups. These functions are arranged so as to facilitate the analysis of how each

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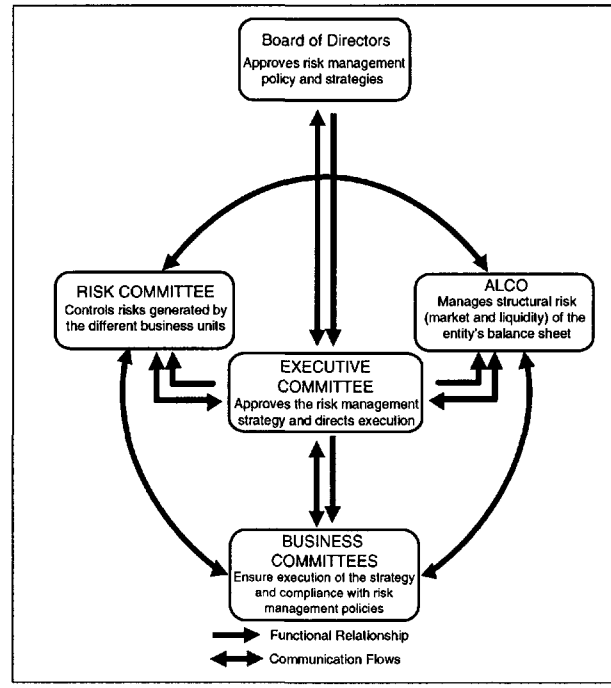
Figure 2-2. Strategic Structure Composition



function attempts to answer any of the six sets of questions, presented in chapter 1, that define the scope of risk management.

In subsequent sections the structure of the aforementioned groups is explained, and a more detailed description of the functions that they must assume with respect to risk management is provided.

THE BOARD OF DIRECTORS

Elected by the shareholders, the Board of Directors is the most senior group responsible for the creation of value. The Board is also responsible for approving the strategies and policies of the company. Within the area of risk management, its functions are to:

- Know and understand the risks taken on by the entity.
- Ensure the existence of the capital needed to support the global risk of the entity.
- Protect the value of the entity against potential losses.
- Approve the risk management strategy, which must include risk appetite criteria.
- Define risk management guidelines.
- Periodically review results and the levels of risk taken.
- Ensure existence of the resources needed for efficient risk management.
- Promote a risk management organizational culture inside the company.

In some organizations, Board approval of risk management strategy and policies takes place in sections, i.e., the structure of limits, structural risk management policies, control procedures, etc., are approved at different times.

A better alternative is approval by the Board of Directors of a document previously approved by the Executive Committee. That document should fully state the *risk management strategy* guidelines of the entity, and would contain at least the following information:

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Table 2-1. Basic Functions of the Areas of the Hierarchical Structure

Area	Establishment of Risk Tolerance Criteria	Analysis and Evaluation of Existing Risks	Make Decision on Positions	Performance Evaluation	Implementation	Communication
Board of Directors	Approves the risk management strategy (limits structure). Establishes guidelines for risk management.	Knows and understand the risks the entity assumes. Ensures the existence of the capital needed to support the global risk of the entity.	Approves the risk management strategy (rate of return goals).	Knows the results achieved and the risks taken.	Ensures the existence of the resources needed for risk management.	Promotes a risk management culture.
Executive Committee (EC)	Approves the risk management strategy. • Limits structure • Countries/businesses in which entity operates	Knows the risks and uses of capital of the business units and the structural positions.	Makes the management decisions that can have a significant impact on the value of the stock of the entity.	Analyzes the results achieved based on assumptions and risks. Allocates capital among the businesses based on RORAC.	Approves allocation of the resources needed for risk management, as well as incentives policy and organization.	Approves the risk management information system (MIS). Approves the information on risks that is to be distributed externally.
Risk Committee (RC)	Ensures proper execution of the risk management strategy. Recommends the limits structure to the EC for approval.	Knows the positions and risks assumed in detail (in terms of capital) in relation to the limits. Approves excesses over limits when relevant.		Informs the EC of the results achieved in relation to the risks assumed.	Defines and ensures proper implementation of the policies, methodologies and procedures needed to control risks.	Recommends the structure of the MIS to the EC. Recommends to the EC what information on risks can be distributed externally.
Assets and Liabilities Committee (ALCO)	Ensures compliance with the risk management strategy in relation to structural risk. Establishes the benchmark for management of structural risk.	Analyzes the sensitivity of the value of the entity to changes in risk factors.	Defines the tactics and objectives of balance sheet risk management. Makes decisions on structural risk management proposals made by the ALM area.	Reviews the management reports of the ALM area.	Ensures compliance with the policies, methodologies and procedures defined by the RC, as applied to structural risk.	
Business Committees	Ensures, within their areas of business, compliance with the risk management strategy.	Analyzes the sensitivity of the results of each business area to changes in risk factors.	Makes decisions on risk management proposals made by the business areas.	Reviews the management reports of the business areas.	Ensures that the business areas comply with the policies, methodologies and procedures defined by the RC.	

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- The limits structure, which defines what types of risks the entity wants to assume and in what amounts. When possible, these risks should be quantified in terms of Capital-At-Risk.
- Countries and lines of business in which the entity wants to operate, within the established risk limits.
- Target returns in the different lines of business as a function of the risks taken. The objective is to evaluate what transactions are of interest and which are not.
- General policies on structural risk management, such as the percentage of exchange rate risk of the market value of structural foreign investments that should be hedged, a policy for hedging foreign exchange exposure on the expected profits from those investments, establishment of a maximum difference between the life of the asset and the liability on the global balance sheet of the entity, etc.
- Risk control policies (for example, independence, type of internal controls, etc.)
- Structure and criteria to be used in the preparation of risk management reports[1] (MIS).
- Risk information that will be distributed to external agents.

This manual will explain in detail how each of the aspects cited above should be defined.

THE EXECUTIVE COMMITTEE

Appointed by the Board of Directors, the Executive Committee is the ultimate management body of the organization, and as such is responsible for managing the risks assumed by the entity. The functions related to this responsibility are as follows:

- Ensure proper performance of the decisions of the Board.
- Analyze the results of the business units relative to their budgets, identifying deviations, and defining measures to correct them. The analyses of the results must take into account the risks assumed in achieving them.
- Regularly analyze the advisability of reallocating capital among the business units based on profits and capital risked (RORAC).
- Periodically inform the Board of Directors about risk management-related matters.
- Design and approve the entity's risk management strategy and direct its implementation. As noted previously, it is advisable to formalize this strategy in a written document in which all of these aspects are defined. Once this document is approved by the Board of Directors, it may be used by the Executive Committee to communicate the risk management strategy throughout the organization.
- Know the risks faced and the capital used by the business units and the structural positions.
- Make management decisions that can have a significant impact on the value of the entity.
- Promote a risk management and control environment inside the organization.
- Define an organizational structure and an incentive policy that is congruent with the risk management philosophy.
- Approve allocation of the resources needed for risk management.

[1] Chapter 8 includes examples of risk management reports that may be used to report to various levels of the organization.

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- Ensure the existence and use of policies, processes, methodologies and systems that facilitate measurement and management of quantifiable risks, and that will control those risks that cannot be quantified.

Although the composition of the Executive Committee will vary at each entity, depending on its organizational structure, generally the senior executives of each division should be part of the Executive Committee, including the CEO, CFO, Risk Management Director, and the directors of all large business areas, support areas, internal audit, etc.

The Executive Committee should meet every week on an ordinary basis and whenever necessary for special matters. In turn, it should create other committees (assets and liabilities committee, risk committee and business committees) that report to it, and to which it will assign specific responsibilities and functions about different aspects of the management of the entity. It is important that at least one member of the Executive Committee participate in these committees.

THE ASSETS AND LIABILITIES COMMITTEE (ALCO)

The ALCO is really a business committee responsible for managing all of the entity's assets and liabilities (balance sheet and structural positions). The ALCO usually delegates daily analysis and management of structural risks to specialized units such as the asset and liability management area, or ALM area[2].

The ALCO must manage the market risk and liquidity risk implicit in the balance sheet of the entity. To do this it must:

- Ensure compliance with the risk management strategy, in relation to the structural risk.
- Establish a benchmark for the management of structural risk.
- Analyze and make decisions based on the ALM area's structural risk management proposals.
- Establish the tactics and objectives of balance sheet risk management and communicate them to the Executive Committee for approval.
- Analyze the sensitivity of the value of the entity and of earnings (financial or operating margin) to changes in different market risk factors.
- Analyze the information provided by ALM, and compare the actual results against the original objectives and the risks taken.
- Analyze the entity's budgets and new product proposals for the commercial bank against the balance sheet risk management strategy and objectives that were established.
- Ensure compliance with the policies, methodologies and procedures defined by the Risk Committee for application to structural risk.

Although the composition of the ALCO will depend on the structure of each entity, it should generally include the CFO, ALM director and directors of the business units exposed to market risk (for example, commercial banking).

[2] In financial institutions, this unit is usually part of the treasury division. In point of fact, this unit is the true and only treasury, since the other areas that are typically also considered part of the treasury (trading, clients, etc.) have completely different goals (take speculative positions, do arbitrage, sell financial products to clients, etc.). Therefore, these areas should be considered independent business units. ALCO is responsible for analyzing and managing day-to-day financial risks resulting from the company's balance sheet structure (interest rates, exchange rates, liquidity, etc). This activity is also known as ALM, for Asset and Liability Management.

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The ALCO's decisions will be communicated to the rest of the entity by the functional heads of the different areas that are part of this committee. Each participant is responsible for proper implementation of the decisions that affect his/her area, as well as follow-up and control. They must also present any required reports to the ALCO regarding execution of the actions required.

Based on the above, decisions regarding global management of the entity's assets and liabilities will mostly affect:

- The commercial banking areas, which can be informed of the need to make changes in business policy in order to modify balance sheet sensitivity. For example, if the ALCO notes that the duration of commercial bank assets is too high in comparison with the company's objective or interest rate forecasts, it can decide to push floating rate loans instead of fixed rate loans, and/or cut the term offered on fixed rate loans.

  Managing the balance sheet through business policies is a slow process. A much more flexible alternative is to manage the balance sheet through treasury transactions (for example, bonds, swap, options, etc), assuming that sufficiently liquid financial markets exist. The ALM area is responsible for execution and control of these transactions (which make up the ALCO portfolio). It can go directly to the market or use the services of other units of the treasury division, which consider it to be a client.

  In addition, the decisions made by ALCO regarding transfer pricing policies[3] will affect the commercial banking areas, because this policy removes market risk from the commercial banking area and transfers it to the ALCO.
- The ALM area that analyzes and manages the ALCO portfolio. This area carries out tactical activities such as hedging or taking strategic positions adopted by the ALCO to manage balance sheet risk. For example, if the ALCO expects interest rates to fall, which could hurt the financial margin of the entity, it can offset that effect by taking bond positions, which would generate gains that would offset the margin loss if interest rates fall.

  Another decision that the ALCO might make in this situation (in which the duration of commercial assets is too high) would be to hedge the fixed rate mortgage loan portfolio with interest rate swaps in which the entity pays fixed and receives floating.

In making decisions, the ALCO will use the reports[4] and analyses provided by the ALM area. The frequency of ALCO meetings will depend on how often the organization wants to analyze and manage its structural risks. Common practice is to have two types of meetings; a weekly meeting for detailed follow-up of short-term management objectives, and a monthly meeting with a broader perspective to analyze balance sheet risk management strategies and their impact on the organization's long-term objectives. The ALCO may also call special meetings if internal or external variables make it advisable.

THE RISK COMMITTEE

The Risk Committee is the body to which the executive committee delegates responsibility for defining policies and procedures and for ensuring that business units are properly executing the risk management strategy approved by the Executive Committee.

[3] Market risk in commercial banking will be extensively covered in chapter 4. Basically, the transfer pricing applied should equal the cost of eliminating the market risk exposure.

[4] Chapter 8 provides examples of the types of reports that may be received by ALCO.

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Due to the wide range of functions performed by the ALCO and the Risk Committee, it is understandable that in some cases their responsibilities may overlap. Therefore it is important to clarify and establish the scope of their respective duties:

- The ALCO is responsible for the global structural risk management (market and liquidity) of the balance sheet of the entity.
- The Risk Committee is responsible for controlling the risks generated (mainly market and credit risk, but sometimes operating and legal risk) by the different business units (including the ALCO).

The Risk Committee should be made up of the Risk Director and the senior managers of the operating areas involved in the risk measurement and control process. The members of this committee must have sufficient technical background to understand the methodologies and procedures used by the entity to measure and control risk. This committee should formally meet with the same frequency as the Executive Committee (the advisability of weekly meetings was previously noted).

The specific functions of the Risk Committee[5] *vis-à-vis* control of market and credit risk are as follows:

- Ensure proper execution of the risk management strategy and inform the Executive Committee of its progress.
- Define and ensure proper implementation of policies, methodologies, and processes that are in line with approved risks and that enable measurement and control of quantifiable risks (market and credit risk).
- Propose risk control limits to the Executive Committee for its approval.
- Know in detail the positions and risks assumed (in terms of capital) in relation to the appropriate limits.
- Approve temporary excesses beyond limits when relevant.
- Inform the Executive Committee of the results achieved by the different business units in relation to the risks taken.
- Propose an MIS structure to the Executive Committee, as well as propose which information on risks should be distributed outside the entity.

Beside market and credit risk responsibilities, the Risk Committee will also be responsible for defining policies and guaranteeing the adequate implementation of processes required to control other risks such as operational risk, legal risk, etc.

The Risk Committee will delegate responsibilities to the risk analysis and control group with regard to implementation issues. The Risk Committee will monitor implementation of risk management strategies[6] based on weekly reports provided by the risk analysis and control group.

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[5] The fact that the Risk Committee has authority over market risk and credit risk may justify the existence of a market risk committee and a credit risk committee. If so, both committees will have similar functions but with a clear focus on the type of risks that they manage and control. However, this separation should not prevent being able to have integrated control of both risks.

Large financial entities (universal banks) are accustomed to more separation of the market and credit risk control functions. Investment banks do not usually make such a differentiation because their activities are more concentrated on treasury operations.

[6] Chapter 8 provides sample reports used by the Risk Committee.

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BUSINESS COMMITTEES

As we mentioned before, each division (treasury, commercial banking, investment banking, asset management etc.) may have its own committee. In addition to their profit-generating responsibilities, these areas must assume the following functions:

- Ensuring that the risk management strategy established is followed.
- Analyzing the sensitivity of the results of each business area to changes in risk factors.
- Making decisions on risk management proposals made by the business areas.
- Reviewing the business areas' management reports in order to analyze performance against their goals and the risks assumed.
- Ensuring that the business areas follow the policies, methodologies and processes established by the Risk Committee.

Composition and Functions of the Operational Structure

The operational structure consists of the different areas of the entity responsible for executing the strategy and implementing the risk management policies in accordance with their assigned functions in the organization. The operating structure consists of four types of areas, whose functions must be kept clearly separate:

- *Risk analysis and control area*
- *Asset and liability management area* (ALM area)
- *Business areas*: like the business committees, each business area will represent a segment of the activity of the entity (treasury, commercial banking, investment banking, asset management, etc.).
- *Support areas*: these areas perform structural functions inside the organization. From the risk management point of view, the most important areas are:
  - Back office
  - Technology and systems area
  - Legal and tax advisory
  - Human resources and training
  - Internal audit

There should be two-way communication lines between the operating areas to ensure proper and efficient coordination of performance of the functions assigned to each area.

Table 2-2 summarizes the basic functions to be assumed by the operational structure. These functions are arranged so as to facilitate the analysis of how each function (independently of the other functions) attempts to answer any of the six sets of questions, presented in chapter 1, defining the scope of risk management.

In the following sections the structure of the areas mentioned above will be explained, together with a more detailed description of the functions that these areas take on with respect to risk management.

RISK ANALYSIS AND CONTROL UNIT

The risk analysis and control unit is responsible on a daily basis for the analysis and control of the risks faced by the company (market and credit risk). The risk analysis and control unit's responsibilities can be grouped around two basic functions:

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Table 2-2. Basic Functions of the Operational Structure Areas

Area	Setting Risk Tolerance Criteria	Analysis and Evaluation of Existing Risks	Making Decisions on the Position	Performance of Evaluation	Implementation	Communication
Risk Analysis and Control Area (RAC)	Analyze the limits recommended by the business areas and the ALM area. Analyze the division of risk capital among the units and make alternative recommendations of limits to the Risk Committee.	Measure risks according to the methodologies approved and monitor compliance with limits.		Calculate the operating results and RAROC of the different business areas.	Implement and ensure compliance with the policies, methodologies and procedures defined by the Risk Committee.	Prepare the MIS reports for the Risk Committee. Prepare information on risk management to be distributed to external agents.
Asset and Liability Management Area (ALM)	Recommend to the risk analysis and control area the limits needed to manage structural risk.	Analyze the structural risks.	Manage structural risk, based on the guidelines of the ALCO.	Prepare management reports analyzing performance in relation to objectives and risks taken.	Implement and comply with the policies, methodologies and procedures defined by the Risk Committee.	Prepare reports on structural risk for the ALCO.
Business Areas	Recommend to the risk analysis and control area the limits needed to comply with the objectives set for business.	Follow up the risk measurements made by the risk analysis and control area.	Establish the risk management strategy on real market positions in the different markets.	Prepare reports analyzing performance in relation to objectives and risks taken.	Implement and comply with the policies, methodologies and procedures defined by the Risk Committee.	Provide information on the different businesses to the ALM area and to the risk analysis and control area.
Support Areas	Provide support to the risk analysis and control area, the ALM area and the business areas. Implement and comply with the policies, methodologies and procedures defined by the Risk Committee.					

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- Risk control function:
  - Implement and ensure performance of the policies and procedures defined by the Risk Committee.
  - Calculate positions and mark them to market.
  - Establish which independent sources should be used to obtain the market variables (prices, interest rates, volatility, etc.) required to value and measure risks.
  - Measure market and credit risks with approved methodologies, and monitor compliance with established limits.
  - Quantify operating results and the RAROC of the different business units.
  - Calculate the use of capital-at-risk by the different business units.
  - Check the entity's liquidity against established limits.
- Risk analysis function:
  - Develop and define market and credit risk valuation and measurement methodologies, and validate the systems already in place at the entity.
  - Perform a solvency analysis on clients and counterparties and, using that analysis, assign them a credit rating[7]. The ratings must be reviewed regularly (at least annually), and whenever significant changes occur that could affect them.
  - Analyze the operating areas' proposals on market and credit risk limits. Present these proposals to the Risk Committee.
  - Analyze the division of capital-at-risk among the different business units.
  - Analyze the potential losses the entity could suffer in a market crisis (stress testing).
  - Evaluate requests for exceeding limits. Recommend approval, as applicable, to the Risk Committee.
  - From a risk standpoint, evaluate proposals on new products or activities that are presented by the various business units.
  - Prepare reports[8] for the Risk Committee with the following information:
    - Brief description of the market positions (e.g., mapping cash flows) and credit positions (e.g., equivalent loans).
    - Analysis of credit risk concentration by country, industry, term, ratings or counterparty.
    - Analysis of the risk factors that affect the potential profits and losses of the positions.
    - Analyze risk/return profiles and their sensitivity to changes in positions.
    - Scenario analysis (e.g., stress testing).
    - Analyze performance and variances from established targets. Identify explanatory factors.
    - Analyze expectations of business and market trends.
    - Evaluate alternative strategies to manage existing risk.
  - Prepare risk management reports for external agents[9] (e.g., investors, analysts, regulators, etc.)

In some large companies, control and analysis functions are performed by two different areas. However, to avoid misunderstandings and conflicts of interests, one management unit must have authority over both areas, particularly with respect to definition (analysis) and use (control) of the credit and market risk management methodologies.

[7] Chapter 5, which discusses credit risk management and control, will cover different alternatives for assigning credit ratings to clients and counterparties.

[8] Chapter 8 provides sample reports prepared by the risk analysis and control unit for the Risk Committee.

[9] Chapter 8 describes the risk management information that should be available to external stakesholders.

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The size of the risk analysis and control area should be based on the volume of activity and complexity of the products and instruments offered, mainly in the treasury area. For example, a medium-size company that offers standard products (loans, deposits, bonds, futures, forwards etc.) requires fewer people with fewer technical skills than a large company that offers more complex products (loans with embedded options, structured products and exotic options, etc.). In general, the risk analysis and control unit should have people with highly technical[10] backgrounds and experience in risk control.

ASSET AND LIABILITY MANAGEMENT AREA (ALM)

The ALM area is the operating department designated by the ALCO to handle daily financial risk analysis and management (market and liquidity) derived from the balance sheet structure of the entity.

The basic tasks of the ALM area include:

- Recommending limits for management of structural risk to the risk analysis and control area.
- Market analysis and follow-up.
- Managing the balance sheet of the entity through treasury transactions (bonds, swaps, options, etc.), according to ALCO guidelines, provided that there are sufficiently liquid financial markets. The ALM area can execute transactions directly in the open market or through other units in the treasury area, which consider it a client.
- Preparing reports for the ALCO containing the following information:
  - Analysis of the balance sheet exposure to market risk.
  - Financial margin sensitivity analysis.
  - Sensitivity analysis of the market value of the entity.
  - Analysis of the liquidity structure of the entity.
  - Proposals for alternative strategies to manage the entity's structural market risks and liquidity risks.
  - Preparation of management reports comparing actual performance against the goals established and risks taken.
- Implementing and following policies, methodologies, and procedures defined by the Risk Committee.

BUSINESS AREAS

The business areas are responsible for taking risks according to the previously defined strategies and parameters. Regardless of their specific responsibilities, the following functions related to risk management are common to all business areas:

- Convert the risk management strategy into real market positions among the different businesses.
- Maximize return for each level of risk accepted.
- Recommend new business opportunities (products/markets) to the Risk Committee for approval and inclusion in the organization's risk management policy.

[10] Chapter 13 describes professional background and technical experience required for each division of the organization.

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- Recommend market and credit risk limits (to the risk analysis and control area) that are necessary to conduct business and achieve established objectives.
- Track the risk measurements made by the risk analysis and control area.
- Divide the general risk limits into sublimits according to each area's specific activities.
- Provide information on the different business areas to the risk analysis and control unit and to the ALM unit.
- Prepare management reports analyzing performance against the goals established and the risks taken.
- Implement and follow the policies, methodologies, and processes defined by the Risk Committee.

SUPPORT AREAS

The support areas are responsible for a range of activities necessary for the implementation of the risk management strategy and policies. In general, these areas provide support to the risk analysis and control area, the ALM area, and the business areas. They also implement and carry out, within their own range of activity, the policies, methodologies, and processes defined by the Risk Committee.

The specific functions that each support area performs with respect to risk management are listed below.

Back Office Unit

- Process (record, confirm, settle, etc.) all the transactions entered into by the business areas. The policies, methodologies, and processes defined by the Risk Committee must be followed at all times.
- Record all the transactions in compliance with the standards and criteria established by the regulators.
- Ensure the integrity of the databases used by the risk analysis and control area.
- Ensure compliance with the controls and procedures established to reduce operating risk and inform the Risk Committee of errors and discrepancies found.

Systems and Technology Area

- Develop, install and maintain the systems needed for all areas of the entity to perform risk management and control functions.
- Set up the information controls established in the operating risk policies.
- Ensure proper use of information systems, as well as their integrity and proper functioning.
- Create a systems contingency plan.

Legal and Fiscal Advisory Area

- Define and establish the necessary procedures to adequately control the entity's legal risk.
- Ensure that all operations comply with the rules and laws established by applicable regulations and standards (compliance).

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- Verify that all transactions are correctly documented as to time and content, and that this documentation is not lost.
- Evaluate and draw up the contracts that support each business area's transactions.
- Ensure proper compliance with existing tax regulations.
- Propose an efficient fiscal structure for each business area.
- Identify business opportunities based on legal treatment.

Human Resources and Training Area

- Define and implement recruiting policies and training programs[11] that ensure that all functions related to risk management and control are performed by professionals who are appropriate in terms of number, experience, and degree of specialization.
- Select the appropriate personnel based on each business area's requirements.
- Define and implement compensation and incentive policies appropriate to the needs of the different areas of the entity, provided that they are not inconsistent with established risk policies.
- Define and ensure compliance with the entity's code of conduct.

Internal Audit Area

- Regularly examine and evaluate, on an independent basis, the global effectiveness and appropriateness of the entity's risk management and control structure.
- Compare actual implementation of policies and procedures with those that were established.
- Verify that all transactions are correctly recorded, valued, and booked, and that all accounting standards and rules established by regulators are being followed.
- Report any material weakness detected in the performance of analyses to the Executive Committee, and propose alternatives.

The internal audit area must be completely independent from the other areas involved in the risk management and control process in order to avoid any type of interference in the performance of its functions. To ensure this independence, it is important for the internal audit area to be set up as "staff" or a support area of the chief executive (President or General Manager) and it must also report directly to the Executive Committee.

An Internal Audit Committee exists at some companies, and includes as members the senior executives of the business, control and support areas. Internal audit reports its findings and proposals regarding problems identified directly to this committee. At other entities these matters are discussed in the Executive Committee. One good alternative is for the internal audit area to make a detailed presentation to the Internal Audit Committee. Then a report on the most important issues is presented to the Executive Committee. Each entity must decide, based on its size and specific needs, whether to create an Internal Audit Committee or to defer the performance of this responsibility to the Executive Committee.

[11] Chapter 13 describes risk management training programs.

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The company should also hire external auditors to perform a regular and independent review of the financial statements, as well as of the integrity of the risk management and control functions. These auditors should also evaluate compliance with both internal and external established policies and procedures. The external auditors will report their findings to the Executive Committee and the Internal Auditing Committee, if the latter exists.

Risk Management Organizational Structure

In the previous sections we have identified the different areas of the entity involved in risk management, and the functions of each. In this section, we propose an organizational structure model consistent with this risk management philosophy. In this model we explain the basic dependency relationships that should exist between the areas of the entity. Adjustments may be necessary based on the size, complexity and scope of each entity's business activities.

The organizational model presented in Figure 2-3 is based on functions rather than people. Therefore, the business area would include all the businesses (A, B, C, etc.). This does not mean that only one person should be responsible for all the business units. Each organization must make this decision based on its complexity and ability to establish synergies.

If the complexity of the organization increases and macro-business units are created, such as foreign offices that require full-fledged organizational structures (strategic and operating), there will be an evolution towards an organizational structure with a matrix reporting system:

- The areas that make up the operating structure of the macro-unit will report to the general management of the macro-unit, and also to the person in charge of that function on a global level for the group.
- The committees that make up the strategic structure of the macro-unit will report to the Board of that specific unit and also to the equivalent committee in the matrix.

For example, let's assume that an Argentine financial entity (the parent) buys a Venezuelan bank (the subsidiary). To effectively coordinate the risk management of the group, the parent would logically make the organizational changes at the subsidiary required for the two to have similar strategic and operating structures.

Once both entities have similar organizational structures to support risk management requirements, the next step would be to define the dependencies and relationships that should exist between the different areas of both to enable coordinated, efficient operations. For example, the risk analysis and control area of the subsidiary would report to both local management and the risk analysis and control area of the parent.

This double dependency structure must be designed to achieve the following objectives:

- The committees and the head office areas must coordinate management strategies and standardize risk management policies and processes within the macro-units.
- The parent areas and committees must ensure that their counterparts at each of the macro-units perform their functions properly and in accordance with the guidelines established for them by the parent.
- The strategic structure of each macro-unit must have detailed information about risk management and control at its macro-unit, and at the same time, the strategic structure of the parent must be adequately informed of the most significant risk management and control issues facing each of the macro-units that make up the group.

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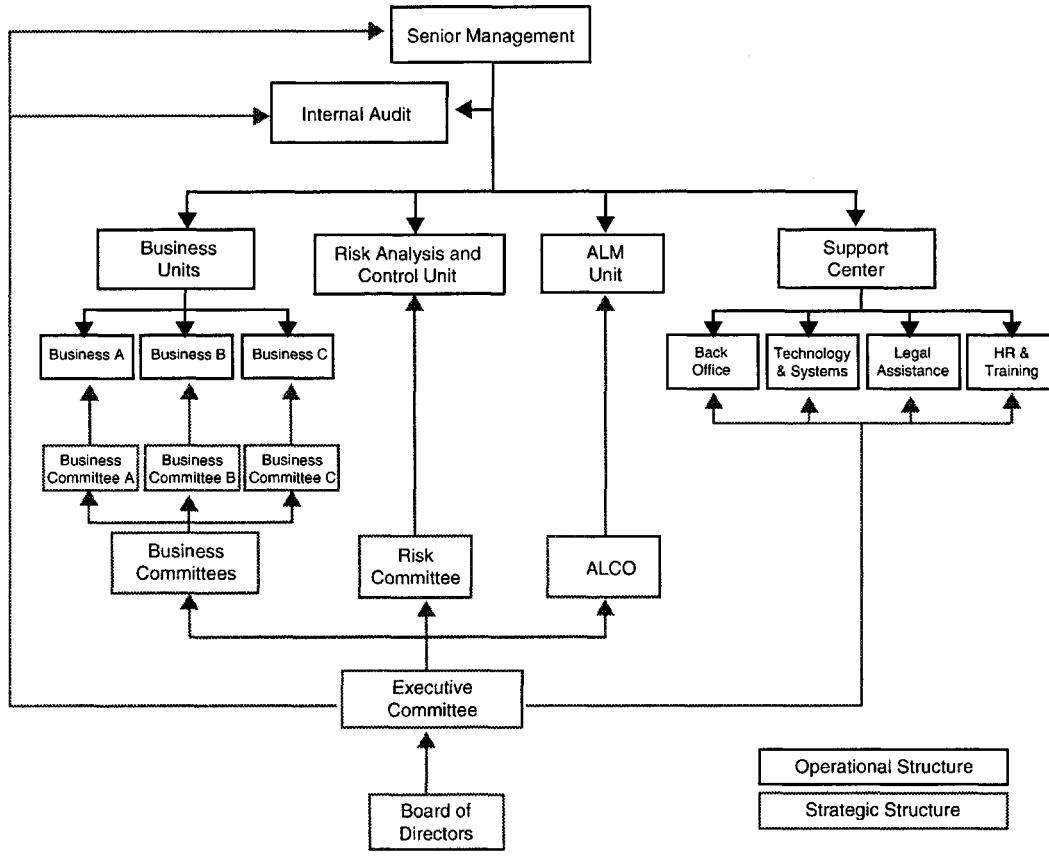
Figure 2-3. Organizational Model



The design of this type of structure must be balanced, i.e., it must have sufficient flexibility to promote decision making within the macro-units while still providing the coordination necessary for the parent to maintain control. Important factors that shape the relationships between the parent and the macro-units are the nature, size and autonomy of the latter. For example, a branch or office is normally less autonomous than an entity that forms part of the group (such as a bank acquired by the parent).

International Standards Recommendations Regarding Organizational Structure

Recommendations of the Group of Thirty

- Entities should use derivatives according to the risk management policies approved by the Board.
- Risk management policies should be kept current so that they take into account changes in the market and the company.
- Senior management must approve the procedures and controls needed to ensure implementation of risk management policies. The rest of the organization must follow these policies.
- The entities must have an independent market risk control function with the following responsibilities:

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- Develop policies for establishing market risk limits as well as ensuring compliance.
- Design stress scenarios and analyze their impact on earnings.
- Analyze performance as a function of each risk component contribution.
- Define market risk methodologies and models.
- Analyze the validity of the models used by performing historical analysis of the predicted or forcasted values and actual values (back testing).
- Review and approve valuation models used by the front and back offices as well as define reconciliation processes if both areas use different systems.

- The entities should have an independent credit risk control function with the following responsibilities:
  - Approve credit exposure measurement methodologies.
  - Establish credit risk limits and monitor compliance with them.
  - Review credit concentrations.
  - Review and check credit risk reduction agreements (for example, guarantees).

Recommendations of the Derivatives Policy Group

- Senior management should explicitly define the businesses in which they want to operate as well as the levels of risk they want to take.
- Senior management must approve a document containing the risk management policies. This document should address the following:
  - Authorized products and businesses.
  - Market and credit risk limits.
  - Structure and independence of the management and control areas.
  - Controls and procedures that ensure compliance with established policies.
- The entities must request an independent periodic review (external auditors) to ensure that risk management policies are being adopted and that control procedures are in place.

Recommendations of the Bank for International Settlement

- Policies and procedures must be defined to manage and control risks based on the nature and complexity of the businesses in which an entity operates.
- An independent unit should be responsible for the design, management and implementation of the risk control policies and procedures. The functions of such a control unit include:
  - Reporting the company's exposures to market and credit risk periodically to senior management.
  - Monitoring the business units to confirm that they are not exceeding the market and credit risk limits established by the management bodies of the entity and report excesses.
  - Defining the methodologies to be used to measure risk.
- Senior management should approve the risk management policies and procedures defined by each business unit.
- Management of the entities will be responsible for the existence of an adequate organizational structure and for the availability of resources to implement risk management policies and procedures previously approved.
- The entities must submit periodically to internal and external audits of policies, procedures, methodologies and systems used in risk control and management.

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Chapter 3

Market Risk Management and Control

Introduction

It is important to remember that the main goal of any company is to *create value* for society in general and its shareholders in particular. To do this, a company must assume a number of business risks and manage them efficiently.

Risk management is clearly strategically important to a company and the main source of value creation. Therefore, risk management must be closely supervised by senior management, who must define the operating framework and ensure that policies are carried out accordingly. This is where the risk control function enters the picture: it ensures the correct implementation of the risk management strategy approved by the Executive Committee and sanctioned by the company's Board of Directors.

As mentioned in chapter 2, from a risk management perspective the management and control functions should be separated in order to avoid conflicts of interest that could result in inadequate management of the risks taken and the consequent destruction of shareholder value.

From a general point of view, the approved strategy results in the allocation of resources (capital), and the definition of an operating framework. For market and credit risk, this occurs through the implementation of a limit structure that ensures that the risks taken are in accordance with company strategy. The control unit is responsible for overseeing and monitoring the limit structure. The business units make their decisions within that structure, while attempting to maximize returns. The steps below must be followed to define and implement the company's risk management strategy:

- Risk selection: First, select the businesses in which risks will be taken. Clearly identify the market factors that drive value for each of the units (risk factors). Then analyze, for each factor, historical and projected performance so that the level of risk assumed can be estimated.
- Capital allocation: After identifying the risk factors and their contribution to the overall risk of the entity, the next step is to allocate resources to each of the business units, for each of the risk factors, based on the entity's risk profile. These resources are allocated based on the limit structure, which establishes the operating framework for each of the units and enables them to begin operations.
- Risk management: Each business unit manages the allocated resources as efficiently as possible based on the established limits, its knowledge of markets and its expectations regarding changes in the related risk factors. Each business unit is free to independently choose the risks it wants to take, provided that they are similar to previously selected ones and that their contribution to the entity's risk does not exceed established limits.

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- Limit monitoring: To ensure compliance with the defined risk management policies, business units are monitored once they begin to operate in order to ensure that the risks taken comply with the established limit structure. Limit monitoring should be performed independently of the business units. If limits are exceeded, the limit overage procedures established in the policies should be followed.

In any case, the objective is clear: to guarantee implementation of the company's strategy, assuming risks and managing them efficiently without exceeding approved risk levels.

The purpose of this chapter is to develop techniques and procedures for market risk management and control. Market risk is defined as the possibility of a loss due to an adverse movement in market variables that determine the company's value, such as interest rates, exchange rates, stock prices, commodity prices, etc.

In the following segments of this chapter we will discuss in more depth topics previously touched on that are associated with risk control and management. The outline is as follows:

- Risk identification: This section discusses the different risks a company may face in its current or future operations. The effect of each on portfolio value is quantified. Companies operating without having implemented a risk management structure should perform this analysis prior to the implementation.
- Risk control: This section covers all the functions associated with defining the operating framework for each of the company's units and verifying compliance with that framework once it is operative.
- Risk management: This section covers some of the techniques available to manage the risks assumed by the entity, based on expected changes in the various risk factors.

Sometimes these tasks are the responsibility of a single area or department, but often they are shared by various areas. Thus, the risk analysis and control area is responsible for controlling limits, and the business units are responsible for risk management. Nevertheless, the identification of the risk factors and their contribution to the entity's total risk and the definition of limits are strategically important to the organization. Therefore, commitment to them is required from all the areas responsible for providing support to the different committees during the strategy definition process, which extends all the way to final approval by the Executive Committee.

Identification of Market Risks

Before implementing a risk management strategy, it is essential to identify and analyze each of the market risk factors to which the entity could be exposed because of the business strategy it intends to pursue. If the entity is already operating, the actual risk factors it is facing must be analyzed.

To move on, we assume that an entity wants to implement a risk management strategy that enables it to control and optimize its current portfolio, while analyzing the impact of new strategies it intends to pursue. Thus, before implementing these new business strategies, we must understand the risk factors currently affecting the portfolio and the effects of the new decisions on total value. Therefore, the steps to be followed in order to obtain a complete picture of the risks assumed by the entity are:

- Identification of risk factors: A requirement for correct definition of a risk strategy is the clear identification of the risk factors that cause changes in portfolio value. This

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requires a profound understanding of all the areas in which the company operates. If there has not been any activity thus far, this analysis is conducted for the potential business areas of interest.

- Position maps: Through the use of equivalent positions,[1] position maps show the sensitivity of portfolio value to changes in the value of the risk factors that define them. This analysis explains, in a very simple manner, where the portfolio is concentrated and enables rapid calculation of the repercussions of a market movement on the income statement. However, this technique generates an inconsistent risk measurement, because it shows individual behaviors when in reality all the factors are interrelated and do not change independently. Therefore, it is necessary to introduce an additional method that takes these relationships into account.
- Profit and loss distribution: This analysis calculates the effects of specific changes in the risk factors on total or partial portfolio value. The final result is a group of possible value changes with specific probabilities of occurring. Once the profit and loss distribution has been obtained, a series of related risk-return measures are defined. These measures summarize the distribution's main characteristics. Two of these concepts are Capital-at-Risk and Return on Risk-Adjusted Capital (RORAC).

If a new business is created, both analyses should be performed based on the resources (capital) that are expected to be allocated to the new business or risk factors. This process enables senior management to understand clearly the real risks the entity will face if the business strategy is actually approved.

In addition to defining the risk factors to which it is exposed, the entity must analyze the instruments available in the market, as well as those that can be developed, to partially or totally hedge the risks that it faces. The study of these instruments should be completed with an analysis of the associated costs, as well as the liquidity and availability of the instruments in times of crisis. Deep knowledge of the markets in which the entity operates is essential to efficient risk management.

MARKET RISK FACTORS

It is important to identify the risk factors that affect the value and characterize the behavior of each business. For market risk, these factors are defined by financial market variables: interest rates, exchange rates, stock prices, commodity prices, volatilities, macroeconomic variables, etc. Below, each factor is analyzed individually, with an explanation of the circumstances under which the value of the entity could be exposed to that risk factor.

In general, changes in a business's value due to changes in market conditions may begin at one of the following four levels:

- Assets: As market conditions change, resulting changes in the value of investments change the value of the business. For example, a portfolio of listed securities is subject to changes in the prices of those securities.
- Liabilities: The company's financing benefits or suffers from changes in market conditions. For example, a fixed rate financing would benefit from a rise in interest rates

[1] Two positions are considered equivalent when their value changes by the same amount and in the same direction upon changes in the risk factors that affect them.

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since the company would be financing its needs at terms better than those available in the market. However, if the company had floating rate financing, it would suffer because it would have to make higher interest payments that would affect its income statement.

- Off-balance sheet: Off-balance sheet transactions may also be affected by changes in market conditions. For example, a currency hedge transaction generates profits or losses depending on fluctuations in the exchange rate between the currencies.
- Income Statement: The company's income statement may also be affected by changes in market conditions, if these changes affect operating margins. For example, in the commercial banking business, the general level of interest rates influences the spread between deposits and loans.

Next we will analyze what occurs when a business is exposed to different market risk factors, and the influence the latter have on the value of the business. The risk factors that will be analyzed are:

- Interest rates
- Stock prices
- Commodity prices
- Exchange rates

Each of the risk factors will be discussed separately without considering the interdependence that actually exists between them. That relationship will be considered when we analyze the collective effect of all the factors. For example, a drop in interest rates translates into increased stock prices. However, in order to facilitate identification of the risks that determine the value of the business, interest rate risk will be dealt with separately from equity risk. The objective is to build a global risk map for the business one step at a time. First we will define the position map, based on the different risk factors, and then these factors will be related to each other in order to obtain the profit and loss distribution.

Interest Rate Risk

An entity or business is exposed to interest rate risk when its value is dependent on the level of interest rates in the financial markets. An entity is exposed to interest rate risk when:

- The change in its assets' market value resulting from a change in market rates does not match the change in the market value of its liabilities, and this difference is not offset by changes in the market value of off-balance sheet instruments.

  The sensitivity of assets and liabilities to market factors differ when they have different maturities, amortization schedules, coupon reference rates (fixed or floating), credit ratings, other characteristics (e.g., existence of embedded options that allow prepayment or extension of these instruments), etc.
- Future earnings from outstanding transactions are dependent on interest rates.

However, there is not only one risk factor associated with interest rates. There is an interest rate term structure associated with each of the financial markets, so it is necessary to identify precisely which markets and maturities the entity is exposed to. For example, an entity could have invested its assets in 1 and 10-year fixed rate U.S. instruments, and in 3-month fixed rate Mexican instruments. As a result, the value of its assets would be exposed to movements in three risk factors: U.S. short and long-term rates, and Mexican short-term rates.

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Therefore, each of the interest rate risk factors that affect the value of the business must be identified. For example, assume that the term structure is divided into three buckets (short, medium and long-term) in each market. It would then be necessary to define which elements of the matrix affect the value of the business.

Identification of Interest Rate Risk

	Market 1	Market 2	...	Market n
Short-term	✓			✓
Medium-term		✓		✓
Long-term		✓		

It is important to note here that although all of the factors described above have to do with interest rate risk, each behaves differently, and non-parallel shifts in the yield curve can occur. Therefore, it is very important to identify the maturity to which the entity is exposed, since short-term and long-term rates behave differently. Short-term rates are set mainly by Central Bank monetary policy, while long-term rates reflect the expectations of market participants.

Equity Risk

An entity is exposed to equity risk when its value depends on the prices of specific stocks or stock indices.

Equity risk exposure will exist when it has made investments in other companies, regardless of whether they were made for speculative purposes or to influence the management of the company. An entity is also exposed when it owns derivatives whose underlying is exposed to equity risk.

Commodity Price Risk

An entity is exposed to commodity price risk when its value is affected by the prices of commodities in the international markets.

There is commodity price risk when:

- The entity invests in commodities, for speculative purposes or for business purposes.
- The entity has derivatives positions whose underlying asset is exposed to commodity price risk.
- A specific commodity is intensively used in the entity's production processes.
- A specific commodity is a substitute for one of its products.

Exchange Rate Risk

An entity or business is exposed to exchange rate risk when its value is affected by fluctuations in the exchange rates of currencies in the financial markets.

An entity is exposed to exchange rate risk when:

- The present value of its assets in each currency does not match the present value of its liabilities in the same currency, and the difference is not offset by off-balance sheet instruments.

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- It has derivatives positions whose underlying is exposed to exchange rate risk and the sensitivity of the entity's value to exchange rate changes has not been completely hedged.
- It is exposed to interest rate, equity or commodity price risk in currencies other than its reference currency. These currencies can affect the balance between the value of its assets and liabilities in the reference currency and thus generate profits and losses.
- Its margins are directly dependent on exchange rates. This may occur, for example, if it must import raw materials.
- Its business is affected by competitors whose costs are dependent on foreign currencies (importers/exporters).

BUSINESS VALUE

We have previously identified the different risk factors that influence the value of the entity and the portfolio. In this section we will explain both terms, and discuss the concept of *business value*.

If the portfolio consisted solely of financial products, the value of the portfolio would equal the liquidation value of the entity. In that case one would analyze only changes in the liquidation value *vis-à-vis* changes in the risk factors. However, if we assume that the entity is an ongoing concern and will therefore be capable of generating some amount of future profits through management of the risks it assumes, there is business value unrelated to the liquidation value of its portfolio. As already noted, the risk factors not only influence the value of the entity through its asset and liability positions (*liquidation value*), they can also influence its income statement (*business value*). This is clearly demonstrated in the following example:

> *Suppose that a financial institution raises funds from clients through checking accounts on which it pays 3% p.a. compounded daily, and that the available funds are invested in inter-bank deposits paying 5% p.a. If the institution performs this transaction daily on an ongoing basis, by year-end it will have earned an amount equal to 2% of the average daily balance maintained during the year. The liquidation value of the entity is equal to zero because if all the clients withdrew their deposits, the institution would not have resources to invest in inter-bank deposits. However, its portfolio of instruments would not be exposed to market risk because the transactions mature daily and are for an amount equal to the funds held in the checking accounts. Does this mean that the business has no value? Of course not. The ability to raise funds at 3% and place them at 5% has a value, which would be calculated by discounting the estimated future spreads that the entity would generate based on market rates. This would be the business value. Therefore, the liquidation value of the business is zero, but the* business value *is not.*

This example brings us to a new question. Is business value exposed to market risk? The answer is yes. The reason is that future value is based partly on future cash flows and partly on the discount rates used to calculate the present value. The future cash flows are in turn a function of changes in the various risk factors.

> *Returning now to the original example, if interest rates rise, it is likely that the difference between asset and liability rates will also increase, but if they drop, that difference will narrow. In addition, the entity must analyze what will occur to asset and liability balances based on different interest rate levels. The combination of the two effects will determine the P&L impact.*

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Therefore, *business value* also depends on and is sensitive to changes in the risk factors. The entity must manage both the market risk associated with the liquidation value of the portfolio of instruments and the market risk related to business value.

This approach is applicable to all types of entities, not just financial institutions. Thus, if a company's earnings are extremely dependent on the price of a specific commodity and financial derivatives with that underlying are traded in a market, company management could, if it deems it advisable, decide to take a position in these instruments. This would enable it to hedge the value of the business.

The method would be the same in both cases. As with a portfolio, the risk factors that affect *business value* must be identified and their impact quantified. Therefore, for each risk factor identified a sensitivity map would be produced, similar to the one used with a portfolio of financial instruments, in which the *sensitivity* would derive from the change in the *business value* vis-à-vis changes in each of the risk factors identified. However, the analysis required to determine the sensitivities is more complex than the analysis necessary for a portfolio of instruments, because it requires understanding and identifying all the risk factors that affect the entity's results.

Sensitivity Map

Risk Factors	Sensitivity	Units
Risk Factor 1	Sensitivity_1	u_1
Risk Factor 2	Sensitivity_2	u_2
. . .	. . .	. . .
Risk Factor n	Sensitivity_n	u_n

Chapter 4, which covers market risk in the commercial banking business, will analyze this issue in greater detail.

Once the sensitivity map has been obtained, senior management must decide whether or not to hedge the *business value*. If it should decide to hedge part of the value, it would have the necessary tools, since the hedge portfolio is obtained from the sensitivity map just as in the case of a portfolio of instruments. The same representative instruments are used to calculate the equivalent positions. The hedges would be subject to the same problems described above.

Now, having discussed the differences between portfolio value and business value, we can move on to an analysis of the different tools available for determining the risk map of a portfolio and its application to market risk management and control.

GLOBAL RISK MAP

Let us look at an entity that has a portfolio of financial products. The portfolio is subject to changes in the different risk factors to which it is exposed. Therefore, once the risk factors associated with the value of the entity have been identified, it is necessary to:

- Quantify each factor's contribution to business value.
- Quantify the impact of changes in a specific factor on business value.
- Quantify the impact of changes in various factors on business value.
- Quantify the behavior of the business value as a function of the expected behavior of all the risk factors combined.

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The objective of building the global risk map is to answer all the above points, so that it can be used as a basic tool in the decision making process by:

- Clarifying the interdependence between changes in the entity's value and the positions in each of the risk factors.
- Measuring the level of risk assumed.

To do this, we will develop the following tools:

- Position map: By preparing a position map for the entity, the contribution of each factor to the entity's value can be quantified. It also enables the entity to quantify changes in value due to changes in market conditions. Therefore, by making different assumptions for the risk factors, the value of the entity under each scenario can be calculated. However, the actual evolution of the factors needs to be included.
- Profit and loss distribution: Once the position map is finished, we have a clear understanding of the composition of the portfolio and how it is affected by specific changes in the risk factors. However, the position map is only a summary of the financial instruments that make up the portfolio. It does not indicate the actual level of losses the entity could experience, because it does not take into account changes in each factor. However, by introducing these components into the position map, we can obtain the evolution of the value of the company and thus, the actual risk of losses (given actual market conditions) in the value of the entity.

Position Map

The purpose of preparing a position map is to quantify the effect of each of the risk factors to which an entity is exposed on its value. To this end, a series of risk measures will be defined that serve this purpose.

Nominal Position

The first risk measure to be considered is the nominal position in each of the financial instruments in the portfolio. But this creates the following problems:

- The nominal value of an instrument is nothing more than a reference value that indicates the volume held of that specific instrument. It provides no other information on the risk factors that affect the instrument.
- The nominal position does not have the same meaning for all instruments, so comparisons and aggregations are not possible. Thus, two instruments with the same nominal position are not subject to the same risk. A nominal position of US$1,000 in Brazilian bonds does not have the same risk as the same nominal position in U.S. Treasury bills.

However, nominal positions are not completely useless. Knowing the nominal position of each instrument on an ongoing basis is necessary, though not sufficient, for the creation of more reliable risk measures.

In the case of a portfolio of similar instruments (e.g., different fixed income instruments in the same currency and with the same maturity), knowing the nominal position could be considered a risk measure. It would be a very basic measure, but in this specific case, it could

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be enough. Obviously, all the instruments of this portfolio are subject to similar risk factors, and they react in the same way to changes in these factors.

However, the value of an entity is subject to more than one risk factor, and the instruments that comprise the value are heterogeneous. Thus, if the portfolio above also contained short-term instruments, it would no longer be homogeneous and would be dependent on two different risk factors. However, this approach could still be used if the portfolio were divided into homogeneous sub-portfolios, one long-term and the other short-term. However, it would not be possible to consolidate them because, from a risk perspective, the same nominal position in each sub-portfolio does not entail the same level of risk as the other, and thus the two cannot be directly combined. Therefore, we need to keep looking for additional measures that will provide more accurate risk estimates.

Market Value

As we have seen, one of the limitations of the nominal position is that it does not allow consolidation of heterogeneous instruments. However, each instrument has a price at which it can be sold or closed out. In general, if we multiply the nominal position by that price we obtain the market value of each instrument, which can be summed to obtain the total market value of the portfolio. However, as is the case with nominal positions, two instruments with the same market value do not have the same risk, although knowing the market value is also a necessary condition to developing better measures. On the other hand, many derivatives (futures, FRAs, IRSs, etc.) have a market value of zero when entered into, which does not mean that these instruments cannot undergo significant changes, creating exposure to risk.

Knowing both the nominal position and the market value of the portfolio is necessary for accurate risk measurement. However, these measures by themselves are insufficient since they are not homogenous from a risk management perspective. Therefore, some additional measure that enables uniform measurement and comparison of the instruments in the portfolio is necessary. This measure is the sensitivity to the risk factors that determine the market value of each instrument and the overall portfolio.

Sensitivity to Risk Factors

Once the risk factors to which the entity is exposed have been identified, it is necessary to quantify the influence of each factor on that value, by analyzing the sensitivity of the company to changes in the value of the factors. We define the sensitivity of an instrument to risk factor i as the change in the market value of that instrument given a specific change in the value of the factor. We assume that the other factors stay constant[2]:

$$sensitivity_i = \frac{\Delta value}{\Delta factor_i}$$

[2] It is important to mention here the interdependence among the different risk factors. It is well known that changes in interest rates influence the stock market, and that higher interest rates reduce stock prices. However, for the purposes of this section, and in order to maintain the traditional concept of sensitivity, it will be assumed that they are independent. The dependence between the different factors will be considered later to determine the global risk map of the entity.

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Thus, considering each risk factor independently, any change in risk factor i will change the value of the instrument. This change can be roughly expressed as[3]:

$$\Delta value = sensitivity_i \bullet \Delta factor_i^*$$

where $\Delta factor_i^*$ corresponds to the change that we want to simulate. Keeping in mind that the change in portfolio value is the sum of the changes in the value of each instrument, if the sensitivities of each instrument to factor *i* are summed up, the sensitivity of the portfolio to factor i is obtained.

Therefore, we have obtained a risk measure for each one of the risk factors that allows us to add the different instruments regardless of their individual characteristics.

The risk of the portfolio is expressed as a set of sensitivities to each of the risk factors. However, this measure does not enable aggregation of all risks at the global level because each of the sensitivities is linked to a specific risk factor that cannot be added directly to the rest.

These risk measures enable us to simulate the effects on the portfolio of changes in each of the related risk factors. Assuming a specific change in each of the factors, we can obtain an approximation of the total change in portfolio value:

$$\Delta value = \sum sensitivity_i \bullet \Delta factor_i^*$$

which could be represented in table format, listing each of the risk factors, the sensitivity to changes and the units for which the sensitivity has been calculated.

Equivalent Portfolio

The real position of the entity, which is made up of numerous instruments and transactions in a multitude of currencies, can be converted by sensitivity analysis into a breakdown of sensitivities by risk factor. However, in order to facilitate risk management and explanation of risk components, it is common market practice to build an equivalent portfolio made up of reference instruments, so that the values of the real and equivalent portfolios change by exactly the same amount and sign upon changes in the factors.

The equivalent portfolio is made up of a series of basic instruments that are related to the risk factors in a simple, unique way, i.e., each basic instrument is dependent on a single risk factor. These instruments are usually reference assets used by traders as representatives of market movements. Good examples of reference assets are Government Treasury bonds for the most liquid maturities, market IRS for each time period, or futures on the most widely held local stock market index.

The sensitivity map calculated in the prior section will be the starting point for the equivalent portfolio. It is combined with the reference instruments in order to determine what amount of each instrument is needed to replicate the real portfolio from a risk perspective. Therefore, the equivalent position of the portfolio in reference instrument *i* is equal to a nominal position in that instrument, such that a change in the associated risk factor should cause the values of the equivalent position and the portfolio to change by the same amount. Therefore,

$$N_i \bullet individual\ sensitivity_i = sensitivity_i$$

[3] This sensitivity analysis takes into account only first order terms (duration, deltas, etc.). However, in some products, such as portfolios with options, second order factors (convexity, gamma) can be very important and should be included in the analysis. In that case it will be necessary to analyze changes in the value given different scenarios of changes in the risk factors.

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where N_i is the equivalent position in instrument i, *individual sensitivity*$_i$ is the change in one monetary unit of instrument *i* given a change in factor *i*, and *sensitivity*$_i$ is the sensitivity of the portfolio associated with the same change in the risk factor.

Once the risk factors for each instrument have been obtained, the next step is to build the sensitivity table with two additional columns that show the chosen reference instrument and the equivalent position.

Keeping in mind that the equivalent positions are nominal, the portfolio must now be grouped into homogenous sub-portfolios defined by risk factors. Therefore, as with nominal positions, these results cannot be aggregated because they are not homogenous.

Equivalent Portfolio

Risk Factors	Instrument	Equivalent Position	Sensitivity	Units
Risk Factor 1	Instrument 1	N_1	Sensitivity$_1$	u_1
Risk Factor 2	Instrument 2	N_2	Sensitivity$_2$	u_2
. . .	. . .	. . .	. . .	. . .
Risk Factor n	Instrument n	N_n	Sensitivity$_n$	u_n

In addition to being necessary (as will be shown later) for limit monitoring, this tool is a very powerful management tool because if the opposites of the equivalent positions were actually transacted, the value of the new portfolio would not change when the risk factors change. The initial portfolio would be fully hedged. An additional advantage of this tool is that the reference instruments tend to be sufficiently liquid to facilitate entering into the hedge and modifying it easily. We will expand on this point later when we elaborate on market risk management.

Both the sensitivity and the equivalent position maps are considered to represent the position map of the entity. All the dependencies of business value on the various risk factors have been summarized in the map. Each line provides a risk factor and a related equivalent position. Thus, we have:

- Quantified each factor's contribution to business value.
- Quantified the impact of changes in a specific factor on business value.
- Quantified the impact of changes in various factors on business value.

Therefore, the position map meets the first three of the four objectives. However, as we have seen, the position map does not take into account the behavior pattern of each risk factor. Instead, it analyzes the risk factors' influence on the value of the entity. The next step will define the behavior of the risk factors as a whole and apply it to the sensitivity map to obtain a behavior pattern for the value of the entity. To do this the profit and loss distribution will be obtained.

Profit and Loss Distribution

The sensitivities or equivalent positions approaches enable the easy simulation of portfolio behavior in different scenarios. However, not all scenarios are equally probable, nor do the factors move independently of each other.

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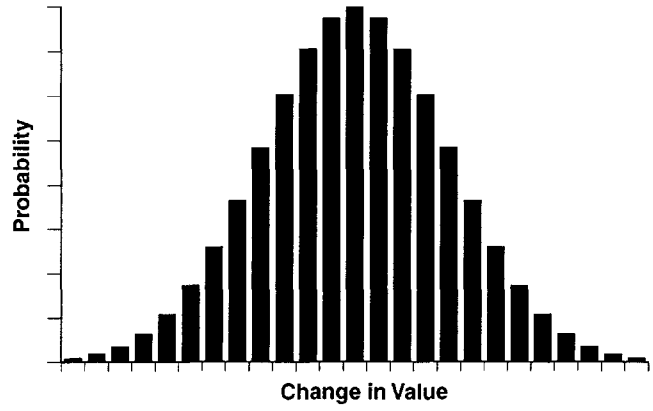
Figure 3-1. Profit and Loss Distribution



The position map calculated previously gives the business value's concentration in and sensitivity to each risk factor. However, the position map does not show the real risk of losses of the portfolio, since it does not take into account the level of risk associated with each factor. Obviously, a short-term investment in U.S. Treasury bills has a lower risk than an investment in the Mexican stock market. Thus, to complete the map we need to include the behavior pattern of each risk factor.

We will introduce this behavioral pattern as a probability distribution. A probability of occurrence will be assigned to each possible change in the risk factor. However, business value is dependent on many risk factors, which means that we must analyze the global behavior pattern model for all risk factors, because the latter are not independent. Instead, they move as a group. Therefore, each possible combination of changes in the risk factors will be assigned a probability that translates into a change in business value. After considering all the possible outcomes, we will obtain a sequence of value changes with an occurrence probability assigned to them. After taking into account all the possible combinations of the risk factors, we will obtain a series of value changes, each with a specific probability of occurrence. By combining all the possible scenarios for the established time period, each change in portfolio value will have a specific probability of occurring, which will show the real risk of losses for the portfolio. (Figure 3-1).

This information or a summary of it, plus a summary of the position (whether through a breakdown of sensitivities or through the equivalent portfolio) are part of the global risk map of the entity. They enable the quantification of the real risk of losses and the understanding of the behavior of the value given changes in different risk factors. To summarize this information, we will develop a number of risk-reward measures associated with the profit and loss distribution. These risk-reward measures represent the global risk of the portfolio with a single value.

Risk-Return Measures

Once we have the portfolio's risk map, a number of risk-adjusted return measures are defined that facilitate homogenous quantification of risk exposure for all transactions, as well as the risk-adjusted rate of return. These measures are:

- Value-at-Risk: Maximum estimated loss during a specific time period, with a specific confidence interval.

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- Capital-at-Risk: Capital exposed to risk. It is equal to the Value-at-Risk plus the financial costs associated with the position.
- RORAC: Return on Risk-Adjusted Capital. Riskier investments must provide higher returns.

The following sections define these risk-reward measures in more detail. The methods used to calculate them are provided in chapter 9.

Value-at-Risk

Value-at-Risk (VAR) is defined as the maximum estimated loss in the value of a portfolio during a specified period of time and for a specific confidence interval (c). The confidence interval is defined as the probability of not exceeding the level of losses defined by VAR. Thus, the loss in portfolio value is less than VAR with a c% probability and there is a (1-c)% chance of experiencing a loss greater than VAR (Figure 3-2).

VAR is usually expressed as an absolute value, so

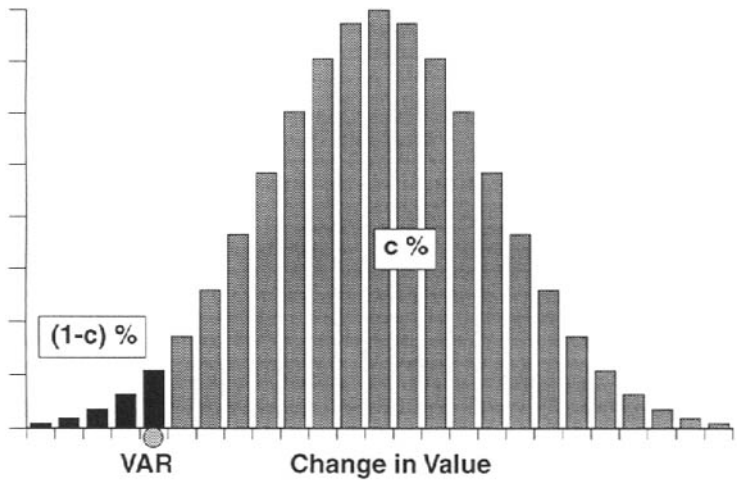
$$probability(value_{initial} - value_{final} > VAR) = (1 - c)\%$$

The mean of the above probability distribution equals the expected change in value. VAR is the difference between the unexpected loss and the expected change in value. This gives us the following equation:

$$VAR = maximum\ expected\ loss = maximum\ unexpected\ loss - expected\ change\ in\ value$$

It is important to mention here that as of yet we have not developed a hypothesis regarding the type of probability distribution that will be used to determine the VAR, since this is a general concept in any distribution (normal, lognormal, etc).

Figure 3-2. Value-at-Risk (VAR)



Capital-at-Risk

Every portfolio or financial instrument places a portion of the entity's capital at risk (Capital-at-Risk, or CAR), due to the potential losses that may occur on that position, which are quantified by the *Value-at-Risk.*

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The Capital-at-Risk is determined by calculating the minimum capital that must be allocated to a position to avoid bankruptcy if the maximum expected loss occurs.

In performing the calculation, remember that the portfolio must be financed with the entity's own capital or borrowed funds, which results in an additional cost associated with the position. In order to treat all portfolios the same, regardless of their actual financing, we will assume that the entire market value of each position is financed with debt. However, because the portfolio may experience losses, it is necessary to allocate enough capital to protect the position from bankruptcy. This allocated capital is invested in risk-free assets, which produces a balance sheet like the one shown in Figure 3-3.

Therefore, the returns associated with the total balance sheet are determined by the change in value of the position, plus the interest expenses, less interest earned from investing the allocated capital. This means that the CAR is the minimum capital that ensures that the maximum possible losses can be covered, while repaying any financing, plus interest.

Therefore, once we have the Value-at-Risk of the portfolio, we can define the Capital-at-Risk (CAR) as the maximum loss of value in the portfolio for a specific confidence interval (c) during a specific time period, also taking into account the financing costs of the position and compensation on capital during said time period.

$$CAR = VAR + financial\ costs - capital\ compensation$$

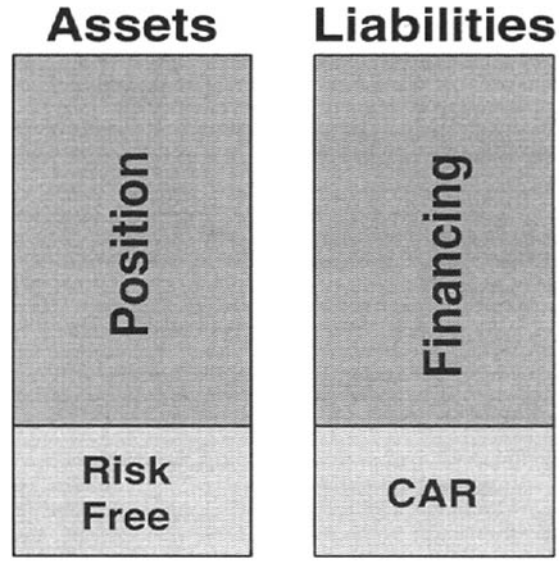
where capital compensation equals:

$$capital\ compensation = CAR \bullet Z_{RF} \bullet t$$

where Z_{RF} is the risk-free interest rate associated with time t. Therefore, CAR is expressed as:

$$CAR = \frac{VAR + financial\ costs}{\left(1 + Z_{RF}\right)^{t}}$$

Figure 3-3. Financing and Capital-at-Risk Associated with the Position



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The equation above indicates that the CAR allocated to a position equals the present value of the maximum potential loss at future instant t as a result of the loss in the value of the position and the payment of financial interest costs.

The Capital-at-Risk concept also applies to liability positions, under the assumption that they are invested in the market and that the CAR is invested in risk-free assets.

In that case,

$$CAR = VAR - financial\ revenues - capital\ compensation$$

where financial revenues are the interest earned by the investment in risk-free assets. Therefore, the CAR is expressed as:

$$CAR = \frac{VAR - financial\ revenues}{\left(1 + Z_{RF}\right)^{c}}$$

RORAC

Up to now, only risk measures have been established. The next step is to include expected and historical return measures, which enable comparison of past and future investment decisions on a common basis. The higher the risk taken, the greater the required return will be.

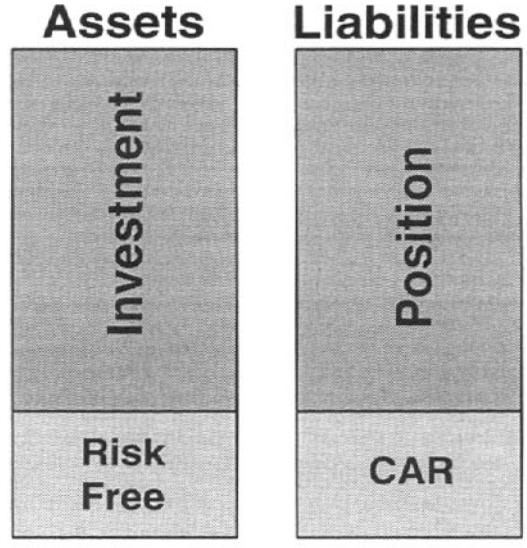
Return on Risk-Adjusted Capital, or RORAC, will be used as a risk-return measure. To calculate RORAC, we begin with the same balance sheet used to calculate the CAR. Therefore, RORAC will be defined as the after-tax return associated with the position divided by the Capital-at-Risk (CAR):

$$RORAC = \frac{\Delta value - financial\ costs + capital\ compensation}{CAR}(1 - tax\ rate)$$

and, for a liability position, as:

$$RORAC = \frac{\Delta value + financial\ revenues + capital\ compensation}{CAR}(1 - tax\ rate)$$

Figure 3-4. Investment and CAR Associated with the Position



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If the return associated with the position is negative, the RORAC is negative and a tax shield is generated.

Historical RORAC

The earnings of a portfolio can be evaluated by calculating the change in the real value of the position, the financial costs associated with the portfolio and the average CAR during the period in question. This in turn gives us the capital compensation.

Expected RORAC

To evaluate the risk-return of a potential transaction, the change in value can be estimated by using the expected profits and the CAR of the position using current conditions.

Example

Suppose there is a portfolio of instruments for which the market value is US$100 million, the expected return is 7%, the financing cost is 5%, and the time horizon is one year.

Also suppose that the risk map for the portfolio was calculated and that, at a 99.86% confidence interval, the maximum unexpected losses are 20%.

VAR is defined as the maximum expected loss that could occur within the time horizon in question for the confidence interval specified. Therefore, the maximum estimated loss is 13%; i.e., the maximum unexpected losses (20%) less the expected return (7%). Thus, the VAR associated with the portfolio is 13 million.

To calculate the CAR (Figure 3-5), the VAR must be added to the financial costs of the position, which total 5 million. This gives a maximum potential loss at year-end of US$18 million. However, the CAR must cover these losses within one year, so in order to determine the CAR, the present value of the losses will be calculated using the risk-free rate, which is assumed to be equal to the financing rate. Therefore,

$$CAR = \frac{13+5}{1.05} = 17.14$$

Now we will determine the expected RORAC of the portfolio. To do this we will assume a tax rate of 35%. The expected revenues associated with the position are equal to the sum of the expected appreciation, plus the capital compensation, less financing costs.

Expected appreciation	=	7.00 million
Financing costs	=	–5.00 million
Capital compensation	=	0.86 million (17.14 • 5%)
Total	=	2.86 million

This results in an expected after-tax RORAC of:

$$RORAC = \frac{2.86}{17.14} \bullet (1-0.35) = 10.85\%$$

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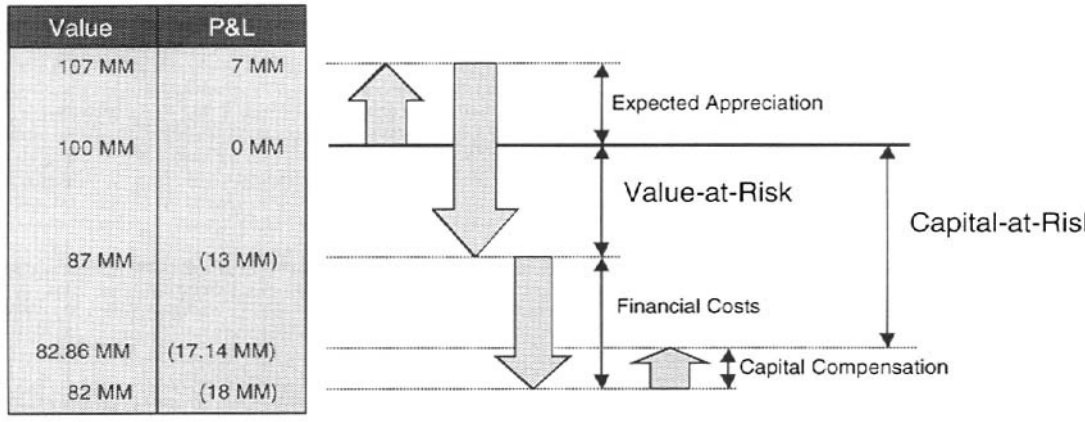
Figure 3-5. CAR Calculation



Controlling Market Risk

After identifying the risks to which the entity is exposed, and quantifying the related risk levels, a limit structure must be designed that reflects the risk management strategy the company wishes to follow. This structure is used to allocate resources to the different business units so that they can operate according to the goals set by management and provides a follow-up and control process that ensures that the established limits are not exceeded.

Although both creating and monitoring the limit structure are included in the concept of risk control, the design of the limit structure is really part of the management process, since it is the tool used to convey the type and amount of desired risks. Therefore, the limit definition process must be approved by the Executive Committee, based on the work of various committees, which are supported by the different operating areas. Thus, the only pure control process is the limit monitoring function, which is carried out by the risk analysis and control area.

Both functions will be discussed below:

- Definition of the limit structure
- Limit monitoring

LIMIT STRUCTURE

The question facing us is how to define this structure. We must keep in mind:

- What risk exposure does the entity want to manage in a global manner?
- What is the structure of the business units (current or future) of the entity?
- What types and amounts of risk will each unit assume?

The first question is related to the company's general goals, while the second is an organizational issue. However, the third question requires quantification of risks, and to do this we have defined various measures that are part of the global risk map of the entity (the sensitivity map or the profit and loss distribution). The limits may be structured using any of these

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measures, all of them, or a combination of them. The company's management, supported by the technical areas, must decide what combination and amounts most accurately reflect the risk strategy that it wishes to implement.

Three of the concepts presented previously will be considered as possible measures for establishing the limits:

- Nominal position
- Equivalent position
- Capital-at-Risk

The limits are of course subject to the same advantages and disadvantages as the different measures of risk. In addition, how each of the authorized products will be accounted for should be indicated when calculating usage of each of the limits.

Thus, we can define three basic matrices associated with each of the measures, which show the different limits established for each business unit. Each business unit may operate freely within the framework established by its limits. Therefore, if the unit were divided into subunits, portfolios or another similar structures, the manager responsible for the whole unit could decide how to distribute the global limit among them, provided that the unit's limit is not exceeded.

Nominal Position Limits

A matrix such as the following is defined for each business unit and each of the products to which these types of limits are to be applied. The total limit for each product is the sum of the limits for each unit. However, a total limit cannot be established for each unit since each product represents a different risk that cannot be aggregated through the use of nominal positions.

Nominal Position Limits

	Unit 1	Unit 2	...	Unit *u*	Total
Product 1	$NPL_{1,1}$	$NPL_{1,2}$	...	$NPL_{1,u}$	$\Sigma NPL_{1,j}$
Product 2	$NPL_{2,1}$	$NPL_{2,2}$	...	$NPL_{2,u}$	$\Sigma NPL_{2,j}$
...	...	...	...	...	...
Product *n*	$NPL_{n,1}$	$NPL_{n,2}$	...	$NPL_{n,u}$	$\Sigma NPL_{n,j}$
Total	NA	NA	NA	NA	NA

This type of limit structure is only useful for small portfolios that systematically invest in the same products. It would be useful, for example, for a unit that only transacts exchange-traded futures and wants to limit the open position in each. For each product its risk would be characterized by a single risk factor. However, as the portfolio becomes more complex, this approach is no longer useful since it is not possible to combine different products that behave similarly *vis-à-vis* specific risk factors.

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Equivalent Position Limits

A matrix such as the following is defined for each business unit and each of the risk factors to which these types of limits are to be applied.

Equivalent Position Limits

	Unit 1	Unit 2	...	Unit *u*	Total
Equivalent Instrument 1	$EPL_{1,1}$	$EPL_{1,2}$	...	$EPL_{1,u}$	$\Sigma EPL_{1,i}$
Equivalent Instrument 2	$EPL_{2,1}$	$EPL_{2,2}$	...	$EPL_{2,u}$	$\Sigma EPL_{2,i}$
...	...	...	...	...	...
Equivalent Instrument *n*	$EPL_{n,1}$	$EPL_{n,2}$	...	$EPL_{n,u}$	$\Sigma EPL_{n,i}$
Total	NA	NA	NA	NA	NA

As with nominal position limits, it is not possible to have a global aggregate limit for a unit because each equivalent instrument will be based on a different risk factor. However, this approach solves the problem of complex portfolios, since the limits are established not by product but by the risk factor to which there is exposure.

Capital-at-Risk Limits

A matrix such as the one below is defined for each business unit and each risk factor to which these types of limits are to be applied.

Capital-at-Risk Limits

	Unit 1	Unit 2	...	Unit *u*	Total
Risk Factors 1	$CARL_{1,1}$	$CARL_{1,2}$	...	$CARL_{1,u}$	$\Sigma CARL_{1,i}$
Risk Factors 2	$CARL_{2,1}$	$CARL_{2,2}$	...	$CARL_{2,u}$	$\Sigma CARL_{2,i}$
...	...	...	...	...	...
Risk Factors *n*	$CARL_{n,1}$	$CARL_{n,2}$	...	$CARL_{n,u}$	$\Sigma CARL_{n,i}$
Total	$\Sigma CARL_{i,1}$	$\Sigma CARL_{i,2}$	...	$\Sigma CARL_{i,u}$	

Unlike with the previous methods, in this approach it is possible to establish a global Capital-at-Risk limit for each unit, for each risk factor, and for the entity as a whole. The reason is that Capital-at-Risk is a homogeneous measure for all the products, since it incorporates the behavior pattern of each risk factor. However, it has a serious shortfall, which is that the results obtained cannot be added together. Therefore, the total Capital-at-Risk of an entity is not equal to the sum of the Capitals-at-Risk associated with each risk factor. Rather, it is dependent on the correlation coefficients between the different factors.

Therefore, a situation could arise in which the global limit of the unit is exceeded, despite the fact that the sublimits for each factor are within the prescribed limits. This creates a problem

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related to selecting a risk factor to act upon in order to reduce the global risk of the unit. Furthermore, if the unit limits are established based on a certain degree of diversification between various units' positions, it may be that each unit is in compliance with its limits but the total risk exceeds the total limit. However, this should not lead to a policy of establishing limits based on a "worst-case" scenario, with little diversification among the units, because this would lead to underutilization of capital.

LIMIT MONITORING

Once the limit structure has been established, the risk analysis and control unit is responsible for ensuring that the activity level of each unit is within the established limits and that none of the limits are exceeded without authorization from the company's Risk Committee.

This requires tools that enable the control area to evaluate the risks taken by each unit, based on the criteria established in the limit structure, and that also enable the traders to know their risk exposure, limit usage, and the impact of new transactions on limit usage. In general, business areas must not enter into transactions that exceed established limits unless they have authorization to do so.

In order for the control process to function properly, the same calculation methodologies must be used in all the phases involved. Implementation of a limit structure defined according to specific criteria is of no use if the same limits are not used by the traders to evaluate the risk that their transactions introduce and by the risk analysts to ensure compliance with the limit structure.

If the limits are exceeded, the analysis and control area must do an evaluation, and the excess must be verified with the business area involved. If the overage is not justified, the business area must cancel the transaction or execute an opposing transaction that cancels out the risk introduced by the first transaction. If the excess is justified, it must be approved by the Risk Committee.

Limit monitoring is done by replacing the defined limits in the cells of the matrices created previously with the real risk map of each unit. This results in three new matrices that show the usage of each limit and highlight those cells in which limit usage exceeds 100%. There should also be a special follow-up on limits that are underutilized, since some portion of the risk the entity was willing to take on is left unused. If the company's expectations have changed, the resources allocated to that risk factor should be redistributed to the factors that the entity believes will most improve the overall RORAC.

Nominal Position Limit Usage

	Unit 1	**Unit 2**	**...**	**Unit *u***	**Total**
Product 1	$NPLU_{1,1}$	$NPLU_{1,2}$	...	$NPLU_{1,u}$	$\Sigma NPLU_{1,i}$
Product 2	$NPLU_{2,1}$	$NPLU_{2,2}$	...	$NPLU_{2,u}$	$\Sigma NPLU_{2,i}$
...	...	...	...	...	...
Product *n*	$NPLU_{n,1}$	$NPLU_{n,2}$	...	$NPLU_{n,u}$	$\Sigma NPLU_{n,i}$
Total	NA	NA	NA	NA	NA

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Equivalent Position Limit Usage

	Unit 1	Unit 2	...	Unit *u*	Total
Equivalent Instrument 1	$EPLU_{1,1}$	$EPLU_{1,2}$	...	$EPLU_{1,u}$	$\Sigma EPLU_{1,i}$
Equivalent Instrument 2	$EPLU_{2,1}$	$EPLU_{2,2}$	...	$EPLU_{2,u}$	$\Sigma EPLU_{2,i}$
...	...	...	...	...	...
Equivalent Instrument *n*	$EPLU_{n,1}$	$EPLU_{n,2}$	...	$EPLU_{n,u}$	$\Sigma EPLU_{n,i}$
Total	NA	NA	NA	NA	NA

Capital-at-Risk Limit Usage

	Unit 1	Unit 2	...	Unit *u*	Total
Risk Factor 1	$CARLU_{1,1}$	$CARLU_{1,2}$	...	$CARLU_{1,u}$	$\Sigma CARLU_{1,i}$
Risk Factor 2	$CARLU_{2,1}$	$CARLU_{2,2}$	...	$CARLU_{2,u}$	$\Sigma CARLU_{2,i}$
...	...	...	...	...	...
Risk Factor *n*	$CARLU_{n,1}$	$CARLU_{n,2}$	...	$CARLU_{n,u}$	$\Sigma CARLU_{n,i}$
Total	$\Sigma CARLU_{i,1}$	$\Sigma CARLU_{i,2}$	...	$\Sigma CARLU_{i,u}$	

Market Risk Management

The business units' goal is to maximize profits through use of the resources allocated to them, while keeping the level of exposure to the risk factors within the limits established by the entity. Within these limits, the business units are free to make decisions about the management of current and potential risks. The traders of each unit base their expectations on market information and act on them by entering into transactions with other market participants.

The transactions entered into expose the value of the entity to different risk factors, which appears on its global risk map. As stated previously, this is not merely a control tool that facilitates supervision of limit compliance. It should also be used as a management tool. Usually, an entity's positions in financial instruments consist of a mix of heterogeneous instruments dependent on the same risk factors. Therefore, if we know the global risk map of the entity, we can quantify the contribution of each risk factor to the entity's value and the impact of changes in a factor. It also gives us a measurement of the real risk of losses facing the entity. The position map (equivalent portfolio) covers the first function, and the profit and loss distribution the second.

By using these two tools, the managers are fully aware, from a risk perspective, of their positions and of the amount of approved resources left unused. This knowledge, combined with the managers' expectations regarding the evolution of different risk factors, translates into decisions that modify the risk profile as efficiently as possible to achieve the ultimate goal of maximizing the Return on Risk-Adjusted Capital and creating shareholder value. However, the decisions that derive from these strategies must always be subject to the limits established by senior management and should not be exceeded without its approval, since they represent the level of risk the entity is willing to assume.

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The two basic risk management strategies that we will consider are:

- Speculative positions: When the managers' expectations and the global risk map of the entity indicate a situation that could potentially generate profits, the entity enters into speculative positions that exploit expected movements in risk factors to generate profits for the entity.
- Hedges: When the global risk map combined with managers' expectations indicate potential losses, or there is a desire to reduce the entity's risk, all or part of the entity's value are hedged. Any new transactions entered into change in value by the same amount but in the opposite direction than the value of the initial portfolio, *vis-à-vis* changes in the risk factors.

The first option obviously involves greater exposure to risk than the second, and equates to nothing more than taking a market view, in the form of positions in specific instruments. If the expectations are proven correct, the portfolio generates profits. If they proven wrong, a portion of the entity's value is lost. The second alternative keeps the value of the entity stable. If the expectations that led to the decision to hedge the portfolio are proven wrong, the entity foregoes profits the portfolio would otherwise have earned, but it does generate losses. In other words, it incurs an opportunity cost.

We will now discuss in more detail how hedging is performed and what its implications are, since it is more complex, from a technical and methodological point of view, than managing speculative positions. The latter is nothing more than taking positions in market instruments that generate profits if the risk factors move in accordance with managers' expectations.

A *hedge* is a transaction or series of transactions that is performed for all or part of the value of the entity. It eliminates risk *vis-à-vis* the selected risk factors (*hedged risk factors*).

Therefore, the goal of hedge transactions is to guarantee that the value of the entity does not change when the value of the hedged risk factors changes. This also ensures that the income statement item that these risk factors would affect is protected.

To enter into this type of transaction, we must have the global risk map for the part of the entity to be hedged. If the risks to which the entity is exposed, and the losses that the risks would introduce, have not been correctly identified and quantified, it is not possible to hedge.

We will use the same risk measures employed to generate the global risk map and establish the limit structure to analyze the different alternatives that may exist when a hedge is put on. In fact, if the manager is required to stay within the established limits, he/she must use the same measures that define the limits so that he/she can adjust the risk of his/her portfolio accordingly. Therefore, the two main concepts used to manage risks are the two components of the *global risk map:*

- Position map: *equivalent portfolio*
- Profit and loss distribution: *Capital-at-Risk*

The first tool takes into account only the dependence of the entity's value on each risk factor; the second takes into account the behavior of each factor.

HEDGE PORTFOLIO

The procedure for calculating the equivalent portfolio is the same regardless of whether all or a portion of the value of the entity is to be analyzed. Once the portfolio to be considered has been defined, each of its components is analyzed. The risk factors to which it is exposed are

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identified and the sensitivity of the portfolio value to changes in each factor is calculated. This gives us the sensitivity map of the portfolio. A market instrument that is representative of that factor is chosen and the equivalent position is determined. This process leads to a table such as the following, which gives the nominal positions in each of the equivalent instruments that replicate the portfolio value changes.

Equivalent Portfolio

Risk Factor	Instrument	Equivalent Instrument	Sensitivity	Units
Risk Factor 1	Instrument 1	N_1	$Sensitivity_1$	u_1
Risk Factor 2	Instrument 2	N_2	$Sensitivity_2$	u_2
...	...	...	...	
Risk Factor *n*	Instrument n	N_n	$Sensitivity_n$	u_n

Therefore, if the goal is to hedge the changes in portfolio, one only has to change the signs of the equivalent positions to construct the hedge portfolio[4]

Hedge Portfolio

Instrument	Hedge Position
Instrument 1	$-N_1$
Instrument 2	$-N_2$
...	...
Instrument *n*	$-N_n$

MANAGEMENT OF CAPITAL-AT-RISK

The impact of a new transaction on the *equivalent portfolio* is simple to determine. A sensitivity map is created for each risk factor of the potential transaction. It is then added to the sensitivity map of the entire portfolio in order to study its effect.

However, calculating the impact on the *Capital-at-Risk* is more complicated, because we must analyze the effect of combining the new sensitivity map with the actual evolution of the different risk factors, which results in a new profit and loss distribution. Unlike the sensitivity map, real risk of loss maps are not additive because they take into account the interrelationships between the different risk factors. Therefore, in principle, in order to analyze the new transaction, the global sensitivity map for the portfolio must be recalculated and the global risk map that includes the new conditions must be regenerated. In order to identify the effect on risk of changes in positions in advance, it is advisable to know the sensitivity of the Capital-at-Risk to changes in the sensitivity map.

[4] To perfectly hedge the changes in portfolio value, it would be necessary to ensure that the sensitivities of the real portfolio and the hedge portfolio remain the same for each of the possible changes in the risk factor. If the sensitivity is dependent on the magnitude of the change in the risk factor, one must also take into account second order effects (see p. 59, on higher-order risks).

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Therefore, the ideal would be to have a new concept that makes it possible to manage this situation simply by using the sensitivity map of the transaction. To do this, the CARDelta is defined as the change in the Capital-at-Risk of the portfolio with respect to the sensitivity to a risk factor. This can be expressed as follows:

$$\Delta CAR = \sum CARDelta_i \bullet \Delta sensitivity_i$$

This makes the concept of Capital-at-Risk linear and makes it possible to calculate the change in the Capital-at-Risk by including a series of transactions with a specific sensitivity map. Since sensitivity maps are additive, the change in the total sensitivity of the portfolio equals the sum of the sensitivities of the new transactions. Therefore,

$$\Delta CAR = \sum CARDelta_i \bullet \Delta sensitivity'_i$$

where $sensitivity'_i$ are the sensitivities to each of the risk factors of the new transactions. Therefore, once the CARDelta terms associated with each risk factor have been calculated, it is easy to determine the contribution of a new group of transactions to the CAR of the entity. The methodology for calculating the CARDelta terms is discussed below.

CARDelta

The change in the portfolio value is expressed as:

$$\Delta Value = \sum sensitivity_i \bullet \Delta factor_i$$

Therefore, by using matrix multiplication the volatility associated with the portfolio value is calculated as follows:

$$\sigma^2_{portfolio} = \mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}$$

where s is the sensitivity vector and $\mathbf{C}$ is the variance–covariance matrix of the different risk factors.

The CAR of the portfolio is given by:

$$CAR = K \bullet \sigma_{portfolio} = K \bullet \sqrt{\mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}}$$

where K is dependent on the confidence interval we wish to analyze and on the time horizon used. Therefore, for a 99.86% confidence level, K is equal to:

$$K = \frac{3}{1 + Z_{RF} \bullet T_{daily}}$$

Therefore, we derive for each of the sensitivities

$$\frac{dCAR}{dS_i} = K \bullet \frac{\sum C_{ij} \bullet S_j}{\sqrt{\mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}}}$$

Therefore, the vector *CARDelta* is equal to:

$$CARDelta = K \bullet \frac{\mathbf{C} \bullet \mathbf{s}}{\sqrt{\mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}}}$$

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As can be shown, by pre-multiplying the above vector by the sensitivity vector we obtain [5]

$$s' \bullet CARDelta = CAR$$

so that an additive relationship with which to analyze the CAR has been obtained. If, instead of multiplying by the sensitivity vector of the portfolio, one multiplies by a sensitivity vector associated with another group of transactions, one obtains the change that would occur in CAR if these transactions were included in the initial portfolio.

SECOND ORDER EFFECTS

The following two assumptions are made in the construction of the profit and loss distribution and the hedge portfolio:

- Only first order terms are considered (linear behavior) in the sensitivity analysis

$$\Delta value = sensitivity \bullet \Delta factor$$

- All the risk factors have an associated liquid, highly traded market instrument.

However, when analyzing a real portfolio these assumptions often cease to be valid. Therefore, when an instrument is priced at a premium over the representative market instrument, all that is being hedged is the common risk factor. The portion of the risk factor due to the premium remains open (*basis risk*). Additionally, when the portfolio is made up of products with options, the second order effects (*gamma*) can be very significant. Therefore, even though the portfolio is more-or-less hedged, there will be a change in real value if there is a substantial change in the risk factors.

These secondary effects must be analyzed, as they may be sufficiently significant to cause the hedge to be ineffective.

Basis Risk

Basis risk exposure occurs when the risk factors that define the behavior of portfolio value are not the same as the risk factors that define the behavior of market-traded instruments. Normally, the change in the value associated with any risk factor can be broken down into a change due to a market risk factor common to a group of instruments and a change due to the specific risk of the instrument itself. In other words, we assume that any risk factor can be expressed as the sum of a systemic risk factor plus a specific risk factor. Examples of this behavior can be found in the main products. Therefore:

- The rate of return on a fixed rate instrument is usually expressed as the sum of the risk-free rate of return (often the return on a bond with similar characteristics, issued by the local Government) and a spread that takes into account the specific factors of the instrument (such as credit rating, market depth, liquidity, etc.).

[5] By pre-multiplying by the sensitivity vector:

$$\mathbf{s}' \bullet CARDelta = K \bullet \frac{\mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}}{\sqrt{\mathbf{s}' \bullet \mathbf{C} \bullet \mathbf{s}}} = K \bullet \sigma = CAR$$

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- The return on a stock is usually expressed as a return that is dependent on market returns (through the *beta* of the company) and a return spread dependent on the specific characteristics of the company.
- In the international commodities markets, the price of an equivalent product in the largest international market (normally the Chicago exchanges) is used as a reference, and a premium is added to that price to capture the characteristics of the actual product different from the characteristics of the reference product: market, country, climate, quality, etc.

Therefore, the change in the risk factor could be expressed as:

$$\Delta factor = \Delta factor_{market} + \Delta factor_{specific}$$

such that the change in value is expressed by:

$$\Delta value = sensitivity \cdot \Delta factor = \text{sensitivity} \cdot \Delta factor_{market} + \Delta factor_{specific}$$

Therefore, the value is actually exposed to changes in two different risk factors, i.e., systemic risk and specific risk. However, the purpose of building the equivalent portfolio is to make the portfolio homogeneous based on risk factors that are easily available in a liquid and deep market. The instruments used to create the equivalent portfolio must be instruments representative of the market. However, these instruments are only affected by changes in the systemic component of market risk, so the hedge covers only this component (when calculating the hedge, it is assumed that the other factors do not change). Therefore, if the hedge portfolio is constructed, its change in value will equal:

$$\Delta value_{hedge} = - sensitivity \cdot \Delta factor_{market}$$

Therefore, by adding the hedge behavior to the initial portfolio behavior, we obtain the change in value of the total portfolio:

$$\Delta value_{total} = sensitivity \cdot \Delta factor_{specific}$$

This component of portfolio risk is referred to as *basis risk*; it is that part of the risk that cannot be hedged by normal equivalent portfolio analysis.

Returning to the three prior product examples, and assuming that a position in them is hedged through an equivalent position, this hedge may be of little use if there is a change in the risk factors:

- Assume that a position in a fixed rate instrument is hedged with an equivalent portfolio in risk-free fixed rate instruments whose prices are stable. If the fixed rate instrument issuer begins to have financial problems, the market will penalize it by requiring that it provide a higher-than-market spread. This means that the new return required on that instrument will increase by exactly the same amount as the change in the spread, but the return associated with the market will remain unchanged. Therefore, the value of the equivalent portfolio will not change, but the initial fixed rate instrument will suffer a loss.
- Assume that the purchase of a perishable commodity in a local Latin American market is hedged by the sale of futures on a representative commodity on the Chicago exchange. If, as a result of its specific characteristics, there is no demand in the local market for the product, its price will fall significantly. However, the price of the reference product will remain the same, the value of the hedge portfolio will not change, and the commodities purchased will be sold at a loss.

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- Assume that a stock purchase is hedged by selling the appropriate amount of index futures on the local stock exchange. While the stocks and the index will move similarly, the losses on one would be offset by profits on the other, and vice versa. However, if the company's situation were to deteriorate due to internal factors, the price of the stock would drop and would not be offset by market movements, because the stock price is due only to the specific company component.

The cases presented above could be considered extreme. However, the managers of the business, and those responsible for managing and monitoring risks, must give special attention to specific risk components in portfolios that are apparently hedged. The hedge works only for so long as there is no change in the market's perception of that specific component.

However, this does not mean that this effect cannot be controlled. In fact, the approach above assumes that the specific component and the systemic component move independently. This is not always true. A general increase in benchmark interest rates normally translates into lower ratings on issues and higher spreads, since it may be more difficult for the issuer to make payments on the debt due to the increase in its financing costs. With this in mind, we note that an equivalent portfolio with a slightly higher nominal position could hedge part of this effect. However, to achieve this it would be necessary to assume a series of interrelationships between the market risk factors and the specific factors, which are not well-defined and for which there is no solution unless the correlation is equal to one (1) or negative one (-1)[6].

Higher-Order Risks

In the sensitivity approach used previously, we assumed that the behavior of the value of a portfolio given changes in the risk factors follows a linear relationship and higher-order terms were eliminated. However, when the portfolio under consideration is made up of options or instruments with options, these terms (*gamma* effect) could be very significant. This effect is even more obvious if we extrapolate the global risk map.

The price of options or instruments with options depends on three risk factors[7]:

- Price of the underlying asset
- Volatility of the price of the underlying asset
- Interest rates through the maturity of the option.

---

[6] Assume that the change in the instrument price (ΔP) is equal to the sum of a market component (ΔP_m) and a specific component (ΔP_{spe})

$$\Delta P = \Delta P_m + \Delta P_{spe}$$

The change in the value of the initial portfolio plus the hedge, assuming that the market affects each in the same way, would be:

$$\Delta value = (N - N_c) \bullet \Delta P_m + N \bullet \Delta P_{spe} = K \bullet \Delta P_m + N \bullet \Delta P_{spe}$$

In order for the hedge to take into account the relationship between the specific risk and the systemic risk, the volatility of the total portfolio should equal zero, such that:

$$K^2 \bullet \sigma_m^2 + 2 \bullet \rho \bullet K \bullet N \bullet \sigma_m \bullet \sigma_{spe} + N^2 \bullet \sigma_{spe}^2 = 0$$

In this equation, K only has a real solution when the correlation is equal to one or minus one.

[7] The price of an option also depends on the period of time to maturity (*theta*) but is not included in this analysis, because it is not a risk factor. If market conditions do not change, the passage of time per se does not introduce any uncertainty, but there will be a change in value that would be known *a priori*.

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If we were to determine the sensitivity map of an option, there would be three contributions to first order risk:

- *Delta*: Sensitivity of the price of the option to changes in the price of the underlying asset.
- *Vega*: Sensitivity of the price of the option to changes in the volatility of the price of the underlying asset.
- *Rho*: Sensitivity of the price of the option to changes in risk-free interest rates:

Therefore, the change in the value of the option would be expressed as:

$$\Delta value = Delta \cdot \Delta price + Vega \cdot \Delta\sigma + Rho \cdot \Delta interest\ rates$$

However, in the case of options, the second order effects on the price of the option could be significant, and are defined as:

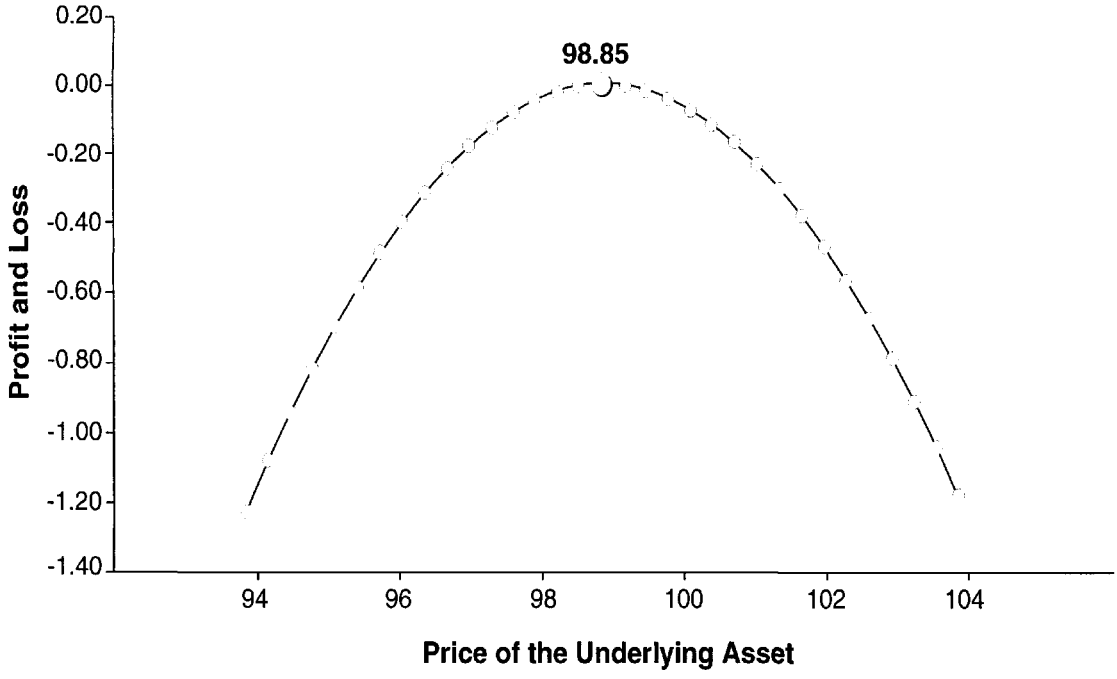
- *Gamma:* Change in the delta of the option given changes in the price of the underlying asset.

If we include this term, the instantaneous change in the value of the option is expressed by:

$$\Delta value = Delta \cdot \Delta price + \frac{1}{2} Gamma \cdot \Delta price^2 + Vega \cdot \Delta\sigma + Rho \cdot \Delta interest\ rates$$

Let us assume an options portfolio made up of a written put option and a written call option at the same exercise price on the same underlying asset, adjusted so that the *delta* of the portfolio is equal to zero. If we create a profit and loss profile resulting from an instantaneous

Figure 3-6. P&L of a Written Straddle Due to an Instantaneous Change in the Price of the Underlying Asset.



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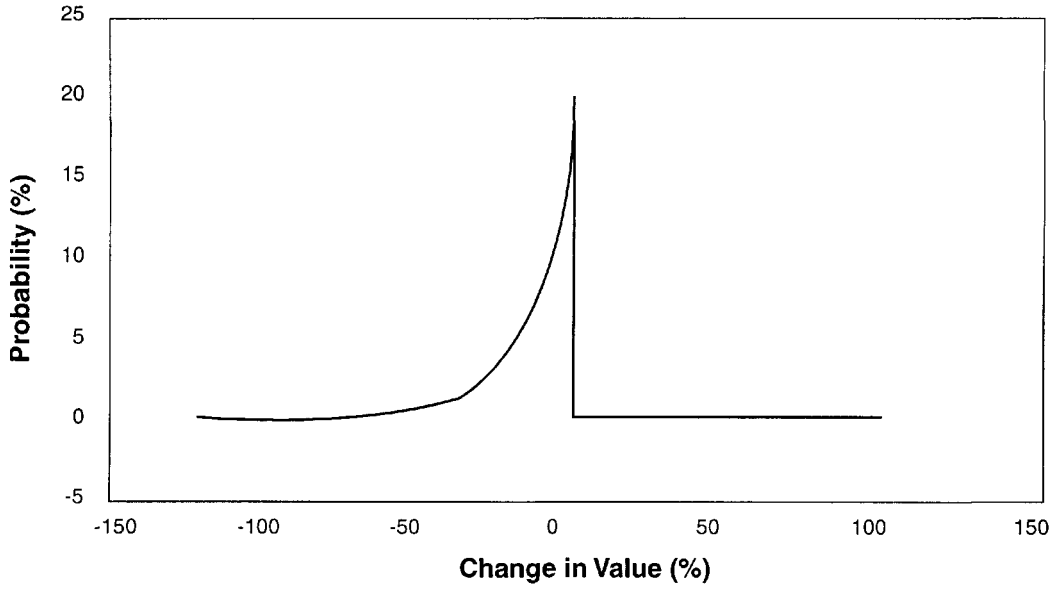
change in the price of the underlying asset, we get a graph such as that in Figure 3-6. It shows that the sensitivity of the portfolio to very small changes in the price of the underlying asset is very small, but increases significantly as the changes increase. In addition, at present,[8] any change in the price of the underlying asset would result in a loss for the portfolio, which nevertheless could become profitable again with the passage of time.

Now, if we assume a lognormal distribution for the price of the underlying asset and combine it with the results above, we obtain the profit and loss distribution for the portfolio, shown in Figure 3-7.

Figure 3-7. P&L Distribution of a Straddle



As we can see, this options portfolio does not have a normal distribution. Moreover, this portfolio would have a zero sensitivity map since its delta would be zero. However, the higher-order terms would introduce a risk of real, significant losses. Therefore, when the portfolio being analyzed consists of options or instruments with embedded options, it must be analyzed carefully from both a management and a control perspective. In addition, the effects that higher-order terms would introduce to the sensitivity analysis and generation of the profit and loss distribution should be taken into account. These problems are discussed in greater detail in chapter 9, which discusses market risk measurement methodologies, including Monte Carlo simulation.

Recommendations for International Standards on Market Risk

Recommendations of the Group of Thirty

- Entities should mark their positions to market at least once a day.

[8] The effect of the passage of time would, in this specific case, cause the portfolio to generate profits in a progressive fashion.

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- Derivatives portfolios should be valued at average market prices, including adjustments for expected future costs such as credit losses, costs of closing out the position, investment/financing costs or administrative costs.
- Entities should regularly analyze the components of the profits obtained and relate them to the risks assumed.
- Entities should measure the market risk of their positions daily and compare it to the established limits.
- Use of Value-at-Risk (VAR) is recommended for market risk measurement.
- All market risk components must be considered: absolute change in the price or interest rate (*delta*), convexity (*gamma*), volatility (*vega*), correlation, discount rates (*rho*) and passage of time (*theta*).
- Market risk limits should be established in accordance with the entity's risk appetite, the capital it wishes to risk, market liquidity, expected profits, business strategy and traders' experience.
- Entities should perform periodic simulations to analyze the behavior of their portfolios under extreme conditions (*stress testing*). Historical or projected scenarios can be used to illustrate abnormal market behavior. The effect of long periods of inactivity in which market liquidity drops significantly should also be simulated.

Recommendations of the Derivatives Policy Group

- Entities should evaluate their risk exposure through the use of quantitative methodologies that allow estimation of the change in portfolio value, as a means of then enabling the calculation of Capital-at-Risk.
- It proposes a method for calculating the Capital-at-Risk due to market risk, defining it as the maximum loss caused to a specific portfolio, which is exceeded once every one hundred biweekly observations. It points out the following as deficiencies of this method:
  - Historical volatilities and correlations may not be good predictors of the future behavior of risk factors.
  - Entities may suffer higher losses than those indicated by the Capital-at-Risk calculation. It proposes the use of extreme simulations with especially adverse scenarios to estimate these losses.

Recommendations of the Bank for International Settlements

- Entities should measure their market risk daily. They can do this using the Value-at-Risk method, scenario simulation, or sensitivity analysis.
- Entities should analyze their results adjusting for the risks assumed.
- Entities should mark their positions to market daily.
- A VAR method should be used to measure market risk (although it does not offer a specific technique). It recommends use of the following to measure VAR:
  - a single tail 99% confidence interval;
  - a time horizon of at least 10 days;
  - an historical observation period of at least one year for calculation of volatilities and correlations;
  - correlations between factors belonging to the same category as well as between types of risk factors;

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- The market risk measurement methodologies used should adequately consider the risks (delta, gamma, vega, etc.) associated with instruments that do not behave in a linear fashion (e.g., options).
- Entities should verify the validity of the models used to measure risks through the use of back testing and should check to see that the results of these tests are in line with the confidence interval used.
- Entities should periodically analyze how their portfolios would behave under extreme market conditions (stress testing).

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Chapter 4

Focus on Commercial Banking

Introduction

The primary goal of risk management within the commercial banking unit of a financial institution is the creation of value. This requires optimization of the relationship existing between returns obtained and risks assumed. The market risk—chiefly interest rate risk—of the commercial banking business will be analyzed below.

Commercial banking consists primarily of obtaining funds by paying a set rate for them (deposit rate), and then investing these funds at a higher rate (loan rate) while at the same time assuming an acceptable credit risk level. The goal of commercial banking is to generate earnings through the proper management of the credit, operational and business risks implicit in this activity. A commercial bank specializes in managing these risks and must be compensated appropriately for their management.

Notwithstanding, commercial banking necessarily entails exposure to both credit and market risk. Because of the range of products and the differing needs of clients, there is usually a mismatch between funding periods and placement periods, as well as between interest rate levels and the frequency with which these rates are adjusted. Nevertheless, for a number of reasons, commercial banking cannot and should not manage this market risk:

- Commercial banking does not specialize in market risk management, but rather in credit, operational and business risk management. Its business does not consist of market risk management nor is it compensated for it.
- The commercial bank takes funds for periods over which its customers wish to invest and lends funds for periods over which its customers wish to be financed. That is, commercial banking has little room to maneuver when it comes to reducing the temporary mismatch between the periods for which funds are obtained and those for which they are invested.

  The average funding period is usually shorter than the average loan period. Customers normally request loans and credits from financial institutions for periods over which, based on their capacity to save, they are able to repay these loans and credits. When the amount requested is significant (mortgages) the periods are usually longer than for a small amount (consumer loans). Depositors usually place their money in financial institutions for the short-term (demand deposit accounts), because when they wish to invest for the long-term they normally use other types of instruments (bonds, stocks, mutual funds, etc.).

A commercial bank's transaction portfolio creates market risk, and some area within the entity must be responsible for managing this risk. This function should be assigned to the Assets

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and Liabilities Committee (ALCO), which delegates the analysis and daily management of this risk to a specialized management unit, the Asset and Liability Management area (ALM).[1]

PORTFOLIO RISK

The ALM area is responsible for managing commercial banking market risk and is compensated based on this management. The ALM area should first determine a procedure that allows it to fully hedge the market risk of the commercial banking transaction portfolio, thereby transferring it to the ALCO portfolio in order to manage it. The procedure that institutions typically use to achieve the above goal is transfer pricing.

In general, transfer pricing means that each time a commercial bank performs an asset transaction (for example, a loan), the ALM area finances it through an internal transaction with the same structure (period, currency, fixed or variable rate, option to prepay, etc.), but almost free of credit risk, thus hedging the market risk that such a transaction produces in the commercial banking area. At the same time, whenever the commercial banking area performs a liability transaction (for example, receives a deposit), the ALM area receives funds, also through an internal transaction with the same structure.

The rates at which the ALM area finances or invests the transactions of the commercial bank are usually called transfer prices and must equal the cost assumed by the ALM area to hedge the market risk arising from the commercial banking transactions. The difference between the transfer prices and the rates charged or paid by the commercial bank to its customers is the financial margin (of loans or of deposits) that compensates the commercial bank for the management of credit risk (and also operational risk) and for the costs it assumes.

By following this procedure, the ALM area always has positions in the ALCO portfolio exactly equivalent (differing only in rate and credit risk) to the commercial bank's transactions, because the ALCO portfolio has the same exposure to market risk as the transaction portfolio of the commercial bank. The function of the ALM area is to manage the market value of the ALCO portfolio. Let's look at an example.

Suppose that the ALM area of a financial institution is currently using the following transfer rates: a 3-month rate of 5% and a 6-month rate of 5.5%. Let us further suppose that the commercial banking area of this institution performs the following transactions today:

- Situation A: Receives a deposit from a customer for 3 months at 4% and extends a loan to another customer, also for 3 months, at 6%. Therefore, the ALM area has to perform two internal transactions with the commercial banking area. First it receives a deposit for 3 months at 5% and then it extends a loan for 3 months at 5%.

  The two transactions performed by the commercial bank produce a total margin of 2% (6%-4%), which must be divided so that the commercial banking area is compensated for the credit risk it assumed and the ALM area is compensated for the market risk it assumed.

  The commercial banking area obtains a margin on the asset transaction of 1% (6%-5%) and another on the deposit transaction, also 1% (5%-4%), that is, it obtains a total margin of 2%. On the other hand, the ALM area obtains no margin, because it lends to and takes funds from the commercial banking area for the same period (3 months) and at the same rate (5%, transfer rate).

[1] As indicated in chapter 2, the ALM area is in fact the treasury of the institution. This area is responsible for analyzing and managing, from day to day, the financial risks stemming from the structure of the balance sheet of the institution.

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The above division is justified, because the two commercial transactions, which have the same term, do not create market risk—they merely result in credit risk. Therefore, the commercial banking area receives the total margin (2%) for having managed the credit risk, and the ALM area receives nothing since it did not manage any market risk.

- Situation B: Receives a customer's deposit for 3 months at 4% and extends a loan to another customer for 6 months at 6.5%. Thus, the ALM area has to perform two internal transactions with the commercial banking area. It first receives deposits for 3 months at 5% and then lends funds for 6 months at 5.5%.

  The two transactions performed by the commercial banking area produce a total margin of 2.5% (6.5%-4%), which must be divided such that the commercial banking area is compensated for the credit risk assumed and the ALM area is compensated for the market risk assumed.

  The commercial banking area obtains a margin for the asset transaction of 1% (6.5%-5.5%) and another for the deposit transaction, also of 1% (5%-4%), that is, it receives a total margin of 2%. For its part, the ALM area obtains a total margin of 0.5% (5.5%-5%).

  In this case, the two commercial transactions, because they have different periods, produce market risk and credit risk. Therefore, the division of the margin is also justified, since the commercial banking area receives a margin of 2% for managing the credit risk, and the ALM area receives a margin of 0.5%, which is approximately the cost of hedging the market risk.

If a financial institution were to implement the above approach, it would assure, through the ALM area, the management of the market risk inherent in the commercial bank's existing transaction portfolio; in other words, it would assure that portfolio risk was managed.

The ALM area can calculate the sensitivity of the existing transaction portfolio as the change in value of this portfolio *vis-à-vis* movements of approximately 10, 50 or 100 basis points in the market rates used to value these transactions.

One alternative available to the ALM area for managing the portfolio risk is to completely hedge this risk, which means building a portfolio of financial instruments (bonds, deposits, IRS [interest rate swaps], caps, floors, etc.), whose value changes symmetrically (by the same amount but in the opposite direction) with the changes in the value of the commercial bank's existing transaction portfolio that are caused by movements in interest rates.

STRUCTURAL RISK

Were the ALM area to hedge each and every transaction individually, as previously mentioned, the institution would have its portfolio risk completely hedged. However, this does not mean that the institution would have completely hedged the market risk of the commercial bank's present value. It merely means that the entity would have hedged the fluctuations in the market value of its current transaction portfolio.

We must bear in mind that when a company or business is valued, two components must be considered:

- The liquidation value: is the value of the assets the company has at that moment in time minus the value of the liabilities; that is, the amount that would be obtained if the company or business were to be liquidated.
- The going-concern value of the business: is the present value of the cash flows (tax-free distributable profits) that the business is anticipated to be capable of generating in the

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future. Therefore, the going-concern value of the business depends on the variables to which the cash flows are subject and the rate at which these flows are adjusted. For example, in an industrial company, the cash flows would depend on variables such as: sales price of products, sales volume, prices of raw materials, volume of purchases of raw materials, costs of conversion, etc.

In order to value the business of commercial banking, the two components mentioned previously must also be considered:

- The liquidation value is the present value of the existing transaction portfolio (assets and liabilities) of the commercial bank.
- The going-concern value of the business is the present value of the cash flows (tax-free distributable profits) that the commercial banking business is anticipated to be capable of generating in the future. By drawing a parallel with an industrial company, we can say in the case of the business of commercial banking that cash flows would depend on such variables as asset rates (sales prices of products), level of assets (sales volume), liability rates (prices of raw materials), level of liabilities (volume of purchases of raw materials), costs of the banking network (conversions costs), etc.

  Summary analysis of the variables behind the cash flows generated in the business of commercial banking results in identification of a common factor: all the previously mentioned variables depend directly or indirectly on interest rates, which is to say that the present value of the commercial banking business basically depends on interest rate movements and levels.

Based on the above, it is easy to understand that the ALM area must manage the market risk of the commercial banking business, and cannot limit itself to managing the portfolio risk. In other words, it cannot limit itself to managing the liquidation value of this business, but must also manage the going-concern value—that is, it also has to manage what we are going to call structural risk.

We can define the *structural risk* of the commercial banking business as the loss in value that the business could sustain as a result of interest rate fluctuations once the market risk of each of the existing transactions has been hedged.

In order for the ALM area to adequately hedge structural risk, it must be able to calculate the present value of the commercial banking business, as well as the sensitivity of this value to interest rate fluctuations. One alternative for performing the above calculations would be the following:

- Identify the variables behind the future evolution of cash flows (tax-free distributable profits) produced by the commercial banking business. For example, the customary asset and liability margins, fees for banking services, costs, etc., less the reinvestments needed for the business to operate.
- Model the behavior of each explanatory variable (margins, fees, costs, etc.) based on interest rates.
- Perform a simulation of the future evolution of interest rates.
- Calculate the value of the explanatory variables for each of the future interest rate scenarios and, therefore, the cash flow value as a combination of these variables.
- Determine the appropriate discount rate and use it to update the flows, thus calculating the commercial banking business value.
- The sensitivity of the present value of the commercial banking business may be derived by first calculating this value based on an initial rate scenario and then creating addi-

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tional scenarios 10, 50 or 100 basis points above or below the initial one. For each scenario the present value of the commercial banking business is calculated.

Just as we explained in the case of portfolio risk, one of the alternatives available to the ALM area for managing structural risk is to fully hedge this risk. It can do this by building and taking a position in a financial instrument portfolio (bonds, deposits, IRS, caps, floors, etc.), whose value changes symmetrically (by the same amount but in the opposite direction) with the fluctuations in the value of the commercial bank's business that are caused by movements in interest rates.

In general, though, we do not claim that the value of a business or a share of stock is insensitive to interest rate fluctuations, because if an entity opts for a strategy of making the value of its business completely insensitive to rate changes, in an environment of declining rates, its stock would offer a low return to investors in contrast to that offered by the stock market index. Therefore, entities must set a benchmark[2] on management of the value of their business; that is, they must decide how sensitive the value of their business should be to interest rate changes.

In order to establish this benchmark, entities can analyze their company's sensitivity to rate changes based on the historical behavior of:

- Their own stock (if listed on a stock exchange).
- Listed stocks of domestic or foreign competitors.
- Sector or general stock indices.

Once behavior *vis-à-vis* the interest rates expected by investors has been defined, the entity must analyze whether internal management should adjust the institution's sensitivity to the level that is generally discounted by investors, or whether it is appropriate to deviate from this target in order to create value through a series of cost reductions[3] in areas such as:

- Bankruptcy costs.
- Cost of debt.
- Tax costs.
- Costs of illiquidity.

If these aspects indicate such a deviation, the desired amount of sensitivity to rate fluctuations and the means of managing them internally must be communicated to investors. The RORAC and risk itself must be measured against deviations from this neutral position.

CONCLUSIONS

Summarizing the above, the following conclusions may be highlighted:

- The business of commercial banking creates credit, operational, business and market risk. The first three must be managed by the commercial banking area and the last by the ALCO through the ALM area. Each of these areas must be compensated based on the risks they manage.

[2] This aspect has already been discussed in chapter 1 under the subject of setting criteria for acceptance of risk as noted on p. 8.

[3] In chapter 1, see the section referring to the value of risk management on p. 11.

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- The transfer pricing system allows the ALM area to hedge the market risk of the commercial banking portfolio by transferring it to the ALM portfolio for management. This system also allows for efficient division of the margin of the transactions into two parts: one goes to the commercial banking area for management of the credit risk and the other goes to the ALM area for the management of market risk.
- Exposure to market risk (basically the interest rate) for the commercial banking business is made up of two components: portfolio risk, which stems from changes in the value of the existing commercial transaction portfolio, and structural risk, which stems from fluctuations in the business value of the commercial banking operation.
- The ALM area must manage not only the portfolio risk but also the structural risk of the commercial banking business.
- One alternative available to the ALM area for managing the market risk of the commercial banking business is to build two functionally equivalent portfolios with financial instruments (bonds, deposits, IRS, caps, floors, etc.):
  - The first portfolio must be built so that its value fluctuates in step with the value of the commercial bank's existing transaction portfolio. This portfolio allows management of portfolio risk.
  - The second portfolio must be built so that its value fluctuates in step with the value of the commercial banking business as such. This portfolio allows management of structural risk.

    By using the equivalent portfolios previously mentioned, the ALM area can measure and manage the market risk of commercial banking by directly applying the general concepts and methodologies mentioned herein (Value-at-Risk, Capital-at-Risk, RORAC, etc.).

The problem of calculating the transfer pricing curve and valuing commercial banking transactions will be analyzed in the sections that follow. The final section will discuss some of the methodologies traditionally used by financial institutions to measure market risk in the commercial banking business.

Calculation of the Transfer Pricing Curve

As stated in the introduction, transfer pricing should make it possible to achieve two basic objectives:

- Elimination of interest rate risk on the transactions balance sheet of the commercial banking area by transferring it to the ALCO portfolio for centralized management by the ALM area.
- Distribution of the margin on the commercial transactions such that each area is compensated according to the risk managed; that is, the commercial banking area is compensated for management of the credit risk, and the ALM area for management of the market risk.

In order to meet these goals, the ALM area must set transfer rates that reflect the cost of hedging the interest rate risk of the transactions of the commercial banking area. Thus, the transfer rates must be obtained from a market-based funding-investment strategy, without interest rate risk, for the flows created by the commercial banking transactions.

From a practical point of view, the transfer rates must be at least a good approximation of these strategies. The risk of prepayment is an important factor in this regard.

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As we will see in the section that follows, in the business of commercial banking, there are loans (chiefly mortgages) in which customers have the option to prepay principal in addition to the installments scheduled in the contract. In liability transactions, there is the risk that customers will prematurely withdraw time deposits. Logically, the ALM area must consider these risks in its hedging strategies, and their costs must be reflected in the transfer rates through appropriate adjustments.

When the commercial banking area grants a loan in which the customer has the option to prepay, an implicit prepayment option is also being sold to that customer. Therefore, the ALM area, if it wishes to hedge this risk, must calculate how much it would cost to purchase a similar option in the marketplace and must incorporate this cost into the transfer prices.

We must keep in mind that when the ALM area calculates the market cost of hedging a specific loan, it does so based on the contractual period of the transaction. Therefore, when a customer decides to prepay, he is reducing the term of the loan. This compels the ALM area to adjust the hedge, and this results in a cost that must be reflected in the transfer prices.

The ALM area must therefore calculate the value of the prepayment options[4] and adjust the transfer rates by a spread equal to this value (option-adjusted spread, or OAS). Investment banks that specialize in mortgage loan securitization sometimes publish these spreads.

In addition, in order for the transfer pricing curve to truly combine all hedging costs, other adjustments must be made. The principal adjustment arises from the spread that exists between the rates at which the ALM area can finance itself and invest in the interbank market (bid-ask spread). Typically, entities use existing average interbank rates for different periods to construct transfer rates, and subsequently make an adjustment to account for the bid-ask spread. This means that the ALM area is treating the commercial banking area as one of its best customers.

All fees the ALM area expects to pay, as well as all costs arising from the execution of hedging strategies, must be reflected in the transfer prices, even though most of these are already reflected in the bid-ask spread.

As an example of the problems that can result from an incorrectly determined transfer rate, it is interesting to analyze the case of some entities that use a single transfer rate (a 3-month interbank rate), which is applied to all commercial banking transactions, regardless of term. This practice leads to a series of consequences that undermine the goals of the transfer pricing system. The major implications are:

- A single transfer price does not allow the cost of hedging the interest rate risk to be incorporated into the commercial banking transactions.

  If the commercial banking area were to leave management of interest rate risk to the ALM area, it would have to finance itself or invest the proceeds of its transactions without mismatches in periods, durations, options purchased or sold to customers, etc. Logically, the ALM area would not be able to finance or invest the commercial banking transactions in the market at a single rate. The rate at which it would be able to operate in the market, and consequently the transfer rate as well, would depend on the term of the commercial banking transactions.

  Only a transfer pricing curve can eliminate that portion of the profits of the commercial banking area stemming from speculation on interest rates while simultaneously eliminating risk.
- A single transfer price leads to errors in setting prices for commercial banking transactions, opening up the possibility of rejection of profitable transactions and the acceptance of others that would result in losses. We are going to analyze this issue with two examples.

[4] This aspect is analyzed in greater detail in the section that follows.

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Example 1

Let us suppose that the yield curve is inverted such that the 3-month interbank rate is 6% and the 3-year IRS rate is 5%. In this scenario, the use of single transfer rate (for example, a 3-month interbank rate), would prevent advantageous transactions from being performed.

A customer requests a 3-year loan. A manager evaluates the customer's credit risk and estimates that he must pay 25 basis points over the market rate for the same period; that is, the customer must pay 5.25% (5% + 0.25%) for the loan. Let us suppose that the customer is prepared to pay this rate (5.25%).

However, if a transfer rate of 6% (3-month interbank rate) is applied to the transaction, the loan will result in a loss of 0.75% for the manager, unless interest rates change, and the most likely outcome is that the manager will decline to perform the transaction.

If a transfer rate of 5% (based on the term of the loan) had been applied, the manager would have performed the transaction and realized a profit of 0.25% per year for the next 3 years. For its part, the ALM area would have been able to cover the interest rate risk of the transaction by entering into a 3-year interest rate swap paying a fixed rate of 5% (the same paid by the commercial banking area), and thus receiving a 3-month interbank rate. The latter income would have been canceled out because the ALM area would have financed with 3-month interbank deposits the funds that it had to transfer to the commercial banking area through an internal transaction.

Example 2

Now let us suppose that the yield curve is positive, the 3-month interbank rate is 5%, and the 3-year IRS rate is 6%. In a scenario such as this one, the use of a single transfer price (a 3-month interbank rate) would lead the commercial banking area to perform transactions at prices much lower than current market prices, and it would be necessary to cover losses if it decided to hedge the interest rate risk.

A customer requests a 3-year loan. A manager evaluates the credit risk and estimates that he must pay 15 basis points over the market rate for the same period; that is, the customer must pay 6.15% (6% + 0.15%) for the loan. Let us suppose that the customer has obtained an offer from the competition to pay only 5 basis points over the market rate, that is, to pay 6.05% (6% + .05%).

The manager, believing that a transfer rate of 5% (3-month interbank rate) will be applied to him, decides to better the offer and grant the loan to the customer at 5.9%. For the first three months, the manager earns 0.90% p.a. (5.9%–5%). Subsequent earnings depend on the movements of the 3-month interbank rate. For its part, if the ALM area expects rates to rise, and decides to cover the interest rate risk of the transaction, it will enter into an IRS paying 6%. Since the institution is only receiving 5.9% from the customer, it will have a loss of 0.10% per annum for the next 3 years.

In this rate scenario, a manager might think that he could increase total annual profits substantially by lending for 3 years at 5.5%, because the volume of loans granted would be (hypothetically) 5 to 10 times greater than it would be if lending rates were higher than 6%. This could lead to an enormous volume of transactions that would generate certain losses if the interest rate risk were hedged.

- A single transfer rate cannot eliminate interest rate risk from the transaction balance sheet of the commercial banking area, so to manage this risk the area must assume the functions of the ALM area.

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In the second example, the margin of 0.9% would be achieved by the commercial bank during the first three months, but from that point on, its margin will depend on changes in the 3-month interbank rate. During periods when this rate is less than 5.9%, the bank will have a positive margin; when the 3-month interbank rate is greater than 5.9%, it will have a negative margin. Therefore, the commercial banking area will find itself having to manage the interest rate risk of its margin, which should be the responsibility of the ALM area.

- The single transfer price does not allow distribution of the margin on commercial transactions, which is required for the commercial banking area to be compensated for management of the credit risk and the ALM area for management of market risk.

  The fact that it is impossible to separate the profit earned from taking credit risk (which would be the margin over the hedging cost) from the profit earned by taking of speculative positions on interest rates prevents correct valuation of commercial banking transaction proposals based on the credit risk assumed, which is essential in the evaluation of whether the compensation is appropriate to the credit risk assumed.
- The single transfer rate does not allow the ALM area to measure and manage in an integrated way the interest rate risk created by the commercial banking business.

  As stated in the introduction, in order for the ALM area to be able to measure and manage the portfolio risk and the structural risk of the commercial banking business, a system of transfer prices that allows for hedging the interest rate risk of each transaction performed by the commercial banking area is absolutely essential. Our examples make it easy to understand that transfer pricing based on a single rate does not allow for such hedging.

Therefore, we recommend that financial institutions use a transfer pricing curve instead of a single transfer rate. Generally speaking, the interbank[5] yield curve is used as a baseline, because these rates reflect the marginal cost or revenue at which the ALM area can finance itself or invest in the interbank market.

Valuation of Commercial Banking Transactions

In general the procedure for valuation of a specific transaction is based on calculating the present value of the cash flows to be generated by this transaction in the future, i.e., between the current date and the maturity date. In order to be able to properly value a transaction, it is necessary to know or be able to calculate the due dates of cash flows and their amounts, as well as the appropriate discount rates.

In the case of treasury transactions, one usually knows the due dates, and either the amount (for bonds, deposits, etc.) or how to calculate it (for swaps, options, etc.).

Commercial banking transactions are valued on a case-by-case basis, based on the degree of specificity of the various contracts. In Table 4-1, three of the most common types of commercial banking contracts are listed, along with their degree of specificity.

[5] In the absence of long-term interbank rates (interest rate swaps), institutions may use rates given to customers with a high credit rating (preferential rates).

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Table 4-1. Degree of Specificity of Contracts

		Principal payments		Interest payments	
		Date	Amount	Date	Amount
Loans without options	Fixed rate	Known	Known	Known	Known
	Floating rate	Known	Known	Known	Method of calculation known
Loans with options	Fixed rate	Known	Method of calculation Known	Known	Method of calculation known
	Floating rate	Known	Method of calculation known	Known	Method of calculation known
Account	Demand deposit	Unknown	Unknown	Known	Unknown

The critical items for valuation of these three types of contracts are discussed below.

LOANS WITHOUT OPTIONS

In loans without options, due dates and amounts (amortization of principal and interest) are clearly defined in the contracts. Therefore, the only problem in valuing this type of instrument is determining the appropriate rates at which to discount these cash flows. To do this, institutions may proceed as follows:

- Divide the current portfolio of loans without options into groups based on the credit rating of the counterparties and maturity dates.
- For each of the above groups, determine the credit risk premium (credit spread). There are two ways to define credit spreads using credit ratings and maturity dates:
  - Use spreads based on the relationship between rates at which the issues of institutions with different credit ratings and different maturity dates are being priced and rates of credit risk-free assets (for example, government debt).
  - Calculate these spreads internally by estimating anticipated credit losses plus an adjustment for the risk premium. [6]

    The estimate of expected losses can be based on the entity's own experience (historical analysis of defaults of the institution's credit portfolio) or on a credit rating derived from tables of expected losses published by credit rating agencies.

    The risk premium adjustment can be defined to achieve the RORAC credit goal.

    The adjustment can also be obtained by taking the difference between market rates at which issues of entities (including those from other countries) with different credit ratings and different terms are being priced in relation to expected credit losses.

[6] We discuss the concept of expected credit loss (credit provision) in detail in chapter 5, which must be considered as a cost, given that we are dealing with the best estimate of losses expected. The margin charged to customers on transactions must be sufficient to cover the provision and earn a profit (risk premium) to justify the capital risked, in order to obtain the RORAC that adequately reflects credit considerations.

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- Calculate the credit risk-free rates (IRR) for different periods and add the previously calculated spreads to them, thus obtaining the yield curves for each of the credit ratings into which the portfolios have been divided.

LOANS WITH OPTIONS

In the commercial banking business, there are loans (chiefly mortgages) in which customers have the option to prepay principal in addition to the amounts scheduled in the amortization structure set forth in the contract.

When a commercial bank grants a loan with these characteristics, it is also implicitly writing customers a prepayment option, which they will exercise when the amount that must be paid to pay off the debt is less than the amount available upon replacing the loan with an identical one (with the same rate, maturity and prepayment options). This occurs when the repayment amount is less than the market value of the loan. When the commercial bank grants the loan, it must reflect the value of this option in the price of the transaction. The calculation takes into account any penalties that apply in the case of prepayment (generally a percentage of the prepayment amount).

The value of a loan portfolio with prepayment options at a specified moment in time is equal to the value of this portfolio without considering the options (this value is calculated as discussed in the preceding point) minus the market value of the prepayment options portfolio.

In order to value the prepayment options portfolio, it is necessary to develop a model that allows a statistical determination of the prepayment probabilities at different points in time during the life of the loans.

In general, a model with these characteristics calculates the balance expected to be prepaid by using two functions:

- Function 1. This function reflects the effect of a set of variables that customers have in mind when prepaying mortgages. Many variables may be used, but the most typical are:
  - The difference between the rate of the mortgage at that specific time and the market rate for mortgages for a period equal to the remaining life of the original mortgage. Logically, we can expect the coefficient associated with this variable to be positive, because the higher the mortgage rate in relation to the market rate, the higher the incentive to prepay.
  - The difference between the mortgage rate and the market rate when raised to an exponent higher than one. This variable captures prepayment acceleration, because large differences in rates cause an effect on prepayment that is more than proportional. The coefficient associated with this variable in the model is also positive, but its influence is not as great. In other words, the coefficient of this second variable is small (if it is very small, the variable may be omitted).
  - Proportion of the mortgage or group of mortgages already prepaid. This variable attempts to reflect the so-called "burnout" effect, which says that within a specific mortgage portfolio, the mortgages not already prepaid belong to customers less sensitive to variables that influence prepayment, so the rate of prepayments slows. We can model this variable at time t as: $\ln \frac{A_t}{B_t}$, where A_t is the outstanding principal at time t and B_t is the principal that would have been outstanding at time t if there had been no prepayment (payments made as specifically agreed in the contract).
  - A variable that reflects the effect of seasonality throughout the year. The tendency to prepay may depend on changes of residence (which is customarily greater at vacation time, the end of the school year, etc.), family liquidity (months of higher income), etc.

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- Function 2. This function basically depends on the age of the mortgage and attempts to reflect customer behavior that does not depend on a set of variables. It reflects the average intrinsic prepayment behavior of customers; the probability of prepayment tends to be very low during the first years, then increases, only to fall again as the mortgage ages.

DEMAND DEPOSIT ACCOUNTS

As previously discussed demand deposit accounts lack a high degree of definition and, therefore, are the contracts that present the most complex valuation problems.

The first issue is that, within the generic category called demand deposit accounts, there exists a wide range of commercial products, which should be separated into different groups for purposes of analysis. The separation criteria can be, for example, the compensation (accounts of low, average and high compensation) and the type of customer for which they are designed (individuals, businesses, etc.).

In order to value and calculate sensitivity to changes in deposit rates, we must develop models that explain the behavior of rates and balances of various account categories.

For example, we can develop a behavioral model for deposit rates based on the following equation:

$$CDDR_t = \overline{CDDR}_{t-1,t-n} + (a \bullet \Delta RR) + (b \bullet \Delta Sp)$$

Where,

- $CDDR_t$ is the current rate for demand deposit accounts
- $\overline{CDDR}_{t-1,t-n}$ is the average compensation for demand deposit accounts in the period from "t-n months" to "t-1 months." Tests must be performed to determine which historical period best fits the model.
- ΔRR is the change in the benchmark interest rate. We must decide what market rate to use as a benchmark in order to determine the deposit rates: generally it is a short-term interbank rate that is sufficiently liquid. The method for measuring the change in the benchmark interest rate differs for each category of demand deposit accounts. In general the change is the difference between:
  - The current benchmark rate (RR_t) or the average benchmark rate between the current date and a prior date $\overline{CDDR}_{t,t-m}$
  - The average benchmark rate in a prior period ($\overline{RR}_{t-m',t-n}$), where m' is the same moment in time or prior to m.
- The coefficient a associated with ΔRR is the sensitivity to change in the benchmark interest rate, as defined above. The sensitivity of deposit rates to changes in the benchmark rate is asymmetrical; that is, decreases in the benchmark rate affect deposit rates more than do benchmark rate increases.

  The sign of this coefficient is positive, because there is a direct relationship between the change in the benchmark rate and the change in the deposit rate. The value of this coefficient depends on:
  - The category of demand deposit account: the coefficient is usually higher for individual accounts than for business accounts. In other words, entities usually make a higher adjustment (positive or negative) for individual accounts than for business accounts given the same change (positive or negative) in the benchmark.
  - The sign of the change in the benchmark interest rate (ΔRR): the coefficient is higher when this fluctuation is negative and lower when positive due to the asymmetrical effect previously noted.

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- ΔSp is the difference between the existing spread and the desired spread. The spread is the difference between the benchmark rate and the deposit rate. The method for measuring the change in the spread differs for each account category. Generally it is measured as the difference between the two following magnitudes:
  - The desired spread (Sp_{de}). Entities try to maintain a desired spread between the benchmark rate and the deposit rate. When the actual spread is higher than the desired spread, competitive pressures are usually unleashed that force the entity to increase deposit rates. On the other hand, when the actual spread is lower than the desired spread, entities tend to lower deposit rates in order to achieve the desired spread. The desired spread varies for each account category (it is usually higher for individuals than businesses).
  - The average spread in a prior period ($\overline{Sp}_{t-m,t-n}$).
- The coefficient b associated with ΔSp is the sensitivity of deposit rates to the spread change defined in the previous point. The higher this coefficient, the faster the adjustment of the existing spread to the desired spread.

  The sign of this coefficient is negative, because there is an inverse relationship between the existing spread and the desired spread and the change in the deposit rate. When the existing spread is higher than the desired spread, the institution tends to increase the deposit rate in order to reduce the spread to the desired level. The reverse occurs if the change in the spread is positive.

  The value of this coefficient depends on the account category; for example, it is usually higher for business accounts than for individual accounts which means that the rate of adjustment of the spread toward the desired goal is usually faster on business accounts than on individual accounts.

A behavioral model must also be developed for account balances. Given that account balances depend in part on the compensation paid, it seems logical to think that some of the variables discussed in the model above might also explain changes in account balances. In the balance model, it is very important to reflect the effect of seasonality, not only on individuals (months with additional income, months of higher consumption, etc.) but also on companies (payment of payrolls, taxes, etc.).

Traditional Methodologies for Market Risk Measurement in the Commercial Banking Business

In this section we will first describe the methodologies that have traditionally been used by financial entities to measure market risk in the commercial banking business, and then analyze these methodologies in order to compare them with the alternatives previously discussed.

DESCRIPTION OF TRADITIONAL METHODOLOGIES

The first phase undertaken by institutions in the process of implementing a system for measuring the market risk of commercial banking is to create a model of the balance sheet for the commercial banking area in order to create an ALM balance sheet that will allow it to manage market risk (chiefly the interest rate).

Subsequently, and using the ALM balance sheet as a base, two types of methodologies are typically applied to measure the risk of commercial banking. These methodologies are the gap and simulation methodologies.

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Creating a Model of the Commercial Banking Balance Sheet

Creating a model consists of grouping all products and accounting entries comprising the commercial bank's balance sheet into balance sheet lines that behave similarly in terms of market risk. These groups of lines make up what is known as the balance sheet for asset and liability management or ALM balance sheet.

Creating a model relies on a superior knowledge of how commercial banking works, as well as its policies and products; therefore, three fundamental sources of information are usually referred to:

- Preparation of the confidential accounting balance sheet.
- Catalog of the commercial bank's products.
- Interviews with heads of commercial banking operations.

The process of defining and structuring the ALM balance sheet for commercial banking usually comprises the following stages:

- Sensitivity analysis. Within the commercial bank's balance sheet, first the entries sensitive to interest rate fluctuations are separated from those that are not. Subsequently, with the help of the product catalog, the products sensitive to a fixed rate are separated from those products sensitive to a variable rate.
- Grouping of products into ALM balance sheet lines. Once the commercial bank's products have been classified according to their sensitivity, they are grouped into ALM balance sheet lines with similar behavior, according to contract periods, benchmark rates, spreads, reset periods (variable rate products), currency, etc.
- Discussion of the model with the areas involved. Once a first estimate of the ALM balance sheet has been made for the commercial bank, a round of interviews is conducted with the areas of the institution involved. The goal of these interviews is to critique the model and reach a consensus, that is, to gather alternative opinions from those responsible for the products reflected on the ALM balance sheet lines, with regard to the following subjects:
  - Definition of ALM balance sheet lines.
  - Allocation of the institution's products to the ALM balance sheet lines.
  - Maturity dates and rate reset dates (floating rate products).
  - Operating characteristics of the products.
  - Potential for obtaining information needed to perform simulations of the ALM balance sheet line.
  - Policies governing contract periods and prices.
  - Customer options (prepayments).

When defining the commercial bank's ALM balance sheet, the number of balance sheet lines should be set so as to achieve a breakdown that captures and permits analysis of the current situation of the institution, while not making future maintenance of the balance sheet overly difficult. It must also provide the information needed to perform simulations.

Gap Method

The gap is the difference between assets and liabilities that are sensitive to interest rates (rate resets or maturity dates) within a specified period. Therefore, this gap is an index of the exposure of the commercial bank's balance sheet to interest rate fluctuations. It is a statistical

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measure that is useful as a first estimate of the interest rate risk implicit in the current portfolio of the commercial bank, but does not project the future.

The existence of a positive gap (in which the volume of sensitive assets due to mature or be repriced is greater than the volume of sensitive liabilities due to mature or be repriced) within a specified period means that a drop in market interest rates (benchmark rates) will have a negative impact on the financial margin, because financial revenues will decline to a greater extent than expenses when rates or maturities change on a larger volume of sensitive assets. On the other hand, an increase in interest rates will have a positive affect on the financial margin, because financial revenues will increase by more than expenses. On the other hand, the existence of a negative gap within a specified period means an increase in the financial margin if rates fall and a decline in this margin if rates increase.

The gap method gives a very basic estimate of the change in the financial margin, which is calculated by multiplying the gap by the anticipated change in benchmark rates. This estimate has the following limitations:

- Assumes that volumes always remain in balance and are always renewed at maturity.
- Assumes parallel shifts of yield curves and fails to consider the possibility of specific movements for different terms on these curves.
- Assumes that the change in rates affects all periods, currencies and products equally and fails to consider sensitivity to interest rate fluctuations.

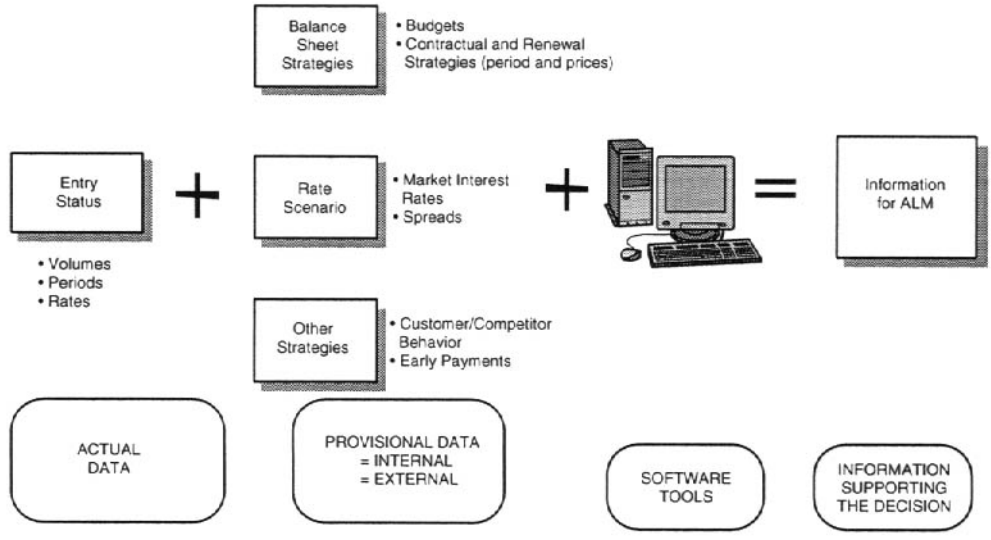
Simulation Method

Simulation is a technique for projecting the financial margins and value of commercial banking based on combining possible interest rate scenarios with policies governing the institution's contractual periods, prices and budgeting strategies.

This technique requires a significant amount of information (Figure 4-1), given its highly dynamic nature. Specifically, for each line of the ALM balance sheet, we need to know:

- Actual data: balance by maturity date or reset date and rates.
- Forecast data: budgets, contractual policies regarding periods and prices.

Figure 4-1. Simulated Method



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The objective of this technique is to estimate, based on all of the above information, the commercial bank's future balance sheets at different points in time, by simulating the evolution of its financial margin and value under different scenarios for benchmark rates and budgets. The efficiency of this method basically depends on the ability of the institution to foresee the evolution of the balances of its commercial banking products, as well as of its contractual policies governing periods and prices.

COMPARATIVE ANALYSIS OF METHODOLOGIES

The gap method is to some extent a very general estimate used to measure portfolio risk. We have previously stated that in order to measure the market risk of an existing portfolio of commercial banking transactions, the ALM area must calculate the value of each transaction in order to then calculate the sensitivity of the portfolio to interest rate fluctuations.

Each gap represents a position, which allows us to estimate the change in value of the current portfolio. However, this estimate is very inaccurate because:

- The gap does not calculate the present value of the portfolio, so it is impossible to determine the exact amount to protect in the face of adverse rate fluctuations. This is particularly important when the portfolio contains loans to companies or bonds with a low credit rating. For example:

  A loan of 100 million Chilean pesos, at a fixed rate with 5 years remaining to maturity that was granted to a counterparty whose credit rating has declined significantly since the loan was granted, has (in the absence of movements in market interest rates) a present value (for example, 70 million pesos) much lower than its nominal value, thus indicating a high probability of bankruptcy. The fluctuations in this value that must be hedged. The gap approach does not consider this: if the loan were financed with a transaction with the same maturity at a fixed rate, the gap analysis would show no risk. However, the latter payments of the loan granted have a high probability of not being paid, whereas the cash flows of the financing transaction must be paid in order to avoid bankruptcy of the bank itself. Therefore, the sensitivity of the financing transaction, whose present value is close to 100 million, is greater than that of the loan. The difference in values leads to unhedged market risk.

- The gap does not allow for value recalculations immediately following changes in benchmark interest rates. This calculation can be done very simply when the position is part of the treasury, through sensitivities or swaps. The gap can be built by grouping maturities around the terms of the appropriate benchmark interest rates. This method allows the institution to obtain an idea of sensitivity (through duration), but this is not explicitly reflected in the gap.
- The gap does not adequately reflect the options included in transactions. A hypothesis is typically made about the behavior of customers when exercising options (for example, prepaying mortgages) under various scenarios. Since the option value is unknown and no model of fluctuations based on rate changes is created, it is impossible to determine how to stabilize it (hedge it) or how to measure the full risk by assigning probabilities to levels of loss.

  Moreover, scenario analysis opens uncertainty about what the position actually is while providing no clear answers. For example:

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If the principal of fixed-rate mortgages that customers must pay within 5 years reaches 100 million Mexican pesos, we can replace it with 80 million in a scenario of interest rates that are 2 points lower (assuming that the remaining 20 million will be prepaid) or with 60 million if rates are lowered by 3 points, or leave it as is in a scenario of rising rates. But then, how much must be financed at 5 years in order to eliminate the risk: 100, 80 or 60 million? We can choose the amount of the most likely scenario, but this means that the accuracy of the position depends on the accuracy of the expectations themselves, and two institutions with the same portfolio can thus believe their positions are different.

- In the gap method, demand deposit accounts are arbitrarily assigned to one or more time buckets based on attempts to distinguish those whose rates are sensitive to market rates (for example, interbank) from those that are insensitive. As in the case of options, only an analysis of their present value and its changes when the yield curve is modified can specifically reflect the risk and indicate the transactions to be performed in the financial markets in order to close it out, if desired.

Therefore, the gap approach cannot replace management of portfolio risk based on the present value of the portfolio and its sensitivity to interest rate movements.

For its part, the traditional method of margin simulation attempts, to some extent, to measure structural risk, but it has obvious deficiencies in comparison with structural risk management based on the value of the business:

- In traditional simulation methodology, future scenarios are not realistic, because they are based on forecasting, several years into the future, the complete structure of the balance sheet (balances, maturities, proportion at fixed rate and variable, etc.) and the hedging decisions to be made at future points, depending on the market situation and the expectations of managers regarding the future. Those institutions that apply this type of methodology typically do not use horizons of more than 3 years in their analysis.

  In the present value management approach, all transactions are to be fully hedged, so projections are concentrated on large items and margins by monetary unit. These projections are obtained by using the entity's budgeting process and models that relate transaction amounts and margins to interest rates. These projections are much more reliable than projections of the balance sheet structure. The fact that future transactions are individually hedged allows concentration of the analysis on the commercial banking business, thus separating it from positions taken in the financial markets. If this does not occur, the judgment of the market risk managers is being included, implicitly, in the future margin. It even means that hedging decisions are being made today based on the positions that may or may not be open in the future, which is illogical.
- Traditional simulation methodology typically centers on the financial margin, or on operating margin, without including costs or calculating distributable profits (or free cash flows), making it impossible to determine the value of the business and its sensitivity to interest rates.
- Margin analysis over a limited number of years (usually no more than 3) fails to consider the substantial portion of the entity's value that is due to its operations over the long-term. Present value management is equivalent to managing all future profits, not merely those from a few years, weighting them based on the time value of money. If management's horizon is arbitrarily limited, it may sustain losses on margins in subsequent years because of interest rate changes that had already been anticipated by

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long-term rate changes, as reflected in government bond issues, but against which no measures had been taken.

If the nature of portfolio and structural risks is analyzed, it is easy to understand that an entity can and must plan for change over time in its structural risk, but attempting to plan for change over time of its macroeconomic risk, as in the simulation method, makes no sense, because this means trying to forecast what its portfolio of commercial transactions and its actual hedge are going to be within a few months or years. It is like trying to predict today what the position of a trading portfolio will be in the future.

We can understand that, given an environment of stable interest rates, ample financial margins, highly stable behavior among customers and scarce competition, if institutions can manage market risk solely through balance sheet strategies, they will be inclined to use the traditional methodologies previously discussed.

On the other hand, in a volatile environment with reduced margins and strong competition, management of the market risks inherent in commercial banking takes on strategic importance and must be dealt with more exhaustively and precisely. In this case, institutions should attempt to use the approach outlined in this book, which is to execute strategies with financial instruments (bonds, deposits, IRS, caps, floors, etc.) in order to manage and hedge the market risk—including both its portfolio and structural components—of commercial banking.

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Chapter 5

Credit Risk Management and Control

Introduction

Credit risk is generally defined as the possibility of suffering losses if clients and counterparties fail to meet their contractual obligations due to insolvency.

A financial entity assumes credit risk in its various lines of business. In the commercial banking business (corporate, small business, individuals, etc.) entities assume credit risk related to the loans, lines of credit, guarantees, etc. that they provide. In treasury activities entities assume credit risk related to balance sheet assets (bonds, deposits, stocks, repos, etc.) and to positions in OTC derivatives (forwards, swaps, options, etc.).

The nature of credit risk and related risk management and control criteria are the same for commercial banks and treasury departments. The only difference lies in the specific methodology to be applied to the different types of instruments in these lines of business.

Entities should manage and control credit risk on an aggregate basis, taking into account both commercial banking and treasury positions. In addition, counterparty credit risk limits should be allocated for all types of transactions (commercial bank and treasury). Limit usage should also be monitored on an aggregate basis.

To enable adequate credit risk management and control, the following questions must be answered:

- Questions regarding potential losses (risk):
  - *What is the potential loss in case of counterparty bankruptcy?* To answer this question, the company should calculate its *credit exposure* by position.
  - *What is the expected credit loss for each transaction?* To answer this second question, the company should calculate the *credit provision* for each outstanding transaction.
  - *What is the maximum estimated credit loss for a portfolio of transactions?* To answer this question, it is necessary to calculate the *credit risk capital*.
- Questions related to expected and actual profits:
  - *What return is expected on the credit risk capital of the portfolio? What were the profits in a past period? How do you compare those profits to the Capital-at-Risk in that period?* To answer these questions, it is necessary to calculate the credit RORAC, or Return on Credit Risk-Adjusted Capital.
- Questions related to the credit position:
  - *How should the credit position be stated? Should the basis be nominal amounts, mark-to-market values, risk measures (exposure, provision, capital, etc.)? How should diversification be taken into account? How do new transactions affect potential losses and expected profits?* To answer these questions, the company must decide how to describe its *credit position*.

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The first part of this chapter begins to answer the above questions. The second part summarizes the fundamentals of credit risk in commercial banking and outlines their similarity to the credit risk related to treasury operations. The third part develops in detail all the aspects related to credit risk management and control in treasury operations.

CREDIT EXPOSURE

Credit exposure measures the loss that would result at a specific time if a counterparty were to default on its contractual obligations (because of the negative effect, including bankruptcy, such obligations would have on the counterparty) and assumes a recovery rate of zero. Note that credit risk is only generated by balance sheet assets or off-balance sheet items that represent collection rights now or in the future.

Credit exposure has two components: current exposure and potential exposure. Current exposure is equal to replacement cost, while potential exposure estimates future changes in the value of the position. An entity's *current credit exposure* is equal to the cost of replacing existing transactions at current market rates or prices (market value), provided that this market value is positive for the entity. Current credit exposure is the cost of replacing a transaction in the event of counterparty bankruptcy.

Potential credit exposure represents potential changes in credit exposure during the life of a transaction given its particular characteristics and changes in market conditions. Potential credit exposure can be estimated accurately only if the distribution of possible values of the transaction and their related probabilities are known. Because this is very difficult to calculate, potential credit exposure is generally defined with the following two curves:

- Maximum potential exposure: maximum value of the transaction (or zero if negative), at each point in time, for a given confidence level.
- Average potential exposure: expected value of the transaction (or zero if negative), at each point in time.

An important factor to be considered in evaluating credit risk is whether collateral exists that would become the property of the entity in the event of default. Credit exposure is reduced by the market value of the collateral.

CREDIT PROVISION

The credit provision for a specific transaction is equal to the present value of the expected credit losses for the time remaining to maturity of the transaction. The expected loss on a position due to counterparty bankruptcy at time t equals:

$$\textit{Expected credit loss}_t = (1 - p_r) \bullet c_t \bullet q_t$$

where C_t is the expected value of the transaction at time t (credit exposure),[1] q_t is the probability of counterparty bankruptcy at time t and p_r is the recovery rate. Therefore, the credit provision

[1] Credit risk exposure exists only if the market value of the position is positive from the point of view of the company on that particular day.

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for a specific transaction equals the present value of the sum of the expected credit losses for the time remaining to maturity of the transaction:

$$Credit\ provision = (1 - p_r) \bullet \sum_{t=1}^{n} C_t \bullet q_t \bullet D_t$$

where D_t is the discount factor from time t to the present.

The credit provision should be regarded as a cost because it is the best estimate of expected losses. The margin charged to customers on transactions should be large enough to cover the credit provision and earn a profit (risk premium) which compensates for the Capital-at-Risk. The credit provision should be booked in advance as an anticipated loss when marking positions to market.

CREDIT RISK CAPITAL

Since the credit provision is taken into account when pricing transactions, the entity is protected from expected credit losses. However, if actual credit losses exceed the credit provision for a specific period and the company does not have adequate capital, it can go bankrupt.

The *credit risk capital* must cover the maximum estimated loss of portfolio value due to credit losses (Figure 5-1). Such a maximum loss should be determined for a particular confidence interval and time horizon. A reasonable time horizon is a year, which is sufficient to observe changes in credit quality and to adjust available capital. In addition, it facilitates the calculation of an annual return (RORAC). The selected confidence interval depends on the credit rating desired by the entity. For example, a confidence interval of 99.8%,[2] which implies an investment grade rating, indicates that bankruptcy will be avoided in 99.8% of years.

In order to calculate credit risk capital, one has to determine the maximum credit provision for one year that produces a certain probability (i.e., confidence interval, for example 99.8%) that actual credit losses during the year will not exceed the provision. The difference between the one-year maximum credit provision and the one-year actual credit provision is the credit risk capital. The entity must have this amount of capital available in order to avoid bankruptcy in case of counterparty bankruptcy.

CREDIT RORAC

Credit RORAC is the Internal Rate of Return (IRR) earned by shareholders in return for their initial capital contribution, which is exposed to credit risk. RORAC also takes into account subsequent withdrawals or injections of capital and profits earned throughout the life of the transaction. Credit RORAC should be calculated based on future expectations to determine whether a transaction should be done and using historical data to evaluate actual results.

In order to calculate the *Return on Credit Risk-Adjusted Capital (credit RORAC)* the entity must estimate the credit risk capital that must be allocated throughout the life of the transaction portfolio. For each transaction, the return shareholders will receive on the credit risk capital is

[2] This confidence interval is the one required for the entire entity after taking into account the effects of diversification. Therefore the confidence interval could be somewhat lower for individual portfolios or risks.

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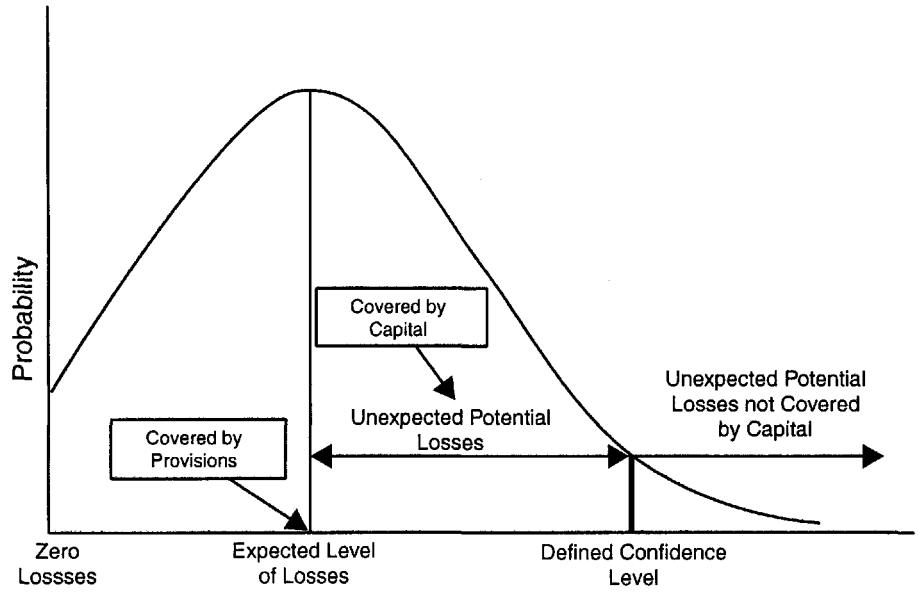
Figure 5-1. Potential Losses Due to Credit Risk



approximately equal to the discount rate that makes the net present value of these three cash flows zero:

- Expected after-tax return;
- Capital injections[3] or withdrawals which shareholders make or receive over time;
- Capital compensation[4] (after-tax), which is earned by investing the credit risk capital in risk-free assets.

CREDIT POSITION

The *credit position* is an estimation of the credit risk faced by the company and must have clear parameters that enable macro-level decision-making. The estimation process should concentrate on selecting a credit risk portfolio that maximizes the return on the capital risked. The portfolio must be divided into risk categories by sector, country, credit rating and maturity.

Three different measures of risk should be calculated for each category: credit exposure, Capital-at-Risk, and credit provision. This approach paints the full picture, although it also results in a large volume of data. Eliminating any part of the information is hazardous, since the view offered by each piece of data has limited use in isolation:

- Current exposure does not measure potential future losses.
- Potential exposure estimates future losses. However, maximum exposure overestimates the risk of derivatives while underestimating the risk of loans. In the former case it is unlikely that the maximum exposure will be exceeded, while in the latter case it is likely

[3] In case of an annual credit risk capital, shareholders should inject enough capital into the company to cover the potential losses during the year. The shareholders can withdraw capital in the years when estimated Capital-at-Risk is lower than the amount of capital on hand. They have to inject more capital in the years when estimated Capital-at-Risk exceeds the amount of capital on hand.

[4] This concept was explained in Chapter 3 in the discussion of Capital-at-Risk.

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that it will be surpassed in case of bankruptcy. Meanwhile, average exposure underestimates the risk of derivatives.

- In any case, exposure does not take into account the risk of bankruptcy. This makes it difficult to identify the riskiest areas. The credit provision does incorporate the probability of bankruptcy. However, since it is an average, it is not an adequate risk measure.
- Credit risk capital takes all risk into account in a single number, including the probability of bankruptcy throughout the life of the contract and the probabilities of all the possible exposures. Therefore it is theoretically an excellent measure of credit risk and exposure. Nevertheless, its use presents various problems:
  - The combined credit risk capital for a portfolio depends on the diversification effects of the transactions in the portfolio. If such effects are not taken into account, credit risk is overestimated. If they are, risk depends on the combination of positions in the portfolio.
  - Credit risk capital depends on numerous market (interest rate and foreign exchange rate volatility) and credit (changes in credit quality) factors. This makes it difficult to determine the contribution of each factor to the final result. An increase in interest rate volatility can change the level of risk substantially. This is realistic but makes it more difficult to use Capital-at-Risk figures intuitively.

Another way to summarize the credit position is through an equivalent loan portfolio. In the equivalent portfolio, each actual transaction with a counterparty is represented by a portfolio of bullet loans to the same counterparty, whose maturities occur throughout the life of the actual transaction (every six months, for example). The current and expected Capital-at-Risk of the actual transaction and the equivalent portfolio must be equal at all times. The equivalent portfolio for a particular transaction is constructed as follows:

- Determine the number and maturity dates of the loans to be included in the equivalent portfolio (for example, one every six months until the final maturity of the actual transaction).
- For the dates on which each equivalent bullet loan matures, calculate the current and expected Capital-at-Risk figures for the actual transaction.
- Using an arbitrary but consistent notional principal value, calculate the Capital-at-Risk for each equivalent bullet loan at the same points in time for which the Capital-at-Risk figures for the actual transaction were calculated.
- Determine the notional amount of each equivalent bullet loan by equating the Capital-at-Risk for the actual transaction, at each given point in time, to the sum of the Capital-at-Risk figures of the equivalent loans for the same points in time.

The advantage of the equivalent loan portfolio is that it represents the actual portfolio with simple instruments that are easy to interpret while retaining the same risk measure (Capital-at-Risk). However, it is necessary to recalculate the equivalent portfolio frequently because the relationship between the actual transaction and the equivalent portfolio varies according to market conditions. After the position has been constructed, sensitivity analyses must be performed to simulate the effect of new positions on the credit risk capital and the portfolio return.

The credit exposure calculation facilitates credit risk analysis on an aggregate basis, since the credit exposure calculation must take into account both commercial bank and treasury exposures. Counterparty credit limits should be assigned and usage of the limits should be monitored on an aggregate basis.

Given everything stated about these credit risk measures (exposure, provision, Capital-at-Risk, and equivalent loan portfolio) that define the credit position, the close relationship

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between market and credit risk is apparent. Credit risk depends on the value of the positions at different points in time (current and potential). Chapter 10, which discusses emerging markets issues, is therefore very applicable to credit risk.

We have demonstrated the need to analyze, evaluate, and control credit risk on an aggregate basis. We shall now briefly discuss credit risk in the commercial banking business, and then will concentrate on credit risk for the treasury, answering each of the questions posed in the beginning of the chapter.

Credit Risk in the Commercial Bank

This section of the chapter outlines the calculation of the credit provision, credit risk capital, and credit RORAC for a commercial bank. The objective is to lay a foundation on which to build the discussion of the treasury operation in the next part of the chapter.

CREDIT PROVISION

In a commercial bank, the expected credit loss (credit provision) equals the average expected present value of non-payments in a particular portfolio during a particular period. In general, this credit provision is equal to the product of three factors:

$$Credit\ provision = (1 - p_r) \bullet \sum_{t=1}^{n} C_t \bullet q_t \bullet D_t$$

where q_t is the probability of counterparty bankruptcy at time t (expected delinquency rate), C_t is the expected value of the position at time t, p_r is the recovery rate and D_t is the discount factor.

Expected Delinquency Rate

Banks should estimate the expected delinquency rate by sector and time period. To accomplish this, clients must be classified by credit rating. This classification is then translated into a default probability for a particular period (e.g. a year).

When banks begin to develop a credit risk management system, they often rely on information from ratings agencies, which publish annual default probabilities by credit rating (for example AA, A, BBB, etc.). Banks generally equate their internal credit ratings to the agency ratings in order to utilize the default probabilities published by the agencies (generally the banks use an average).

As banks gain more experience with credit risk management, they begin to use their own internal loss probabilities, which take into account historical default percentages in the loan portfolio by credit rating and year.

Internal credit rating methodologies are usually based on financial statement analysis when that information is available. Small businesses and private banks are evaluated by using credit scoring. Regardless of the internal credit rating methodology used, results should be comparable between sectors.

Credit Exposure

Banks must estimate the maximum economic loss that could occur in case of default. In general, these estimates are made for specific time periods (such as a year) for simplicity's sake. The complexity of these estimates depends on the product involved.

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For balance sheet transactions, total risk equals total capital plus outstanding interest. For products such as credit lines, where the risk varies based on the balance from time-to-time, risk should be estimated as a percentage of the total credit line.

The risk of off-balance sheet transactions depends on the type of transaction and its term. For example, a guarantee granted by the company to a client creates the same credit risk exposure as a loan of the same amount with the same maturity.

Recovery Rate

The recovery rate depends on the type of instrument and client. To estimate it, companies must rely on their historical experience. The existence of guarantees is an important factor in determining the recovery rate. Banks should analyze the types and levels of existing guarantees.

CREDIT RISK CAPITAL

As indicated earlier, banks should allocate capital to cover credit losses that exceed expected losses, in addition to having previously set aside credit provisions. This allocation can be determined through scenarios that simulate:

- Changes in market variables, essentially interest rates, which determine credit exposure for most products.
- Changes in the credit quality and therefore the delinquency rate of counterparties.

Credit losses must be calculated for each scenario (consisting of a specific combination of the above variables) for a specific time horizon. This results in a credit loss distribution. The maximum credit loss is then selected from this loss distribution according to the confidence interval selected. The bank should allocate capital equal to the Capital-at-Risk for this maximum credit loss less the credit provision.

CREDIT RORAC

Once Capital-at-Risk has been estimated, capital compensation can be measured uniformly by using, for example, RORAC. RORAC equals the expected after-tax return divided by the Capital-at-Risk. Expected return (ER) equals:

$$ER = (FI - FC) + CO - CP + CC - T$$

Where $FI - FC$ is the margin (financial income less financial costs), CO is commissions, CP is the expected loss (credit provision), CC is the capital compensation, and T are taxes.

Credit Risk in Treasury Activities

The philosophy of credit risk is essentially the same for the treasury department as for commercial banking. However, there are some differences, which will be outlined in subsequent parts of the chapter. We now move on to outlining the key concepts that need to be considered in credit risk management and control in the treasury.

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CREDIT EXPOSURE

Like commercial banks, treasury departments are exposed to credit risk only in transactions that involve current or future collection rights. In the case of balance sheet transactions (bonds, repos, deposits, etc.), credit risk is obviously generated only by assets. Liabilities create credit risk only for the counterparty. Off-balance sheet transactions (forwards and other derivatives) are more complicated, because they can be either contingent assets or contingent liabilities depending on the evolution of market prices. An example is provided below:

A company bought a 3/6 FRA (forward rate agreement) at 6% on US$ 10 million a month ago. Assume that one of these three scenarios is the current situation:

- *Scenario 1: the 2/5 FRA is quoted at 6.05%.*[5] *The market value of the position and the current credit exposure equal:*

$$\frac{(0.0605-0.06)\bullet 10^{7}\bullet\frac{91}{360}}{\left(1+0.0605\bullet\frac{91}{360}\right)}\bullet\frac{1}{1.06^{\frac{61}{365}}}=\text{US\$1,232.79}$$

- *Scenario 2: the 2/5 FRA is quoted at 6%, the market value of the position is 0 and therefore the credit risk is 0.*

- *Scenario 3: the 2/5 FRA is quoted at 5.92%.*[6] *The market value of the position equals:*

$$\frac{(0.0592-0.06)\bullet 10^{7}\bullet\frac{91}{360}}{\left(1+0.0592\bullet\frac{91}{360}\right)}\bullet\frac{1}{1.0605^{\frac{61}{365}}}=\text{US\$1,972.94}$$

Current credit risk is 0, because the current market value is negative. There would be no loss if the counterparty were to default at this time.

This example highlights that, for this type of instrument, credit risk exists only when the market value of the instrument is positive from the entity's point of view. Depending on how prices move during the life of the transaction, credit risk may (positive market value) or may not (negative or zero market value) exist at any particular time.

Current credit risk exposure measures the loss that would be incurred in case of counterparty default at the current time. Just because there is a specific credit exposure today does not mean that the exposure will stay constant over time. Therefore, it is also necessary to estimate potential credit risk exposure. Although the calculation of current and potential credit exposure is relevant to all treasury-related positions, it is important to make the following exceptions:

- Balance sheet assets (bonds, deposits, repos, etc.) always generate credit risk. Its level depends on their market value.

[5] The USD 2 month (61-day) zero-coupon rate is 6% and the 5 month (152-day) rate is 6.165% (actual/365 day convention).

[6] The USD 2 month (61 days) zero-coupon rate is 6.05% and the 5 month (152 days) rate is 6.10% (actual/365 day convention).

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- Derivatives quoted on an exchange (futures and options) do generate credit risk, but such risk is mostly mitigated by margin requirements. In general, the credit risk of these positions is considered to be zero.
- Over-the-Counter (OTC) derivatives (forwards, swaps, etc.) create a credit exposure only to the party to whom the market value is positive.
- Long positions[7] (purchases) in OTC options always generate a potential credit risk exposure. At expiration the option position has credit risk only if the option has intrinsic value,[8] i.e. if it is in the money.
- Short positions[9] (sales) in OTC options never have credit risk, regardless of their market value.

When calculating the credit risk exposure of treasury-related positions, collateral should be taken into account. Collateral reduces credit exposure by an amount equal to its market value. For example, an interbank loan does not generate the same credit risk as a reverse repo. The exposure related to a loan equals the sum of the principal and interest. On the other hand, the exposure related to a repo is much smaller because it equals the difference between the repurchase price and the current market value of the instrument used as collateral.

OTC derivatives may have features that manage or reduce the credit risk exposure. These features should be taken into account when calculating credit exposure:

- Collateral requirements similar to organized exchanges. Counterparties can execute a bilateral agreement stipulating that trades be valued periodically and that the party with the negative position put up collateral equal to that amount.
- Bilateral netting as part of a master agreement[10] signed before entering into OTC derivative transactions. This allows the party in compliance to offset its obligations against other positions with the counterparty by an amount equal to the obligations on which the counterparty has defaulted. The problem with netting is that, in many countries, its application is restricted by law.

  If an entity has a netting agreement with a particular counterparty (legally binding on both parties), combined credit risk exposure for all positions with that counterparty should be calculated. For example, current credit exposure equals the net mark-to-market value of all positions, whenever positive.

If there is collateral (for example bonds or other types of assets) the company must establish controls for monitoring redeemability, changes in its value, and changes in the value of the credit risk it covers. These controls should alert the company when, as a consequence of changes in market variables, credit risk increases while the value of the collateral stays constant or diminishes. In this situation the company should be able to demand that the counterparty put up additional collateral.

[7] Purchased options have limited downside (premium paid) and unlimited upside. Therefore, when the option has positive value, there is credit risk.

[8] The intrinsic value of an option is the profit that would be realized if the option was exercised at that moment. For call options, intrinsic value is the higher of 0 and the difference between the spot and the strike. For put options, intrinsic value is the higher of 0 and the difference between the strike and the spot.

[9] Written options have limited upside (premium earned) and unlimited downside. Since the maximum profit is the premium earned at the time of option writing, there is no credit risk.

[10] The problems with netting and master agreements are explored in Chapter 7, which is dedicated to legal risk.

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CREDIT PROVISION

Treasury operations generate two types of quantifiable risks: market and credit (i.e. counterparty) risk. This implies that the prices of instruments should reflect both risks. The way that credit risk affects treasury products depends on the type of instrument:

- Fixed rate instruments incorporate the credit risk of the issuer in their prices. For these types of instruments the only risk that exists is settlement risk.
- Repos are similar to deposits, but, because of the collateral component, they are regarded as practically free of credit risk.
- Exchange-traded derivatives are transacted through a clearinghouse without knowing the identity of the counterparties. The credit risk is covered by the clearinghouse through margin requirements. Therefore it is assumed that exchange-traded derivatives have no credit risk.
- Deposits, forwards and OTC derivatives (FRAs, swaps, options, etc.) are instruments whose value is quoted based on market conditions and the credit rating of the counterparty.

When valuing instruments in the last category, entities should take into account the credit provision when measuring credit risk.

In general, when calculating the market value of the above types of instruments by present-valuing future cash flows, credit risk is not taken into account:

- The yield curve used to discount the cash flows is generally not dependent on the credit rating of the counterparty. In general, a single zero-coupon curve is constructed using interbank instrument rates (deposit rates or swap rates). These rates are more applicable to transactions between financial entities that are market-makers, since this type of transaction presumes significant daily trading volume.
- Expected cash flows are assumed to equal the contractual cash flows, disregarding the possibility of counterparty bankruptcy.

In order to adequately take into account the credit risk of these types of positions, their market value should be calculated as the present value of[11]:

- The contractual future cash flows, disregarding credit losses,
- Less future cash flows that are expected to be lost due to counterparty bankruptcy.

Expected credit losses for a specific transaction type and counterparty credit quality should be taken into account when quoting prices or rates in order to incorporate them as a cost of doing business. Below is an example:

> *Assume that a client asks a highly rated bank (a market-maker) for a quote on a five-year USD interest rate swap in which the client pays fixed annually and the bank pays 6 month Libor.*
>
> *Assume that 5-year interest rate swaps are being quoted at 6.13-6.15 in the market and that the bank could hedge the swap with another bank of the same credit*

[11] The same discount rates must be used for both calculations, regardless of the credit ratings of the counterparties.

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quality at these same rates. If the bank wanted to hedge the swap quoted to the client, it could enter into another swap paying 6.15% fixed annually and receiving 6 month Libor.

Assume that the bank estimates (using methodology explained later) the present value of the expected credit losses for this transaction with this counterparty to be X.

If the bank wants to incorporate expected credit risk in its quote, it will quote n basis points above 6.15% so that at the time of the quote the swap has a positive market value at least equal to X.

Adjustments in the fixed rate can compensate counterparties for assuming credit risk. When issuing fixed rate debt, issuers with a low credit rating have to pay a higher rate to compensate investors for taking on more credit risk. Similarly, in the interest rate swap market, counterparties with lower credit ratings have to pay a higher fixed rate or receive a lower fixed rate.

The credit provision[12] is the present value of expected credit losses throughout the life of the contract. As mentioned earlier, the credit provision should be regarded as a cost[13] of doing business, to be recovered in pricing. This provision is like a reserve that allows the company to absorb most losses due to counterparty default.

The credit provision calculated at the initiation of the transaction may change during the life of the contract due to:

- Changes in the market value of the position.
- Changes in the counterparty's credit rating.

Changes in either of these factors immediately affect the credit provision. Below is an example.

Assume that the bank in the previous example entered into an interest rate swap with the client. The bank receives 6.17% fixed annually and pays 6 month Libor. When transacted the swap had a positive market value of X, which is treated as a credit provision to cover expected credit losses.

At initiation the bank calculated the credit provision based on its expectations of interest rate trends, and therefore expected changes in the market value of the swap (credit exposure), as well as expected changes in the counterparty's credit rating (default probability).

Assume that a year passes and expectations have changed:

- *Interest rates have decreased and are expected to continue doing so. Since the bank is receiving fixed and paying floating, the market value of the swap has increased and credit risk exposure is higher than anticipated a year ago.*
- *The client is having financial problems and its credit rating has deteriorated. Consequently, the probability of default is higher than anticipated a year ago.*

Logically the revised expectations translate into expected credit losses higher than the credit provision made a year ago. Therefore, the bank should increase the credit provision.

On the other hand, if the revised expectations (for example increase in interest rates or amelioration of the client's credit rating) had implied lower expected credit losses, the bank could have released a part of the initial credit provision.

[12] The process of calculating the credit provision is described in more detail in Chapter 11, which discusses methodologies for credit risk mitigation.

[13] Chapter 11 analyzes the way credit losses affect return, distinguishing credit-related effects from market-related ones.

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CREDIT RISK CAPITAL

Theoretically, if the company has a well-diversified portfolio in terms of transaction types and counterparties, credit provisions could in the long run equal the actual credit losses, if the provisions have been calculated accurately. During a specific time period, however, credit losses could exceed the credit provisions. If the company does not have sufficient capital to absorb those losses, it could go bankrupt. Accordingly, the company should allocate capital to cover credit losses exceeding credit provisions in addition to the credit risk capital.

The capital allocated to the treasury department should be sufficient to guarantee its continuity for a sufficient time to generate returns that justify treasury's existence. In general, Capital-at-Risk is calculated for a year, using an annual default probability approximated by the credit rating.

The company should allocate to treasury *credit risk capital*[14] sufficient to absorb credit losses superior to credit provisions during the course of a year. At any point in time credit risk capital is equal to:

- The present value of the maximum credit provision for one year,
- Plus the maximum losses that could occur during the year,
- Less the current credit provision.

Note that the credit provision relates to all the expected losses from the end of the year to the final maturity of the contract.

The company should select a confidence interval consistent with its credit rating objective for the calculation of the maximum credit provision for the year. This interval determines the probability that credit losses will exceed allocated capital and therefore the probability of bankruptcy. In order to calculate the maximum credit provision during the year, three factors have to be estimated:

- Possible changes in the market value of the transactions during the year. In case of counterparty bankruptcy only positions with positive mark-to-market value generate credit losses.
- Counterparty bankruptcies during the year.
- Deterioration in the counterparties' credit ratings, which would imply a higher probability of bankruptcy in the future.

As already mentioned, the calculation of the credit provision and credit risk capital should take into account possible collateral or netting agreements.

RETURN ON CREDIT RISK-ADJUSTED CAPITAL

In order to avoid bankruptcy of the company, shareholders must inject enough capital into the business to cover the credit risk capital throughout the life of the transactions (generally years).

To determine how much value treasury is adding on the credit risk assumed, the company should estimate the return that shareholders are expected to receive on the allocated capital throughout the life of the positions (RORAC). This return[15] equals the discount rate that would make the net present value of the following cash flows zero:

[14] In addition to the market risk capital Chapter 11 discusses the calculation of credit risk capital in more detail.
[15] Chapter 11 provides a more detailed discussion of how to calculate the Return on Credit Risk-Adjusted Capital.

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- Expected earnings, after subtracting the credit provision and taxes.

  Companies should quote treasury transactions at prices or rates that generate expected earnings (value when priced) sufficient to cover the credit provision and to provide an adequate return on the Capital-at-Risk,
- Capital injections or withdrawals to be made by the shareholders during the life of the contracts.

  It is necessary to calculate the changes expected changes in the credit risk capital throughout the life of the contracts. This calculation should take into account portfolio diversification effects. The effect (positive or negative) of each position on total credit risk for the portfolio should also be considered. The effect incorporates both market value (credit exposure) and concentration or diversification of risk between different counterparties (bankruptcy probability),
- The after-tax capital compensation, which assumes that credit risk capital calculated at the beginning of each year is invested in risk-free investments until the end of that year.

ESTABLISHING AND MONITORING CREDIT LIMITS

Control of treasury-related credit risk limits usually includes the following basic steps:

- Establishment of a credit risk limit structure, i.e. establishing credit risk lines for all the different counterparties of the company.
- Credit risk management and control, i.e. evaluating credit risk assumed pursuant to established credit limits.

The process of defining the credit risk limit structure should be performed independently of business units. As mentioned in Chapter 2, the risk analysis and control department[16] should be responsible for establishing the credit limit structure. The limits should be approved first by the Risk Committee and then by the Executive Committee.

The establishment and monitoring of credit limits should be done uniformly. Credit limits should be unique to each counterparty, and the procedures to calculate limit usage should be the same for all the business units that operate within these limits. Companies should establish a system to monitor limit usage by counterparty. Having such a system is particularly crucial for companies with treasuries in different locations, whether in the same or different time zones. The system should function in real time, so that before entering into a contract with a counterparty, a business unit can consult with the front office to determine the remaining credit limit. In addition, the system should update credit limits each time a transaction is added or subtracted.

Traders should not be allowed to enter into transactions with counterparties without an authorized credit limit or with a remaining credit limit lower than that required for the proposed transaction. Any limit excesses should be analyzed by the risk analysis and control department and approved by the Risk Management Committee, if appropriate.

[16] The process of defining the credit limit structure should consider how the structure could be implemented in the business units (in the case of treasury, the front office).

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Limits Based on Credit Exposure

One method for setting a credit limit structure is to start at the country level. The first step is to divide the total global credit limit into country limits according to the country of the counterparty. The second step is to divide the country limit between the potential counterparties in that country. The third step is to divide each counterparty limit among the subsidiaries and affiliates of that counterparty, if any.

Credit limits assigned to countries depend mostly on the sovereign credit rating of the country (country risk) and the volume of activity with counterparties in that country. These limits should be analyzed and updated annually or whenever there are significant changes in economic or political conditions in the various countries.

Counterparty credit limits can be assigned based on credit agency ratings. An internal credit rating process needs to be developed for unrated counterparties. This process must consider both internal[17] and external[18] factors. Internal factors reflect the counterparty's credit quality, whereas external factors may affect it.

Each counterparty should have a total risk limit. This can be subdivided into sublimits, for example, to control settlement risk or credit risk related to particular products or maturities.

As mentioned before, in addition to establishing a credit limit structure, the risk analysis and control department must set up a process to determine credit limit usage. This process should be applied uniformly across products and treasury centers.

Different positions use up credit limits at a different rate, depending on their credit exposure. Credit exposure depends on the characteristics of the instruments and is independent of the default probabilities of the counterparties.[19] Higher or lower credit limits are allocated based on the counterparty's default probability. After such limits have been established, a similar instrument with two different counterparties consumes an equal amount of the credit limit, regardless of the counterparty's default probability.

For balance sheet assets (such as bonds and deposits) credit exposure can be calculated statically as principal plus expected interest payments. More correctly, the exposure can be calculated dynamically as the mark-to-market value of the position (current exposure) plus an estimate of the maximum lifetime increase in the value of the position at a particular confidence interval (based on the concept of Value-at-Risk).

There are several alternative ways to calculate credit exposure for forwards and other OTC derivatives. The following discussion outlines these different techniques, proceeding from the simple but imprecise to the complex but more correct.

Original Exposure Method

The original exposure method calculates credit exposure as a percentage of notional amount. The percentage varies by maturity and by risk type.

The Bank for International Settlements (BIS) allowed the use of this method until the end of 1997. The percentages to be applied for this method are in Table 5-1.

[17] Some internal factors to be considered are the strength of the financial statements, historical and expected results, competitive position, revenue structure and earnings stability, financial risks, liquidity, debt and equity structure, management quality, etc.

[18] Some external factors to be considered are volatility, sector outlook, local legislation, etc.

[19] As will be apparent later, if credit limits are expressed in terms of Capital-at-Risk, both the characteristics of the instrument and the counterparty default probability influence limit usage.

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Table 5-1. Percentages for the Calculation of Original Exposure

Maturity	Interest rate Contracts	Foreign Exchange and Gold Contracts
Up to 1 year	0.5%	2.0%
From 1 to 2 years	1.0%	5.0%
For each additional year	1.0%	3.0%

For interest rate contracts BIS allowed banks to choose between original maturity and time-to-maturity when selecting percentages. For floating rate and commodity contracts (except gold) BIS requires the use of the current exposure method outlined below.

This method is simple but it has several deficiencies. The main ones are:

- No differentiation between current and potential exposure.
- Mark-to-market value of the instrument is not taken into account.
- Exposure is static and does not vary based on market factors.
- Does not take into account the real sensitivity of the different instruments or the volatility of market variables.
- The confidence interval of the credit exposure estimate is unknown.

Current Exposure Method

The current exposure method consists of calculating credit exposure as the mark-to-market value of the position, if positive, plus a percentage of notional amount (add-on factor). The percentage varies based on time-to-maturity and risk type.

The BIS currently permits the use of this method. The percentages recommended by the BIS are listed in Table 5-2.

Table 5-2. Percentages for the Calculation of Potential Exposure

Remaining Life	Interest Percentage	Foreign Exchange and Gold Percentage	Floating Rate	Precious Metals	Other (Commodities)
Up to 1 year	0.0%	1.0%	6.0%	7.0%	10.0%
From 1 to 5 years	0.5%	5.0%	8.0%	7.0%	12.0%
More than 5 years	1.5%	7.5%	10.0%	8.0%	15.0%

This method satisfies some of the deficiencies of the original exposure method, because it differentiates between current and potential exposure, takes into account the mark-to-market value of the instrument, and has a dynamic component.

The deficiencies of this method relate to the calculation of potential exposure. It does not take into account actual sensitivities of the instruments, volatility, or market prices. In addition, the confidence interval of the estimate is still unknown.

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Method Based on Value-at-Risk (VAR)

The Value-at-Risk (VAR) method consists of calculating credit exposure of treasury positions as a sum of the following two components:

- Current exposure: take the higher of the mark-to-market value and zero.
- Potential exposure: calculate the maximum lifetime increase in the mark-to-market value of each position at a particular confidence interval.

  In market risk measurement Value-at-Risk is used to calculate the maximum potential loss of a particular position, whereas in credit risk measurement VAR is used to calculate the maximum potential gain.

  Assuming that gains are normally distributed, the same VAR used for market risk measurement would also be that position's potential credit risk exposure.

  In Latin American markets, the same problems analyzed in Chapter 10 for market risk arise when credit risk is calculated. The solutions outlined in Chapter 10 can be used for both types of risk.

Comparison of the Three Methods

Credit exposures derived using the three different methods may of course be completely different. These methods are contrasted below using the example from the beginning of the chapter.

A company entered one month ago into a 3/6 forward rate agreement at 6% on US$ 10 million. Assume that a 2/5 FRA is currently quoted at 6.05%. The mark-to-market value of the position is:

$$\frac{(0.0605-0.06)\bullet 10^7 \bullet \frac{91}{360}}{\left(1+0.0605\bullet\frac{91}{360}\right)}\bullet\frac{1}{1.06^{\frac{61}{365}}} = \text{US\$1,232.79}$$

Assume that the 2/5 interest rate has an implied annual volatility of 15.68%. This implies that average volatility until the maturity of the contract (61 days) is:

$$\frac{605\bullet 0.1568}{\sqrt{250}}\bullet\sqrt{61} = 47\text{bp}$$

Based on this volatility and a confidence interval of 99.86% (3 standard deviations assuming normality), the interest rate can vary between 6.05% and 7.46% (605 + 47•3) in the 61 days left until maturity. This would imply an increase in market value of:

$$\frac{(0.0746-0.06)\bullet 10^7 \bullet \frac{91}{360}}{\left(1+0.0746\bullet\frac{91}{360}\right)} - 1{,}232.79 = \text{US\$34,989.71}$$

Based on these calculations, credit exposures can be calculated using each of the three methods.

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- Original exposure method: taking into account that the FRA is an interest rate instrument and has a maturity of under a year, using the coefficients suggested by BIS results in:

$$10^7 \bullet 0.005 = \text{US\$50,000}$$

- Current exposure method: using the coefficients given by BIS, the credit exposure is:

$$1,232.79 + (10^7 \bullet 0.00) = \text{US\$1,232.79}$$

- VAR method: using this method, credit exposure equals:

$$1,232.79 + 34,989.71 = \text{US\$36,222.50}$$

Let us examine what would happen if the third scenario of the original example happened. Assume that a 2/5 FRA is quoted at 5.92%, i.e. its value is USD – 1,972.54. Using the same volatility as in the previous example (15.58%), this implies that average volatility until the maturity of the contract (61 days) is:

$$\frac{592 \bullet 0.1568}{\sqrt{250}} \bullet \sqrt{61} = 46\text{bp}$$

This volatility would imply that at the confidence interval of 99.86% (3 standard deviations assuming normality) the interest rate could increase from 5.92% to 7.30%. This would imply an increase in the market value of the instrument of:

$$\frac{(0.0730 - 0.06) \bullet 10^7 \bullet \frac{91}{360}}{\left(1 + 0.0730 \bullet \frac{91}{360}\right)} + 1,972.54 = \text{US\$34,238.26}$$

In this scenario credit exposure of the FRA would be:

- Original exposure method:

$$10^7 \bullet 0.005 = \text{US\$50,000}$$

- Current exposure method:

$$0.00 + (10^7 \bullet 0.00) = \text{US\$0.00}$$

- Value-at-Risk method:

$$0.00 + 34,238.26 = \text{US\$34,238.26}$$

The following conclusions can be made based on this detailed analysis:

- The original exposure method is completely static. The exposure derived using this method does not take into account changes in market value or volatility.
- The current exposure method takes into account changes in market value but not volatility.
- The VAR method is the most comprehensive method, taking into account market value and volatility changes.

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Limits Based on Capital-at-Risk

The previous part of the chapter discussed different alternatives for setting and monitoring credit limits. The three methods all set limits based on the credit quality of the counterparty. After the limits have been established, a similar instrument with two different counterparties uses up the same amount of the credit limits, regardless of the default probability of the counterparty. The three methods differ in the way that limit usage is calculated.

Another alternative is to set limits based on Capital-at-Risk using the following process:

- Determine the total capital that the company wants to risk
- Divide the total Capital-at-Risk between different counterparty groups by credit rating and sector, then by time period (usually years)
- Establish concentration limits, so that no more than a specific percentage of the total Capital-at-Risk is used up by a single counterparty.

After these limits have been set up, each time that a new trade is transacted with a counterparty of a specific credit quality, credit limit usage of the credit category with that credit quality is updated for each of the time periods until the final maturity of the contract.

Recommendations for International Standards on Credit Risk

Recommendations of the Group of Thirty

- Companies should measure credit risk related to derivatives based on two components:
  - Current exposure, which is equal to replacement cost, i.e. mark-to-market value.
  - Potential exposure, which is an estimate of the future replacement cost of the derivative. It should be calculated using a probabilistic method with a sufficiently high confidence interval.
- Companies should aggregate credit exposure with a counterparty between product groups such as derivatives and other types of transactions. The calculation should take into account netting agreements.
- Companies should measure their credit exposure against the limits on a regular basis.
- Companies should explore possibilities to petition their counterparties for agreements that reduce credit risk, such as collateral, third-party guarantees, or special purpose vehicles (SPVs).

Recommendations of the Derivatives Policy Group (DPG)

- Companies should control concentration of credit risk at the counterparty level. Special attention should be paid to the 20 counterparties with the highest net credit exposure.
- Companies should measure total credit exposure as well as credit exposure by counterparty, credit rating, sector, and region.
- Capital should be allocated to absorb credit losses. Two components should be considered when calculating credit exposure:
  - Current exposure, which equals the net replacement cost by counterparty multiplied by the probability of bankruptcy as published by the rating agencies.

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- Potential exposure, which is usually estimated based on historical bankruptcy probabilities and estimates of changes in Value-at-Risk. The DPG recommends using the same method of calculating Value-at-Risk for the purpose of credit risk as for market risk (1 out of 100 biweekly observations). In no case should probabilities lower than 0.001 be used.

Recommendations of the Bank of International Settlements (BIS)

- Companies should set up a procedure for assigning credit ratings to all counterparties. The following factors should be taken into account: sector, competitive situation, and the quality and reliability of financial information and economic analysis on the counterparty.
- Companies should set and revise credit limits periodically. Criteria for limit usage should also be established.
- Companies should take into account both current and future exposure when measuring their credit risk.

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Chapter 6

Operational Risk Management and Control

Operational Risk: Definition and Scope

Operational risk can be defined as the possibility of a financial loss due to unexpected events in the operating and technological environment of an entity. Operational risk is a very broad concept that usually encompasses many types of risks, such as:

- Internal control problems
- Inadequate procedures
- Human error and fraud
- Computer system failures

These general categories of operational risk can be broken down as follows:

- Internal control problems:
  - Organizational structure: this is the risk caused by the lack of appropriate segregation of duties, at two levels:
    - Primary: between business and control areas, and
    - Secondary: between the processing, confirmation, settlement, reconciliation, payment and valuation functions.
  - Authorizations: this is the risk of transactions being performed that are not explicitly and fully authorized (instrument, market, currency, counterparty, etc.) according to the operating framework of the entity.

    Assume that an entity has not authorized its treasury department to trade options, because it does not believe that it is capable of controlling the risks inherent to these instruments. However, a trader in the treasury department believes he is perfectly knowledgeable about them and takes a position in options. This trader has exposed his entity to operational risk. Even if he is qualified to take and manage this options position, he may not know that the entity's systems are not capable of processing it, that the back office personnel are not trained to handle it, and that the risk management area personnel do not have the knowledge necessary to control the related risks. These are all reasons why options trading was not authorized.
- Inadequate procedures:
  - New activities and products: this is the risk created by engaging in a new activity or offering a new product without sufficient knowledge or an adequate operating and risk control structure.

    The example of the unauthorized trader who takes a position in options is also valid here. To avoid this problem, entities should have a policy that requires new

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activities and products to be analyzed and approved by a new products committee before full-scale operations involving them can commence.

- Transaction processing: this is the risk of errors or control failures in one or more of the following phases of processing transactions:
  - Recording: the risk created when transactions are not recorded or are recorded incorrectly, which results in incorrect information regarding risk exposure and thereby affects decisions.
  - Position calculation: the risk caused by undetected differences between the position reported by the business areas and the control areas.
  - Confirmation: the risk that the confirmation process does not detect incorrect data in recorded transactions, or overlooks transactions done but not recorded.
  - Settlement: the risk that financial assets are not collected (received) or paid (delivered) on the agreed dates, or that this is done incorrectly.
  - Physical access: the risk that cash or other assets (securities, checks, etc.) are accessible to unauthorized personnel.
  - Systems access: the risk that unauthorized personnel can read or modify information contained in the systems.
  - Financing: the risk that incorrect funds management can result in interest on overdrafts or an opportunity cost due to underutilization of funds.
  - Valuation: the risk that transactions are not valued properly due to use of incorrect market data or valuation models. Valuation risk can occur when pricing an instrument or when the instrument is subsequently marked to market.
  - Accounting entry: the risk related to an accounting record that is incorrect according to the standards existing in each country for each type of transaction.
- Human error and fraud:
  - Integrity and good judgment: the risk that personnel intentionally or unintentionally does not comply with the established policies, procedures and controls.
  - Human resources: the risk of inefficiencies or errors in execution and processing transactions due to a shortage of personnel, insufficient training or high turnover.

    A situation that often arises is significant differences in training for the personnel of business areas and those in administrative and control areas. This can become a significant source of operational risk.
  - Fraud and conflict of interest: the risk that personnel put their own interests before those of the entity.

    For example, conflict of interest can be caused by the existence of a bonus, which some areas (e.g., treasury) calculate as a percentage of returns. This practice derives in some cases from the assumption of significant risk by traders, who know that if their "bets" turn out well, the entity will benefit and they will receive proportional bonuses. However, if their "bets" go bad, the entity will suffer a loss and they will continue receiving the fixed portion of their salaries.

    It is very important for incentive policies to be in line with risk control policies; one method is to base bonuses on both earnings and RORAC. It is also very important to establish Capital-at-Risk limits.
- Computer system failures:
  - Interruptions in transaction processing: the risk created by the inability to process transactions due to computer equipment failures, strikes or natural disasters.

Although in principle it is difficult to measure operational risk, an attempt must be made to quantify it so that the necessary capital can be allocated. One way of doing this is the following:

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- First evaluate the quality of the internal controls in place in the different businesses in which the entity operates, so that an overall rating can be made of the quality of operating controls.
- The magnitudes that are the most representative of the operational risk assumed must then be defined for each business, as follows:
  - Asset and liability transaction balances.
  - Volume of revenues and costs.
  - Volume of assets and liabilities (including off-balance sheet transactions).

  These magnitudes are a good approximation of operating volume and therefore exposure to operational risk.
- Last, the operational risk assumed by each business must be calculated.

  For a specific business, operational risk is equal to a percentage of the variables defined as representing that operational risk (e.g., for a commercial banking unit it may be 10% of the sum of assets and liabilities). The percentage depends on the variable and the overall quality rating of the operating control achieved by that specific business (the higher the quality, the lower the percentage).

The fact that operational risk is difficult to quantify does not mean that it should not be managed through the establishment of a control framework that ensures data integrity and appropriate segregation of duties.

The operating control structure must be flexible enough to adapt to the entity, markets and instruments for which it is to be used. The objective of this structure must be to control and reduce operational risks in a reasonable manner, since the establishment of overly strict control structures can hurt the operation and reduce the activity level without achieving an equivalent reduction in operational risk.

For example, businesses such as commercial banks normally have sufficient time to perform all operating controls before closing a transaction (for example, granting a loan). In an area like treasury this may not be the case, especially when the markets are very active. This does not mean that operating controls should be relaxed for treasury activity, but instead that they must be adapted to the business reality.

Entities should prepare manuals for each of their businesses that describe in detail all the policies and procedures[1] implemented to control operational risk. The personnel involved in the entity's trading activities must follow these policies and procedures.

As we will see when we discuss the code of conduct, failure to comply with these policies and procedures may result in sanctions. Defining them is the responsibility of a professional ethics committee, which reviews the gravity of each case and determines the appropriate sanctions.

Operational risk control manuals should contain at least the following information:

- Business description:
  - Business objectives and strategy
  - Organizational structure of the area, including specification of functions for each committee and department
  - Type and characteristics of the products
  - Type and characteristics of the type of activities performed

[1] Procedures are practices and ways of acting that must be taken into account when processing transactions, from the time they are contracted until the time that they mature. Policies are basic operational risk management principles.

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- Operating procedures and controls for the business areas and the administrative and control areas.
- Operational risk control policies:
  - Code of conduct
  - Authorized operations
  - Approval of new activities and products
  - Levels of operating authority
  - Other specific policies for each type of business
  - Review and maintenance of the manual
  - Systems contingency plan.

The specific content of the operational risk control manuals and the definition of policies and procedures should vary based on the type of entity (manufacturer, financial entity, etc.) and type of business within the entity (e.g., treasury, corporate, private banking, etc. within a financial entity).

Based on the structure above, a basic policies and procedures model is outlined below. All types of companies should establish such a model for treasury and capital markets activities.

Operating Procedures and Controls for the Treasury

The starting point for implementing an efficient operating control system is an organizational structure that includes appropriate segregation of duties between the business, administrative and control areas. The treasury function must be completely separate and independent of the front office, back office and risk management area.

The independence of the risk management area depends on the size and complexity of the treasury activity. Institutions that have significant treasury volume in a wide variety of products and markets are justified in having a risk management area that is completely independent of the front and back offices.

In entities with uncomplicated treasury activity in a few specific instruments, there may be no reason for a separate risk control department. Instead, management or a special committee can perform this function, using mechanisms that ensure independent control.

Regardless of the size and complexity of the treasury department, however, there must always be complete separation of the front and back offices. Such separation ensures that a single area or person is never responsible for performing functions (e.g., contracting and processing transactions) that jeopardize proper operating control.

The controls and procedures outlined below apply to any treasury department. Controls and operating procedures should be stricter for complex, unusual or very large transactions (for example secondary validation).

GENERAL OPERATING PROCEDURES AND CONTROLS

Systems Access

The purpose of controlling access to systems is to prevent unauthorized persons from accessing certain treasury system functions that would allow them to read, alter, add to, or erase information contained in the databases, or to enter unauthorized transactions.

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System access controls must be designed so each treasury area member can access only the functions strictly necessary to their job performance. Access controls ensure segregation of duties.

Security controls and access codes must be controlled by a treasury systems administrator who must be independent of the areas that use his services. This person is responsible for evaluating the level of security, managing the access systems and control codes, and auditing security policy compliance.

Control and Maintenance of Static Data

Static data is basic information the treasury systems need to operate. Static databases usually contain information about counterparties and clients, brokers, schedules, correspondents' accounts, currencies, portfolios, calculation conventions, basic information on instruments (e.g., debt issues), systems users and access levels, etc.

The data in static databases is normally entered once and changed only when necessary (e.g., change in client's address, change in correspondent's account number, change in user access level, etc.). Controls are necessary to maintain static databases adequately:

- The treasury systems administrator (technology and systems area) is responsible for maintaining static databases. The administrator must be independent of the areas that use his services.
- Changes, additions and deletions of information must be proposed by those responsible for the front office, back office and risk management areas, and then reviewed and approved by the technology and systems area.
- All of the procedures and controls outlined below regarding entry and verification of data must be followed.
- It is very important to have common static databases for all the treasury systems. If this is not the case, the entity must establish controls that ensure that the static data is consistent across all systems.

Ticket Control

All transactions not fed directly into back office systems from front office systems are subject to the following manual ticket controls:

- The tickets must be pre-numbered sequentially, and grouped in blocks. Each ticket consists of an original and some number of copies, depending on how many people must receive a copy of that ticket.
- All of the unused blocks must be handled on a centralized basis by the back office in a secure location. New blocks are to be distributed to brokers on an as-needed basis, in exchange for the used preceding block.
- All blocks distributed must be entered into a control registry. By checking the ticket number, the registry can be used to identify the broker who used a specific ticket.
- The brokers must send the back office all the used tickets, including voids.
- Each product traded should have a preset closing time that accommodates the trading needs of the front office and enables the back office personnel to process the transactions properly and on time.

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- At the end of the day, the back office must review all the transactions and identify any that are out of sequence, locate the trader involved, and look for the missing ticket or obtain an explanation. The back office is responsible for ensuring that all transactions for a given day have been entered.
- Once the day is closed and the tickets have been matched, they are held in safekeeping by the back office.

Telephone Conversation Tape Control

A system should be installed to tape all brokers' conversations. Controls should also be implemented to ensure that all transaction closings occur on telephones in the trading room that are part of the taping system.[2]

When there is a discrepancy with a counterparty, or when a trader so requests, the relevant tape is reviewed by the trader involved and by someone from the back office. A record must be entered into a conversation review access registry specifying the person that is requesting the review, the reason, line listened to, date and time of the taping, and date and time of the review. In no case may a trader have access to tapes that do not belong to the area in which he works.

Telephone conversation tapes should be kept for a reasonable period of time (which depends largely on the term of each transaction). If discrepancies arise, tapes should be kept until the discrepancy is fully resolved.

In addition, the back office should periodically review the tapes of brokers' telephone conversations. This should be scheduled on a rotating basis such that selected conversations for each trader are reviewed at least once per quarter. This procedure entails the following steps:

- Select a trader, then obtain a block of used tickets with the time and date of the transactions noted.
- Pull the appropriate tapes and listen to a one-hour section of a tape.
- Compare the transactions recorded on the tape to the transaction information on the ticket block, and note any discrepancy between the two.
- Note any discrepancy or other inappropriate information heard on the tape and record it in a telephone tape observation registry.
- Discuss discrepancies with the trader involved and with the person in charge of the front office.

Automatic System Controls

- All treasury systems should have automatic validation controls to ensure the accuracy of the data entered.
- The system should have controls that verify the key data (counterparty, trader, maturity, currency, instrument, etc.) for the transactions entered, and it should be possible to compare such data to that in the static databases in order to detect errors or violations of established authorizations.

[2] An exception to this are transactions done off-premises (see p. 125)

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- The system should have controls to ensure data accuracy and integrity (such as alphanumeric tests, amount confirmation tests, verification of codes and required fields).
- The system should have controls that do not allow a transaction to be entered if all required basic information has not been provided.
- The system should generate an error report for review by those responsible for entering data into the system to enable corrections to be made as quickly as possible.
- If the system lacks automatic controls, there must be manual review of the data entered.

Controls on Direct Data Transfer between Systems

If a treasury department uses a number of systems to perform different transacting and processing functions, the transaction data that is transferred from one system to another without manual intervention must be subjected to the following controls to ensure its accuracy and integrity:

- Automatic tests of the receiving system, such as control field or message end characters.
- Communication by the receiving system to the sending system of the number of messages, total transactions sent as confirmation, or both.
- When a transmission is incomplete or invalid, the new transmission should be done immediately, either manually or automatically.

FRONT OFFICE OPERATING PROCEDURES AND CONTROLS

An operating control system can be efficient only if there is adequate separation between the areas involved in treasury activities and also segregation of duties within these areas. Specifically, there should be separation in the front office of traders who trade for the entity's account and those who trade on behalf of third parties. Procedures must be defined that ensure the separation of these two activities and keep the interests of the entity from prevailing over those of the client.

The procedures and controls that should be implemented in the front office relate to the different phases of front office activity:

- Start of the day
- Prior to executing a transaction
- After executing a transaction
- End of the day

Start of the Day

- Each trader must check all his personal documentation to establish usage of his personal limits.
- Each trader must go over the closing position reports for the prior day for each product he is authorized to trade so that he knows his starting position.
- Each trader should analyze and study market reports.
- A daily morning meeting is recommended for all traders and desk heads, in order to establish the strategy for the day based on current positions, market reports and price movement expectations.

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Prior to Executing a Transaction

- Make sure that the counterparty has a valid line of credit, and that the amount of the proposed transaction does not exceed the line amount available.
- Check the current open position and make sure that the new transaction will not cause established market limits to be exceeded.
- If the transaction is to be done through a broker, make sure he is authorized by the entity.
- If the credit or market limits will be exceeded, request authorization prior to closing the transaction and verify that the authorization has been approved by the appropriate person. This authorization should be documented in writing.
- Quote or agree on market prices. For instruments that do not have a benchmark market price (e.g., some OTC derivatives), use valuation models already approved by the risk management area.
- In transactions with clients, the seller must be sure that clients have sufficient experience in the instruments they want to trade and that they understand all the risks implicit in the trade they want to do. In the case of sophisticated products or inexperienced clients the seller must, before closing the transaction, send the client a written term sheet that describes the characteristics of the transaction, and the implicit risks.
- Close the transaction if it is acceptable and is in compliance with all limits and authorizations (product, currency, etc.).

After Executing a Transaction

- Access the direct data entry system (if there is one) and enter the transaction data. If there is no such computer system in the front office, complete the trade ticket (including all data), sign it, and date and time-stamp it.
- Update the risk management systems (market and counterparty) and the position calculation system. This process must take place after each transaction is closed, in order to ensure real-time knowledge of the position and risks assumed.
- Send the original ticket to the back office so that it can begin to process the transaction, and file a copy of the ticket in the front office.
- For complex transactions the trader must contact the back office to ensure that it understands the transaction and that there are no problems related to processing it.

End of the Day

- At closing time, prepare end-of-day reports of trading positions and results, including all transactions contracted during the day prior to closing time.
- All transactions contracted after closing time must be included in the next day's report. The tickets for such transactions must be delivered to the back office as soon as possible so that they can be processed correctly.
- Give the back office the end-of-day reports so that they can reconcile them with the back office information.
- Investigate the differences found during the reconciliation process. Errors can result from errors on tickets, misplaced tickets, or transactions performed after closing time but not included in any report.

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- Correct the computer systems as necessary. The front office traders may not leave until their position and transactions have been matched with the back office.
- Prepare a new, corrected report, if necessary.
- Sign the reports to indicate reconciliation is complete and file.

BACK OFFICE OPERATING PROCEDURES AND CONTROLS

A basic goal of the back office is to ensure proper treatment and management of the transactions initiated by the front office. It does this by performing the three types of tasks listed below:

- Control tasks: the back office is the guarantor of the integrity and accuracy of the information managed in the treasury area. It must ensure that the transactions entered into the systems exactly match the transactions actually contracted.
- Administrative tasks: the back office is responsible for ensuring correct processing of all phases of the transactions (data entry and verification, confirmations, settlements, reconciliations, revaluations, etc.).
- Accounting tasks related to the transactions.

As in the front office, certain back office functions must be kept separate for the back office operating control system to be efficient. The entity must allocate back office tasks so that no one person is responsible for one of the following combinations (unless a specific control procedure is established that mitigates that situation):

- Data entry and verification.
- Data entry and confirmation processing.
- Data entry and supervisory functions.
- Data entry and settlement processing.
- Generation and release of payment orders.
- Settlement and reconciliation of accounts at correspondent banks.

We describe below the procedures and controls that an entity should establish to reduce operational risk related to the processing of transactions by the back office. It is important to note that when implementing these procedures and controls, some adaptation may be necessary to accommodate the peculiarities of the back office of each entity, the products, and the confirmation and closing mechanisms of each market.

Data Recording and Verification

All the procedures and controls related to entering and verifying data for a given transaction should be performed by the back office on the day that the transaction is closed.

Transactions performed after closing time should be processed on that same day; however, these transactions should not be included in the end-of-day reports. They should instead be included in the reports for the next day.

The nature of the controls the back office establishes to ensure correct data entry in its systems depends on whether it receives transaction feeds automatically from the front office or whether it instead receives tickets and enters transaction information manually.

If the transactions are entered into the system by the front office traders and are automatically fed to the back office system, the procedures and controls should be those used in

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conjunction with direct data feeds between systems. Although the transaction data should already have been validated by the front office system, the back office must do a second check to ensure the absence of errors and the reasonability of the transactions (e.g., noting that the market value is similar to the price paid or charged) before validating them in its system.

If the back office receives tickets and enters the transactions into its system manually, the following procedure should be established:

- Review the data on the trade ticket and verify that all pertinent data is included and that the trader is authorized to trade that product. If some piece of data is omitted, return the ticket to the trader for revision. If the trader is not authorized to trade that product, notify the person in charge of the front office and obtain his approval to process the ticket.
- Check to see that the trade ticket meets all requirements (original ticket, time stamp, trader's signature) and return any incomplete tickets to the trader.
- Enter the transaction data into the trading system.
- Do a visual verification, comparing key data to the screen data to ensure that the ticket data has been entered correctly. It is important that this verification be done by someone other than the person who entered the data.
- Sign the ticket as evidence of entry and verification.

In addition to transaction data verification controls, and regardless of whether the data is entered automatically or manually, the back office must establish a mechanism that enables it to compare the prices or rates entered for each transaction against those available from independent sources in order to ensure that all the trades have been transacted at market prices or rates. This price comparison can be done automatically via computer or manually via sampling. Those transactions that do not fall within a preset range must be investigated and reported to those in charge of the front office, back office and risk management area.

Confirmation Processing

The entire process of issuing, receiving, and reconciling confirmations (back office) must be totally independent of the trading/business function (front office). All documentation must be completed and exchanged as quickly as possible after the close of each transaction.

In general, all of an entity's transactions should be confirmed either directly or through a clearinghouse. The entity should also require its counterparties to confirm all transactions.

Generation and Sending of Confirmations

All confirmations of transactions performed with external counterparties must be sent to the attention of a department of the counterparty (generally the back office) that is independent of the trading/business function. The process of generating and sending back office confirmations requires that the following procedures be established:

- Generate an outbound confirmation that contains precise data on the transaction. The confirmation can be generated manually or automatically from the back office system.
- Compare the key data on the confirmation with the information shown in the system. Any discrepancy must be satisfactorily corrected.

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- Send the confirmations to the counterparties via SWIFT, fax, telex or mail[3] as soon as they are generated and reviewed.
- File a copy of the confirmation.

Some transactions have interim or final payments that are dependent on market conditions (FRA, swaps, options, etc.). In such cases, except for products traded on an organized exchange, the new cash flows must be confirmed each time they are recalculated. The back office achieves this by establishing the following procedures:

- Obtain the applicable exchange rate or interest rate from an independent market source at the specified time prior to the due date of the payment (usually the preceding or same day). If the rates are obtained from the front office, compare them with rates obtained from an independent source.
- Prepare a confirmation containing the key data for the settlement.
- After the confirmation has been appropriately reviewed, send it to the counterparty via SWIFT, fax, telex or mail.

Some products require confirmation of interim or final payments because the payment occurs some time after the transaction closes (e.g., long-term swaps). In this case, the back office must follow the procedures below:

- Review the payment schedule. Prepare a payment confirmation for transactions that need one, indicating to the counterparty the amount and payment instructions.
- Send the confirmation to the counterparty via SWIFT, fax, telex, or mail.
- Investigate or resolve any discrepancy with the counterparty.

Processing Confirmations Received

An automatic confirmation matching system can be used for all confirmations received via SWIFT or a similar communications system. This type of system generates lists of reconciliations that do not match, including confirmations with minor discrepancies and confirmations with discrepancies in key data. All confirmations received by telex, fax or mail must be processed manually according to the following procedures:

- Stamp all confirmations with their arrival date and time.
- Compare the data in the confirmation to that in the system and related ticket.

Once all of the confirmations have been processed and reconciled, the back office must follow the procedures below:

- For all transactions that have been matched or have only minor discrepancies, document the fact that the transaction has been reconciled, either in the system or on the tickets.
- For transactions with key data discrepancies, note them in an error registry, investigate the problem and resolve it.

[3] Any method chosen for sending confirmations must leave a trail evidencing that the confirmation has actually been sent.

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- For transactions on which confirmations have not been received within a reasonable period, telephone[4] the counterparty to confirm the transaction data and request a written confirmation.

Transactions that are settled through a clearinghouse are matched by it. In the event of discrepancies, the clearinghouse notifies the counterparties to the transaction so that they can investigate the discrepancy and resolve it.

Settlement Processing

The back office must always ensure that transactions or payments have been satisfactorily confirmed before settling them (releasing payment). Payment may be released without confirmation if such an action has been approved at a high enough level.

The procedures and controls that the back office should establish for settlement of transactions through the account of the counterparty depend on how payment orders are to be generated.

Manually Generated Payment Orders

The following procedure is designed for the manual preparation of payment instructions. Payment instructions are transmitted only after they have been reviewed and approved by an appropriate back office employee. Review is required only when the payment data is prepared and sent by the same person. The steps to be followed are:

- Identify daily all the transactions that require a payment order (e.g., value date in two days) and obtain all the data on the transactions to be settled.
- Prepare the payment orders for authorization by the back office person in charge of that function.
- File a copy of the payment order with the other transaction documents.
- Release the payment orders via the means used (SWIFT, telex, or fax). This function should be performed by someone other than the person who prepared the payment orders.
- Send a payments registry to the area responsible for managing correspondent bank accounts.

Automatically Generated Payment Orders

This procedure is designed for systems that prepare payment orders automatically. These systems have security controls that prevent the entry or modification of a transaction, except by means of standard data entry procedures. The steps are as follows:

- Generate payment notices from the system.
- Review for errors, investigate and resolve them.

[4] Using a line that tapes the call.

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- Send the payment notices for authorization by the back office person in charge of that function.
- Send the payment notices.

Transactions that are settled through a clearinghouse do not require specific settlement procedures, because the clearinghouse itself is responsible for control.

Reconciliations

The back office is responsible for doing reconciliations, which can be separated into three basic categories:

- Positions
- Broker accounts
- Collection/payment accounts

Reconciliation of Positions

The reconciliation of front office and back office positions must be performed every day after the established cut-off time. All the reconciling entries must be investigated, explained and resolved. The reconciliation procedure is:

- Generate a list of back office net positions.
- Meet with appropriate front office personnel and reconcile the net positions.
- Resolve any discrepancy by reviewing the positions, transaction by transaction, until the difference has been explained.
- If the difference has to do with one transaction not entered or entered incorrectly into the trading system, locate the trade ticket, correct it and send the data to the person responsible for entering data in the system so that it can be processed.
- Document the reasons for the discrepancies in the net position list of the front or back office, as the case may be.
- Note the result of the reconciliation in a position reconciliation registry.

Reconciliation of Broker Accounts

All brokerage expenses must be invoiced separately and should not be included in transaction prices. Any discrepancies in brokerage expenses must be resolved by the back office to avoid order flow compensation between the broker and the front office traders. The procedure that the back office should implement to reconcile the broker accounts is as follows:

- Generate a list of the transactions performed with each authorized broker during the period being reconciled.
- Apply the commission percentage for each broker to the volume of transactions performed in that period.
- Compare the commissions invoiced by the brokers with the amounts calculated.
- Investigate and resolve discrepancies found during reconciliation and note them in a brokers' commission discrepancy registry.

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Reconciliation of Collection/Payment Accounts

Every day the back office must reconcile the statements for the accounts held at correspondent banks and clearing houses against the collections and payments resulting from the transactions done. All errors found must be investigated, resolved and recorded. The reconciled account statements must be signed by the person responsible for performing these reconciliations, and then filed.

Revaluations

The procedures and controls outlined below refer to the revaluation of positions for accounting purposes, although it is important to reconcile accounting revaluation and revaluation for risk management purposes. Accounting revaluations must comply with local regulations, which can include requirements related to time, frequency and methodology. The main points to bear in mind are:

- For revaluation purposes, transactions should be taken from the back office system, which must be reconciled with the front office system.
- The front office must not be involved in the revaluations; all market data should be obtained by the back office from independent sources.
- The back office documents the material differences found between the prices and rates used by the front office and those obtained from independent sources in a discrepancy registry. It also records the impact of these differences on the income statement.

Posting of Transactions

The purpose of the following procedure is to control the transaction posting process:

- Generate the accounting entries manually, or automatically from the back office system.
- Generate a report with the accounting entries and send it to the back office person in charge of reviewing and approving accounting entries.
- Send the entries to the department responsible for posting.

Policies for Operational Risk Control in the Treasury

In addition to establishing the procedures and controls described above, entities should implement the basic managerial principles of operational risk management in the treasury area. The policies that should be defined and implemented for this purpose are outlined below. In chapter 2 we defined the responsibilities and functions of the different areas of the entity in relation to operational risk control:

- The Board of Directors must approve the risk management strategy after it has been approved by the Executive Committee. The strategy must establish the operational risk control policies and procedures.
- The Risk Committee must define and ensure proper implementation of the policies and procedures needed to control operational risk.

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- The business committees and the ALCO must ensure that the directives established in the risk management strategy are followed in their respective areas of responsibility, and specifically, that the operational risk control policies and procedures established by the Risk Committee are followed.
- The risk management area must implement the operational risk control policies and procedures and ensure that all other areas follow them.

CODE OF CONDUCT

The code of conduct defines the standards and conduct to be observed by all employees of the treasury area during the course of their daily activities so as to avoid operational risk and protect the rectitude and integrity of the entity. This promotes public trust in the entity.

Once the code of conduct is defined and approved, each active member of the treasury area must sign a document stating that he is aware of the contents of the code and agrees to abide by it.

The code of conduct should establish for the employees of the treasury area required standards of behavior that govern the following items:

- Independence: professional independence is the ability to act with integrity and objectivity. This independence must be reinforced through compliance with the following policies:
  - All actions must be governed by professional criteria, and never by personal considerations.
  - Treasury personnel may not have financial or investment interests in entities with which relations exist as a result of treasury area activity (restricted entities); such relations could create a presumption of a lack of objectivity in performing transactions.

    The code of conduct should establish restrictions regarding relationships that treasury area personnel, their spouses or persons financially dependent on them might have with restricted entities. These relationships may take the form of financial interests; contractual, employment, or advisory relationships; application for or granting of loans or trusts, special terms on purchases of goods and services, acceptance of gifts, etc.
- Use of confidential information: confidential information is understood to mean any non-public information that is nevertheless available to treasury personnel as a result of normal treasury area activity, and also includes any information designated by management of the area as confidential.

  The code of conduct should establish standards that prohibit treasury employees from divulging confidential information to third parties, using it to their own benefit, or recommending transactions to third parties based on such information.
- Conflict of interest: the code of conduct should contain standards that prevent and govern conflicts of interest that may arise between the treasury area and other areas of the entity, clients, and in general, third parties.
- Use of the entity's name: the code of conduct should contain standards prohibiting any member of the treasury area from using the name of the entity to carry out activities or execute transactions for which the person does not have authorization. The code should also stipulate that when the name of the entity is used for authorized activities or transactions, it is done professionally, without compromising the financial stability of the entity or placing its image or credibility in question.

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- Professional ethics committee: the code of conduct should establish the composition and functions of a professional ethics committee that oversees compliance with the standards defined in the code and establishes appropriate sanctions in the event of non-compliance.

AUTHORIZED TRANSACTIONS

The Risk Committee must define, explicitly and in writing, the types of transactions that are authorized from different points of view:

- Authorized products: the products that the treasury can trade must be defined. Any restrictions regarding specific methods, positions and types of transactions within the different products must be specified.
- Authorized currencies: the entity must specify the currencies that are allowed, along with any restrictions on the positions that may be taken in any one of them.
- Authorized brokers: the entity must prepare and keep current a list of authorized brokers[5] through which the treasury can trade the different instruments for which it has authorization.
- Authorized traders: the entity must prepare and keep current a list of the persons authorized to trade in the treasury area. The products that each is authorized to trade and the risk level that may be assumed must be specified.

APPROVAL OF NEW ACTIVITIES AND PRODUCTS

By means of this policy the Risk Committee defines the standards to be followed in reviewing and approving new activities and products, so that the associated risks and benefits may be identified before beginning operations. The standards should cover the following:

- Criteria for determining when an activity or product is to be considered new and is therefore subject to this policy.
- The analysis that must be done to obtain approval for a new activity or product, including who must do the analysis, and what the analysis should comprise.
- Composition and activities of a committee that is responsible for reviewing and approving new activities and products.
- Procedures and phases of the approval process.

AUTHORITY LEVELS

This policy is used by the Risk Committee to establish the responsibilities and authorities associated with operating and processing issues related to treasury transactions. Some of the aspects that should be governed by this policy are:

[5] "Brokers" is understood to mean market participants that act as intermediaries between counterparties in treasury transactions, help their clients to close transactions on the best terms possible, and always seek to find the best price and best counterparty for the transaction that the client wants to perform. According to this definition, brokers do not take positions and their profit comes from the commissions charged to counterparties each time they close a transaction.

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- Who can authorize operating errors, and up to what volume.
- Who can authorize investigations and corrections related to operating errors and discrepancies.
- Who can authorize and sign payment order releases.

OTHER POLICIES SPECIFIC TO TREASURY ACTIVITY

The Risk Committee must define and ensure implementation of policies that govern the following specific aspects related to the treasury activity:

- Revaluation of positions: the frequency, methods, procedures and computer systems that must be used to revalue treasury positions must be defined.
- Portfolio classification: the different portfolios into which treasury transactions can be classified must be defined, along with classification and valuation criteria, from both an accounting and management point of view.

  When defining this policy and revaluing positions, the entity must take into account the accounting standards and criteria established by the regulatory authorities. The criteria established for management purposes may differ from those established by these authorities.
- Trading outside the trading room: as a rule, all treasury transactions should take place inside the trading room in order to maintain security, take advantage of available information and tape telephone conversations. However, there are times when market volatility or different time zones make it necessary to execute transactions in other locations. To address this situation, specific standards must be established that specify which brokers are authorized to do this, what type of transactions can be performed, and what types of operating procedures must be followed.
- Inter-company transactions: these are transactions performed between the desks of a single treasury in order to hedge positions, finance portfolios or transfer risk from one book to another. The entity must define the criteria and standards for executing and processing internal transactions.
- Contract assignments and cancellations: assignment of a contract is a legal procedure in which one party (the assignor) transfers to another party (the assignee) all its rights, responsibilities and obligations pursuant to a contract already executed with a third party (counterparty). Cancellation of a contract is a legal procedure in which one party terminates all of its rights, responsibilities and obligations related to an existing contract prior to the maturity/expiration date. The entity must define standards and criteria for contract assignments and cancellations.
- Unacceptable practices: the entity must define explicitly those actions or practices it considers totally unacceptable within the treasury activity, and the controls needed to identify and eradicate them. Some examples of practices that could be classified as unacceptable are:
  - Transfers between portfolios not allowed by applicable regulations.
  - Use of broker points: this consists of offsetting discrepancies between traders and brokers through the use of advantageous pricing terms on future transactions. This practice, besides delaying settlement of differences until such future transactions occur, distorts operating results and prevents management from knowing what is really occurring in the treasury area.
  - Prices adjusted by agreement: this consists of hiding a loss in a specific security or position whose market value has dropped by making an agreement with another

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entity for a broker acting on behalf of the entity to sell that entity the security in question at the historical purchase price and to offset that sale with a second sale of another security at an off-market price.
- Off-market prices: the entity should generally prohibit performance of transactions at prices other than market prices.

REVIEW AND MAINTENANCE OF THE MANUAL

Entities must define and implement operational risk control manuals for the different activities in which they are involved. One of the policies that should be established in such a manual is a policy on review and maintenance of the manual, which should cover the following:

- Responsibilities related to establishing, implementing and supervising compliance with the procedures and controls defined in the manual.
- Responsibilities related to maintaining the manual, in order to ensure its integrity and continued applicability.
- Procedures for modifying and updating the manual.

Another alternative is for the Risk Committee to delegate responsibility for the manual to the risk management area.

Systems Contingency Plan

The dependence of the treasury area on computer systems justifies the creation of a contingency plan[6] that enables the entity to act rapidly and efficiently in the event of a possible disaster or emergency and to minimize the consequences of such an event. The systems contingency plan for the treasury area should include at least the following:

- Definition and characteristics of the systems structure and topology of the network (rings, bridges, concentrators, file servers, communications servers, communication routers, printer servers, etc.).
- Identification of the users and/or groups of users connected to the treasury network, specifying the servers to which they are connected.
- Establishment of backup procedures so that the information contained in the file servers (the total or partial loss of which would cause serious damage to the area) is duplicated.
- Definition of the possible contingencies that could occur and affect systems in the area, as well as procedures to be followed if such a contingency occurs.
- Identification of the persons from the technology and systems area to contact in the event of contingencies.
- Definition of a crisis plan that permits continued operation at an alternative physical location in case of disaster.

[6] This topic is covered in more depth in chapter 12, which discusses risk management systems.

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Recommendations for International Standards on Operational Risk

Recommendations of the Group of Thirty

- Management should indicate explicitly who is authorized to trade derivatives.

Recommendations of the Derivatives Policy Group

- Financial entities should establish internal standards that govern relationships with clients, particularly those that trade OTC derivatives. These standards should cover aspects such as:
  - Confidentiality agreements
  - Presentation of reports and proposals to counterparties so that the latter understand the risks they are assuming and know the nature of the relationship being established between the parties.

Recommendations of the Bank for International Settlements

- Entities should be structured in a way that ensures adequate segregation of the business, administrative and control functions.
- Entities should have policy and procedure manuals for all the businesses in which they are involved. These manuals should specify all necessary operating controls.
- Before allowing the use of new products, entities should ensure that procedures and controls exist to value them and measure the risks inherent in them.
- Entities should establish a code of conduct, which must be followed by all personnel.
- Entities should decide which counterparties, clients and brokers it authorizes dealing with.
- Entities should establish appropriate compensation systems and should in no case promote excessive risk taking.

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Chapter 7

Legal Risk Management and Control

Introduction

The purpose of this chapter is to analyze the main legal issues that must be taken into account when entering into transactions. Although some of our discussion is applicable to any financial transaction (granting a loan, obtaining a deposit, etc.), our main interest is in analyzing the legal issues related to treasury transactions.

We begin by assuming that entities in general and their senior management in particular perform transactions in good faith in the belief that the latter do not violate any basic legal principles. We do not discuss the risks that are run by an entity that decides to perform a transaction while knowing that it is illegal.

The second section of the chapter defines the scope of legal risk and the objectives that an entity pursues in the management and control of this risk. In the third section, we present a manual on control of legal risk in treasury transactions. It outlines the situations that expose an entity to legal risk and defines the controls that should be established to mitigate the legal risk created by these situations. In the last four sections we examine legal issues[1] specific to Latin America with respect to four areas related to treasury activities:

- Foreign currency transactions
- Derivatives and master agreements
- Netting
- Collateral

Legal Risk: Definition and Scope

Entities are exposed to legal risk as a result of the possibility of losses due to:

- *Lack of legal capacity to exercise the rights* presumably granted in the executed documents that pertain to the transactions performed, as a result of:
  - Lack of adequate documentation.
  - Lack of authorization of the traders or signers of contracts.
  - Violation of a legal rule.
  - Changes in the law subsequent to performing a transaction.

[1] The material in this chapter should not be taken to be an exact description of the legal situation in the Latin American countries, since legal changes may have occurred since this work was published. In any case, the material in this chapter is not a substitute for specific legal advice.

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  - Errors in interpretation of the law, leading to good-faith but nevertheless illegal execution of transactions.
- *Financial compensation to third parties* (clients, suppliers, Government, etc.), as a result of failure to comply with the law. This compensation can take the form of indemnification, fines or taxes not originally projected.
- *Decrease in business volume*, as a result of:
  - Loss of reputation due to litigation with third parties, which may create, for example, an image of the entity as one that does not respect the law.
- Changes in the law, such as anti-monopoly laws that are applied when the entity is "too successful" compared to its competitors, or new liberalization measures that promote the entrance into the market of new competitors.
- Loss of business opportunities, due to the fact that the entity:
  - Is too zealous in trying to protect against potential losses due to legal risk, requiring, for example, excessive legal protection for the market in question. This leads the entity to reject certain types of business or transactions without considering whether the expected return compensates for the level of risk assumed.
  - Does not do thorough follow-up of legislative changes (tax, market regulation, etc.) in the markets in which it operates. This prevents it from taking timely or even any advantage of new business opportunities resulting from such changes.

In order to perform follow-up tasks and to control legal risk effectively, entities must have a specialized area[2] that has the resources it needs, based on the type of activity and volume of business. The legal department should perform its function with the following objectives in mind:

- Ensure that the entity has the legal capacity to exercise its rights. As explained in the next section, the legal department must establish the controls necessary to avoid situations that could endanger the entity's legal capacity to demand performance from its counterparties under transactions entered into. This includes ensuring that there is correct documentation of the different contracts used, that care is used in the preparation and modification of these contracts, that appropriate powers of attorney exist, and that the need for collateral and its type are analyzed, etc.

  It is important for documentation that is signed to comply with all established legal requirements, so that transactions performed are not invalid or unenforceable under the law.
- Ensure compliance with legal requirements. The legal department must identify all the requirements established by applicable laws with respect to the entity's business, and monitor compliance with them. The purpose of this function is to avoid performing transactions not allowed by the law, which if performed may be null and void. It is also meant to avoid the situation where failure to comply with the law results in an obligation to compensate the parties contracted with or some third party, or imposition of a sanction or fine, etc.

  It is especially important for the legal department to ensure that the entity is complying satisfactorily with all tax regulations.

[2] Legal and fiscal advisory area, as described in chapter 2. For the sake of brevity, in this chapter we will call this the legal department.

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- Identify business opportunities. The legal department must monitor the evolution of the laws in the main countries in which the entity does business in order to identify new business opportunities, such as:
  - Ability to perform transactions with certain products or clients not previously authorized by the law.
  - Ability to perform transactions that enable the entity to take advantage of differing tax treatments between countries.
  - Ability to structure business so that it is tax-efficient.

  The legal department should also alert the entity to the implications that legislative changes occurring over time could have on transactions that have already been entered into.
- Evaluate and control legal risk. Even if all of the steps outlined above have been performed, there is always the possibility of residual legal risk (due to supervening causes, incorrect or incomplete analysis, etc.), which must be considered by the entity when evaluating its situation from a legal point of view *vis-à-vis* transactions performed.

  Legal risk management can mitigate, but not eliminate, legal risk. The legal department must be capable of evaluating the legal risk faced at any point in time while seeking to reduce it as much as possible.
- Promote the creation of an adequate legal framework. It is important for entities, through their legal departments, to make the authorities in different countries aware of the need to create a legal framework that enables financial markets to develop. This involves identifying and defining derivative products; regulating netting; facilitating the use and development of master agreements that cover as many derivative products as possible and that allow for netting; clarifying what occurs in these types of contracts and transactions in the event of bankruptcy, etc.

Legal Risk in Treasury Transactions

The purpose of this section is to provide a manual for control of legal risk in treasury transactions. Particular emphasis is placed on those cases where counterparties are clients. In the left-hand column of the tables below we list the situations that expose entities to legal risk, and in the right-hand column we define the controls that entities should establish to mitigate the legal risk created by these situations.

A. Prior to Contracting Transactions

Situations that Create Legal Risk	Controls
• Prior to contracting a transaction by telephone, the identity of the party is not confirmed (especially in the case of a new client), nor is there confirmation of the party's authority to bind the entity that he states he represents.	• The traders in treasury must try to confirm the identity of the persons with whom they contract transactions by telephone (especially in the case of new clients) to verify that they actually represent whom they say they represent. • When transactions are performed over the telephone, the traders must tell the party that the conversation is being taped and request their authorization to do so (especially if it is the first time a transaction is being

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	contracted with that specific person or if it is a person who is not accustomed to performing this type of transaction).
• The legal capacity of the counterparty to contract such a transaction is not confirmed prior to entering into the transaction (e.g., public agencies contracting derivatives for speculative purposes).	• The legal department must ensure that the counterparty can perform the transaction in question, i.e., that there is no legal impediment that prohibits or prevents the counterparty from entering into certain transactions.
• Failure to confirm, prior to performing a transaction, that the counterparty understands perfectly the risks it is assuming, and that in case of losses it can be liable.	• The entity must establish mechanisms that enable the traders to be sure that the client understands the risks and potential losses associated with the transaction the client wants to do. The mechanisms can vary depending on the type of client and the complexity of the transaction: • For uncomplicated transactions or clients who are experienced traders (financial entities, mutual funds, insurance companies, etc.) verbal explanation of the characteristics of the transaction is sufficient. • For more complex transactions or less experienced clients, the client should be sent a written proposal for the transaction in question, specifying the associated risks and giving an analysis of the results generated by the transaction under different scenarios. All proposals made to a client must include the legal clauses that have been prepared by the legal department. If these clauses must be modified, approval must be obtained from the legal department to ensure that there is sufficient legal protection. In this regard, it is very important that the entity always act as an executor of the transaction, not as an adviser to the client (and this should be made clear to the client).

B. After Contracting Transactions

Situations that Create Legal Risk	Controls
• A transaction is performed and confirmation is not sent to the counterparty.	• Once a transaction has closed at the agreed price, the back office must send the client a confirmation stating the agreed financial terms of the transaction. The wording and content of the confirmations must be prepared by the legal department, based on the characteristics of the transactions in ques-

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	tion. Confirmations should be sent as quickly as possible and always within 24 hours of the close of the transaction. The confirmation should be signed by the client and returned immediately by fax and also by mail.
• A transaction has been performed and confirmation has not been received from the counterparty, nor has a contract been signed within a reasonable time.	• The back office must ask the client for all confirmations that have not been returned within, for example, one week. If a client habitually fails to return duly signed confirmations, it would be appropriate for the entity to stop dealing with the client. • When contracting for the first time with a client, the legal department must send it the master agreement, which the client must sign if it wishes to continue dealing with the institution. The legal department must be responsible for negotiating, if applicable, the clauses in the master agreement that must be modified, based on the transaction being performed and the client with which it is being done. If treasury performs these negotiations, the legal department must always be the area that gives or withholds final approval of the changes discussed. It is very important for all transactions to be covered by master agreements. Therefore, a maximum period within which these contracts must be signed with each new client has to be set. If the master agreement has not been signed within that period, a decision must be made on whether or not to continue doing business with the client in question.
• A confirmation has been received from the counterparty or a contract has been signed but the counterparty has not confirmed that the persons who signed these documents have been authorized to do so.	• The legal department must ensure that the persons with whom transactions are contracted can commit the entity they represent to that type of transaction. In order to ensure that this is the case, the legal department must assume the following responsibilities: • Ensure that the entity has powers of attorney for all of its clients. • Check the signatures and validity of the powers of attorney. • Periodically request from clients an update or confirmation of the validity of the powers of attorney.

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• Clients are not sent revaluations of their positions.	• The entity must provide revaluations of positions to clients when requested, and offer clients the ability to receive, if they wish, periodic revaluations of their positions. This procedure attempts to avoid extraordinary, unexpected losses for clients, since this could damage the image of the entity. It is very important for the legal department to include paragraphs in these revaluations stating their purpose, in order to prevent the client from mistakenly regarding the price or revaluation provided by the entity for accounting purposes as the price at which a position could be closed out at a given point in time.

C. In General

Situations that Create Legal Risk	Controls
• Trading is begun in a new product without approval from the legal department.	• All new products[3] must be reviewed by the legal department before being offered to a client. They must also be reviewed by the other areas affected by the introduction of the new product. The ideal is for all areas affected to be involved not just prior to the introduction of the product, but from the inception of the design throughout the development process, including the final approval process.
• A confirmation or contract is signed that has not been reviewed or authorized by the legal department. • Clients are sent transaction proposals or revaluations that include legal clauses that were not prepared or reviewed by the legal department.	• In general, the legal department should prepare and approve all legal clauses included in correspondence with clients, whether related to transaction proposals or revaluation information, transaction confirmations, contracts, etc. The legal department must ensure that these clauses are included in all correspondence that is sent out.
• There is doubt that all the documentation related to transactions is appropriately held in safekeeping, in order to avoid loss of the documents.	• The legal department must record all transactions in the system for control and follow-up. This system must be arranged to allow for review of the following: documentation not yet delivered, statistics on confirmations not received, statistics on response times, average period for signing of master agreements, etc.

[3] Chapter 6 discusses the policy for obtaining approval of new activities and products.

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	It is extremely important for the legal department to ensure that all documentation on the different transactions performed is obtained, classified and held in appropriate safekeeping.
• The entity itself does not have well-defined powers of attorney and authorizations (by amount, product type, etc.) for the persons that can contract transactions.	• The legal department must prepare the powers of attorney to be granted to the treasury personnel of the entity to perform different types of transactions, up to specific amounts, and must review them periodically based on the evolution of the market and the performance of new transactions.
• Changes that occur in the laws of the countries in which the entity operates are not known to the entity.	• The legal department must monitor the situation in the main countries in which the entity does business so that, based on the laws adopted as well as the lawsuits that arise (and the solutions reached in them), it can obtain the information required to enable it to avoid or anticipate similar situations.

Foreign Currency Transactions

Before engaging in foreign currency transactions, it is important to find out whether foreign exchange restrictions exist that could affect the validity of the transactions. In some countries, foreign currency inflows must be authorized in advance by the relevant authority.

The first thing to check is whether the applicable laws of the country in question permit uncontrolled conversion of currencies. Then one must find out whether legal restrictions or requirements exist. If there are any, they must be analyzed to ensure that they will not affect the planned transactions. All required formalities must be met (e.g., administrative, informational, requirement to perform the transaction at a specific market rate, etc.), so that the transactions performed will not be considered invalid.

In Mexico today there are no restrictions on currency conversions or currency inflows or outflows.[4] This does not mean that the Mexican government might not adopt emergency measures to keep the reserves of the Central Bank from decreasing to an extent that could endanger the economy.

In Chile, foreign currencies may be freely converted,[5] although the Central Bank of Chile (CBCH) reserves specific powers with respect to the performance of certain transactions.[6] This means that in practice there are certain limitations on foreign currency transactions. The CBCH has renewed these powers annually, by resolution of its Board of Directors, after considering the

[4] The Mexican peso is freely convertible and the exchange rate fluctuates based on supply and demand.

[5] Organic Law 18,840 of the Central Bank of Chile (LOC) of October 10, 1989, article 39, expressly establishes the principle of uncontrolled currency conversion. Therefore, anyone may freely perform international currency transactions.

[6] The same article of the LOC establishes that certain transactions must be reported in writing and that some transactions must be done within the Formal Foreign Exchange Market (FFEM); specific restrictions may also be imposed on the transactions that are done or must be done in this market.

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appropriateness of maintaining these restrictions for the purpose of preserving the stability of the currency and adequate financing of Chile's balance of payments.[7]

In Venezuela, although no restrictions exist today,[8] it should be noted that the President of the Republic, with the Council of Ministers, may establish restrictions when the situation requires.

In Colombia,[9] the only item required for currency to leave the country is a currency declaration. As for inflows,[10] taking time deposits and savings deposits in foreign currency is prohibited. Direct investments (in companies) are unrestricted, unless related to: defense and national security; processing and disposal of toxic, dangerous or radioactive wastes not produced in the country; companies whose main activity is the purchase, sale or lease of real property, unless constructed for the companies themselves; or investment in real estate securitization or real estate funds. Investments of foreign capital by institutional investors are permitted and must be registered with the Banco de la República (Central Bank) within 3 months of the date on which the foreign currency is converted into Colombian pesos in order to acquire rights to remit abroad the amount of the investment and the returns obtained.

Legal Issues Related to Derivative Contracts

Although the issues addressed in the preceding sections are applicable to all treasury contracts, special attention should be given to the legal implications of derivatives contracts, due to their special nature.

LEGAL IMPLICATIONS OF DERIVATIVES MARKETS

Derivatives are traded in two different types of market, each of which has its own specific legal implications:

- Organized markets are markets that are governed by the regulations of each country regarding access, trading, settlement, and other issues. Therefore, entities that wish to operate in these markets must analyze issues such as:
  - Restrictions that affect a specific product.
  - Need for a legal opinion in order to establish the enforceability of the contract.
  - Differences, if any, between regulations on local derivatives (derivative transactions regulated by local authorities) and non-local derivatives (on products regulated by foreign authorities).

[7] With this goal in mind, the CBCH has ordered that foreign currency inflows from investments, capital contributions or foreign loans must be authorized in advance by the CBCH, and that this authorization is subject to the condition that a reserve be established in U.S. dollars for an amount equal to 30% of the inflow, for a period of one year, and that the reserve will not accrue interest. There are some exceptions to this reserve, such as for settlement of foreign currencies related to derivative transactions with persons domiciled abroad, provided that the relevant exemption has been granted by the CBCH.

[8] Pursuant to the provisions of article 89 of the Law of the Central Bank of Venezuela.

[9] Foreign exchange controls are governed by Resolution No. 21 of 1993, of the Board of Directors of the *Banco de la República* and subsequent amendments or complementary rules.

[10] Capital inflows (foreign currencies) for investment purposes are governed by Resolution 51 of 1991 of the National Board of Economic and Social Policy, CONPES, and the rules that complement and amend it.

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- Prohibitions or limitations on certain types of institutions, which are particularly significant in the cases of public authorities, pension funds and fund managers, insurance companies, investment funds, brokerage firms, and others.

- Unregulated markets (more often known as OTC, or over the counter, markets) are markets not governed by any official regulations, and in which trading occurs freely between the two parties. Since there is no official regulation, each contract is tailored to the needs of the parties. However, the general rules regarding commercial and civil obligations and contracts do apply. Because of this, and to avoid the uncertainty caused by having different types of contracts, trading normally takes place under a master agreement[11] prepared by professional associations for those who operate in that market.[12] However, master agreements are subject to applicable national mandatory laws.[13] In general, each master agreement establishes rules for the trading of different derivatives.

TREATMENT IN DIFFERENT LATIN AMERICAN COUNTRIES

- In Chile, the requirements and conditions established by the CBCH[14] must be met in order to enter into derivative contracts through the Formal Currency Market.

  Combinations of the different types of derivative product contracts are also allowed, provided that they meet with established requirements. The combinations might include a group of different options, bonds, or insurance policies that include an option, etc.

- In Peru there is no legal definition of derivative product contracts,[15] which does not prevent certain futures and options transactions from occurring, since certain laws cover them. Nor is any formality required to assure validity when entering into certain types of contracts; this means that an agreement reached over the telephone on a futures transaction, for example, is binding on the parties from the moment it is concluded. For evidentiary purposes, however, it is advisable to sign a document that details the terms of the contract.

- In Colombia derivative products must be expressly authorized. Derivative products currently include futures, forwards, options, swaps, floors, caps and collars. Practically no contracts exist in which various derivative products are combined.

- In other countries only some derivative products are regulated. This is the case in Mexico[16] with local derivative products; brokers may offer only local products that are

[11] These contracts contain rules that the parties accept upon signing them. This acceptance makes the contracts binding on the parties.

[12] Note that each transaction closed under a master agreement normally presumes that a document called a "confirmation" is sent, confirming the financial terms of the specific transaction. The master agreement is thus the general framework and the confirmation is the document containing the specific financial/economic terms of each transaction.

[13] Hence the attempt to adapt such agreements to the laws of different places or to have them contain general legal rules that are valid under any legal system. For example, the rules in a master agreement regarding a specific derivative product cannot be applied if the laws of that country do not allow trading in that derivative.

[14] Contained in chapters VI and VII of the Compendium of International Foreign Exchange Rules.

[15] There is only a definition of commodity contracts in the General Law of the Financial System and the Insurance System, and the Organic Law of the Superintendency of Banking and Insurance.

[16] In this country we must distinguish between local derivative products (derivative transactions governed by Mexican law that may be offered in Mexico by authorized financial brokers, such as Mexican banks and brokerage houses) and offshore derivative products (derivative transactions that are commonly performed outside Mexico and are governed by foreign authorities, although sometimes with Mexican counterparties).

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governed by Mexican regulations.[17] Private entities, however, are free to enter into any type of derivative products contract, as well as any type of formal derivative transaction abroad. It should be noted that financial institutions are limited in their ability to pledge assets as collateral.[18] A Mexican bank's agencies and branches located abroad can perform transactions not regulated in Mexico but regulated in the country in which they are operating, provided that the transaction is not expressly prohibited by Mexican law and has been authorized by the Ministry of Finance and Public Credit. Affiliates are governed by the laws of the place in which they were established.

Mexican financial institutions are not expressly authorized to participate in transactions with offshore derivative products.[19] Securities market legislation does not allow brokerage houses to participate in offshore derivative products.[20]

Mexican insurance law does not expressly authorize insurance companies to participate in derivative transactions and therefore, as is the case for other financial entities, they may only engage in the activities for which they have express authorization.[21]

There is no regulation that permits pension funds and retirement fund managers to participate in offshore derivatives. Private entities are not subject to any restrictions.

Public agencies may engage in offshore derivative transactions provided that the product is used as financing. The entity must be subject to the provisions set forth in the public debt in question.[22]

- In Venezuela the Options and Futures Clearing House of Venezuela (CACOFV) has just been established, and its regulatory framework was established by the National Securities Commission. The CACOFV is limited to operating in futures on the Caracas Securities Exchange index, shares of *La Electricidad de Caracas,* shares of *C.A. Teléfonos de Venezuela* (CANTV) and the bolivar/dollar exchange rate.

MASTER AGREEMENTS

As stated above, for derivative instruments traded in OTC markets there are no official regulations at the federal government level governing either their content or trading system. But because they are complex contracts, certain terms need to be specifically established, such as the form and date of payment, the obligations of the parties, and the possible effects of the contract. Since it is not possible to discuss all the possibilities here, nor foresee all problems,

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[17] *Banco de México*, which has amended circular 2019/95 (which governs the derivatives market) several times, has said that it will shortly issue a new circular expanding the participation of Mexican brokers in the local derivatives market. Mexican banks normally offer exchange rate forwards, options and futures, interest rate forwards, or forwards based on the national consumer price index.

[18] Article 49 of the Law on Credit Institutions.

[19] However, pursuant to article 49 of the Law on Credit Institutions, banks may invest the funds obtained provided that they are used for the purpose of hedging risks and not speculative purposes. In addition, circular 2019 of *Banco de México* establishes that banks may enter into options on foreign currency futures on the Mexican peso, on the consumer price index, and in connection with Brady Bonds and on commodities (precious metals only), provided that these transactions are authorized by *Banco de México*.

[20] As deduced from article 22 of the Law on the Securities Market and Circular 10-186 of the National Securities and Exchange Commission. However, Circular 10-157 of the National Securities and Exchange Commission establishes that warrants may be issued in relation to other securities, groups or baskets of securities, or foreign stock price indices recognized by the Mexican Securities Exchange.

[21] Pursuant to the provisions of article 34, Section XVI, there exists the possibility that the Ministry of Finance and Public Credit may decide that a specific derivative transaction qualifies as analogous or related to insurers' business activities.

[22] It is necessary to distinguish between municipal and state entities, as indicated previously.

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a series of policies have been developed (master agreements) by unofficial associations of those trading in the market, which the parties can use as a legal framework for OTC derivatives contracts.

Master agreements should be agreements in which the two parties establish, among other items, the following:

- Events that trigger early termination of the financial transactions covered by the master agreements, as well as the contract itself.
- Rules for calculating the amount of debits and credits generated by financial transactions when early termination occurs.
- The ability to utilize a netting agreement, in which multiple debts and credits are replaced by a single debit or credit, i.e., the net amount. When necessary, these amounts are converted into the currency agreed upon for payment. In other words, one is committed to pay (when there is a debit balance) and to receive (when there is a credit balance) only the amount of the net balance, and not each and every one of the mutual debits and credits.
- The methods for determining the amounts payable or collectable in case of early termination.

Normal causes of early termination include default, bankruptcy and liquidation. The fact that one party incurs one of these causes for early termination does not mean that the contract automatically terminates, but that the other party is required to declare whether it wishes to accelerate the maturity of the contract.

For cases of early termination, the contracts must specify the date to be used for reference prices to determine the settlement amount of the transactions covered under the contracts. The contracts normally indicate that prices are to be taken from the date on which the party that is not in default calls the contract, i.e., the date on which early termination occurs.

There are a number of internationally recognized master agreements, such as:

- IFEMA (International Foreign Exchange Master Agreement), used to document transactions.
- The PSA (Public Securities Association)-ISMA (International Securities Market Association) agreement, a master agreement to contract temporary assignments of assets (Global Master Repurchase Agreement).
- The PSA agreement for OTC options contracts.
- The ISDA agreement (International Swaps and Derivatives Association, Inc., formerly the International Swap Dealers Association, which was established in May 1985), which was designed initially as a swap contract but has expanded over time to cover other derivatives instruments.

Of these master agreements, the most widely used at the international level is the ISDA. The last revision of this model for swap transactions dates from 1992. There is a model for international contracts (Multicurrency-Cross Border Master Agreement) that is more complex, and another for those entered into between nationals of the same country (Local Currency-Single Jurisdiction Master Agreement).

In addition to the master agreement *per se* an annex and confirmation are used that contain the specific rules for each swap transaction, stating the notional amount, interest rate or exchange rate payable by each party, the payment dates, etc. The annex to the ISDA policy is a document in which the special terms agreed to by the parties appear as appendices to the master agreement and are therefore applicable to all the swaps contracted between the

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parties under the master agreement. This annex personalizes the master agreement by adapting it to the specific needs of each party, but unlike the confirmation, it has a general character.

For example, in the ISDA master agreement and with respect to collateral (analyzed below), there are two types of annexes from which the parties must choose:

- Credit Support Annex, which is subject to the laws of New York (there is also one subject to Japanese law). This document establishes a pledge of the asset granted as collateral. Rehypothecation is permitted; i.e., the asset can be pledged again by the entity that received it as collateral in an earlier, separate transaction.
- Credit Support Deed (Security Interest), which is subject to English law. This annex takes two forms: the charge-based form (type of legal hypothecation of collateral) and the title transfer approach (outright transfer), which transfers title. English law does not permit rehypothecation.

Both documents establish bilateral provision of collateral.

In the last section of the ISDA master agreement definitions appear that establish the meaning of different legal concepts used in the text of the master agreement. The outline of the ISDA contract is as follows: an introduction; obligations of the parties; representations and agreements; early termination (the rules on this differ depending on whether there is an event of default or a termination event); and other provisions (miscellaneous).

The main effect of early termination is to necessitate the calculations that must be done to establish the payments that must be made by each party. The payments can be calculated in two ways:

- By taking into account the losses that the early termination has caused the injured party.
- By using as a reference the cost that the market makers quote for a transaction equivalent to the one that is being terminated, for the time remaining, so that the same benefits are obtained on the same terms as those that are no longer available because of the termination. In this latter case it is understood that the resulting amount includes the losses.

There are also two payment methods. The first method implies that the party in default (in the case of an event of default) or affected (in the case of a termination event) will pay the other party the difference between the expenses caused for each party by early termination. If the difference is in favor of the party that has defaulted on its obligations or was affected, it pays nothing and receives nothing. If the second method is used, the party that owes a net amount must pay that difference to the counterparty, even if it is the party that has not defaulted or is not affected.

Although the ISDA master agreement is used in Latin American countries, it is most frequently used in transactions performed with non-residents. Transactions between residents make use of the contracts that have been developed by the parties or that are habitually used in the market.

For example, in Peru the model contract that the Association of Banks (ASBANC) suggests for use by its members is used. In Mexico, besides the ISDA, the IFEMA contracts are used. The ISDA contracts are not used in Colombia, since each entity has established its own contract but consensus has not been reached on the use of a single document. Treasury transactions are normally governed by commitment letters.

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Netting Agreements

The purpose of netting agreements is to avoid having to total the credit risks derived from a number of financial transactions for the purposes of calculating the corresponding credit factors. To do this, banks establish bilateral or multilateral systems for settlement of net sums.

Netting agreements allow the replacement of multiple debts and credits resulting from numerous financial transactions (especially financial transactions that are settled on a net basis) with a single debit or credit that is the net amount of all the mutual debits and credits resulting from the financial transactions performed.

The importance of master agreements derives from their acceptance as netting agreements. All of the transactions covered by them are netted against each other so that there is a single debit and single credit. That is why it is important, where netting is allowed, for the law to recognize the existence and effects of master agreements and to define the types of transactions that may be documented by this type of agreement.

International financial institutions and market traders defend the need for all payments to be offset, one against another, to arrive at a single amount owed (netting). This implies endorsing the notion that all contracts included under a single master agreement constitute a single contract, and therefore, by being treated as a whole, can be offset to arrive at a single debit owed by one of the parties. The clause that is normally included in all cash settlement contracts, which states that all payments due at the same time, even if related to different specific transactions, are to be netted, would lead to the same conclusion. This netting arrangement is their main advantage.

The legal department must determine whether netting is allowed by the laws of the countries in which the counterparties are domiciled. Specifically, it must determine what would happen in the event that a counterparty were to enter bankruptcy proceedings.

Netting clearly benefits the bankrupt's creditor, which would collect the entire amount owed it by the bankrupt (which makes it a preferred creditor compared to other creditors). For this to occur, netting should be expressly allowed by the applicable law, which does seem to be the norm in many countries. However, it should be remembered that in those countries where netting is allowed it is more often a part of financial contracts of the type we have been discussing than a general rule in bankruptcy law.

In general, netting as such is not specifically regulated in Latin American countries, although the situation varies in each specific case:

- In Chile and Colombia the concept of set-off is used to defend the ability to use netting agreements.
- In Mexico and Peru, the law does not specifically cover netting agreements. However, the civil code does speak of a set-off agreement. This does not necessarily mean that parties can automatically set off derivative transactions; to do so, they must have specified in the contract the cases in which set-off will occur, as well as the related terms.

  In bankruptcy situations, Mexican law states that the debts of the bankrupt may not be set off. The creditors of the bankrupt must petition the judge for recognition of their credits. Parties to derivative transactions that include netting clauses have the same obligations and rights as were contracted prior to the declaration of bankruptcy. The outstanding obligations of the bankrupt are considered due and payable. The possibility of a declaration of retroactivity can affect derivative transactions, if they occurred after the parties were aware of the financial situation at the time the transaction was performed.

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In Mexico, financial institutions in general receive the same treatment as any other person with respect to bankruptcy (except for minor exceptions). A financial institution that is a creditor of a bankrupt has no privilege over other creditors, and if it were to have some preference it would be due to the quality of the credits it held. The stipulations entered into between the parties establishing the filing of a voluntary bankruptcy petition or a determination of bankruptcy as an event of early termination of the contract are admissible, provided that they were agreed to by the parties prior to the bankruptcy petition or determination of bankruptcy. Otherwise they would be considered creditor fraud.

In Peru, according to the special regulations applicable to companies that are part of the financial system, publication of the resolution to liquidate the company presumes that the credit entity cannot on its own comply with its obligations, which will be assumed by the liquidator. Any netting agreement entered into during the 6 months preceding the filing of the liquidation agreement can be declared null and void. The cash settlement amount is added to the list of creditors of the bankrupt entity and treated like any other credit.

- In Venezuela, in addition to the legal right of set-off provided by the civil code, there is contractual set-off, which is derived from an act of the parties, and right of set-off, which derives from a request from the party injured by an obstacle that prevents legal set-off.[23]

One must also determine how set-off works under different assumptions, such as the case of related obligations, i.e., obligations that derive from a single contract or a single negotiation, even though these obligations may be enforceable at different times.

When bankruptcy is declared, the start date for suspension of payments must be set. The date cannot be more than two years retroactive.

Banks and financial institutions are expressly excluded from the laws regarding benefit and delay of the bankruptcy. Set-off would occur between those primary debtors[24] of the financial institution who are themselves primary holders of credits against the financial institution (or other institutions taken over that belong to the same financial group).

Legal Issues Regarding Collateral

Because of the growing issuance of international debt, and the increasing sophistication in assurance techniques, the use of securities as collateral to reduce credit risk between the parties appears to have increased. When those securities are deposited in an international netting system,[25] it is important to define an agreement that governs the specific rights of each party.

By providing collateral, entities insure assets in favor of or transfer assets to a counterparty in order to reduce credit risk to another counterparty. Securities deposited with the ICSD are fungible. Cash accounts maintained at the ICSD can also be offered as collateral.

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[23] In Venezuela the principle of set-off is not activated upon a declaratory judgment of bankruptcy. Therefore, the party that is both debtor and creditor of a bankrupt must, as the debtor, pay all amounts it owes and as the creditor, be subject to bankruptcy law. However, set-off is effective if it takes place prior to the judgment of bankruptcy (provided that the debt in question was payable and enforceable prior to the judgment of bankruptcy). On an exception basis, debt can be admitted for set-off subsequent to the judgment of bankruptcy if the credits and debts in question derive from the same source.

[24] "Primary debtors" is understood to mean those who were original participants in the debt relationship created, not those to whom credits may have been assigned.

[25] Commonly called International Central Securities Depositary (ICSD).

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The assets that can be offered as collateral are: cash, government debt, eurobonds and other types of corporate debt (although this is less common), stock (which is rarely used as collateral in commercial transactions, although it is frequently used in structured financing), etc.

Entities must determine whether the use of collateral is allowed by the laws of the specific country, which securities may be used as collateral, what requirements must be met for the collateral to be valid, etc.

The main problem is related to how a bankruptcy proceeding can affect the collateral given, which in turn depends on the type of collateral. In a bankruptcy proceeding, creditors that have collateral should petition for separation of the assets pledged in order to exercise their rights.

Below are some examples of existing regulations on the use of collateral in certain Latin American countries:

- In Chile, banks cannot pledge their physical assets. However, non-banking institutions, may use all types of assets as collateral (time deposits, pledges on stock or bonds, mortgages, etc.).
- In Mexico various types of collateral are allowed, such as pledges of securities (which are easily documented and can be rapidly executed; however, as they are relatively new, the courts still have little experience in this area), securities trust (an advantage of which is that in case of bankruptcy the assets pledged remain separate from other assets; a disadvantage is that establishment of the trust results in an expense that must be analyzed to determine the return on the transaction), guarantee, etc.
- In Colombia, foreign currencies may not be taken as deposits to secure obligations.

The laws of each country specify the requirements for formalization of each type of collateral. In general, collateral is perfected by means of a notarially recorded instrument (except, for example, pledges on securities, which can be established by other means) or recording in a public registry. In order for this to occur, the guarantor must be duly authorized to pledge the collateral in question.

Recommendations for International Standards on Legal Risk

Recommendations of the Group of Thirty

- Entities should try to execute master agreements with their counterparties that are as broad as possible so that they cover all possible derivative instruments and forwards. The master agreements should provide for netting as to both payments and settlement of transactions.
- If local law does not allow netting of positions with a counterparty, it should not be done since the book values and risk measures can vary considerably.
- Regulators and supervisory authorities should recognize the advantages of netting and promote its use by providing for it in regulations regarding capital adequacy of financial entities.
- Legislators, regulators and supervisory authorities should work with entities to identify and eliminate legal gaps in areas such as:
  - Documentation required to formalize derivative contracts and master agreements.
  - Ability of the parties (e.g., governmental entities, insurance companies, pension funds) to contract derivative transactions.

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  - Enforceability of netting agreements and collateral in bankruptcy situations.
  - Legal validity and enforceability of derivative contracts.
- Legislators and fiscal authorities should revise tax regulations that act as a disincentive to use derivatives to manage risk. An example is the existence of inconsistencies in tax treatment of income on hedging derivatives in relation to income on the positions whose risks they hedge.
- The accounting standards of the different countries should deal with the accounting treatment of all financial instruments, including derivatives. The goal should be international homogeneity in the accounting treatment of derivatives.

Recommendations of the Bank for International Settlements

- Entities should have a specialized unit that is responsible for control of legal risk.
- Entities should analyze the advisability of establishing netting agreements with counterparties, while keeping in mind their legal enforceability.
- Entities should try to execute master agreements with their counterparties that are as broad as possible so that they cover all types of present and future transactions with derivative instruments. Entities should ensure that these agreements are valid under applicable law in order to ensure their legal validity in case of default by the counterparties.

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Chapter 8

Risk Management Information Systems

Introduction

This chapter describes the information that is generated and circulated throughout an organization as needed to manage and control risk. A section is also dedicated to external communication, in order to highlight the importance placed on risk management by market participants.

The concept of a management information system (MIS) is quite broad, and includes three clearly separate elements—information, users, and computer equipment—but this chapter concentrates on the first element, information. Organizational structure (i.e., users) is discussed in Chapter 2, and risk management information systems are discussed in Chapter 12.

Completely defined procedures for report preparation is an absolute necessity for the entire information process. This should explicitly specify report generation frequency, responsibility for generating reports, distribution, information content, etc. Such procedures avoid implementation of an information process based solely on *ad hoc* reports, which can lead to confusion inside and outside the entity.

We classify reports into three basic categories, depending on the purpose they serve:

- Evaluation reports. These reports provide information on the entity's profits and losses, risk, and return on risk-adjusted capital (RORAC), as well as the most significant changes that have occurred since the last report.
- Control reports. These reports analyze whether the true situation of the entity is appropriate, in terms of compliance with CAR limits, asset and liability gap structure, and hedge percentages.
- Reports supporting decisions made. The basic purpose of these reports is to present expected results, based on a combination of analysts' market expectations and the current position of the entity.

Internal Information Used for Risk Management

This section presents some reports that can be useful in risk management. These reports are intended for internal use and therefore should provide all the information that may be relevant to each area of the entity.

The reports presented are considered basic to the ability of each area to perform the functions for which it is assigned responsibility when a risk management strategy is implemented.

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INFORMATION TO THE BOARD OF DIRECTORS

The Board of Directors of the entity must be informed periodically regarding how the risk management strategy is being executed through a number of reports that summarize the overall situation. The board may also request other information that it deems necessary in order to understand the precise condition of the entity's businesses and how risks are being managed.

A number of reports are presented below that summarize the status of risk management at the entity. They show the main aspects that are of interest to the Board of Directors.

Evaluation of Results

Table 8-1 is a report on the profitability of each of the businesses in which the entity is active, and the risks assumed as a result of that business. It also explains the factors responsible for the results obtained and provides comments about the most significant events.

The first section of Table 8-1 (*Risk/Return Evaluation*) shows the results obtained by the different business units across different periods. Following this are measures of risk (Capital-at-Risk) and return on risk-adjusted capital (RORAC) for the current fiscal year.

Table 8-1. Report to the Board of Directors on Result

Evaluation of Results

Risk/Return Evaluation

	Results			Average CAR for the Fiscal Year			RORAC for the Fiscal Year
	Since Last Report	Since Beginning of the Month	Since Beginning of the Year	Market	Credit	Total	Total
Business 1							
Business 2							
Business 3							
Total							

Explanation of Results Since Last Report

	Sensitivity		Change	
	Interest Rate	Exchange Rate	Interest Rate	Exchange Rate
Business 1				
Business 2				
Business 3				

Comments

Person Responsible:
☎:

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The RORAC is stated on an annualized basis, which requires that the CAR and P&L measures used to calculate it also be annualized. This means that the annualization calculation must be made on the basis of specific assumptions that must be clearly defined and also must be known by the users of the reports, so that they are in a position to evaluate the accuracy of the measures, and the assumptions under which they are valid.

The second section (*Explanation of Results Since Last Report*) provides a summary analysis of results since the last report date. It provides the most significant positions, measures average sensitivity to different risk factors during the period covered for the different businesses, and then shows the changes that have occurred in the risk factors during the same period.

Evaluation of Foreign Exchange Risk of Direct Investments

Table 8-2 is a summary report on the management of the foreign exchange risk to which the entity is exposed through its direct investments.[1] This report provides information to the Board of Directors on the entity's position, the extent to which objectives have been achieved, and the results of hedging transactions.

The report analyzes the underlying, hedge, and open positions for each currency in which the entity has direct investments, for two different time periods. First it gives the most recent month (e.g., February 1999) and then the year-to-date figure (e.g., since January 1999). The following information is shown for each position:

- Average position. This is entity's position in the various items listed, for the periods defined.
- Profits and losses. These are the entity's total profits and losses for the period analyzed. The portion of profits and losses due to currency revaluation and to the interest spread is also shown.
- Historical CAR. This is calculated by taking the average of all the daily CARs for the period in question.
- Annualized historical RORAC. Finally, the table provides an annualized risk/reward measure for each of the positions described. The P&L and CAR measures must be annualized to calculate this measure, and the annualization should be performed according to known criteria and consistently with the information provided.

Calculating these measures presents some difficulties, such as the fact that the manager does not know in real time what the existing underlying asset position is, which causes the hedge position to be mismatched, which in turn causes the RORAC calculation to be approximate rather than precise.

Table 8-3 is a report on the results of direct investment foreign exchange risk management for the specific month and the year-to-date. Each of the currencies in which the entity has investments is identified. The critical element in preparing this report is selecting the exchange rates to be used in the budgets so that foreign exchange risk management of the projected profits for the year can be evaluated. The exchange rates selected must allow for separation of the operating earnings of the business from earnings due to open foreign exchange positions.

One solution is to use the forward rates quoted in the market for each of the currencies as of December 31 of the prior year, since the manager could have used them to hedge his positions. This would ensure that there would be no deviation from the budgeted currency amount.

[1] In this context, "direct investment" is defined as the stake held in the capital of entities located in other countries.

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Table 8-2. Report to the Board of Directors on the Foreign Exchange Risk of Direct Investments

Evaluation of Results

Direct Investments

Month Evaluated: Feb/99	Underlying Position					
		Monthly P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Monthly CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Evaluation Since: Jan/99	Underlying Position					
		Cumulative P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Y-T-D CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Month Evaluated: Feb/99	Hedging Transactions					
		Monthly P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Monthly CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Evaluation Since: Jan/99	Hedging Transactions					
		Cumulative P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Y-T-D CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Month Evaluated: Feb/99	Open Position					
		Monthly P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Monthly CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Evaluation Since: Jan/99	Open Position					
		Cumulative P&L				
Currency	Average Position	Total	Revaluation	Interest Spread	Historical Y-T-D CAR	Annualized Historical RORAC
US Dollar						
T&T Dollar						
Jamaican Dollar						
Barbadian Dollar						

Person Responsible:
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Table 8-3. Report to the Board of Directors on the Results of Management of the Foreign Exchange Risk of Direct Investments

Evaluation of Results

Profits for the Fiscal Year

Month Evaluated: Feb/99 Currency	Budgeted Average Exchange Rate	Projected Profit (Local Currency)	Projected Profit (Base Currency)	Actual Profit (Local Currency)	Deviation from Budget (Base Currency)	Actual Average Exchange Rate for the Month	Projected Profit in Base Curr., Actual Exch. Rate
Dollar							
T&T Dollar							
Jamaican Dollar							
Barbadian Dollar							

Month Evaluated: Feb/99 Currency	Hedge in local Currency	Average Hedge Rate	Hedge Results	Hedge Execution Deviation (Base Currency)	% Deviation from Budget	Real Profit (Base Cur.) at Actual Exch. Rate	Absolute Deviation from Budget
Dollar							
T&T Dollar							
Jamaican Dollar							
Barbadian Dollar							

Evaluation Since: Jan/99 Currency	Budgeted Average Exchange Rate	Projected Profit (Local Currency)	Projected Profit (Base Currency)	Actual Profit (Local Currency)	Deviation from Budget (Base Currency)	Actual Average Exchange Rate for the Month	Projected Profit in Base Curr., Actual Exch. Rate
Dollar							
T&T Dollar							
Jamaican Dollar							
Barbadian Dollar							

Evaluation Since: Jan/99 Currency	Hedge in Local Currency	Average Hedge Rate	Hedge Results	Hedge Execution Deviation (Base Currency)	% Deviation from Budget	Real Profit (Base Cur.) at Actual Exch. Rate	Absolute Deviation from Budget
Dollar							
T&T Dollar							
Jamaican Dollar							
Barbadian Dollar							

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Likewise, the evaluation of the currency risk manager's performance should be based on the assumption of no deviation in budgeted profits (in local currency), since these profits are not under his control, but rather the control of those responsible for the business in each country.

In order for the evaluation to be objective, the following deviations must be kept in mind:

- Deviation from budget: The result of differences between the amounts budgeted in local currency and the actual amounts.
- Deviation from execution of hedges: The result of differences that the change in the exchange rate causes between budgeted profits in the base currency (using the bud-

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geted exchange rate), and budgeted profits in the foreign currency (using the actual average exchange rate for the month being evaluated). This is the deviation that is actually used to evaluate the management of currency risk.

The absolute deviation from the budget is calculated in the last column. This amount is simply the sum of all the deviations.

Management of the Entity's Assets and Liabilities

Asset and liability management can be done for the entity as a whole or for each business, depending on the complexity of the balance sheet. The three reports below can be used to inform the board about asset and liability management in the commercial banking unit. However, they are also valid as models to report on asset and liability management in any business unit, or for the entity as a whole.

EVALUATION AND DECISION-MAKING

The report in Table 8-4 is divided into two parts. In the first, the results of the commercial banking portfolio and its associated management portfolio are evaluated.[2] In the second, the information is intended to facilitate decision-making; it shows the expected scenario for a given month and the impact of the scenario results on the current portfolio. The evaluation section of the report shows the following information:

- The P&L for the prior month and the current fiscal year-to-date.
- The historical CAR for the prior month and the current fiscal year-to-date. These numbers are annualized, so they are an estimate of the capital that could be lost over the next twelve months at, first, the risk levels of the prior month and, second, for the portion of the fiscal year that has elapsed.
- The RORAC for the prior month and for the elapsed portion of the fiscal year (both annualized). It is calculated using the annualized Capital-at-Risk, and the annualized P&L shown in the first column of the report. The criteria used to annualize the RORAC should be known so that those receiving the report understand the assumptions implicit in the results.

The section of this report on decision-making is divided into two parts:

- The first part shows the current position of the entity for different time periods at current value and as an equivalent position in par swaps, and the position's sensitivity to a 100 basis point change. The interest rates quoted in the market for the different periods and the rates projected one month hence appear next. Then there is an estimate of P&L that will be earned in one month if the current position is maintained and, alternatively, if the projected scenario proves correct. Last, the table shows the CAR for this position one day and one month hence. The CAR is then annualized in order to calculate the expected annual RORAC.
- The second part shows the current value of the position, interest rates, and inflows and outflows of cash during the next month for each of the time periods indicated.

[2] For more detail on these topics see chapter 4 on commercial banking risk management.

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Table 8-4. Report to the Board of Directors on Commercial Banking Results

Profitability and Risk Map

Evaluation

Total Portfolio Results

	Cumulative P&L		Historical CAR		RORAC	
	Month	Year	Month	Year	Month	Year
Total Commercial Banking Management Portfolio						

Profitability and Risk Map

Decision-Making

Commercial Banking and Management Portfolio

	Net Position			Interest Rates		Expected P&L 1 Month	Capital-at-Risk			Expected RORAC
	Present Value	Par Swap	Sens. 100bp	Actual	Expected Change 1 Month		Daily	Monthly	Yearly	
Up to 3 months										
3-6 Months										
6-12 Months										
1-3 Years										
3-5 Years										
5-10 Years										
>10 Years										
Total										

Analysis of P&L Scenarios: 1 Month

	Current Situation			Expected Scenario		Parallel Shift in yield curve		Non-Parallel Shift in yield curve			
	Current Value	Interest Rates	1 Month Flow	Expected Rate	P&L	+100bp	−100bp	Flatter	P&L	Steeper	P&L
Up to 3 months											
3-6 Months											
6-12 Months											
1-3 Years											
3-5 Years											
5-10 Years											
>10 Years											
P&L Total											
RORAC Annual											

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Expected interest rates one month hence are then shown for each of the time periods, together with the P&L that would result from the projected scenario. Finally, two types of simulation are performed: the first type shows parallel shifts of the yield curve 100 basis points above and below the yield curve expected to exist one month hence, along with the P&L that would result from the existing position for each of the periods in the report. In the second simulation, the yield curve is rotated; the table then shows the impact that a flattening and a steepening in slope would have on the curve, and how the latter would affect the expected P&L given the current position, for each one of the time periods.

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Table 8-5. Report to the Board of Directors on the Operating Margin of the Commercial Bank

Ordinary Margin

Decision-making

	Actual Portfolio	Δ Assets		Δ Liabilities			Total Expected	Margin Sensitivity	
	Operating Margin	New Transactions	Margin	New Transactions	Margin	Other Margins	Oper. Margin	+100bp	-100bp
Up to 3 Mos.									
3-6 Months									
6-12 Months									
1-3 Years									
3-5 Years									
5-10 Years									
>10 Years									
No Maturity									
Total									

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In this report we have very briefly introduced the concept of the equivalent position in par swaps, which will be used repeatedly throughout this chapter. The advantage of presenting the positions in this manner is that if one wishes to eliminate position risk for a specific period, all that is necessary is to enter into a swap in the same amount as and of the opposite sign than that shown on this map.

Table 8-5 shows a report intended for decision-making, that evaluates the operating margin of the commercial bank in the projected scenario, assuming parallel shifts of the yield curve.

The report in Table 8-5 begins by defining the operating margin of the current portfolio for different time periods. Then the new asset and liability transactions that will be added to the portfolio during the projection period are quantified, together with the estimated margin that will be contributed if the transactions indicated are actually performed. Finally, the table shows the projected operating margin and the margin given parallel shifts of the yield curve.

Table 8-6 is a report on the structure of the assets and liabilities of the current commercial banking portfolio, broken down into equivalent positions for different periods. It then shows the net balance of this portfolio.

INFORMATION FOR THE EXECUTIVE COMMITTEE

The information that is provided to the Executive Committee is almost the same as that provided to the Board of Directors. The main difference is related to the fact that the Executive Committee meets weekly, and is therefore much more involved in follow-up. The Executive Committee may request *ad hoc* reports on an as-needed basis that expand on the information provided by the reports shown below.

Operating Results

The purpose of these reports is to inform the Executive Committee of the risk/return profile of each of the entity's businesses. The three reports below, which are more thorough than those

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Table 8-6. Report to the Board of Directors on the Structure of the Commercial Banking Portfolio

Commercial Banking Portfolio

Description of the Portfolio

Assets

	Average Maturity	Balance	Current Value	Coupon	IRR
Up to 3 Months 3-6 Months 6-12 Months 1-3 Years 3-5 Years 5-10 Years >10 Years No Maturity					
Total					

Liabilities

	Average Maturity	Balance	Current Value	Coupon	IRR
Up to 3 Months 3-6 Months 6-12 Months 1-3 Years 3-5 Years 5-10 Years >10 Years No Maturity					
Total					

Net Commercial Banking Position

	Balance	Current Value	100bp Sensitivity	Interbank Closing
Up to 3 Months 3-6 Months 6-12 Months 1-3 Years 3-5 Years 5-10 Years >10 Years No Maturity				
Total				

Person Responsible:
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provided to the Board of Directors, summarize the situation of the entity and analyze market expectations, and are intended to facilitate decision-making.

Evaluation and Control of Results

Table 8-7 provides the same information as that provided to the Board of Directors in Table 8-1, but also includes a box showing the current CAR of each of the businesses and the percentage utilization of the risk limit, so that the risks being assumed by the entity can be controlled in terms of Capital-at-Risk.

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Table 8-7. Report to the Executive Committee on Results

Evaluation of Results

Evaluation and Control

Risk/Return Evaluation

	Results			Average CAR for the Fiscal Year			Fiscal Year RORAC
	Since Last Report	Since Beginning of Month	Since Beginning of Year	Market	Credit	Total	Total
Business 1							
Business 2							
Business 3							
Total							

Explanation of the Results Since Last Report

	Sensitivity		Change	
	Int Rate	FX Rate	Int Rate	FX Rate
Business 1				
Business 2				
Business 3				

Position Control

	Actual CAR	% Limit Utilization
Business 1		
Business 2		
Business 3		
Business 4		

Comments

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The difference between the current CAR and the average CAR for the fiscal year is that the former is an indicator of the capital that is actually at risk at present, while the latter is an estimate of the capital that has been exposed during the period in question by each business. This is why the current CAR—and not the average CAR for the fiscal year—is the measure that is compared to the limits.

Report to Facilitate Decision-Making Regarding Market and Credit Risk

The market risk report (Table 8-8) has six sections:

- Section One permits interest rate risk analysis, by showing for each currency and each maturity the sensitivity of the equivalent position, the daily expected P&L, the daily CAR and the expected RORAC.
- Section Two permits currency risk analysis, and shows the current position of the entity in each of the listed currencies,[3] together with the daily expected P&L, the daily CAR and the expected RORAC.

[3] This report assumes that the reference or base currency is the Trinidadian dollar.

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Table 8-8. Report to the Executive Committee on Market Risk

Market Risk Position

Decision-Making

Base Currency: Trinidadian Dollar ($TT)

Description of Position

Interest		$TT	US$	Yen	Euro	$Can	$JA	$BD	$GU	$M	£	SF	TOTAL
< 1 Year	Sensitivity Daily Exp. P&L Daily CAR Exp. RORAC												
1–3 Yrs.	Sensitivity Daily Exp. P&L Daily CAR Exp. RORAC												
3–5 Yrs.	Sensitivity Daily Exp. P&L Daily CAR Exp. RORAC												
5–10 Yrs.	Sensitivity Daily Exp. P&L Daily CAR Exp. RORAC												
> 10 Yrs.	Sensitivity Daily Exp. P&L Daily CAR Exp. RORAC												
FX		$TT	US$	Yen	Euro	$Can	$JA	$BD	$GU	$M	£	SF	TOTAL
	Position Daily Exp. P&L Daily CAR Exp. RORAC												
Equity		$TT	US$	Yen	Euro	$Can	$JA	$BD	$GU	$M	£	SF	TOTAL
	Position (index) Daily Exp. P&L Daily CAR Exp. RORAC												
Commodities		Oil	Coal	Gold	Copper	Zinc	Aluminum	Coffee	Cocoa	Sugar	Wheat	Soy	TOTAL
	Position Daily Exp. P&L Daily CAR Exp. RORAC												

	TOTAL
Expected P&L CAR Expected RORAC	

Market Expectations for Next Month

Market expectations		$TT	US$	Yen	Euro	$Can	$JA	$BD	$GU	$M	£	SF	TOTAL
	Short Term Rates Long Term Rates FX Indices												
Commodities		Oil	Coal	Gold	Copper	Zinc	Aluminum	Coffee	Cocoa	Sugar	Wheat	Soy	TOTAL
	Prices												

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- Section Three enables floating rate risk analysis. It shows the entity's equivalent position for each country *vis-à-vis* the most representative stock market index, and then states the expected results of the position, the daily CAR and the expected RORAC.
- Section Four gives the commodity positions of the entity, along with the expected P&L, the daily CAR and the expected RORAC for each position.
- Section Five totals the expected P&L, the CAR, and the expected RORAC.
- Section Six summarizes the entity's market expectations for the next month.

The RORAC is calculated on an annual basis in this report, so before it can be calculated the expected daily result and the daily CAR must be annualized.

The credit risk report (Table 8-9) shows the equivalent positions[4] for different periods, broken down by sectors, countries and credit ratings. Then the total daily credit CAR and the expected annual RORAC are calculated.

Table 8-9. Report to the Executive Committee on Credit Risk

Credit Risk Position, Equivalent Loans

Decision Making

Country 1	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												
Country 2	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												
Country 3	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												
Country 4	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												
Country 5	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												
Remainder	Sector 1			Sector 2			Sector 3			Remaining Sectors		
	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years	< 1 Year	1-3 Years	>3 Years
AAA-A												
BBB												
BB												
B-D												

Total CAR	
Expected RORAC	

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[4] For further information on equivalent loans see chapter 5, on credit risk management and control.

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Evaluation of Foreign Exchange Risk in Direct Investments

The reports presented to the Board of Directors regarding evaluation of foreign exchange risk in direct investments (Tables 8-2 and 8-3) are perfectly appropriate for use by the Executive Committee.

Management of the Entity's Assets and Liabilities

The same reports used to report to the Board of Directors regarding management of commercial banking assets and liabilities can be used to report to the Executive Committee (Tables 8-4 through 8-6). The only change necessary is the addition of information to two reports:

- The report in Table 8-10 contains the same information as shown in Table 8-5, but adds interest rate projections.
- The report in Table 8-11 contains the same information as Table 8-6, plus two sections that analyze the financial margin of the current commercial banking portfolio. The section on the left reviews the financial margin by time period; the section on the right analyzes the changes that occur in the financial margin given parallel shifts in the projected yield curve.

Table 8-10. Report to the Executive Committee on the Commercial Banking Operating Margin

Projected Operating Margin

Evaluation and decision-making

	Projected Scenario	Oper. Margin Current Portfolio	Assets		Liabilities		Others	Total Projected Oper. Margin	+100bp	−100bp
			New Transactions	Margin	New Transactions	Margin	Margin			
Up to 3 Months 3-6 Months 6-12 Months 1-3 Years 3-5 Years 5-10 Years >10 Years No Maturity										
Total										

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Table 8-11. Report to the Executive Committee on the Structure of the Commercial Banking Portfolio

Commercial Banking Portfolio

Description of Position

	ASSETS				
	Avg. Mat.	Balance	Current Value	Coupon	IRR
Up to 3 Months					
3-6 Months					
6-12 Months					
1-3 Years					
3-5 Years					
5-10 Years					
>10 Years					
No Maturity					
Total					

	LIABILITIES				
	Avg. Mat.	Balance	Current Value	Coupon	IRR
Up to 3 Months					
3-6 Months					
6-12 Months					
1-3 Years					
3-5 Years					
5-10 Years					
>10 Years					
No Maturity					
Total					

	Net Commercial Banking Position			
	Balance	Current Value	Sensit. 100bp	Interbank Closing
Up to 3 Months				
3-6 Months				
6-12 Months				
1-3 Years				
3-5 Years				
5-10 Years				
>10 Years				
No Maturity				
Total				

Commercial Banking Portfolio

Description of Financial Margin

	Total Commercial Banking			
	Assets	Liabilities	Interbank Closing	Net
Up to 3 Months				
3-6 Months				
6-12 Months				
1-3 Years				
3-5 Years				
5-10 Years				
>10 Years				
No Maturity				
Total				

	Commercial Banking and Management Portfolio			
	Assets	Liabilities	Interbank Closing	Net
Up to 3 Months				
3-6 Months				
6-12 Months				
1-3 Years				
3-5 Years				
5-10 Years				
>10 Years				
No Maturity				
Total				

	Change Com. Banking		Total Change	
	Projected +100bp	Projected −100bp	Projected +100bp	Projected −100bp
Up to 3 Months				
3-6 Months				
6-12 Months				
1-3 Years				
3-5 Years				
5-10 Years				
>10 Years				
No Maturity				
Total				

Person Responsible:
☎:

INFORMATION FOR THE ASSETS AND LIABILITIES COMMITTEE (ALCO)

This committee is responsible for approving the reports that are provided to the Board of Directors and the Executive Committee regarding the management of assets and liabilities. The ALCO does need more detailed information on this topic. Below we show the reports that the ALM area can provide to facilitate the ALCO's work.

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Table 8-12. Report to the Assets and Liabilities Committee on the Structure of the Commercial Banking Portfolio

Commercial Banking Portfolio

Description of the Position

	ASSETS						
	Avg. Maturity	Balance	Current Value	Coupon	IRR	Modified Duration	100bp Sens.
1 Month							
3 Months							
6 Months							
12 Months							
2 Years							
3 Years							
5 Years							
7 Years							
10 Years							
More than 10 Years							
No Maturity							
Total							

	LIABILITIES						
	Avg. Maturity	Balance	Current Value	Coupon	IRR	Modified Duration	100bp Sens.
1 Month							
3 Months							
6 Months							
12 Months							
2 Years							
3 Years							
5 Years							
7 Years							
10 Years							
More than 10 Years							
No Maturity							
Total							

	Net Commercial Banking			
	Balance	Current value	100bp Sensitivity	Interbank Closing
1 Month				
3 Months				
6 Months				
12 Months				
2 Years				
3 Years				
5 Years				
7 Years				
10 Years				
More than 10 Years				
No Maturity				
Total				

Comm. Bkg. and Mgmt. Portfolio	
Current Value	100bp Sensitivity

Person Responsible:

☎:

Description of the Position

Tables 8-12 through 8-14 can be used by the ALCO to support its decision-making process. They present the commercial banking and management portfolios from different perspectives:

- Table 8-12 is a position report for the commercial banking portfolio. Different measures of the position are shown for the asset, liability and net portfolios. Also shown are the current value and the 100bp sensitivity of the commercial banking and management portfolios.

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- The structure of the report in Table 8-13 is the same as that in Table 8-12, but it provides an evaluation of only the management portfolio of the ALCO.
- Table 8-14 is an analytical report of the changes that occur in the value of the position in the event of parallel shifts in the yield curve. In this report the positions are presented as a function of the equivalent portfolio of par swaps. This analysis takes into account both the commercial banking portfolio and the combination of this portfolio with the ALCO management portfolio.

Table 8-13. Report to the Assets and Liabilities Committee on the Structure of the Management Portfolio

Management Portfolio

Related Financial Instruments

	ASSETS						
	Avg. Maturity	Balance	Current Value	Coupon	IRR	Modified Duration	100bp Sensitivity
1 Month							
3 Months							
6 Months							
12 Months							
2 Years							
3 Years							
5 Years							
7 Years							
10 Years							
More than 10 Years							
No Maturity							
Total							
	LIABILITIES						
	Avg. Maturity	Balance	Current Value	Coupon	IRR	Modified Duration	100bp Sensitivity
1 Month							
3 Months							
6 Months							
12 Months							
2 Years							
3 Years							
5 Years							
7 Years							
10 Years							
More than 10 Years							
No Maturity							
Total							

	Net Management Portfolio			
	Balance	Current Value	100bp Sensitivity	Interbank Closing
1 Month				
3 Months				
6 Months				
12 Months				
2 Years				
3 Years				
5 Years				
7 Years				
10 Years				
More than 10 Years				
No Maturity				
Total				

Person Responsible:
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Table 8-14. Report to the Assets and Liabilities Committee on the Sensitivity of the Commercial Banking Portfolio

Par Swap Position and Sensitivity

Description of the Position

Par Swaps

	Commercial Banking			Net Management Portfolio	Total
	Assets	Liabilities	Net		
1 Month					
3 Months					
6 Months					
12 Months					
2 Years					
3 Years					
5 Years					
7 Years					
10 Years					
20 Years					
30 Years					
Total					

Sensitivity

	Commercial Banking	Mgmt. Portfolio	Total
1 Month			
3 Months			
6 Months			
12 Months			
2 Years			
3 Years			
5 Years			
7 Years			
10 Years			
20 Years			
30 Years			
Total			

Par Swaps with current Yield Curve +50bp

	Commercial Banking			Net Management Portfolio	Total
	Assets	Liabilities	Net		
1 Month					
3 Months					
6 Months					
12 Months					
2 Years					
3 Years					
5 Years					
7 Years					
10 Years					
20 Years					
30 Years					
Total					

Sensitivity with Current Yield Curve +50bp

	Commercial Banking	Mgmt. Portfolio	Total
1 Month			
3 Months			
6 Months			
12 Months			
2 Years			
3 Years			
5 Years			
7 Years			
10 Years			
20 Years			
30 Years			
Total			

Par Swaps with Current Yield Curve –50bp

	Commercial Banking			Net Management Portfolio	Total
	Assets	Liabilities	Net		
1 Month					
3 Months					
6 Months					
12 Months					
2 Years					
3 Years					
5 Years					
7 Years					
10 Years					
20 Years					
30 Years					
Total					

Sensitivity with Current Yield Curve –50bp

	Commercial Banking	Mgmt. Portfolio	Total
1 Month			
3 Months			
6 Months			
12 Months			
2 Years			
3 Years			
5 Years			
7 Years			
10 Years			
20 Years			
30 Years			
Total			

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Evaluation of the Financial and Operating Margins

The main purpose of the reports presented below is to analyze the financial and operating margins of the commercial banking and ALCO management portfolios.

REPORTS FOR DECISION-MAKING

In this section we provide three reports whose purpose is to facilitate decision-making by analyzing the behavior of the financial and operating margins in different scenarios.

The financial margin of the current portfolio under current conditions and in different projected scenarios is presented in the first two reports. Table 8-15 is a report on the behavior of fixed rate transactions, while Table 8-16 presents the behavior of floating rate transactions.

The references to options that appear in tables 8-15 and 8-16 refer to the embedded cancellation options included in the majority of asset and liability instruments traded by a commercial bank. Inclusion of this option ensures that the report accounts for the ability of one party to exercise the option to abandon the position in the future. Projected fees are presented in both reports.

Table 8-15. Report to the Assets and Liabilities Committee on the Financial Margin of the Fixed Rate Commercial Banking Portfolio

Financial Margin of Current Portfolio

Commercial Banking and Management Portfolio: Fixed Rate

	Fixed Rate						
	Assets			Liabilities			
		Coupon			Coupon		Net
	Balance	%	US$	Balance	%	US$	US$
1 Month							
3 Months							
6 Months							
12 Months							
2 Years							
3 Years							
5 Years							
7 Years							
10 Years							
More than 10 Years							
No Maturity							
Total							

	Change in Fixed Rate due to Exercise of Options								
	Scenario		Assets			Liabilities			
			Exercise	Change in Coupon		Exercise	Change in Coupon		Net
	3 Mo. Rate	5 Yr. Rate	Balance	%	US$	Balance	%	US$	US$
1 Month									
3 Months									
6 Months									
12 Months									
2 Years									
3 Years									
5 Years									
7 Years									
10 Years									
More than 10 Years									
No Maturity									
Total									

Commission Payment
US$

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Table 8-16. Report to the Assets and Liabilities Committee on the Financial Margin of the Floating Rate Commercial Banking Portfolio

Financial Margin of Current Portfolio

Commercial Banking and Management Portfolio: Floating Rate

	Floating Rate										
		Assets			Liabilities			Interbank Closing			
	Scenario		Coupon			Coupon			Coupon		Net
	3 Month Rate	Balance	%	US$	Balance	%	US$	Balance	%	US$	US$
1 Month											
3 Months											
6 Months											
12 Months											
2 Years											
3 Years											
5 Years											
7 Years											
10 Years											
More than 10 Years											
No Maturity											
Total											

	Total Fixed Rate + Options		
	Assets	Liabilities	Net
1 Month			
3 Months			
6 Months			
12 Months			
2 Years			
3 Years			
5 Years			
7 Years			
10 Years			
More than 10 Years			
No Maturity			
Total			

Total with Commissions US$

Person Responsible:

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Table 8-17 is a report about the operating margin on hedged futures transactions. The upper portion of the report shows projections for assets, liabilities and the operating margin. The lower portion contains two sections that simulate parallel shifts of the yield curve in order to analyze the sensitivity of the operating margin.

REPORTS FOR CONTROL PURPOSES

Table 8-18 is a report on the financial margin of the current portfolio, and on the margin that would be earned on the commercial banking and total portfolios if parallel shifts of the yield curve were to occur. The purpose of this report is to enable comparison of the changes in the financial margin given parallel movements in rates within the limits set.

The report in Table 8-19 can be used as a control report and for decision-making. It is a simulation of the behavior of the operating margin upon parallel shifts of the yield curve. Although we show a single report, the concept is to provide as many scenarios as are of interest, including a comment that explains the relevance of that scenario.

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Table 8-17. Report to the Assets and Liabilities Committee on the Operating Margin on Hedged Futures Transactions

Operating Margin on Hedged Futures Transactions

Projections

	Operating Margin: Commercial Banking and Management Portfolio										
	Proj. Scenario		Assets			Liabilities			Operating Margin		
	3 Month Rate	3 Year Rate	Proj. Balance US$ Balance	Δ Bal.	Δ Oper. Margin	Proj. Balance US$ Balance	Δ Balance	Δ Oper. Margin	Δ Margin Assets & Liab.	Other Margin	Total
1 Month											
3 Months											
6 Months											
12 Months											
1 Year											
2 Years											
3 Years											
5 Years											
7 Years											
10 Years											
More than 10 Years											
No Maturity											
Total											

Sensitivity Analysis: Operating Margin

	Proj. Scenario + 100bp		Assets			Liabilities			Operating Margin		
	3 Months Rate	3 Years Rate	Proj. Balance US$ Balance	Δ Bal.	Δ Oper. Balance	Proj. Balance US$ Balance	Δ Balance	Δ Oper. Margin	Δ Margin Assets & Liab.	Other Margin	Total
1 Month											
3 Months											
6 Months											
12 Months											
1 Year											
2 Years											
3 Years											
5 Years											
7 Years											
10 Years											
More than 10 Years											
No Maturity											
Total											

	Proj. Scenario – 100bp		Assets			Liabilities			Operating Margin		
	3 Months Rate	3 Years Rate	Proj. Balance US$ Balance	Δ Bal.	Δ Oper. Balance	Proj. Balance US$ Balance	Δ Balance	Δ Oper. Margin	Δ Margin Assets & Liab.	Other Margin	Total
1 Month											
3 Months											
6 Months											
12 Months											
1 Year											
2 Years											
3 Years											
5 Years											
7 Years											
10 Years											
More than 10 Years											
No Maturity											
Total											

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Table 8-18. Report to the Assets and Liabilities Committee on the Changes in the Financial Margin Based Upon Established Limits

Financial Margin on Current Portfolio

Evaluation and Control

	Total Commercial Banking				Commercial Banking and Management Portfolio			
	Assets	Liabilities	Interbank Closing	Net	Assets	Liabilities	Interbank Closing	Net
1 Month								
3 Months								
6 Months								
12 Months								
1 Year								
2 Years								
3 Years								
5 Years								
7 Years								
10 Years								
More than 10 Years								
No Maturity								
Total								

	Commercial Banking Change		Total Change		
	Projected +100bp	Projected −100bp	Projected +100bp	Projected −100bp	Limits
1 Month					
3 Months					
6 Months					
12 Months					
1 Year					
2 Years					
3 Years					
5 Years					
7 Years					
10 Years					
More than 10 Years					
No Maturity					
Total					

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Table 8-19. Report to the Assets and Liabilities Committee on the Simulation of the Operating Margin Given a Parallel Shift in the Yield Curve

Operating Margin Simulation

Decision-Making and Control

	Operating Margin	Sensitivity	
		Projected +100bp	Projected −100bp
1 Month			
3 Months			
6 Months			
12 Months			
2 Years			
3 Years			
5 Years			
7 Years			
10 Years			
More than 10 Years			
No Maturity			
Total			
Current Value Duration			

	Scenario	Operating Margin	Sensitivity	
			Projected +100bp	Previsto −100bp
1 Month				
3 Months				
6 Months				
12 Months				
2 Years				
3 Years				
5 Years				
7 Years				
10 Years				
More than 10 Years				
No Maturity				
Total				
Actual Value Duration				

	Value	Duration	Sensitivity
Limit			

Scenario Description

Person Responsible:

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Evaluation of Results

The report in Table 8-20 enables us to thoroughly evaluate commercial banking results for the current fiscal year and the most recent month. At the end of the report there are a few risk measures and RORAC for the current fiscal year.

Risk/Return Report

The report in Table 8-21 enables the ALCO to evaluate the P&L of the commercial bank and the risk incurred under different scenarios. The upper section of the report shows the P&L expected in one month, the daily, monthly and annualized CAR, and the expected annual RORAC. The lower section of the report provides P&L simulations under the expected scenario, with parallel shifts of the yield curve, and introducing fluctuations in the yield curve.

INFORMATION FOR THE RISK COMMITTEE

The Risk Committee meets about as often as does the Executive Committee, to analyze and monitor the main risks to which the entity is exposed. This committee uses detailed information on the overall risks of the entity, which is prepared by the risk analysis and control area.

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Table 8-20. Report to the Assets and Liabilities Committee on Commercial Banking Results

Evaluation of Results

	Total Portfolio					
	Cumulative P&L		Historical CAR		Annualized RORAC	
	Month	Year	Month	Year	Month	Year
Total Commercial Bank Mgmt. Portfolio						

Results for the Month

	Initial Transactions									
	Initial Situation			Final Situation			Financial Costs	P&L	Monthly CAR	Annualized RORAC
	Current Value	Interest Rates	1 Month Flows	Current Value	Interest Rates	Actual Flows				
1 Month										
3 Months										
6 Months										
12 Months										
1 Year										
2 Years										
3 Years										
5 Years										
7 Years										
10 Years										
20 Years										
30 Years										
Total										

	New Transactions								
	Commercial Banking				Management Portfolio				Total P&L
	Current Value	Cash Flows	Financing Costs	P&L	Current Value	Interest Rates	Financing Costs	P&L	
1 Month									
3 Months									
6 Months									
12 Months									
1 Year									
2 Years									
3 Years									
5 Years									
7 Years									
10 Years									
20 Years									
30 Years									
Total									

Actual CAR		Historical CAR		Historical RORAC	

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Table 8-21. Report to the Assets and Liabilities Committee on the Risk/Return Profile of Commercial Banking Activity

Risk/Return Map

Decision-Making

Commercial Banking and Management Portfolios

	Net Position			Interest Rates		1 Month	Capital-at-Risk			Expected
	Current Value	Par Swap	100bp Sens.	Current	Δ Expected 1 Month	Expected P&L	Daily	Monthly	Annual	RORAC
1 Month										
3 Months										
6 Months										
12 Months										
1 Year										
2 Years										
3 Years										
5 Years										
7 Years										
10 Years										
More than 10 Years										
Total										

Analysis of P&L Scenarios: 1 Month

	Current Situation			Expected Scenario		Parallel Shift		Non-Parallel Shift			
	Current Value	Interest Rates	1 Month Flows	Expected rate	P&L	+100bp	−100bp	Flatter	P&L	Steeper	P&L
1 Month											
3 Months											
6 Months											
12 Months											
1 Years											
2 Years											
3 Years											
5 Years											
7 Years											
10 Years											
More than 10 Years											
Total											

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Reports for Analysis and Control of Market Risk

Some of the reports that can be used to analyze and control market risk have already been presented, because they are also of use to other areas of the organization. Those discussed below are more specific and detailed.

Reports for Evaluation of Market Risk

The report in Table 8-22 enables the Risk Committee to analyze the entity's risks in detail. It breaks out the delta, gamma and vega of each business based on the market risk factors to which they are exposed, the cumulative P&L for the fiscal year for each business, and the RORAC achieved by each business unit. The lower portion of this table reviews compliance with established Capital-at-Risk limits.

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Table 8-22. Report to the Risk Committee for Evaluation of Market Risk

Capital-at-Risk by Business Unit

Capital-at-Risk and Limits

		Capital-at-Risk						Cumulative P&L	Historical RORAC
		Daily			Annual				
		Int. Rate	FX	Consolidated	Int. Rate	FX	Consolidated		
Business Unit 1	Total Delta Gamma Vega								
Business Unit 2	Total Delta Gamma Vega								
Business Unit 3	Total Delta Gamma Vega								

	Limit		
	Daily		
	Interest Rate	FX	Consolidated
Limit Excess Utilization			
Limit Excess Utilization			
Limit Excess Utilization			

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Reports for Market Risk Control

The report in Table 8-23 shows the daily and annualized CAR, for the entity as a whole and for each business. The CAR of the businesses can be compared with the established limits. This report also stress-tests the total CAR of the entity and of each business, under the column heading "correlation+1", which calculates the CAR using the assumption in this example that both market factors shift with full positive correlation (i.e., correlation of +1). The graph at the end of the report is an example of back-testing, which tests the validity of the model used to measure market risk.

Reports for Analysis and Control of Credit Risk

As with the market risk reports, many of the reports that the Risk Committee must use to control credit risk have already been presented. Other more detailed reports are shown below that enable the risk committee to evaluate and control credit risk.

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Table 8-23. Report to the Risk Committee for Control of Market Risk

Risk/Return Map

Summary

Daily Capital-at-Risk

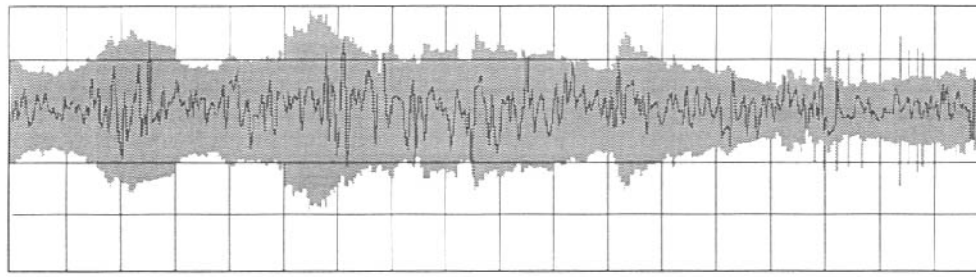
CAPITAL-AT-RISK

	Capital utilization			Business 1				Business 2			Business 3		
	Business 1	Business 2	Total	Correlation +1	Limit	Excess	% Utilization	Limit	Excess	% Utilization	Limit	Excess	% Utilization
Factor 1													
Factor 2													
Total													
Correlation +1													

Annualized Capital-at-Risk

	Capital utilized			Business 1				Business 2			Business 3		
	Business 1	Business 2	Total	Correlation +1	Limit	Excess	% Utilization	Limit	Excess	% Utilization	Limit	Excess	% Utilization
Factor 1													
Factor 2													
Total													
Correlation +1													

CAR VS P&L



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Reports for Evaluation of Credit Risk

Two reports are suggested that enable the Risk Committee to perform a detailed analysis of the credit risk assumed by the entity. The report in Table 8-24 analyzes the credit Capital-at-Risk (CAR), P&L and credit RORAC of the total entity for the current fiscal year, and for each business, with a breakdown by product (although this breakdown could have been performed by country). The graph in the lower portion of the table shows the evolution of the credit RORAC of the entity as a whole, and for each business.

The report in Table 8-25 analyzes the same concepts as Table 8-24, but the breakdown is by counterparty credit rating.

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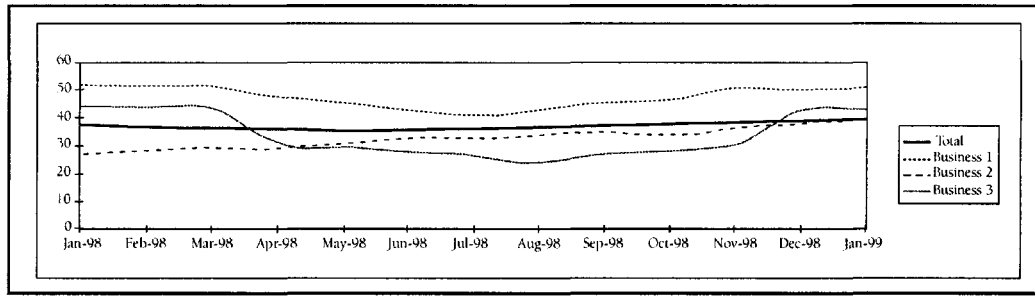
Table 8-24. Report to the Risk Committee on Evaluation of Credit Risk by Product

Capital-at-Risk and RORAC

Entity by Product

Product				Business 1			Business 2			Business 3		
	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC
Product 1 Product 2 Product 3												
Total												

Evolution of RORAC



Moving average - Last 12 months

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Table 8-25. Report to the Risk Committee for Evaluation of Credit Risk by Rating

Capital-at-Risk and RORAC

Business by Rating

Rating				Business 1			Business 2			Business 3		
	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC	CAR	Cumulative P&L	RORAC
AAA AA A BBB BB B CCC CC C D												
Total												

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Reports for Credit Risk Control

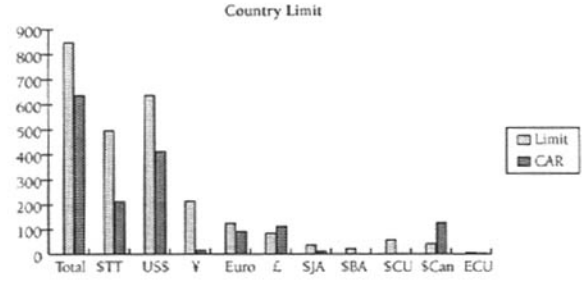
The report in Table 8-26 can be used by the risk committee to control credit risk limits. It shows credit limits (in terms of Capital-at-Risk) and the percentage utilization of the limits by country, sector and business. The counterparties in excess of established limits are listed at the end of the report.

Table 8-26. Report to the Risk Committee for Control of Credit Risk

Simulation of the Ordinary Margin

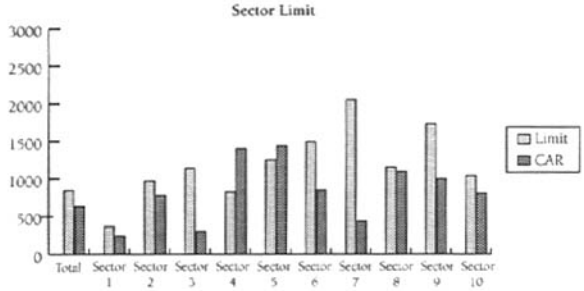
Decision Making and Control

Country Limit



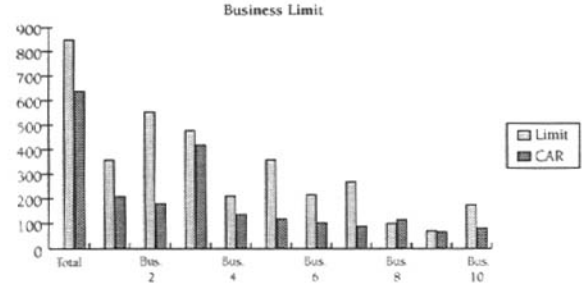
	Limit	CAR	% Utliz
Total	847	637	75
STT	496	213	43
US$	636	412	65
¥	215	15	7
Euro	125	90	72
£	84	112	133
SJA	37	12	32
SBA	22	1	5
SCU	57	2	4
SCan	42	128	305
ECU	5	3	60

Sector Limit



	Limit	CAR	% Utliz.
Total	847	637	75
Sector 1	367	241	66
Sector 2	969	780	80
Sector 3	1138	301	26
Sector 4	826	1402	170
Sector 5	1248	1441	115
Sector 6	1496	852	57
Sector 7	2055	438	21
Sector 8	1154	1092	95
Sector 9	1733	1000	58
Sector 10	1039	805	77

Business Limit



	Limit	CAR	% Utliz.
Total	847	637	75
Business 1	357	208	58
Business 2	551	180	33
Business 3	477	418	88
Business 4	210	135	64
Business 5	358	117	33
Business 6	215	102	47
Business 7	268	88	33
Business 8	100	115	115
Business 9	70	66	94
Business 10	174	80	46

Counterparties Exceeding their Limit

Counterparty	Sector	Business	Country	Limit	CAR	Excess

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Reports for Control of Foreign Exchange Risk of Direct Investments

If the entity has subsidiaries in other countries, the Risk Committee must control the currency risk created by these investments. The following reports are very useful in this regard.

Reports for Evaluation and Decision-Making

Table 8-27 is a report that analyzes the currency position of the entity as a result of direct investments. The risk entailed is identified, as well as the expected RORAC. This shows whether or not return expectations and goals are being met, and provides a basis for recommending changes that must be made in existing positions in order to meet such goals.

The first portion of the report presents the direct investments, showing the position, Capital-at-Risk and expected RORAC for each currency as of a specific date. In order to describe the open position in each currency the table shows the equity value of the investment, the financing of the position in the same currency, foreign exchange transactions (which generally reduce total exposure) and financing of the investments in other currencies (unrelated financing column). The open position in each currency is the sum of these four amounts.

Table 8-27. Report to the Risk Committee for Evaluation of the Foreign Exchange Risk of Direct Investments

Presentation of Currency Risk Positions

Direct Investment

Exchange Rate at the Beginning of the Period	Currency	Equity	Financing	Operations FX	Unrelated Financing	Open Position	
						Base Currency (Millions)	As % of Equity
	US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar						
	Total						

Exchange Rate at the Beginning of the Period	Currency	Annualized CAR	Expected P&L 1 Year			Expected RORAC
			Expected Total	Revaluation	Forward Points	
	US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar					
	Total					

Annual Profits

Exchange Rate Budgeted	Currency	Expected Profit Fiscal Year	Existing Hedge	Open Position	% Hedge	Expected CAR through End of Year	Expected P&L at End of Year	Expected Revaluation	Forward Points	RORAC
	US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar									
	Total									

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After calculating the open position, the maximum loss that could be generated over one year's time can be estimated, assuming the risk level remains stable (annualized CAR). The annual expected profit associated with the maintenance of the open position can also be quantified. This expected P&L shows the excess profit or loss generated by maintaining the open position compared to the risk-free alternative of closing out the position based on forward rates. Finally, the table shows the expected RORAC so that it can be compared with the RORAC goal set by the manager.

The second part of the report shows the annual profits earned on the direct investments. It shows the currency in which the profit is denominated, the expected volume through the end of the fiscal year, existing hedges, as of the time the report is prepared. Using the difference between the latter two amounts the open position in each currency is established. The risk assumed is evaluated by calculating the CAR through the end of the fiscal year, which measures the maximum loss that could occur for a given probability. The calculation should be dynamic, given that the profits imputable to each period of the year generate different currency risks, depending on how close they are to year-end.

Reports for Control Purposes

The report in Table 8-28 enables the Risk Committee to compare the level of foreign exchange risk created by the direct investments to the limits set, by currency and for the entire portfolio.

Table 8-28. Report to the Risk Committee for Control of Foreign Exchange Risk of Direct Investments

Currency Risk Control

Direct Investments

Month Evaluated: Feb/98	Hedge			Annualized CAR		
Currency	%	Minimum Limit (%)	Shortfall (%)	% Utilization	Maximum Limit (%)	Excess
US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar						
Total						

Annual Profits

	Actual Hedge on Expected Profit			CAR at Year-end on Expected Profit		
Currency	%	Mimimum Limit (%)	Shortfall (%)	%	Maximum Limit (%)	Excess (%)
US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar						
Total						

Limit

	% Hedge Limit on Expected Profits				Annual CAR Limit on Total Profits			
Currency	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
US Dollar T&T Dollar Jamaican Dollar Barbadian Dollar								
Total								

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The currency risk limits are controlled with respect to the value of the direct investments as well as the annual profits generated by those investments.

To establish the limits, first one defines a minimum hedge limit of the equity value for each currency and on an aggregate level; then a maximum limit is defined in terms of annualized CAR for each currency and then a total annualized CAR for the portfolio.

Two limits are established regarding annual profits: the minimum percentage of expected profits for the fiscal year that must be hedged, and the maximum percentage of expected future profits (converted to the base currency) that can be risked, i.e., Capital-at-Risk over expected profits.

The numbers that appear in the shortfall and excess columns indicate whether these limits are being observed.

INFORMATION FOR THE BUSINESS COMMITTEES

The business committees need to have information on which to base risk management decisions. Some reports that serve this purpose are provided below.

Reports for Market Risk Management

The report in Table 8-29 summarizes the position of the entity through par swaps (equivalent position) grouped by periods and currencies. The graph in the bottom section of the report shows the entity's positions by period for the most important currencies.

Table 8-30 is a report on daily and annualized Capital-at-Risk in each currency, by market risk factor. In the bottom half of this report is a graph with the CAR for each currency. This table clearly shows in which currencies risk is concentrated.

Reports for Credit Risk Management

The report in Table 8-31 summarizes the nominal position of the entity and the different businesses in equivalent loans of differing periods. The lower portion presents a graph that summarizes the concentration of the position for the different periods.

Table 8-32 also shows the position in equivalent loans, but with the breakdown by country instead of periods. This enables analysis of credit concentrations in the countries in which the entity operates. The bottom graph shows the main credit positions by country.

Information for External Parties

The main purpose of external communication is to make clear the value that risk management provides for each market participant, so that risk management rapidly translates into:

- Higher stock price.
- Regulatory framework based on the needs of efficient risk management.
- Recognition of the entity's credit quality.

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Table 8-29. Report for the Business Committees on the Positions (Equivalent Portfolio) that Generate Market Risk

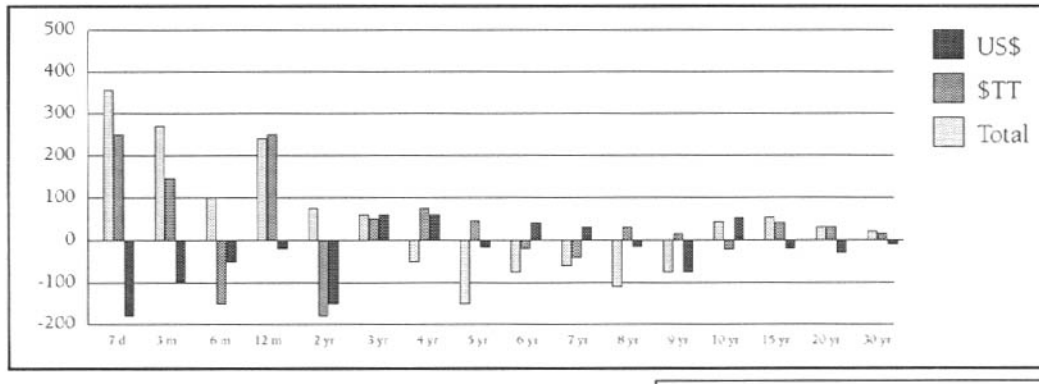
Risk/Return Map

Breakdown by Currency/Period

NOMINAL POSITION

Nominal Position in Instruments at PAR

	Total	$TT	US$	¥	SCAN	£	EURO	$JA	$BD	$GU	SF	ECU
Total Value 7 Days 3 Months 6 Months 12 Months												
2 Years 3 Years 4 Years 5 Years												
6 Years 7 Years 8 Years 9 Years 10 Years												
15 Years 20 Years 30 Years												
Equity Value Net FX												



Person Responsible:
☎:

Risk management information provided by the entity should make it easier for each market participant to do its specific tasks, such that:

- Investors have sufficient information to manage their portfolios.
- Analysts evaluate the prospects of the entity in order to be able to value it.
- Rating agencies can analyze the credit quality of the entity.
- Regulators can establish a legal framework that benefits economic development while eliminating the possibility of fraud and promoting transparency.

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Table 8-30. Report to the Business Committees on the CAR by Currency and Risk Factor

Risk/Return Map

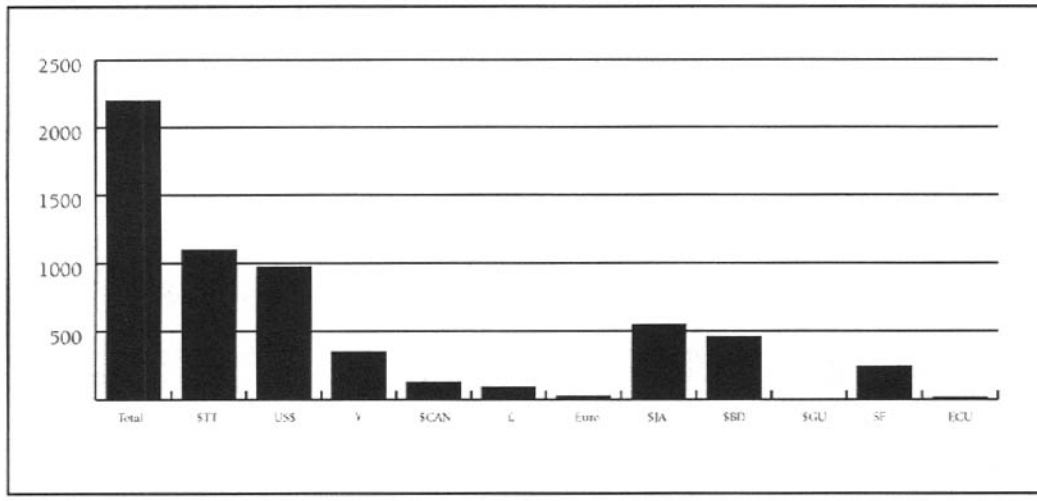
Breakdown by Currency/Risk Type

Capital-at-Risk

CAR

	Total	$TT	US$	¥	$CAN	£	Euro	$JA	$BD	$GU	$SF	ECU
Daily Interest Rate FX												
Annualized Interest Rate FX												

DAILY CAR



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However, despite the advantages to be derived from publication of this type of information, entities must take care when deciding what to publish. Some of the reasons for caution are:

- The fact that the entity does not have a risk management strategy with clearly established policies and procedures that enable it to control risk and to make appropriate decisions.
- The local markets in which the entity operates are not sensitive to the need to measure, control and manage risk. This circumstance is rapidly changing for two reasons: first, increasing participation in international markets, and second, the knowledge that the need to manage risk is greater in less-developed markets. Up to now, it has been possible to delay implementation of the management strategies used in more developed markets.

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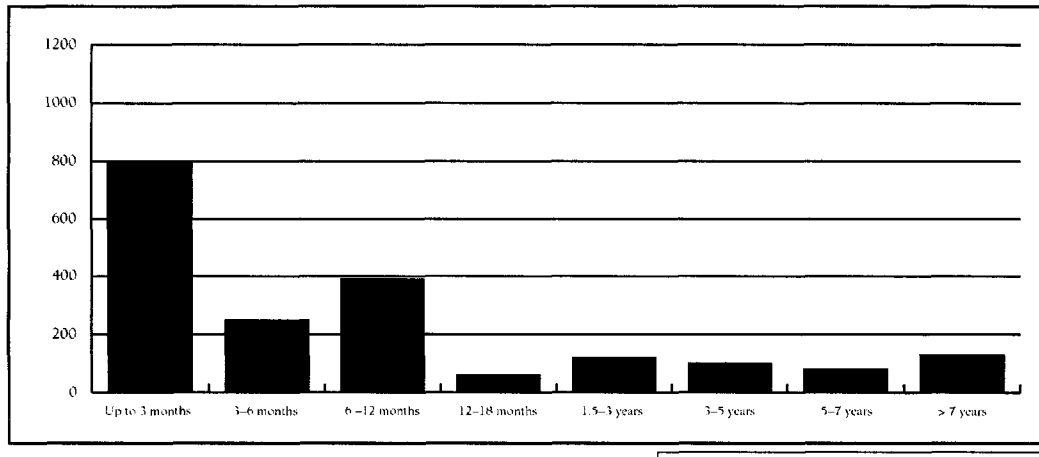
Table 8-31. Report to the Business Committees on Credit Positions (Equivalent Loans) by Business and Period

Position by Business and Maturity

Exposure in Equivalent Loans

NOMINAL POSITION

	Total	Business 1	Business 2	Business 3
Position				
Up to 3 Months				
3-6 Months				
6-12 Months				
12-18 Months				
1.5-3 Years				
3-5 Years				
5-7 Years				
More than 7 Years				
No Maturity				
Pre-dispute				



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- The idea that there are management procedures and strategic information that should not be made available outside the entity in order to protect a competitive advantage or because of the confidential nature of that information, such as the structure of the entity's assets and liabilities, the instruments it is capable of trading, volume of business in each instrument, hedges, etc.
- The lack of defined standards set by the supervisory authorities of each country and the sector in general. In recent years certain entities (BIS, IOSCO, etc.) have begun to define guidelines regarding risk management information to be communicated externally. However, the posture of the supervisory authorities in this regard varies considerably from one country to the next.
- Finally, the fact that providing this type of information implies a commitment to do so in future years.

In any case, the provision of information on risk management is an increasingly common practice. Therefore, some items that should be covered by the information published are specified below. They are useful in understanding the risks to which the entity is exposed, how it manages them, and the results of this management.

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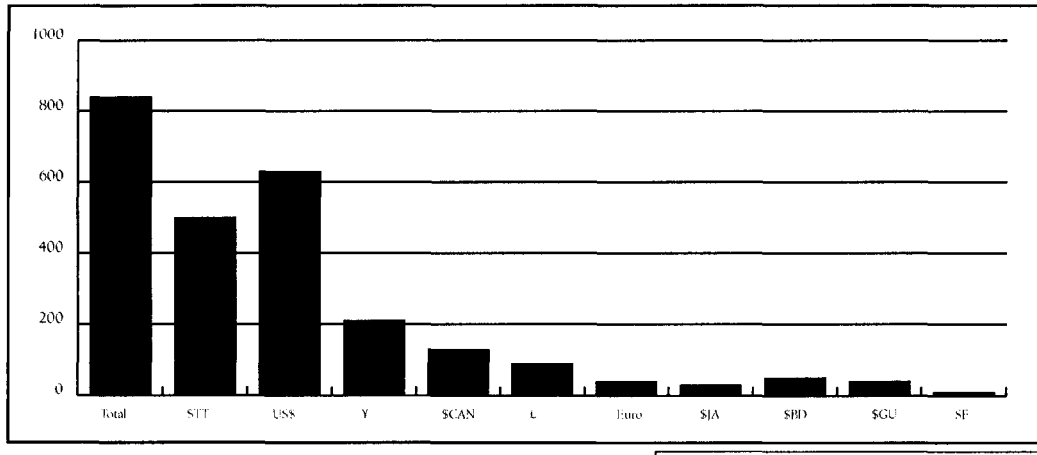
Table 8-32. Report to the Business Committees on Credit Positions (Equivalent Loans) by Business and Country

Position by Business and Country

Exposure in Equivalent Loans

NOMINAL POSITION

	Total	Business 1	Business 2	Business 3
Total Position				
Trinidad & Tobago US Japan Canada				
United Kingdom Germany Jamaica Barbados				
Guyana Switzerland				



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- The information must be consistent with the complexity of the risks to which the entity is exposed and the methodologies and systems used to control and manage it. In other words, it should be a summary of the information that the entity normally handles, and not an *ad hoc* report prepared for inclusion in the annual report that has little to do with the information that is used to manage risk.
- The information should take into account the type of business in which the entity is involved, and its relative importance to the overall balance sheet.
- Quantitative and qualitative information should be included that provides a clear picture of the risk management strategy used and the profits obtained thereby.

The information provided to market participants should be related to the risk management strategy implemented by the entity. An outline of the risk management information that can be distributed to market participants is below:

- Definition of objectives and risk management strategy.
- Analysis and measurement of risks.

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  - Decision-making.
  - Operating control.
  - Evaluation of results.
- Description of the risks to which the entity is exposed.
  - Market risk.
  - Credit risk.
  - Liquidity risk.
  - Operational and legal risk.
- Policy on use of financial derivatives.
  - Description of policies, by instrument.
  - Description of policies, by business.
- Other items of interest.

Recommendations for International Standards on Management Information Systems

Recommendations of the Group of Thirty

- The financial statements of an entity should provide sufficient information about derivative instruments. Specifically, information should be provided on objectives, transaction volume, risk level incurred and the accounted treatment. For financial entities, this type of information should be provided for each type of position and instrument.

Recommendations of the Derivatives Policy Group

- Entities must establish information mechanisms that make it possible to show proper execution of risk management policies.

Recommendations of the Bank for International Settlements

- Management should participate in risk management and control, and should receive periodic reports on the entity's risk exposure. It should also define the maximum allowable risk level.
- Management should receive periodic information on aggregate exposure to different types of risk, compliance with established policies and procedures, and revisions that should be made to the latter (internal and external auditing reports).

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Chapter 9

Market Risk Measurement Methods

Introduction

In this chapter we will explain the methodologies commonly used to calculate the factors that determine the Value-at-Risk and Capital-at-Risk of a specific position.

The purpose of doing these calculations is to obtain a risk map for the position in which each possible profit or loss is assigned a probability of occurrence. The risk map of the position will depend on the risk profiles of each of the products that comprise it and on the relationship between the risk factors inherent in each product.

It is therefore necessary to determine the probability distributions associated with each product considered and each portfolio analyzed.

There are two approaches for doing this: analytical and numerical. Which is used depends on the situation that is to be analyzed:

- The *analytical focus* is based on obtaining mathematical expressions that describe the probability distribution of the instrument considered. An example of this focus is the use of covariance matrices to calculate the risk of a stock portfolio.
- The *numerical focus* is based on scenario simulation techniques, in which the probability distribution is obtained by sampling. An example of this focus is the generation of Monte Carlo simulations to analyze derivatives portfolios.

The analytical focus normally brings greater richness to the analysis and requires fewer calculations, but also requires more effort to carry out and sometimes necessitates the use of simplified assumptions. However, when the products analyzed are especially complex or more sophisticated behavior models must be used, and the resulting risk questions cannot be solved analytically, we can use the numerical focus, frequently at the cost of performing more calculations while obtaining less analytical richness. This means that a compromise between the two, based on the characteristics of the environment being analyzed, must be achieved.

In the analytical focus and in some numerical methods, it is necessary to define in advance the behavior of the risk factors embedded in a given position. Describing behavior requires defining the probability function expression in the first case and modeling the interplay of the risk factors in the second case.

Below we describe how the risk/return measurements defined in Chapter 3 are calculated using both approaches. First we provide a quantitative analysis of behavior and the risk measurements associated with an asset, which we then generalize for the case of a portfolio and finally compare to the results obtained using a numerical model based on Monte Carlo and historical simulations.

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Measures of Risk and Return

RETURN MEASUREMENTS

The risk map represents the probability that there will be a given change in the value of a portfolio in a given time period (T):

$$\Delta Value = V_T - V_0$$

The change in value is the sum of the changes in value of each of its components. Therefore, in order to determine the risk map, the behavior of the value of the portfolio must be modeled.

This is done by analyzing the behavior of asset prices and their effect on the annual rate of return and the continuously compounded rate of return because the return is the variable that is relevant to an investor.

Annual Rate of Return

The annual rate of return is defined as the return associated with the price of an asset, expressed in annual terms. Therefore,

$$r = \frac{1}{T}\frac{\Delta Price}{P_0} = \frac{1}{T}\frac{P_T - P_0}{P_0}$$

where T is the time period, expressed in years, P_0 is the initial price of the asset and P_T is the price of the asset at the end of the period.

Continuously Compounding Rate of Return

The continuously compounding rate of return is defined as the annual return associated with the price of the asset assuming that the returns are reinvested immediately and continually. Therefore,

$$r_c = \frac{1}{T}\ln\frac{P_T}{P_0}$$

Example

Let's assume a financial instrument that had an initial value of US$ 1 million, and that after a period of 23 days it has a market value of US$ 1.02 million, which is a change in value of US$ 20,000 in 23 days (0.063 years). Therefore,

Return = $20{,}000/10^6$ = 2%
Annual rate of return = 0.02/0.063 = 31.74%
Continuously compounding rate of return = (ln 1.02)/0.063 = 31.43%

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ASSET VALUE BEHAVIOR

According to the traditional price behavior model,[1] prices follow a lognormal probability distribution, or, equivalently, the natural logarithm (ln) of V_T behaves like a random variable that follows a normal distribution.

Therefore, the continuously compounding return, which also behaves like the logarithm of the value, will exhibit normal distribution as well, and both the change in the value of the asset and the annual return will behave like lognormal random variables.

Distribution of Asset Values	
Variable	**Distribution**
Price	Lognormal
Value Changes	Lognormal
Annual Return	Lognormal
Continuously Compounding Return	Normal

If we examine a portfolio, its change in value can be expressed as the weighted sum of the changes in value of each instrument that comprises the portfolio. Therefore, regardless of the composition, the change in value of a portfolio is expressed as a function of a sum of random variables that are not independent, each having a lognormal distribution. However, the sum of non-independent lognormal random variables does not necessarily follow any known distribution, which means that risk measurements cannot be calculated using the analytical focus. Consequently, some additional assumptions must be made and/or numerical focus must be used.

Normal Returns Hypothesis

Above we saw that the distribution of changes in value of a portfolio expressed as a sum of non-independent lognormal variables does not allow us to build a closed-form analytical solution.

In order to be able to arrive at a closed analytical solution we must assume that the change in value of each instrument behaves like a normal distribution with the same standard deviation as the continuously compounding return.[2]

This means that we are assuming that the change of value of an asset, and therefore, the value of the asset itself, is normally distributed.

---

[1] From the theory of asset price behavior [Hull, J., *Options, Futures and Other Derivative Securities*, pp. 209-210], one deduces that

$$\ln\frac{V_t}{V_0} \sim Normal\left(\left(\mu-\frac{\sigma^2}{2}\right)\cdot T, \sigma\sqrt{T}\right)$$

where μ is the expected return and σ is the annual volatility of the continuously compounding return. Given that

$$r_c = \frac{1}{T}\ln\frac{V_T}{V_0}$$

we derive:

$$r_c \sim Normal\left(\mu-\frac{\sigma^2}{2}, \frac{\sigma}{\sqrt{T}}\right)$$

[2] For a more detailed justification of this price normality hypothesis, see p. 234 of the appendix.

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Therefore, given that the sum of random variables that follow a normal distribution behaves like normal distribution, the return on the portfolio would present a normal probability distribution of known parameters.

Confidence Interval

Once we know the distribution that governs the evolution of prices, we can calculate the points corresponding to the different confidence intervals. Given a normal distribution of mean $r^{expected}$ and standard deviation d, we obtain the confidence intervals shown below.

Confidence Intervals		
Value	**c(%)**	**1–c (%)**
-3.00•d	99.87	0.13
-2.75•d	99.70	0.30
-2.50•d	99.38	0.62
-2.25•d	98.78	1.22
-2.00•d	97.72	2.28
-1.75•d	95.99	4.01
-1.50•d	93.32	6.68
-1.25•d	89.44	10.56
-1.00•d	84.13	15.87

Therefore, for a 99.87% confidence interval the lowest return possible for period T would be equal to

$$r^* = r^{expected} - 3 \bullet d$$

while the highest return possible for the same confidence interval would be equal to

$$r^* = r^{expected} + 3 \bullet d$$

VOLATILITY

Once a price behavior model has been created, we must estimate the standard deviation that will be introduced into the model and that will determine the maximum loss for the confidence interval selected.

We will introduce the concept of *volatility* and the procedure used to measure it in a past period. Below we present various ways of estimating expected volatility, which is the volatility that actually determines the level of risk to which the portfolio is exposed.

Definition

Asset volatility is defined as the standard deviation of the return of the asset.

Volatility measures the deviation of the possible returns around the expected return. To keep positive deviations from offsetting negative deviations, all the deviations are squared and added and then the square root is calculated. If we know the probability p_i of all the possible returns γ_i that may occur in the future during a specific period, volatility is calculated as:

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$$\sigma = \sqrt{\sum_{i=1}^{N} p_i \bullet (\gamma_i - \bar{\gamma})^2}$$

where

- $\bar{\gamma}$ is the expected return

$$\bar{\gamma} = \sum_{i=1}^{N} p_i \bullet \gamma_i$$

- N is the number of possible returns

So, if there were a limited number of possible returns and they were equally probable, we would have

$$p_i = \frac{1}{n}$$

and therefore,

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{N} (\gamma_i - \bar{\gamma})^2}$$

The calculation above requires complete knowledge of the probability distribution of the asset return. However, the information that is normally available is the historical series of actual returns of the asset during a past period, which is only a sampling of the complete "population." If we use this information we obtain an estimate of past volatility that is expressed as follows:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} (\gamma_i - \bar{\gamma})^2}$$

where

- n is the number of observations in the series[3] and
- γ_i is the return for the period starting at instant $i-1$ and ending at instant i.

Nonetheless, since we have only a limited number of observations of returns during any given period, we cannot be absolutely sure that the true volatility for that period is the same as the estimated volatility.

Predicting Volatility

In the section above we defined *volatility* and how to estimate it for a specific time period in the past. However, there is no guarantee that future price behavior will be the same as past price

[3] We divide by $n-1$ instead of by n because the data series used is a sampling of the asset return behavior, but does not represent all the possible cases. Statistical calculation shows that the best estimate of the standard deviation of a population using sampling data is obtained by dividing the sum of squared deviations by $n-1$.

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behavior. Therefore, a central problem in risk measurement is predicting future volatility, which will be introduced into the models in order to quantify the risk to which the entity is exposed. Knowing the volatility of prior periods is certainly useful, but future volatility cannot be extrapolated without additional analysis.

The methods used to attempt to predict the volatility of an asset in a future period can be divided, depending on the type of information used as the fundamental starting point, into two main types:

- methods based on historical return series, and
- methods based on expectations.

We provide brief explanations below of the main methods used to predict future volatility, and present some techniques for comparison that enable us to choose the method that provides the best estimate.

Methods Based on Historical Return Series

Methods based on historical return series attempt to predict future volatility based on past fluctuations in returns. Depending on how this information is treated, these methods can be divided into:

- historical volatility methods, and
- regression methods.

Historical Volatility Methods

These methods begin by calculating the best estimator of volatility in a certain period, or in a number of periods, in order to extrapolate this estimator to the desired future period. There are a number of ways of arriving at this estimator. For example:

- Use the volatility directly estimated from the returns for a number of past days equal to the future period to be analyzed. If the future period is less than 20 days one would take at least the past 20 days in order to be able to obtain a reliable estimator.
- Calculate the volatility estimator for various historical periods and obtain the average, or the maximum.
- Use the volatility estimated over a long period of time, stopping at the present date.
- Look for historical periods in which economic, political, financial, etc. uncertainty was similar to the present, and calculate the volatility estimator on those periods. Select the average or maximum value.

There are many other options, but the examples above are good representatives of the possible alternatives. As we can see (especially in the last example) even though these models are based mainly on analyses of historical returns, expectations are also taken into account through the selection of sample periods that are expected to have some predictive value with regard to future behavior.

Before selecting a method, a number of tests must be performed on past dates using the observations available to determine whether they would actually have been good predictors of volatility after those dates.

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In spite of these and other issues, the need to calculate volatility for numerous variables and to establish objective, systematic procedures to measure and control risk generally leads firms to base their calculation parameters (number of data, number of periods, etc.) on an initial analysis and then hold them constant for all subsequent calculations. Periodic checks need to be done to assess the quality of the risk measurement results, which may require that the calculation method be used for approximately one year in order to provide relevant information.

As stated above, comparison of the methods described in the examples above requires that their predictive power be verified in each specific case, using the techniques that will be described hereafter. We can, however, indicate some of the advantages and problems that arise in this process, which are mainly related to the number of historical observations to be included in the calculation period:

- The fewer the number of observations, the greater the impact of each recent observation. For example, if prices were to change significantly today, the volatility estimate would increase, indicating greater uncertainty for the immediate future. This would give a better risk estimate than would a prediction obtained using a large number of observations since, in this case, a sharp jump today would have an influence only on the average that defines the volatility estimator.

  Nevertheless, this statement can be incorrect in markets where, for specific variables, it is likely that there will be extended periods of calm followed by sharp jumps, which is what occurs with exchange rates that are regulated by local authorities but are still subject to devaluations at certain intervals. If there has been no recent crisis, the volatility estimated with a small number of observations will be extremely low, but this is not a guarantee that a large jump will not occur in the immediate future. This topic is discussed in greater detail in Chapter 10, which focuses more specifically on emerging markets.
- A second factor to consider is how representative the sample is. An excessively small number of observations can lead to a lack of statistical reliability, which translates into possible modifications of the volatility estimators in the absence of any real change in the risk environment. This can cause practical problems when managing risk. Assume that a trader has taken a position that puts his risk level very close to the limit assigned to him. If there is a greater-than-normal price fluctuation today, the volatility estimator could increase and the risk level calculated using it could exceed the limit, which would force the trader to reduce his position. But if the trader's and the risk management and control unit's perception of risk has not changed, it could be said that the lack of statistical reliability in the calculation of the volatility estimator is causing a decrease in the position that is not in line with the risk levels accepted by the entity. Therefore, independent of the time period for which future volatility is being estimated, the entity must set some number of observations as the minimum necessary to obtain the sample deemed representative of the behavior of the asset. The minimum advisable number of observations is 20.

A small number of observations facilitates adjusting the estimator to the current situation but can ignore the effect of significant, albeit infrequent, crises. It may also lack sufficient statistical reliability.

These problems explain why regulatory bodies prefer to use estimators based on long historical series of at least one year because they are more stable, although it is not as easy to adjust them to the most recent situation. This can be very dangerous when the present risk is much greater than the average level for recent years. Even when a crisis has occurred within

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the period used for the estimate, including long periods of some stability means that the volatility estimate obtained may not reflect the risk of a situation with a high probability of a new devaluation.

A simple solution to this dilemma is to estimate volatility for a short period and a long period that includes a crisis and to take the greater of the two. However, this can result in an excessively conservative risk measurement that underutilizes allocated assets. Another possibility is to use a number of short periods to determine the distribution of the estimators and to select one of them using either a certain criterion (normally a conservative one such as the maximum or the one that exceeds the value of, for example, 90% of the others), or an additional analysis that indicates a similarity between the selected period and the current situation. The latter is costly if performed daily on a high number of financial variables.

In markets where a high risk of sudden crises does not exist, the use of 60-90 observations offers a good combination of adjustment to the current situation, statistical reliability, and inclusion of a reasonable number of different situations. We will discuss environments with a higher probability of crisis in Chapter 10.

A more detailed discussion of the procedure for calculating the historical volatility associated with a specific period is provided below.

Calculation of Historical Volatility

As described above, volatility is estimated on the distribution of returns; we emphasize that it is the historical return series that is analyzed and not the historical price series.

The historical price series will consist of observations for a specific frequency (business days, weeks, months, etc.) which will be used to generate a new series based on the continuously compounding returns between the observations.[4]

$$\gamma_i = \ln \frac{S_i}{S_{i-1}}$$

So the volatility associated with that frequency is calculated by solving for the standard deviation of the sample above.

$$\sigma^2_{frequency} = \frac{1}{n-1} \sum_{i=1}^{n} (\gamma_i - \bar{\gamma})^2$$

However, the volatility used is the annualized standard deviation, so the prior expression must be converted to an annual basis. Therefore,

$$\sigma_{annual} = \sqrt{n^{\circ} periods \bullet \sigma_{frequency}}$$

[4] Dividend payments must be included in return calculations, since on the day on which there is no longer a right to receive the dividend (ex-dividend date) the price of the stock falls. Therefore, the return is calculated as:

$$\gamma_i = \ln \frac{S_i + D}{S_{i-1}}$$

There are also tax effects that have an impact on the price, so another alternative is to not consider the returns for days around an ex-dividend date.

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Where n^0 *periods* is the number of observations in one year. The most frequent case is the one in which the historical data series has a frequency of one business day. Since there are approximately 250 business days in one year,

$$\sigma_{annual} = \sqrt{250 \bullet \sigma_{daily}}$$

Example

We will use the S&P 500 as the benchmark index. Given the daily historical price series, the one-day return is calculated as the logarithm of the quotient of the prices for each day. Therefore, the return for October 16, 1997 is

$$\ln(955.25/965.72) = -1.1\%$$

The historical return series is obtained by calculating returns for the other dates. For the purpose of this example, the last 30 observations are as follows:

Historical Series of Prices and Returns

Date	Value	Return (%)
Oct 15, 1997	965.72	-0.5
Oct 16, 1997	955.25	-1.1
Oct 17, 1997	944.16	-1.2
Oct 20, 1997	955.61	1.2
Oct 21, 1997	972.28	1.7
Oct 22, 1997	968.49	-0.4
Oct 23, 1997	950.69	-1.9
Oct 24, 1997	941.64	-1.0
Oct 27, 1997	876.98	-7.1
Oct 28, 1997	921.85	5.0
Oct 29, 1997	919.16	-0.3
Oct 30, 1997	903.68	-1.7
Oct 31, 1997	914.62	1.2
Nov 3, 1997	938.99	2.6
Nov 4, 1997	940.76	0.2
Nov 5, 1997	942.76	0.2
Nov 6, 1997	938.03	-0.5
Nov 7, 1997	927.51	-1.1
Nov 10, 1997	921.13	-0.7
Nov 11, 1997	923.78	-0.3
Nov 12, 1997	905.96	-1.9
Nov 13, 1997	916.66	1.2
Nov 14, 1997	928.35	1.3
Nov 17 1997	946.20	1.9
Nov 18, 1997	938.23	-0.8
Nov 19, 1997	944.59	0.7
Nov 20, 1997	958.98	1.5
Nov 21, 1997	963.09	0.4
Nov 24, 1997	946.67	-1.7
Nov 25, 1997	950.82	0.4

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Once the historical return series has been generated, the standard deviation of the sample is estimated. We do this by taking the standard deviation for the last 20, 40, 60, 80 and 100 days and then multiplying by the root of 250 in order to obtain the annual volatility.

Volatility Based on Sample Size

Observations	Volatility
20	17%
40	28%
60	24%
80	23%
100	22%

As can be seen, there are differences of up to 10 percentage points between the volatilities estimated using different numbers of observations. The greater the number of observations used, the less difference there is between the estimated volatilities; however, a large-sample volatility is also less reliable as an estimator of the future because it takes into account older data that is less significant to future behavior. If there is no additional information or no procedure to indicate what volatility measure should be used, there may be errors as large as 10% due to the differences between one estimator and another.[5] In this case, the use of volatility of around 25% for the last 60 observations appears to adequately capture the behavior of the S&P500, despite the fact that if the trend for the last 20 observations were to continue there would be over-allocation of risk capital. Since we do not know what the future movement of the index will be, a compromise must be made based on available data.

Regression Methods

While historical volatility methods try to predict future volatility by applying an estimator of historical volatility for a specific period in the past, regression methods try to predict future volatility by using historical returns and their associated deviations to arrive at a comparable deviation for the return expected in the future, through definition of a mathematical expression that systematically analyzes past deviations in order to predict future volatility.

The idea behind the use of regression methods in capital markets analysis is that large fluctuations in the financial markets tend to be followed by further large fluctuations, which may be in the same or in the opposite direction. The same is true of small fluctuations. Thus there is a certain consistency in the level of fluctuations, or, which is the same, the level of volatility. These models try to characterize the duration of this permanence and the evolution of the level of volatility.

The most common regression models can be divided into two general types:

- regressions on past return deviations, and
- regressions on return deviations and prior volatility estimators.

[5] We should note here that making fine adjustments when calculating risk measurements may add little value, since the volatility estimate itself introduces greater order differences.

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Of course, the underlying data used in both cases are the past return deviations. The second group adds the volatilities calculated from the data as a source of semi-processed information. The goal of the model is to predict future volatility based on past returns and volatilities. In general,

$$\sigma_t = f(\gamma_{t-1}, \gamma_{t-2}, \ldots, \sigma_{t-1}, \sigma_{t-2}, \ldots)$$

which is usually expressed as a linear combination of past returns and volatilities:

$$\sigma_t^2 = \nu + \sum_{i=1}^{p} \lambda_i \bullet d_{t-i}^2 + \sum_{i=1}^{q} \delta_i \bullet \sigma_{t-i}^2$$

where

- d_{t-1} is the deviation of the expected return associated with time t–i such that

$$d_{t-1}^2 = (\gamma_{t-i} - \bar{\gamma})^2$$

- ν is a constant
- λ_i are the coefficients of the regression associated with each of the returns P_i
- δ_i are the coefficients of the regression associated with each of the volatilities σ_{t-1}^2

These coefficients are determined with statistical regression techniques that use a model (for example, the function given above) to predict prospective volatility for a given period and then look for the adjustment to the model that best incorporates the volatility estimator for that period *a posteriori*.[6] The predictive ability of the model depends largely on whether it has been calibrated over a sufficiently varied history so as to capture all the situations that may occur in the future, and on whether the model has the intrinsic flexibility to adjust to each situation.

The simple linear regression model relates the variance for a period (s_t), subject to the information available at the moment t when the period starts, to the squares of the return deviations at prior moments t–i (where $i > 0$). If we replace the δ_i's in the prior expression with zero in order to leave out the effect of past volatilities:

$$\sigma_t^2 = \nu + \sum_{i=1}^{p} \lambda_i \bullet d_{t-i}^2$$

The coefficients are adjusted by minimizing the sum of squares of the differences between the prospective quadratic deviations, based on the values of λ that the model calculates for each moment t, and the volatilities calculated *a posteriori*, based on the actual data subsequent to each moment t.

An analysis of the above expression brings out some relevant points:

- The constant ν is the estimate of the *unconditional variance*, i.e., it is not dependent on information available previously. In fact, if we assume that fluctuations prior to a given moment provide no information relevant to the estimate of the subsequent volatility,

[6] In risk management, future volatility predictions are applied to a one-day time horizon, which means that when the *a posteriori* estimate is done there is the problem of choosing or creating the best estimator of one-day volatility, since volatility cannot be estimated using a single datum. One alternative is to take price data from throughout the day, but this presents technical problems and there can be distortions due to differences between bid and offer prices. Therefore, an assumption is made that daily volatility has remained constant throughout a 20-day period and the estimated volatility for that period will be used as the estimator of daily volatility.

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the λ_i coefficients will be zero, and the estimated variance will equal the unconditional variance, which is to say that

$$\sigma_t^2 = v$$

This discussion shows that if one believes that the past is not related to the future, volatility estimates must be based on some other type of information and incorporated into the model as a constant. Such an estimate would obviously not be an example of using a past-returns regression model, but rather an example of using a model based on expectations.

- If, instead of determining the λ_i coefficients with the statistical regression technique, all the coefficients are set equal to $\frac{1}{p-1}$, and the constant v is zero, we have

$$\sigma_t^2 = \frac{1}{p-1} \bullet \sum_{i=1}^{p} d_{t-1}^2$$

which is the best estimator of volatility in the period prior to instant t for which the p data applies. The model simply predicts future volatility based on historical volatility, which shows that the historical volatility model is nothing more than a specific regression model based solely on prior returns.

- To facilitate the coefficient calculations, certain relationships between the coefficients can be predetermined, which reduces the number of independent parameters to be estimated. This makes the model simpler, but at the expense of independence and therefore the ability to precisely reflect reality. The moving average model with exponential weighting uses the following expression for the coefficients:

$$v = 0$$
$$\lambda_i = \lambda^{i-1} \bullet (1-\lambda)$$

where λ is a constant between 0 and 1, so that the coefficients for instants further in the past (i–1 superscript) are less than those for instants closer to the present (i subscript). The closer λ is to 0 the more rapidly the weight of the distant fluctuations drops.

Therefore, the prediction of future volatility is expressed as

$$\sigma_t^2 = \sum_{i=1}^{p} \lambda^{i-1} \bullet (1-\lambda) \bullet d_{t-i}^2$$

with only two estimate parameters:

- λ: discount coefficient
- p: number of observations

In addition, we could add the restriction that the sum of all the coefficients is not excessively distant from unity[7] (if p were infinite the sum would effectively be 1). This

[7] It can be shown that in order for the sum of the p coefficients to be greater than $1-x$ it must be that:

$$p > \frac{\ln x}{\ln \lambda}$$

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restriction is based on treating the weighting coefficients of all the prior fluctuations as the probabilities that are used to define a variance whose sum must be 1. In fact, if the sum of the coefficients were significantly less than 1, on average the variance would be undervalued. The value of λ is set to minimize the mean square deviation between the estimate of the model and the volatility estimated *a posteriori* based on actual data.

- The coefficients can be determined by using autoregression techniques, without using functions or relationships between the coefficients. To do this, all that needs to be noted is that by adding the square root of the actual deviation d_t^2 to the two terms of the original expression we obtain:

$$\sigma_t^2 + d_t^2 = \nu + \sum_{i=1}^{p} \lambda_i \bullet d_{t-i}^2 + d_t^2$$

$$d_t^2 = \nu + \sum_{i=1}^{p} \lambda_i \bullet d_{t-i}^2 + d_t^2 - \sigma_t^2$$

The problem becomes predicting the last term of the fluctuation series based on prior fluctuations, keeping in mind that the term $d_t^2 - \sigma_t^2$ cannot be predicted and is thus random noise that is not explained by the regression. This type of method is known as autoregressive conditional heteroscedasticity[8] (ARCH), because it estimates the last known conditional fluctuation from a series of prior fluctuations.

Generalizing the above model in order to take into account the behavior of the volatilities, we would return to the initial expression shown in this section:

$$\sigma_t^2 = \nu + \sum_{i=1}^{p} \lambda_i \bullet d_{t-i}^2 + \sum_{i=1}^{q} \delta_i \bullet \sigma_{t-i}^2$$

Because this is a model that includes the ARCH as a specific case, it is given the name GARCH (generalized ARCH), and can be expressed autoregressively as

$$d_t^2 = \nu + \sum_{i=1}^{p} (\lambda_i + \delta_i) \bullet d_{t-i}^2 - \sum_{i=1}^{p} \delta_i \bullet (d_{t-i}^2 - \sigma_{t-i}^2) + d_t^2 - \sigma_t^2$$

Models Based on Expectations

These models predict future volatility based on factors other than fluctuations in past returns. These factors can include:

- Option price quotes
- Opinions of participants in the financial markets
- Macroeconomic variables, together with indicators of general volatility in the financial markets

[8] *Heteroscedasticity* means that the variance changes over time.

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Implied Volatility in Options

In the more developed financial markets options are quoted on:

- currencies (normally against the dollar, mark or yen)
- government bond futures
- interest rate futures
- swaps (swaptions)
- short-term interest rate series (caps and floors)
- stock market indices
- individual stocks
- commodity futures, etc.

Although the entire range of available products and instruments is not covered (e.g., all Government bonds) traders can quote options on them and estimate their volatilities based on the volatility quoted for related instruments.

Therefore, the volatilities quoted by such market agents always reflect all the information available in the market at each point in time and represent the average expectation of future price fluctuations. In order to reach a consensus, the agents use the estimates and predictions obtained from the different methods based on historical returns series, but modify these indicators based on their own view of the future and on additional information not contained in the historical prices.

The main problem with this method is the absence of quotations that represent the market consensus on a sufficiently wide range of products. The latter requires the existence of a liquid market, high trading volume and many participants that are equal in terms of pricing power across the range of transactions done (options transactions).

To calculate implied volatility, one must take the option price and determine the volatility that, when introduced into the valuation model used results in that option price. Normally, options with standard characteristics are more liquid and would be valued using the Black Scholes model; these are the options for which the market primarily quotes the volatility, with the price subsequently obtained through use of the model.

As a rule, therefore, volatilities are quoted for options with exercise prices closest to the current price of the underlying asset (i.e., at or near the money) and with the shortest time to expiration since such options are normally the most liquid, the most frequently traded, and the most reflective of short-term risk.

EXAMPLE

Continuing with the above example, the market provides additional information in the case of the S&P500 since there is a liquid options market for that index. As of the close of business on December 10, 1997, the implied volatility of at-the-money options (exercise price = 970) maturing in January 1998 was 20%. This means that, according to the expectations of market participants, the volatility of the index during the next month will be 20%, which differs by 5% from the historical data estimator (25%). When implied volatility data is available, it is a better estimate than those derived using retrospective methods because it incorporates all the information and expectations in the market.

Volatility Based on the Expectations of Market Participants

Sometimes, however, the options market is not liquid enough or broad enough for dealers to quote implied volatilities. If this is the case, one possible alternative to using historical methods

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is to conduct surveys of market participants in order to obtain a forecast of volatility that can be used to measure risk.

These surveys may be performed by banking entities among a group of clients that are active in the underlying markets (currency, interest rate, etc.). One asks for the ranges in which a certain variable may fall (for example, the price of the dollar *vis-à-vis* local currency) within a given time period and for a specific confidence interval. For example, one could ask for the maximum and minimum limit for the price of the dollar *vis-à-vis* the Chilean peso during the next month, such that one is 95% sure that the dollar will not be outside those limits during that period, or stated differently, were the question repeated for 100 months (8 years) the dollar would fall outside the range on 5 occasions. If we assume that the variable has a normal distribution, the 95% confidence interval corresponds approximately to 4 times the volatility ($\pm 2\sigma$ around the expected value).

$$range \approx price \bullet k \bullet \sigma_{period}$$

where k depends on the confidence interval set (it equals 4 for a 95% interval) and σ is the volatility associated with the period.

For example, if given a dollar/Chilean peso price of 450, a survey participant expects with 95% confidence that during the next month the price will range between 465 and 440 (range = 25), he is implicitly assuming that the monthly volatility is 1.39%. If we take the expression stated above and enter these assumptions, we have:

$$450 \bullet 4 \bullet \sigma_{monthly} = 25 \Rightarrow \sigma_{monthly} = 1.39\%$$

If we then take into account that there are twelve months in a year, annual volatility is equal to 4.81%:

$$\sigma_{monthly} = \sigma_{monthly} \bullet \sqrt{12}$$

In order to arrive at a volatility forecast, one calculates the implied volatility from the responses of each survey participant and takes the average (often eliminating the outlying observations). In order for the value obtained to be meaningful, the survey must be performed with a sufficiently large number of entities, which should be informed of the results of the survey as an incentive to participate. In an illiquid market, the results of the survey are a good indicator of the stability expectations of the market participants and therefore of the advisability of hedging or not hedging open positions.

Volatility Based on Macroeconomic Variables

The study of certain macroeconomic indicators of countries that have experienced currency crises makes it possible to associate a crisis probability with each currency, which, combined with information on past volatility, can be used to estimate future volatility.[9]

Once the crisis probability is estimated (p_{cri}), if we determine the historical volatility during crisis periods (σ_{cri}) and stable periods (σ_{stab}), we can estimate an expected volatility (σ_{exp}) as a weighting of the crisis periods and the stable periods, using the expression

$$\sigma^2_{exp} = p_{cri} \bullet \sigma^2_{cri} + (1 - p_{cri}) \bullet \sigma^2_{stab}$$

This method of predicting volatility can also be combined with the methods described above for estimating volatility based on market expectations, for the purpose of determining the

[9] In Chapter 10 we analyze in greater detail the problems of exchange rate risk in currencies with high crisis probability.

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probability that market participants implicitly assign to a crisis scenario. Therefore, to find the probability of crisis in the expression above:

$$p_{cri} = \frac{\sigma^2_{exp} - \sigma^2_{stab}}{\sigma^2_{cri} - \sigma^2_{stab}}$$

Comparison of Predictive Ability

Once we have determined the estimates of future volatility according to the different methods presented above, we must decide which of the results obtained will be presumed to best predict volatility.

It is advisable to use implied volatilities as much as possible. By doing so, we avoid the problems associated with historical volatilities; furthermore, implied volatilities capture the expectations of market participants on an immediate basis, thus eliminating the need to wait for either sharp movements or, conversely, less pronounced fluctuations to suggest a direction. In a situation where the probability of a crisis increases, the implied volatility increases to reflect the increased risk despite the fact that neither market positions nor historical volatility has changed. Historical volatility, on the other hand, does not change significantly until after the crisis has occurred. Once the crisis has subsided, paradoxically, historical volatility measures still indicate higher risk, which can lead entities towards incorrect conclusions that translate into unnecessary reductions of positions. The implied-volatility alternative, however, is not always available due to the lack of sufficiently liquid derivatives products for which the instrument in question as the underlying instrument.

In order to determine the suitability of the different methods presented, a series of comparative tests should be done to determine the size of the adjustments that would have matched the predicted volatility levels to those that actually occurred. For this purpose, there are two analyses that can be done:

- Prediction error
- Profits and losses on options strategies

Prediction Error

Measurement of the difference between the *a posteriori* estimator and the model's prediction is usually done by calculating the mean square error for different periods. The best model is the one with the lowest average mean square error. The process is as follows:

- For each period considered, the volatility is predicted using each method, inputting only the information available on the final date of the period. Therefore, we obtain:
  - σ_{im}: the volatility forecast for period i using method m.
- Then, using the return fluctuations that occurred after the final date of period i we estimate the actual volatility, σ_i.
- The mean square error is defined for each method as

$$e_m = \frac{1}{k}\sum_{i=1}^{k}(\sigma_i - \sigma_{im})^2$$

where k is the number of periods in which we would be comparing the model.

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One of the problems with this type of test is the difficulty in estimating the *a posteriori* volatility for very short time periods (one or a few days). Alternatively, one can make use of the second type of tests, based on options strategies.

Profits and Losses on Options Strategies

The purpose of these tests is to evaluate the accuracy of the different estimation methods by constructing options strategies that are not especially sensitive to instantaneous price movements but are indeed very sensitive to volatility movements. The test involves using the estimated volatilities from each method and their associated prices to execute hypothetical options strategies and then to compare the P&L that result, which should basically be zero if the volatility has been correctly estimated. One strategy that can be used is to purchase a straddle[10] with one day to expiration and an exercise price equal to the current price. For each method, we proceed as follows:

- We assume that each day we buy a straddle at the price obtained by inserting the volatility obtained in the specific method under examination into the valuation formula.
- On the next day we determine the actual profit obtained by taking the difference between the premium paid on the preceding day and the associated cash flow at the maturity of the options, which depends on the actual price and, taking into account the financing cost for one day, is equal to:

$$Profit_{today} = \left|P_{today} - X\right| - premium \bullet \left(1 + r_{daily} = \frac{r}{160}\right)$$

where P_{today} is the price of the underlying asset at maturity of the strategy and X is the exercise price of the straddle.

If the volatility has been estimated correctly, the cumulative result for a sufficiently long period should be zero. Therefore, the most accurate method is the one that produces the result that is closest to zero. The average quadratic deviation of the results from zero, which is the *a priori* expected result each day, must also be monitored in order to avoid offsetting positive deviations against negative deviations. The less the quadratic deviation the greater the accuracy of the method.

In addition, this strategy must be used for both the purchase and sale of a straddle, in order to eliminate the effects of rises or drops in prices.

Each trader calculates the price of the straddle based on his prediction of volatility, so the trader who estimates a higher price will buy the straddle from someone who has calculated a lower price, with the price of the transaction generally equivalent to the average price of the fair value calculated by the traders. With this strategy the two hope to gain in a series of transactions because the buyer always purchases the options at a price lower than the price he deems to be their fair value, while the seller sells the options at a price he deems above their fair value. Therefore, if one volatility prediction method is clearly superior over a period of several months, one of the traders will accumulate a significant profit and the other a loss.

---

[10] A straddle consists of the simultaneous purchase of a call option and a put option at the same exercise price with the same maturity date. At maturity the payment associated with the straddle equals:

$$\left.\begin{array}{ll} call: & c = \max(P - X, 0) \\ put: & p = \max(0, X - P) \end{array}\right\} \Rightarrow straddle = c + p = \left|P - X\right|$$

where P is the price of the underlying asset and X is the exercise price of the straddle.

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RISK MEASUREMENTS

Once the hypothesis of normally distributed returns [hereafter, hypothesis of normality] is established, and the possible procedures for estimating volatility are defined, the next step is to apply them to the different risk measurements defined previously. We will use one day as a benchmark time horizon, and construct annual risk measurements by assuming that the daily risk of the portfolio remains constant during the year.

Daily Risk Measures

As indicated earlier, changes in the value of a portfolio in a specified time period are given by the sum of expected value changes and unexpected value changes (which are due to portfolio volatility).

$$\Delta value = \Delta value^{expected} + \Delta value^{unexpected}$$

The return on the portfolio can be stated as:

$$\frac{\Delta value}{V_0} = \frac{\Delta value^{expected}}{V_0} + \frac{\Delta value^{unexpected}}{V_0}$$

where V_0 is the initial value of the portfolio.[11]

Daily Value-at-Risk

Assuming a time horizon of one business day,[12] and keeping in mind that daily volatility is calculated by taking the annualized volatility and dividing by the square root of 250, volatility per business day is expressed as

$$\sigma_{daily} = \frac{\sigma_{yearly}}{\sqrt{250}}$$

Therefore, the maximum unexpected loss is equal to

$$|V_0| \bullet k \bullet \sigma_{daily}$$

where k depends on the confidence interval selected (p. 184) and V_0 is the initial value of the portfolio.

Therefore, the maximum estimated loss is equal to the maximum unexpected loss less the expected change in value:

$$VAR_{daily} = |V_0| \bullet k \bullet \sigma_{daily} - V_0 \bullet return_{daily}^{expected}$$

[11] In the case of derivatives products, the value of the portfolio can be zero, so this approach presents problems. However, we will continue it for didactic purposes. The final objective is to create a model for changes in value that work for any given value, keeping in mind that the portfolio volatility measure is an assumed input (see p. 201, section regarding portfolio analysis).

[12] Starting here and for the remainder of the manual, one business day will be used as the time horizon for calculating the different risk measurements.

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where k is the number of standard deviations associated with the confidence interval selected (for example, if we consult the confidence interval table on p. 184 for a confidence level of 99.87%, k is 3).

The second term represents the expected profits, while the first represents the variation around these profits.

Daily Capital-at-Risk

By directly applying the expressions obtained in chapter 3 for the CAR we have:

$$CAR_{daily} = \frac{VAR_{daily} + V_0 \bullet z_{RF} \bullet T_{daily}}{\left(1 + z_{RF}\right)^{T_{daily}}}$$

where z_{RF} is the rate at which the positions are financed or invested based on the scheme outlined when the concept of Capital-at-Risk was introduced. The second addend represents the financing costs for asset positions, or the interest earned by investing for liability positions.

If we substitute for the daily VAR expression in the prior equation:

$$CAR_{daily} \approx \frac{|V_0| \bullet k \bullet \sigma_{daily} - V_0 \bullet (r^{expected} - z_{RF}) \bullet T_{daily}}{\left(1 + z_{RF}\right)^{T_{daily}}}$$

where the second addend represents the expected risk premium ($r^{expected} - z_{RF}$), i.e., the expected daily return in excess of the risk free rate.

Therefore, in order to determine the CAR associated with a specific position, it is first necessary to determine the expected return associated with the instrument or portfolio in question. However, the contribution of this term may be considered insignificant[13] compared to volatility, such that the daily CAR can be estimated as:

$$CAR_{daily} \approx \frac{|V_0| \bullet k \bullet \sigma_{daily}}{\left(1 + z_{RF}\right)^{T_{daily}}}$$

As noted in our discussion of the normal distribution hypothesis, the volatility estimate may be introducing greater errors than the fine adjustment introduced by this second addend.

[13] Looking at the order of magnitude of both addends, one notes that on dividing the former by the latter:

$$\frac{k \bullet \frac{\sigma_{annual}}{\sqrt{250}}}{(r^{expected} - z_{RF}) \bullet \frac{1}{365}} \approx 23 \bullet k \bullet \frac{\sigma_{annual}}{r^{expected} - z_{RF}} >> 1$$

since the annual volatility is usually of the same order of magnitude as the risk premium. Thus, the error committed by ignoring the second addend is not significant when estimating the daily Capital-at-Risk and obviates the need to estimate the expected return.

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Expected RORAC

As indicated previously, the contribution of expected profits to the calculation of CAR can be insignificant compared to the contribution of volatility, so the CAR can be estimated without necessarily determining an expected return. However, when dealing with risk/return measures such as RORAC, it is essential to estimate the expected returns. Therefore, as introduced in chapter 3, on market risk,

$$RORAC_{expected} = \frac{return_{expected} + \begin{Bmatrix} -costs_{financial} \\ +revenues_{financial} \end{Bmatrix} + compensation_{capital}}{CAR}(1 - rate_{tax})$$

where the change in the value of the portfolio, taking into account the financial costs and the capital allocated, is equivalent to the change in the value of the instruments that make up the portfolio, less (plus) the cost of financing (income from investing) the net market value of the instruments, plus the interest earned from the investment of the CAR in risk-free instruments.

Therefore, by replacing the change in value with the expected returns we obtain the expected RORAC:

$$RORAC_{expected} = \left[\frac{return_{expected} - V_0 \bullet z_{RF} \bullet T}{CAR} + z_{RF} \bullet T\right](1 - rate_{tax})$$

Example

Assume an investment of US$ 200,000 in a stock portfolio that perfectly replicates the S&P500. As we saw in the section on volatility, our best estimator for future volatility is 20%, which translates into a daily volatility of

$$\sigma_{daily} = \frac{20\%}{\sqrt{250}} = 1.265\%$$

Let's also assume that the position can be financed at the risk-free rate and that this rate equals 5.5%.

Based on the normality hypothesis, for a confidence level of 99.87% the boundary of the interval associated with the maximum unexpected losses for one day is equal to 3 times the daily volatility, so the daily CAR is approximately equal to:

$$CAR_{daily} \approx \frac{V_0 \bullet 3 \bullet \sigma_{daily}}{1 + z_{RF} \bullet \frac{1}{365}} = \frac{200{,}000 \bullet 3 \bullet 1.265\%}{1 + 0.055 \bullet \frac{1}{365}} = \text{US\$7,589}$$

If we want to calculate the CAR using the complete expression, we must estimate the expected return of the investment. If we state the expected return as a premium over the risk-free rate, we obtain the values for the risk/return measures that are shown in the table below.

As we can see, the calculation of the daily CAR has taken into account both the financing and the expected return. However, the difference between the highest and lowest CAR does not

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CAR Based on the Expected Risk Premium

Expected Premium (%)	Daily CAR (US$)
0.0	7,588
0.5	7,586
1.0	7,583
1.5	7,581
2.0	7,578
2.5	7,576
3.0	7,573
3.5	7,570
4.0	7,568
4.5	7,565

exceed 0.3% [=7,588 – 7,565)/7,588], which confirms the adequacy of the CAR approximation incorporating only the contribution of volatility. As with the CAR, the difference between the highest and lowest VAR does not exceed 0.3%.

Therefore, we will use a daily CAR of US$ 7,588, regardless of the expected return.

Inaccuracies in the volatility estimate can introduce differences of 5%, so 0.3% is insignificant, and the simplified calculation means that it is unnecessary to estimate the expected return in order to know the risk exposure.

In order to estimate the expected RORAC, however, this calculation, which depends on market conditions and expectations, must be done.

Annualized Risk Measurements

The risk measurements have been calculated for a one day time horizon. This means that the risk measurements calculated measure only the exposure taken and capital used for one day. However, we assume that the company is operating on an ongoing basis and that longer-term measurements of risk and return are needed. This is why we annualize the risk measurements obtained.

One way of annualizing these measures is to assume that for one year the current level of risk is held constant. This means that profits and losses have the same probability distribution every day, but not that the current portfolio is held constant for one year. We assume that once a daily risk profile has been chosen, the managers are responsible for maintaining it on a daily basis by performing the appropriate transactions.

One alternative is to analyze the profit and loss distribution at the end of one year assuming that the current portfolio is maintained. This approach requires additional assumptions in order to deal with those instruments that are maturing and the type of management to be performed. For example, hedging options is very complex, and the probability that the hedge chosen will work perfectly under actual market conditions is very small. The fragility of this procedure means that it works only in the case of absolutely static (as opposed to actively managed) portfolios.

Below we develop the procedure that enables us to calculate annualized risk measurements, assuming that the same risk is maintained for an entire year.

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Constant Risk

In the interest of methodological development, we assume that the position is closed out every day and that on the following day a new position is opened with the same risk exposure as the prior position, and the same market value [as the closing value of the prior position]. This procedure thus generates a return for each day.

As is logical, the losses must be financed and the profits may be reinvested. We will assume that this is what occurs throughout the year in question, that the one-day interest rate (z) remains constant throughout the year, and that it is expressed as a compound rate.

Therefore, the annualized return and volatility are expressed as[14]

$$return_{expected}^{annualized} = return_{expected}^{daily} \bullet \frac{z}{(1+z)^{\frac{1}{365}} - 1}$$

$$volatility^{annualized} = volatility^{daily} \bullet \sqrt{\frac{250}{365}} \bullet \sqrt{\frac{(1+z)^2 - 1}{(1+z)^{\frac{1}{365}} - 1}}$$

Annualized Value-at-Risk

Once the expected returns and the volatility are annualized, the annualized VAR can be determined as follows:

$$VAR^{annualized} = |V_0| \bullet k \bullet volatility^{annualized} - return_{expected}^{annulalized}$$

Annualized Capital-at-Risk

We must add annual financial costs in order to calculate the annualized CAR. These financial costs are equal to[15]

$$V_0 \bullet z$$

However, the effects of the financial costs and the expected return are assumed to be negligible compared to the contribution of the volatility term, as was the case with the daily CAR.[16] This hypothesis enables us to bypass the estimation of the expected return when calculating the annualized CAR, although this must be done in order to determine the expected RORAC.

Therefore, the annualized CAR, regardless of whether the position is an asset or liability position, can be approximated by:

$$CAR_{annualized} \approx \frac{|V_0| \bullet k \bullet \sigma_{annualized}}{1 + z_{RF}}$$

[14] See the appendix on annualizing risk that appears on p. 235.

[15] See the annualization of financial costs on p. 237.

[16] The effect is more significant in the annualized case than in the daily case, but even so it is not used in the calculation of the annualized CAR, since its effect can be diluted by the error that may be committed when estimating volatility.

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Annualized Expected RORAC

Now we are ready to calculate the annualized expected RORAC. By placing the annualized values in the expression for the expected RORAC we have:

$$RORAC_{expected}^{annualized} = \left[\frac{results_{expected}^{annualized} - V_0 \bullet z_{RF}}{CAR^{annualized}} + z_{RF} \right] (1 - rate_{tax})$$

Example

Take the same situation analyzed earlier in the calculation of the daily risk/return measurements. As stated earlier, the daily parameters are annualized while assuming that the market value and risk exposure remain constant for one year, and that losses are financed and earnings are reinvested.

Keeping in mind that the market interest rate is 5.5%, the annualization factors for the returns and volatility are (based on the formulas on the preceding page)

$$return_{annualized} = return_{daily} \bullet 374.92$$
$$volatility_{annualized} = volatility_{daily} \bullet 22.97$$

Therefore, the annualized volatility is:

$$\sigma_{annualized} = 29.06\%$$

which is greater than the annual volatility observation (20%) used in the earlier example (p. 200), due to the effect of reinvesting the daily earnings.

If we assume in this case that we will only consider the effect of volatility, the annualized CAR is equal to:

$$CAR_{annualized} = \frac{200{,}000 \bullet 3 \bullet 29.06\%}{1 + 0.055} = \text{US\$}165{,}270$$

In order to calculate the annualized expected RORAC, we must proceed as in the case of the daily measurements and estimate an expected return, which is expressed as a premium over the risk-free rate.

CAR and RORAC Based on Expected Risk Premium

Expected Premium (%)	Annualized CAR (US$)	Expected RORAC (%)
0.0	165,256	4
0.5	164,335	4
1.0	163,419	4
1.5	162,507	5
2.0	161,599	5
2.5	160,695	6
3.0	159,795	6
3.5	158,900	6
4.0	158,008	7
4.5	157,121	7

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If we analyze the annualized CAR calculation method in which only the contribution of volatility is considered, we see that the difference between the highest and lowest CAR is 4.8%, which is more significant than in the case of the daily CAR. The reason lies in the fact that the annualization factor for the returns is approximately 16 times greater than the volatility factor, so that the 0.3% error becomes an error of almost 5% when annualized. However, this error can be bypassed simply by estimating the volatility. Here, the incremental error is the difference between using a volatility of 29% or one of 27.6% (=29%/1.05). We will continue with this method, which allows us to avoid estimating the expected return to calculate risk exposure.

Analysis of a Portfolio

The risk/return measurements defined so far have dealt with the behavior of a single asset. The next step is to extend these measurements to a portfolio of financial instruments.

Assume that we are analyzing a portfolio of n instruments in a single currency. The change in the value of the portfolio is obtained from the sum of the changes in value of each of the instruments in the portfolio:

$$\Delta value = \sum_{1}^{n} \Delta value_i$$

Therefore, the rate of return of the portfolio[17] can be expressed as

$$r = \sum \omega_i \bullet r_i$$

where r is the rate of return of the portfolio, r_i is the rate of return on the instrument i, and the weighting coefficient, ω_i, represents the contribution of the instrument to the total market value of the portfolio:[18]

$$\omega_i = \frac{V_0^i}{V_0}$$

[17] The rate of return associated with the portfolio is defined as:

$$r = \frac{\Delta value}{V_0} = \frac{\sum_{1}^{n} \Delta V_1}{V_0} = \sum_{1}^{n} \frac{V_i}{V_0} \bullet \frac{\Delta V_i}{V_i} = \sum_{1}^{n} \omega_i \bullet r_i$$

where the rate of return associated with each of the instruments i is:

$$r_i = \frac{\Delta value_i}{V_0} = \frac{\Delta price_i}{price_0^i}$$

[18] For some derivative products based on futures contracts, the market value of some instruments or of the aggregate portfolio may be zero. In these cases, both V_0 and V_0^i are zero and there are problems with the procedure developed previously. If we remember that the final objective is to model the change in value, these values may be replaced by other values, which affect only the individual analyses of the rates of return but not the analysis of the overall change in value. Therefore, instead of dividing by the market value one can divide by the notional amount of the transaction.

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The rate of return on the portfolio is a random variable that behaves as the sum of n random variables, each of which has a normal probability distribution. Therefore the rate of return of the portfolio is also normally distributed and all the expressions obtained previously for a single instrument can be applied to the portfolio. Appropriate values for the expected returns and the volatility of the portfolio must be used.

PORTFOLIO VOLATILITY

In order to calculate the portfolio volatility, we once again begin with the sum of the random variables:

$$r = \sum \omega_i \bullet r_i$$

Given that volatility is nothing more than standard deviation, according to the basic theory of statistical calculation, we have:

$$\sigma^2 = \sum \omega_i^2 \sigma_i^2 = \Sigma \Sigma \omega_i \omega_j \sigma_{ij}$$

Given that the correlation coefficient between two instruments is defined as

$$\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$$

it is also true that[19]

$$\sigma^2 = \sum \omega_i^2 \sigma_i^2 + \sum \sum \omega_i \omega_j \rho_{ij} \sigma_i \sigma_j$$

DAILY CAPITAL-AT-RISK OF THE PORTFOLIO

In order to calculate the CAR of the portfolio, all we need do is substitute the volatility of the rate of return in the CAR expression. Thus,

$$CAR_{portfolio} \approx \frac{|V_T| \bullet k \bullet \sigma_{daily}}{1 + z_{RF} T_{daily}}$$

[19] The portfolio variance is derived through matrix multiplication:

$$\sigma^2 = \begin{bmatrix} \omega_1 \sigma_1 & \omega_2 \sigma_2 & \dots & \omega_n \sigma_n \end{bmatrix} \begin{bmatrix} 1 & \rho_{12} & \dots & \rho_{1n} \\ \rho_{12} & 1 & \dots & \rho_{2n} \\ \dots & \dots & \dots & \dots \\ \rho_{1n} & \rho_{2n} & \dots & 1 \end{bmatrix} \begin{bmatrix} \omega_1 \sigma_1 \\ \omega_2 \sigma_2 \\ \dots \\ \omega_n \sigma_n \end{bmatrix}$$

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Defining the volatility of the portfolio based on the volatilities of the instruments that make up the portfolio, its daily CAR can be expressed as:[20]

$$CAR^2_{portfolio} \approx \sum CAR_i^2 + \sum\sum \pm CAR_i CAR_j \rho_{ij}$$

As we can see, the Capital-at-Risk is not additive, and in order to be able to aggregate the results obtained for each instrument separately, it is necessary to calculate a geometric pseudo-average based on the correlation coefficient between each of the instruments. It is not enough to analyze each instrument separately; the behavior of each must be analyzed with respect to the other instruments in order to obtain the covariance matrix.

In order to analyze the CAR, we will consider the portfolio to be a single asset. The same annualization factor applied to an individual instrument will be applied to volatility.

Example

Let's assume that we divest US$ 100,000 from the earlier stock portfolio of US$ 200,000 that replicates the S&P500 and invest it in a cash position of US$ 75,000 in Mexican pesos and US$ 25,000 in Brazilian reals.

Benchmark Portfolio

Asset	Market Value (US$)	Weight (%)
S&P500	100,000	50.0
Pesos	75,000	37.5
Reales	25,000	12.5

Each of these instruments individually uses Capital-at-Risk based on the individual volatility of the asset in question. For the S&P500 we will use the individually quoted volatility on the index options, which as we have seen is 20%. We will need to use historical series for the Mexican pesos and Brazilian reals to obtain the annual volatilities that are shown below which will vary based on the number of observations taken:

Exchange Rate Volatility

Number of Observations	Volatility (%)	
	Peso	Real
20	6	1
40	23	2
60	19	2
80	17	2
100	15	2

[20] Substituting the value of the volatility of the portfolio,

$$CAR^2_{portfolio} \approx k^2 \cdot \left[\sum V_i^2 \sigma_i^2 + \sum\sum V_i \sigma_i V_j \sigma_j \rho_{ij}\right]$$

we have:

$$CAR^2_{portfolio} \approx \sum CAR_i^2 + \sum\sum \pm CAR_i CAR_j \rho_{ij}$$

where the ± sign depends on whether each instrument is an asset or liability instrument.

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If we use approximately 60 to 80 observations, we obtain 18% as the estimator of future volatility for the Mexican peso and 2% for the Brazilian real. We will touch here on a point that is characteristic of the emerging markets (which will be discussed in greater detail later). The exceedingly low volatility of the Brazilian real is noteworthy, and therefore, so is its low risk exposure. This circumstance is obviously due to the fact that the exchange rate is controlled and very dollarized. The risk is much higher than that indicated by the historical series due to the possibility of a sharp devaluation (an infrequent but not impossible event), which should lead us to correct this factor.

This subject will be discussed in more detail in Chapter 10, but in this example we will use the original results obtained.

The table below shows the daily CAR of each of the assets for a confidence interval of 99.87%.

Daily CAR of Each Asset

	Volatility (%)		
	Annual	Daily	CAR (US$)
S&P500	20	1,265	3,794
Peso	18	1,138	2,561
Real	2	0,127	95

As stated previously, the daily CAR of the portfolio as a whole is not additive, so it is necessary to take into account the relationships between the prices of each of the assets. The historical series for each of the assets are used to obtain the correlation coefficients between the returns of each asset.[21] In calculating correlations, just as in calculating historical volatilities, the problem of how many observations to consider arises. Regardless of the specific number chosen, the criterion must be consistent in both cases. The correlations obtained for different sample sizes are shown below.

Correlation (%) According to the Size of the Sample

Number of Observations	S&P500 vs. Peso	S&P500 vs. Real	Peso vs. Real
20	54.1	25.0	24.5
40	81.3	1.5	11.4
60	78.5	–0.5	11.6
80	72.9	–3.9	8.3
100	71.3	–3.6	8.2

The estimated correlations for the portfolio in question are given by the coefficients of the following matrix.

[21] The historical series for the exchange rate, expressed as dollars per unit of local currency, is used to calculate the correlations of the exchange rates. The price is normally stated as units of local currency per dollar, so the historical returns are obtained using this series and are multiplied by –1 in order to obtain the historical series of continuous returns for dollars per unit of local currency.

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Matrix of Estimated Correlations (%)			
	S&P500	**Peso**	**Real**
S&P500	100	75	–2
Peso	75	100	10
Real	–2	10	100

Therefore, if we apply the formulas stated earlier (pp. 200-201) the volatility of the total portfolio is equal to 15.7%.

This makes the daily CAR of the portfolio equal to:

$$CAR_{daily}^{portfolio} = \frac{200{,}000 \bullet 3 \bullet \frac{15.7\%}{\sqrt{250}}}{(1+0.055)^{\frac{1}{365}}} = \text{US\$5,957}$$

As we can see, diversifying part of the portfolio reduces the risk exposure from US$ 7,588 for the portfolio that consisted entirely of the S&P500 to US$ 5,957 for the diversified portfolio. This effect is further analyzed in the next section.

DIVERSIFICATION EFFECT

The results above show that, in a portfolio of assets with sufficiently low correlation between the constituent assets, the risk exposure decreases and is less than the exposure for each asset on an individual basis. Risk can be minimized by an appropriate combination of the assets in the portfolio.

Risk/Return and Asset Correlation		
	Expected Return (%)	**Volatility (%)**
Asset 1	10	22
Asset 2	7	15
Correlation		20

For the sake of simplifying our analysis and calculations, assume that we have a portfolio consisting of two assets with the return and risk characteristics shown in the table above, which includes the expected return values, volatility and daily VAR for each possible combination of assets 1 and 2 (assuming a confidence interval of 99.87%).

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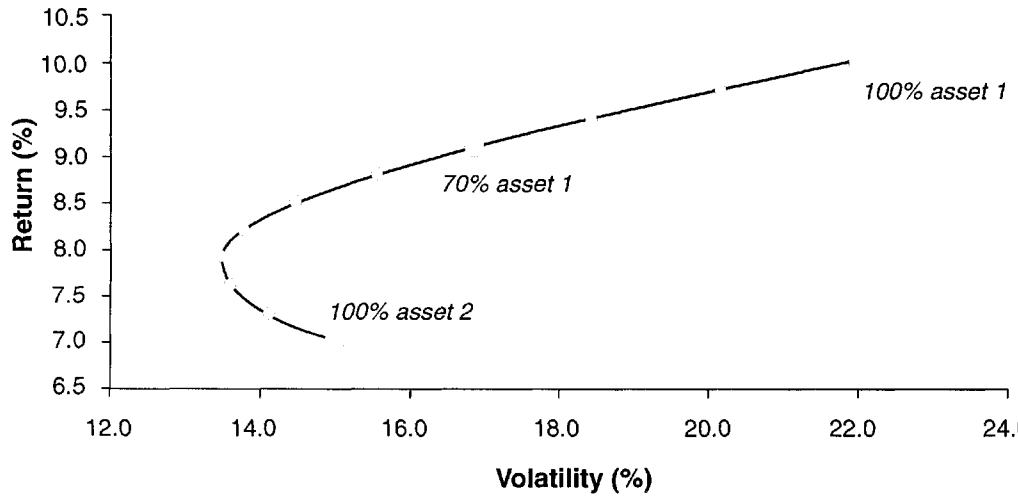
Risk/Return According to Portfolio Composition

Proportion (%) of Asset 1	Volatility (%)	Daily VAR (%)	Return (%)
0	15.0	2.83	7.0
10	14.1	2.66	7.3
20	13.6	2.56	7.6
30	13.5	2.53	7.9
40	13.8	2.59	8.2
50	14.5	2.73	8.5
60	15.6	2.93	8.8
70	16.9	3.18	9.1
80	18.4	3.47	9.4
90	20.2	3.80	9.7
100	22.0	4.15	10.0

Figure 9-1 shows the return and the volatility of the portfolio based on its composition.

Figure 9-1. Return/Volatility Curve as a Function of Portfolio Composition



As we can see, for a portfolio in which asset 1 comprises approximately 30% of the portfolio, the volatility is reduced to its minimum of 13.5%, which is lower than the individual volatility of each asset.

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Figure 9-2. Daily VAR (as a Percentage of Market Value) as a Function of Portfolio Composition

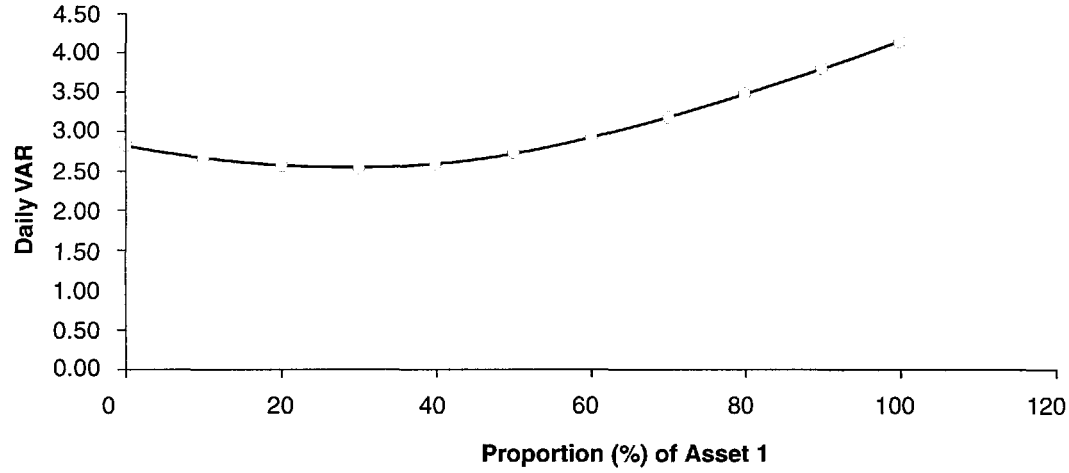

Figure 9-2 provides a graphic representation of the daily VAR depending on the composition of the portfolio, and we can observe that for this same point of minimum portfolio volatility the portfolio VAR would also reach its minimum.

In a low-correlation environment, diversification reduces the portfolio risk to a level that is even lower than the level of the lowest risk asset. In the example presented, this effect is achieved with correlation coefficients below 68%:[22]

$$\rho < \frac{\sigma_2}{\sigma_1} = \frac{15}{22} = 68.2\%$$

The sum of the positions does not equal the sum of the respective Values-at-Risk, as the correlation between the assets minimizes the risk, within the limitations explained above.

---

[22] The volatility of the portfolio is expressed as:

$$\sigma^2 = x^2\sigma_1^2 + (1-x)^2\sigma_2^2 + 2x(1-x)\sigma_1\sigma_2\rho$$

Setting the first derivative with respect to x equal to zero to seek the lowest value the function, we obtain

$$x = \frac{\sigma_2^2 - \sigma_1\sigma_2\rho}{\sigma_1^2 + \sigma_2^2 - 2\sigma_1\sigma_2\rho}$$

Requiring that x belong to the interval [0,1], and given that we are considering a portfolio made up only of long assets, it must be that:

$$\left.\begin{array}{l} x \le 1 \Rightarrow \rho \le \dfrac{\sigma_1}{\sigma_2} \\ x \ge 0 \Rightarrow \rho \le \dfrac{\sigma_2}{\sigma_1} \end{array}\right\} \Rightarrow \rho \le \frac{\min(\sigma_1,\sigma_2)}{\max(\sigma_1,\sigma_2)}$$

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MULTICURRENCY PORTFOLIO

Finally, we must analyze a portfolio with instruments in different currencies. To do this, we will assume that the value of the portfolio is expressed in a single currency. The value of each of the instruments that make up the portfolio is expressed in the reference currency, and these values are added together to obtain the value of the total portfolio.

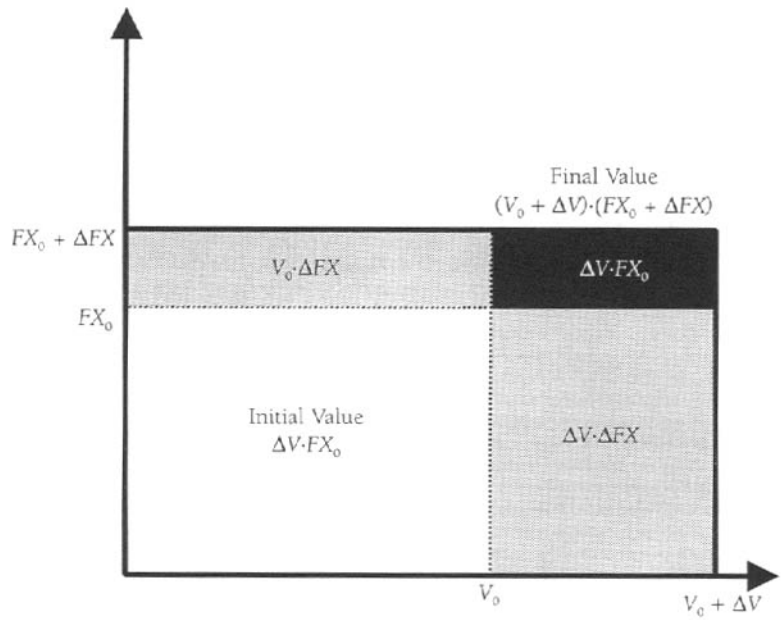
$$V_T = \sum V_i \bullet FX_i$$

where V_i is the market value of the instrument i expressed in its own currency and FX_i is the exchange rate needed to convert from the currency of instrument i to the reference currency. Therefore, the change of value in the portfolio is expressed by

$$\Delta V_T = \sum \left[\Delta V_i \bullet FX_i^o + (V_i^o + \Delta V_i) \bullet \Delta FX_i \right]$$

which, for an instrument denominated in a currency other than the reference currency, can be represented as shown in Figure 9-3.

Figure 9-3. Change in Value Based on Price and Exchange Rate



If we take into account only the first-order effects we have

$$\Delta V_T = \sum_i \left[\Delta V_i \bullet FX_i^o + V_i^o \bullet \Delta FX_i \right]$$

such that, referring to the graph above, we are considering only the shaded areas for each instrument in the portfolio and the effect of the area in black is ignored.

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As we can see, the change in value of the portfolio is the sum of the change in value of the portfolio assuming that the exchange rate remains constant, plus the change in value of the portfolio assuming that instrument prices in their own currencies remain constant.

From here we can pursue two different paths to analyze the combined effect of prices and the exchange rate on the behavior of the portfolio, but we will arrive at the same final result for the portfolio:

- Foreign exchange risk by instrument: The combined effect of a movement in the price of an instrument and its exchange rate, *vis-à-vis* the reference currency, is analyzed for each instrument.
- Foreign exchange risk grouped by currency: The movements in the prices of the instruments and the level of the exchange rate are analyzed separately, and subsequently combined. The effect of a movement in the prices of the instruments, assuming that the exchange rate remains constant, is analyzed for each instrument. In order to take the foreign exchange risk into account, we will analyze the effect of a movement in the exchange rates of the currencies of the instruments that make up the portfolio on the market value of the total portfolio. Finally, the two factors are combined through the existing correlations.

Regardless of the method chosen to perform the analysis, the resulting risk measurement obtained for the portfolio will be identical. In the first method, we are analyzing each of the instruments in the portfolio as if they were instruments in the reference currency, while in the second method the instruments are analyzed in their own currency and then the total effect that a movement in exchange rates will have on the total portfolio is calculated.

Of course, each alternative provides different information regarding the risks to which the portfolio is exposed. In the first approach, we are analyzing what each instrument contributes to overall risk, so we know the impact of a specific instrument on the overall risk of the portfolio, but we do not know, for example, the effect that a movement in exchange rates will have on the overall portfolio. The second focus isolates the contribution of the different risk factors to which the portfolio is exposed, which enables us to have a better understanding of the effect that movements in the different market variables will have on the value of the portfolio. This permits us to execute overall hedges that neutralize the effect of a specific risk factor, but on the other hand, we do not know the direct effect of eliminating a position in a specific instrument.

Foreign Exchange Risk by Instrument

The first alternative involves analyzing the exposure for each instrument from the point of view of the reference currency. The effect of a movement in the local prices and a movement in the exchange rates is combined in order to obtain the price movement of the instrument if the price is expressed in the reference currency. We can start with the expression for the change in the value of the portfolio that appeared in the preceding section:

$$\Delta V_T = \sum_i V_i^0 \bullet FX_i^0 \bullet \left[\frac{\Delta V_i}{V_i^0} + \frac{\Delta FX_i}{FX_i^0} \right]$$

Having defined the weight of each instrument in the portfolio as its market value divided by the total market value of the portfolio, both expressed in the reference currency, we have

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$$\omega_i' = \frac{V_i^0 \bullet FX_i^0}{V_T^0}$$

$$\frac{\Delta V_T}{V_T^0} = \sum \omega_i' \bullet \left[\frac{\Delta V_i}{V_i^0} + \frac{\Delta FX_i}{FX_i^0} \right]$$

The contribution of each instrument to the total portfolio return is arrived at by adding the return associated with the instrument itself and the return due to the changes in the exchange rate, weighting both addends by the weight of the instrument as a percentage of the total value of the portfolio. Therefore, the portfolio return can be expressed as

$$r_T = \sum \omega_i' \bullet r_i'$$

where the return associated with an instrument from the point of view of the reference currency is equal to the sum of the return associated with the instrument in the local currency plus the return associated with the exchange rate between the two currencies:

$$r_i' = \frac{\Delta V_i}{V_i^0} + \frac{\Delta FX_i}{FX_i^0} = r_i + r_{FX_i}$$

In order to determine the volatility of the portfolio, we must first to determine the volatilities of the returns expressed in the reference currency (r') and the correlations between the returns, and then apply the same expressions as for a single currency portfolio.

Keeping in mind that the return associated with an instrument denominated in the reference currency is equal to

$$r_i' = r_i + r_{FX_i}$$

then, the volatility of the portfolio can be expressed as:

$$\sigma_T'^2 = \sum \omega_i'^2 \sigma_i'^2 + \sum \sum \omega_i' \omega_j' \rho_{ij}' \sigma_i' \sigma_j'$$

where:

$$\sigma_T'^2 = \sigma_i^2 + \sigma_{FX_i}^2 + 2\rho_{i,FX_i}\sigma_i\sigma_{FX_i}$$

$$\rho_{i,j}' = \frac{1}{\sigma_i'\sigma_j'}\left[\rho_{i,j}\sigma_i\sigma_j + \rho_{i,FX_j}\sigma_i\sigma_{i,FX_j} + \rho_{FX_i,j}\sigma_{FX_i}\sigma_j + \rho_{FX_i,FX_j}\sigma_{FX_i}\sigma_{FX_j}\right]$$

FOREIGN EXCHANGE RISK GROUPED BY CURRENCY

The second alternative involves analyzing the contribution of each risk factor to the overall portfolio. If we remember that the change in the exchange rate of any currency affects equally all the instruments denominated in that currency, VD_d^0 is defined as the sum of all the market values of the instruments denominated in currency d:

$$VD_d^0 = \sum V_i^0$$

for all the instruments denominated in currency d.

Therefore, we have the expression:

$$\Delta V_T = \sum_i \left[\Delta V_i \bullet FX_i^0 + V_i^0 \bullet \Delta FX_i\right]$$

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which will be divided into two terms,

$$\Delta V_T = \sum_i \left[\Delta V_i \bullet FX_i^0\right] + \sum_d \left[VD_d^0 \bullet \Delta FX_d\right]$$

This separates the change in the portfolio value into the effect of movements in the local values of each instrument and the effect (on the overall portfolio) of movements in the exchange rates *vis-à-vis* the reference currency.

By defining the weight of each instrument in the portfolio as its market value divided by the total market value of the portfolio, both expressed in the reference currency, we have

$$\omega_i' = \frac{V_i^0 \bullet FX_i^0}{V_T^0}$$

and by defining the weight of each of the currencies in the total market value of the portfolio we have:

$$\nu_d' = \frac{VD_d^0 \bullet FX_d^0}{V_T^0}$$

The relative change in the value of the portfolio can be expressed as:

$$\frac{\Delta V_T}{V_T^0} = \sum_i \omega_i' \bullet \frac{\Delta V_i}{V_i^0} + \sum_d \nu_d' \frac{\Delta FX_d}{FX_d^0}$$

which makes the rate of return equal to:

$$r_T = \sum_i \omega_i' \bullet r_i + \sum_d \nu_d' \bullet r_{FX_d}$$

This separates the effects of a movement in local prices and a movement in exchange rates. Generalizing on the expression above for the portfolio's rate of return, we have

$$r_T = \sum W_k \bullet R_k$$

Then the volatility of the portfolio, in the reference currency, can be calculated by using the expressions from the corresponding section (p. 200).

Daily Capital-at-Risk of a Multicurrency Portfolio

All we need to do to calculate the CAR of the portfolio is to insert the volatility calculated in the preceding sections and use the risk-free rate for the reference currency selected. This gives us

$$CAR_{portfolio} = \frac{\left|V_T\right| \bullet k \bullet \sigma'_{daily}}{\left(1 + z_{RF}\right)^{T_{daily}}}$$

where the daily volatility is obtained by dividing the annual volatility by the square root of 250.

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Example

We shall examine the portfolio used in the example on p. 203, except that this time the pesos and reals will not be held in cash positions; instead, they will be invested in assets denominated in these currencies. In our example these assets will be two portfolios of stocks that replicate, respectively, the Mexican stock exchange (Bolsa) and Sao Paulo stock exchange index (Bovespa).

Composition of the Portfolio

Assets	Currency	US$ Amount	%	FX (local $/US$)	Amount in local $
S&P500	US$	100,000	50.0	1.000	US$ 100.000
Mexican Bolsa	Pesos	75,000	37.5	8.125	M$ 609.375
Bovespa	Real	25,000	12.5	1.112	R$ 27.800

The reference currency is US dollars. The portfolio is divided by currency as shown above.

In order to be able to perform Capital-at-Risk calculations, we need to know the volatilities of the Mexican and Brazilian exchanges. Since implied volatilities are not available, we will use historical volatilities for both, as shown below:

Volatility (%) Based on Number of Observations

Number of Observations	Mexican Bolsa	Bovespa
20	29	46
40	55	81
60	46	67
80	42	65
100	39	60

If we assume that the uncertainty of the last 3 or 4 months (60 to 90 business days) is what is most representative of the current situation, we will use 45% and 65% as the future volatility estimators for the Mexican exchange and the Bovespa index, respectively.

Now we can calculate the daily CAR, expressed in local currency, for a confidence interval of 99.87%.

Risk Measurements in Local Currency

Assets	Volatility (%) Annual	Volatility (%) Daily	CAR in Local Currency
S&P500	20	1.265	US$ 3,794
Mexican Bolsa	45	2.846	M$ 52,006
Bovespa	65	4.111	R$ 3,427

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Once we have looked at each instrument in its local currency, we must consider their combined effect based on exchange rate volatilities. As we have seen (pp. 206-208) the volatility of the total portfolio can be obtained in two ways: by analyzing the risk for each instrument and the exchange rates separately, or by analyzing each instrument as if it were a US$ instrument. Regardless of the method chosen, we need to know the complete matrix of volatilities and correlations.

By using the historical series to estimate the correlations between all the assets, we obtain the volatilities/correlations matrix below, where the volatilities are the estimators that we have been defining throughout the example and the correlations have been derived from the returns of the instruments in their own currencies.

Matrix of Volatilities and Correlations (in %)

	Volatilities	S&P500	Mexican Bolsa	Bovespa	Peso	Real
S&P500	20	100	87	75	75	-2
Mexican Bolsa	45		100	73	77	-7
Bovespa	65			100	70	10
Peso	18				100	10
Real	2					100

Analysis by Currency

In this method the contribution of each instrument (without including the effect of exchange rate movements) and each currency to the portfolio value is calculated separately. Based on the contributions of each of the positions, the table below shows the daily CAR associated with each position.

Daily CAR (No Exchange Rate Effect)

	Value	Weighting (%)	Daily Volatility	CAR (US$)
S&P500	100,000	50.0	1.26%	3,794
Mexican Bolsa	75,000	37.5	2.85%	6,401
Bovespa	25,000	12.5	4.11%	3,082
Peso	75,000	37.5	1.14%	2,560
Real	25,000	12.5	0.13%	95

However, these CAR calculations do not take into account the combined effect of movements in prices and exchange rates. The CAR obtained for the Mexican Bolsa represents the maximum possible loss based only on index movements and not the effects of changes in the peso/dollar exchange rate. The CAR associated with pesos represents the maximum possible loss resulting from a change in the peso/dollar exchange rate, but only under the assumption that the prices for all peso-denominated instruments remain the same.

The next step is to analyze the overall behavior of the portfolio given changes in both local prices and exchange rates. By applying the weighting coefficients shown in the table above to the volatilities and correlations matrix, we obtain a portfolio volatility of 38.3%, so the daily CAR of the entire portfolio equals US$ 14,532:

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$$CAR_{daily}^{portfolio} = \frac{200{,}000 \bullet 3 \bullet \frac{38.3\%}{\sqrt{250}}}{(1+0.055)^{\frac{1}{365}}} = \text{US\$14,532}$$

Analysis by Instrument

The previous example separated the effects of prices and exchange rates. Another approach is to analyze each instrument from the viewpoint of the reference currency. Volatility for an asset, expressed in the reference currency, is:

$$\sigma_i'^2 = \sigma_i^2 + \sigma_{FX_i}^2 + 2 \bullet \rho_{FX_i} \bullet \sigma_i \bullet \sigma_{FX_i}$$

and the volatilities (expressed in US$) and the daily CAR for each asset are:

Daily CAR (Including Exchange Rate Effect)

Asset	Volatility in US$ (%)	Daily Volatility (%)	CAR (US$)
S&P500	20	1.26	3,794
Mexican Bolsa	60	3.79	8,533
Bovespa	65	4.12	3,094

These CAR calculations show the possible loss from the combined effects of price changes and exchange rate movements. We see that the CAR for the Mexican Bolsa has increased from US$ 6,401 to US$ 8,533, because the former amount did not take exchange rate changes into account.

All we need to do now to calculate the total portfolio's CAR is determine the correlation matrix for the assets in the portfolio, stated in US$. Since we know that:

$$\rho'_{i,j} = \frac{1}{\sigma'_i \sigma'_j}\left[\rho_{i,j}\sigma'_i\sigma_j + \rho_{i,FX_j}\sigma_i\sigma_{FX_j} + \rho_{FX_i,j}\sigma_{FX_i}\sigma_j + \rho_{FX_i,FX_j}\sigma_{FX_i}\sigma_{FX_j}\right]$$

the correlation matrix, stated in US$, will be as shown in the table below.

Correlation Matrix in US$

	Correlation Coefficient (%)		
	S&P500	Mexican Bolsa	Bovespa
S&P500	100	88	75
Mexican Bolsa	88	100	75
Bovespa	75	75	100

The weight of each of asset in the portfolio, in US$, is used to calculate the portfolio volatility in US$, which equals 38.3%.

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Therefore the daily CAR of the total portfolio is US$ 14,532:

$$CAR_{daily}^{portfolio} = \frac{200{,}000 \bullet 3 \bullet \frac{38.3\%}{\sqrt{250}}}{(1+0.055)^{\frac{1}{365}}} = \text{US\$14,532}$$

which is precisely the same result achieved by performing an analysis by currency.

Simulation Techniques

At the beginning of this chapter, we discussed two methods of determining a portfolio risk map, analytical and numerical. We have now discussed the analytical approach, in which the risk parameters of a portfolio were calculated assuming that the risk factors that determine its value behave as normal random variables. The portfolio volatility can then be determined by using the correlation and volatility matrices associated with those risk factors. Having closed-form mathematical solutions enables richer analysis and requires less calculation power. However, this focus requires us to adopt simplifying assumptions that may not always reflect the actual risk introduced by a specific instrument.

If the basic risk factors appear to conform to certain types of behavioral models, numerical simulations can be an alternative to the analytical focus described above. In the simulation method, adding the profits or losses associated with each of the simulation scenarios generates the real profit and loss distribution. This enables us to analyze the behavior of complex instruments whose value depends on basic risk factors. It is then unnecessary to adopt simplifying assumptions such as eliminating the cross-factor term when analyzing currency risk or assuming normal instead of lognormal distributions.

In this section we consider two possibilities for performing these simulations. One is based on an assumption of a future behavioral standard, while the other uses information on the combined evolution of all risk factors in the past.

- MONTE CARLO SIMULATIONS: A behavioral model is assumed for each risk factor and for the dependency relationships involving the other factors. Then scenarios are generated using the overall behavior model; for each scenario there will be a specific profit or loss. The aggregation of all the scenarios results in the profit and loss distribution.
- HISTORICAL SIMULATION: In this technique, we use as future scenarios actual risk factor changes that occurred during a past historical period (instead of trying to convert past information into a behavior model with parameters). This means that we do not have to make any assumptions in order to create a behavioral model, since our scenario for the future uses changes that actually occurred on a specific day for all the risk factors.

MONTE CARLO SIMULATIONS

As stated at the beginning of the chapter, the ultimate goal is to obtain the probability distribution associated with the portfolio and each instrument. There are two focuses we can use, *analytical* and *numerical*. So far we have discussed the analytical focus. Now we will move on to the numerical focus and discuss Monte Carlo simulations.

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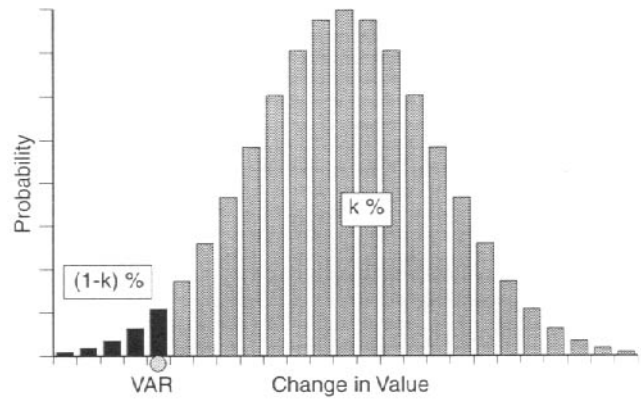
We begin with two main assumptions in the analytical focus that are intended to simplify our formulas and increase our analytical power:

- The daily rate of return is normally distributed.
- The cross-factor terms that arise in multi-currency portfolios are eliminated; this term is the change in value due to the combination of a simultaneous change in the local value of the instrument and in the exchange rate of that instrument's currency *vis-à-vis* the reference currency.

The numerical focus obviates the need for the second assumption, and allows us to replace the first assumption with the assumption of lognormal prices (along with a normally distributed compound rate rather than daily rate). The process we will follow is:

- Paths are generated for each variable that affects the value of the portfolio. These paths model the portfolio's evolution over time, and take into account the path-dependent relationships between the variables (correlation coefficients).
- After simulating the final value for each instrument and path in the time horizon used, the total change in value (S_T–S_0) is calculated. Applying this change in value to the actual position in that instrument gives the change in value of the instrument in question.
- Based on all the changes in value obtained through multiple trials, and keeping in mind that all the paths are equally probable, we build the probability distribution of the change in value of the instrument or portfolio.
- Now, using the probability distribution, we determine the Capital-at-Risk of the portfolio using the expressions given at the beginning of this document.

Figure 9-4. VAR and Profit and Loss Map



The VAR is normally expressed as an absolute value, so

$$Probability\ (Value_{initial} - Value_{final} > VAR) = 1 - k$$

Simulations for a Single Instrument

As stated in the section on price behavior, the classic theory assumes that prices have a lognormal distribution, and therefore the compound rate of return also has a normal distribution.

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In order to model price behavior, we generate a sample compound rate of return for a specific time period and then follow the procedure below for each path we want to simulate:

- The time period is divided into n intervals, so for each path we must do n samples.
- We take random samples of a variable that behaves like a normal variable with an average of 0 and a standard deviation of 1. To do this, we take 12 independent random samples between 0 and 1 and build the variable

$$x = \sum_{1}^{12} z_i - 6$$

  where x is the random sample of the normal variable.
- The rate of return for the interval in question is defined as the sum of the expected rate associated with the interval plus an unexpected rate, which depends on the value of the prior sample (x) and the volatility associated with that interval. Therefore,

$$r = r_{expected} + \sigma_{interval} \bullet x$$

where

$$\sigma_{interval} = \frac{\sigma_{period}}{\sqrt{n}}$$

- The price generated by the model at the end of the first interval is calculated as

$$P_1 = P_0 \bullet e^r$$

- This process is repeated n times until the instrument price at the end of the period in question is obtained

$$P_1 = P_0 \bullet e^{r1}$$
$$P_2 = P_0 \bullet e^{r2}$$
$$\cdots$$
$$P_n = P_0 \bullet e^{rn}$$

- Once we have the price, we can calculate the change in value associated with that path as:

$$\Delta\ value = No.\ instruments \bullet (P_n - P_0)$$

This process is repeated as many times as there are paths we want to simulate; we end up with as many profit and loss points as there were paths simulated, and can determine the probability distribution associated with this population.

Once we have the distribution, we can calculate the Value-at-Risk by looking for the profit and loss value associated with the chosen confidence interval.

Example

To illustrate this procedure we will simulate the behavior of the S&P500 and apply the results to a portfolio with a value of US$ 200,000 that replicates the index. This will be compared to the results we obtained previously using the normality hypothesis and the analytical expressions.

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We will assume a simulation horizon of one day, and will simulate 5,000 paths for each single interval. The expected return and volatility will be the same as in the initial example, i.e., zero expected return and annual volatility of 20%. The current price of the S&P500 index is 969.79.

Therefore, the volatility for the period is the daily volatility

$$\sigma_{interval} = \sigma_{period} = \sigma_{daily} = \frac{20\%}{\sqrt{250}} = 1.265\%$$

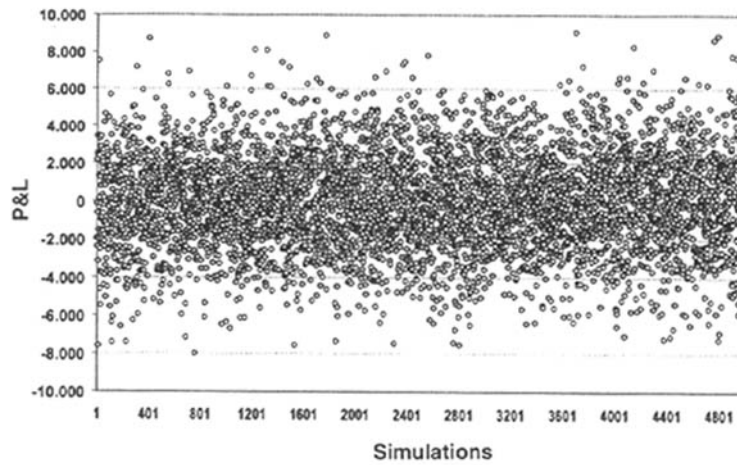
By way of example, the table below shows the first 10 paths out of the 5,000 included in the complete simulation.

Sampling of Simulation Results

x	Return	Final Price	P&L
-0.78	-0.990%	960.24	-1,970
0.84	1.065%	980.17	2,141
-0.06	-0.070%	969.11	-140
-0.96	-1.210%	958.13	-2,405
-0.25	-0.311%	966.78	-620
1.35	1.711%	986.53	3,451
1.34	1.690%	986.32	3,410
0.99	1.251%	982.00	2,518
0.94	1.192%	981.42	2,398
-1.26	-1.598%	954.42	-3,170

Figure 9-5 shows all the profit and loss values obtained for each of the 5,000 paths simulated.

Figure 9-5. Results of the Monte Carlo Simulation



By transforming the observations above into a cumulative probability distribution, we obtain the graph in Figure 9-6, which compares the probability distribution obtained using simulations with a normal distribution using an annual volatility of 20%. As we can see, the Monte Carlo method generates a normal distribution.

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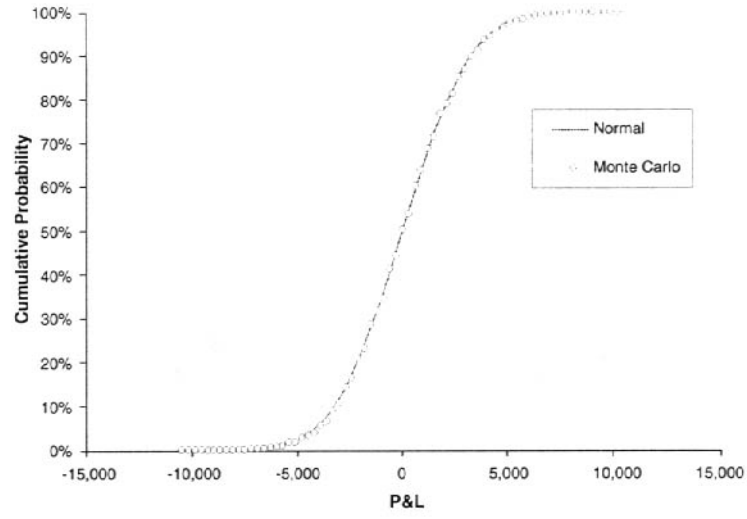
Figure 9-6. Probability Distribution of the Simulation and a Normal Distribution



The CAR is the point on the cumulative probability distribution where the cumulative probability is 0.13% (which equates to a 99.87% confidence interval). The table below shows the values obtained from the simulation and normal distribution models.

Monte Carlo and Normal Distribution Comparison

Model	Volatility (%)	Daily CAR (US$)
Monte Carlo	19.9	7,289
Normal	20.0	7,589

The Monte Carlo volatility is the standard deviation of all the compound return-rate samples generated by the model.

Simulations with a Portfolio of Instruments

If we have a portfolio of different instruments, the procedure to be followed is identical for each instrument. The only difference is in the generation of the normal distributions sample. Since the variables are not independent, we must consider the correlation coefficients between them. Therefore, the procedure will be slightly different at the outset when modeling each of the variables.

Assume that the portfolio consists of K instruments. The procedure is as follows:

- The time period being considered is divided into n intervals, so for each path there are n samples.
- We will take K random samples (x_k) of a variable that behaves like a normal variable with an average of 0 and a standard deviation of 1, as we did when dealing with a single instrument.

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- These K variables have been generated as if they were independent, with zero correlation, but the actual variables are correlated and are not independent. Therefore, the next step is to build the actual variables, which we will call y, as the weighted sum of the former (generated variables) (x), where the weighting coefficients are obtained from the correlation matrix. The method for calculating these coefficients is provided in the appendix on normal multivariate sampling (p. 237).

$$y_k = \sum_{1}^{K} c_{ki} \bullet x_i$$

- Once we have the coefficients, we proceed individually with each instrument, as in the case of the single product, defining the rate of return of each instrument using the new variables and:

$$r = r_{expected} + \sigma_{interval} \bullet y$$

- Once we have the final price of each instrument, we can calculate the change in value associated with a path for the entire portfolio as:

$$\Delta\ value = \sum \text{No. instruments}_k \bullet (P_n - P_o)_k$$

This process is repeated as many times as there are paths we want to simulate, so when we are done we have as many profit and loss values as simulated paths, and thus the probability distribution associated with this population.

Once we have the distribution, we can calculate the Capital-at-Risk by looking for the profit and loss value associated with the chosen confidence interval.

Example

As with the single instrument, we will simulate the behavior of the same variables used in our prior portfolio analyses and will compared the results obtained under the two procedures.

We will simulate the aggregate behavior of the S&P500, Bovespa and Mexican Bolsa indices together with the Mexican peso and Brazilian real exchange rates *vis-à-vis* the dollar. We will use the same matrix of volatilities and correlations as in the analytical examples.

Matrix of Volatilities and Correlations Between Instruments (in %)

	Volatility	S&P500	Mexican Bolsa	Bovespa	Peso	Real
S&P500	20	100	87	75	75	-2
Mexican Bolsa	45		100	73	77	-7
Bovespa	65			100	70	10
Peso	18				100	10
Real	2					100

As in the former example (p. 220) we will use a time horizon of one day and will simulate 5,000 paths for a single interval.

First we simulate 5 normal, independent random variables with a mean of zero and a standard deviation of one. The results obtained for the first 10 paths are shown below.

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Independent Variables Simulation Sample				
x_1	x_2	x_3	x_4	x_5
-1.59	0.63	-0.29	-0.03	-1.27
0.06	-1.42	-1.49	-0.44	0.33
-0.10	-0.62	0.47	0.05	-2.29
-0.67	-0.38	0.74	-2.23	1.38
-0.71	0.91	0.86	-0.46	-1.27
-0.93	-1.28	0.84	2.21	0.76
1.13	-0.71	-1.00	0.47	1.86
-0.11	-0.64	1.72	-0.33	0.68
-1.44	0.04	1.33	0.65	1.86
-1.07	-0.41	0.84	0.53	-0.08

However, these variables are independent and must be adjusted in order to obtain the variables that model the real behavior of prices. Therefore we calculate the weight coefficients that enable us to generate the correlated variables, using the expressions contained in the appendix (p. 237). This gives us the matrix below.

Weight Coefficients (%)					
	c_1	c_2	c_3	c_4	c_5
S&P500	100				
México	87	49			
Brasil	75	16	64		
Peso	75	24	16	60	
Reales	-2	-11	21	18	96

By applying these coefficients to the independent variables, we obtain the correlated variables for the first ten paths.

Sample of Simulated Correlated Variables				
S&P500	Mexico	Brazil	Peso	Real
1.59	-1.07	-1.28	1.07	-1.12
0.06	-0.65	-1.13	0.26	0.39
-0.10	-0.39	0.13	0.18	-2.34
-0.67	-0.77	-0.09	-0.85	0.71
-0.71	-0.17	0.16	-0.09	-1.39
-0.93	-1.44	-0.36	2.19	0.80
1.13	0.63	0.09	-0.25	2.02
-0.11	-0.41	0.92	-0.23	0.16
-1.44	-1.24	-0.23	1.26	1.60
-1.07	-1.13	-0.32	1.08	-0.22

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Now we will follow the same procedure for each instrument that we used in the previous example of the single instrument. We first determine the price associated with each path.

Instrument Price Simulation Sample

S&P500	México	Brasil	Pesos	Reales
950.50	4893.95	8977.55	8.22	1.110
970.58	4953.42	9030.82	8.15	1.113
968.56	4989.10	9511.91	8.14	1.109
961.57	4936.00	9426.71	8.05	1.113
961.10	5020.79	9523.44	8.12	1.110
958.50	4843.30	9324.43	8.33	1.113
983.80	5137.35	9498.08	8.10	1.115
968.47	4986.77	9827.91	8.10	1.112
952.24	4870.83	9374.32	8.24	1.114
956.77	4885.67	9336.05	8.23	1.112

Once we have the prices at the end of each path, we will calculate the final value of the portfolio in question for each path. Then we generate the cumulative probability distribution, which can be used to determine the daily Capital-at-Risk.

Portfolio 1

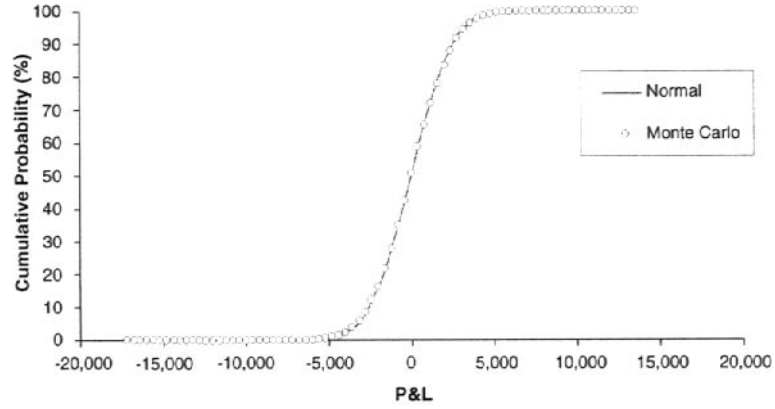
The first portfolio that was analyzed using the analytical focus consisted of the assets shown in the table below.

Benchmark Portfolio

Asset	Market Amount (US$)	Peso (%)
S&P500	100,000	50.0
Peso	75,000	37.5
Real	25,000	12.5

Through simulation we obtain the probability distribution that is shown in Figure 9-7.

Figure 9-7. Probability Distribution Using the Monte Carlo Method and Normal Distribution



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The distribution of the simulation is similar to a normal distribution with volatility of 15.7%, which is the value obtained using the analytical focus.

The value of the CAR is obtained from the point on the cumulative probability distribution where the cumulative probability is 0.13% (which equates to a confidence interval of 99.87%). The values obtained using the simulation and the normal distribution are shown below.

Comparison of Simulation and Normal Distribution Results

Model	Volatility (%)	Daily CAR (US$)
Monte Carlo	15.6	5,600
Normal	15.7	5,964

Portfolio 2

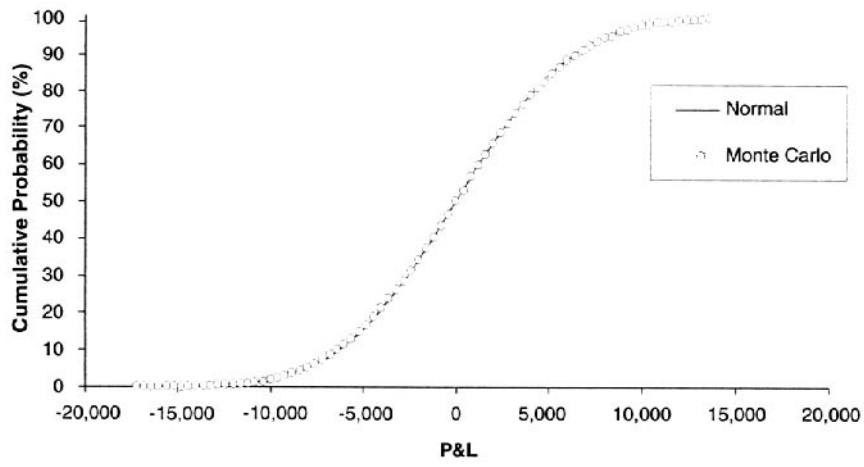
The second portfolio that was analyzed using the analytical focus consisted of the assets shown below.

Benchmark Portfolio

Asset	Currency	US$ Amount	%	FX (Local $/US$)	Local $ Amount
S&P500	US$	100,000	50.0	1,000	US$ 100,000
Mexican Bolsa	Peso	75,000	37.5	8,125	M$ 609.375
Bovespa	Real	25,000	12.5	1,112	R$ 27.800

We proceed as in portfolio 1 and obtain Figure 9-8.

Figure 9-8. Probability Distribution Based on Simulation and on Normal Distribution



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The two probability distributions shown in the graph are comparable, with volatility equal to 38.3%, which is the value we obtained using the analytical focus.

The value of the CAR is obtained from the point on the cumulative probability distribution where the cumulative probability is 0.13% (which equates to a confidence interval of 99.87%). The values obtained using the simulation and the normal distribution are shown below.

Comparison of Simulation and Normal Distribution Results

Model	Volatility (%)	Daily CAR (US$)
Monte Carlo	38.1	13,616
Normal	38.3	14,525

In this case, since some of the assets are denominated in currencies other than the reference currency, part of the difference is due (aside from the number of simulations used) to the fact that the simulations include the cross-factor terms stemming from the foreign exchange risk, which is not considered in the analytical focus.

One More Application: Analysis of an Option Portfolio

When a portfolio contains options, the options must be analyzed independently because of the special characteristics of these instruments, which invalidate the assumptions made for other instruments. These characteristics require very complex models if the risk measurements for the options are to be calculated using the analytical focus.

This leads to the use of simulations, which are applied to the option portfolio together with an asset that replicates the behavior of the rest of the portfolio.

The initial portfolio is divided in two, as follows:

- One part of the portfolio contains all the options and instruments that include options, together with the actual positions in the instruments that underlie the options. We will call this part of the portfolio the *options portfolio.*
- The other part of the portfolio contains the remaining positions of the initial portfolio. We will call this part of the portfolio the *basic portfolio.*

The procedure followed to determine the total risk map of the portfolio is outlined below:

- The basic portfolio analysis is performed using the methodologies and assumptions that are normally used in portfolio analysis. Thus, the basic portfolio is considered an asset whose volatility is the volatility resulting from the direct application of the covariance matrix.
- The correlations between each of the assets underlying the options and the basic portfolio are also calculated. Up to this point we are only analyzing instruments in which the superior order effects are not significant, so the usual methodologies can be applied to them.
- An auxiliary portfolio is built consisting of the option portfolio plus a position in an asset with the same value and risk profile as the basic portfolio, i.e., having the same price and same volatility.

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- The behavior of the auxiliary portfolio is simulated using the Monte Carlo method for the prices of the underlying assets and the asset that simulates the behavior of the basic portfolio. This step could be done using the analytical focus, but doing so would require calculating the prices of all the options, defining a probability distribution for them, and determining all the correlations inherent in the portfolio. Clearly the second alternative is very complex technically. If the number of options and underlying assets is not very high, it does not pay to make this effort; the portfolio is perfectly well analyzed through the use of simulations.
- If simulations are being used, then for each scenario involving the underlying assets and the asset that replicates the basic portfolio, the auxiliary portfolio will be valued through the profit and loss distribution of the initial portfolio, and the Capital-at-Risk measurements can be calculated without difficulty.

We have already explained in detail the calculation methodology needed to analyze the basic portfolio, determine the correlations between this portfolio and each of the underlying assets and perform a Monte Carlo simulation of a number of variables (p. 220 *et seq.*).

HISTORICAL SIMULATION

The Monte Carlo simulation method first requires that the different risk factors and the relationships between them be modeled. Given this, another approach is to do a historical simulation. This technique consists of assuming that any past scenario could be a future scenario, in which the joint movement of the relevant risk factors on a specific day would be determined by the behavioral pattern of all the factors in aggregate. By taking a historical series of past scenarios and applying it to the current portfolio, we obtain a series of profit and loss scenarios for which different risk measurements can be estimated. Therefore, by using this series of scenarios, we can determine their probability distribution and determine the percentile associated with the desired confidence interval, thus obtaining the Capital-at-Risk of the portfolio.

Use of this approach requires us to select a historical period that is considered representative of the real level of risk. We can note the value of the sample in this historical period that corresponds to a loss that has not been exceeded in more than 1% (for example) of all days in the period. However, if a short historical period is chosen (for example, 100 days) the loss selected will be the second worst result and cannot be considered to truly represent a 99% confidence level, since the sample chosen is only one of the series that could have occurred in that period.

In order to better estimate the confidence interval for a certain loss level, we can introduce an additional assumption: the form of the notional distribution of profits and losses. To do this, one attempts to adjust notional distributions to the historical profit and loss sample by determining the parameters of these distributions and then assigning probabilities to each of the losses of that distribution.

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Another alternative that should be noted here is estimation of the volatility of the *profit and loss distribution*, while assuming (for the purpose of calculating the Capital-at-Risk) that the portfolio displays a normal distribution. However, the result obtained is identical[23] to the result we get using a historical correlation and volatility model. There is also the disadvantage that by using the numerical approach on the portfolio as a whole, we lose the information on the individual behavior of each asset and the relationships shown by the correlations.

However, the historical simulation does enable us to determine what the maximum loss for the portfolio would be were the worst scenario considered in the simulation to repeat itself. This is the first stress test for the portfolio being analyzed. Later (p. 231) we will discuss other stress measurements that complete the Capital-at-Risk information obtained by other procedures.

Example

Look at the portfolio we have used in earlier examples.

Benchmark Portfolio					
Asset	**Currency**	**US$ Amount**	**%**	**FX (local $/US$)**	**Local $ Amount**
S&P500	US$	100,000	50.0	1.000	US$ 100,000
Mexican Bolsa	Peso	75,000	37.5	8.125	M$ 609,375
Bovespa	Real	25,000	12.5	1.112	R$ 27,800

The next table shows the daily returns that would have been earned by this portfolio based on the scenarios for the last 40 business days. Since we have only 40 observations, the meaningful confidence interval cannot exceed 97.5%. In this case, the associated percentile is the percentile corresponding to the maximum loss, which equals US$ 25,350 and is a negative return of 13.6%.

If we calculate the volatility for the last 40 days, we obtain 50%, so the related Capital-at-Risk is US$ 18,959 for a 99.87% confidence interval. This CAR is significantly less than the maximum loss of US$ 25,350.

Therefore, we use the historical simulation as a stress measurement that gives the loss that the current portfolio would suffer during the time frame of the simulation under the worst scenario from the historical period selected.

If we had taken 100 days of observations, the maximum loss would be the same but the volatility would be lower, at 35%, which translates into Capital-at-Risk of US$ 13,300 and a confidence interval of 99.87%.

[23] If the instruments that make up the portfolio are denominated in different currencies, the result will not be identical since in the historical simulation the cross-factor terms can be taken into account, whereas they are eliminated when the covariance matrix is used.

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Historical Simulation						
Date	**Brazil**	**Real**	**S&P500**	**Mexico**	**Peso**	**Portfolio**
Oct 16, 1997	-2.0%	0.0%	-1.1%	-0.1%	-0.2%	-0.9%
Oct 17, 1997	-0.7%	0.0%	-1.2%	-1.2%	-0.1%	-1.2%
Oct 20, 1997	1.7%	-0.1%	1.2%	0.7%	-0.4%	1.2%
Oct 21, 1997	2.4%	0.0%	1.7%	1.1%	0.1%	1.6%
Oct 22, 1997	-0.5%	0.0%	-0.4%	-1.3%	-0.1%	-0.8%
Oct 23, 1997	-8.5%	0.0%	-1.9%	-4.6%	-0.1%	-4.3%
Oct 24, 1997	-3.0%	-1.0%	-1.0%	-2.8%	-1.1%	-2.4%
Oct 27, 1997	-16.2%	0.0%	-7.1%	-14.3%	-7.0%	-13.6%
Oct 28, 1997	6.2%	-0.1%	5.0%	11.1%	2.4%	8.1%
Oct 29, 1997	-6.2%	0.4%	-0.3%	0.7%	0.0%	-0.7%
Oct 30, 1997	-10.3%	0.4%	-1.7%	-3.5%	-1.2%	-4.0%
Oct 31, 1997	1.5%	-0.4%	1.2%	0.4%	-0.7%	0.7%
Nov 3, 1997	9.3%	0.3%	2.6%	4.3%	3.1%	5.2%
Nov 4, 1997	3.9%	0.0%	0.2%	0.1%	-0.9%	0.3%
Nov 5, 1997	-2.6%	-0.1%	0.2%	-0.6%	1.3%	0.0%
Nov 6, 1997	-5.7%	0.0%	-0.5%	-0.9%	-2.7%	-2.3%
Nov 7, 1997	-6.6%	-0.2%	-1.1%	-2.5%	-0.7%	-2.6%
Nov 10, 1997	1.9%	-0.2%	-0.7%	-2.6%	0.6%	-0.8%
Nov 11, 1997	-3.3%	0.3%	0.3%	-0.4%	1.1%	0.0%
Nov 12, 1997	-10.8%	0.0%	-1.9%	-4.3%	-1.6%	-4.5%
Nov 13, 1997	3.1%	-0.1%	1.2%	2.6%	-0.4%	1.8%
Nov 14, 1997	7.9%	0.0%	1.3%	1.9%	-0.8%	2.6%
Nov 17, 1997	3.9%	-0.2%	1.9%	1.2%	1.0%	2.3%
Nov 18, 1997	-0.6%	0.2%	-0.8%	0.2%	-0.2%	-0.5%
Nov 19, 1997	3.3%	0.0%	0.7%	1.8%	0.1%	1.4%
Nov 20, 1997	-1.6%	-0.2%	1.5%	3.2%	0.2%	1.8%
Nov 21, 1997	2.5%	-0.1%	0.4%	-2.3%	0.5%	-0.1%
Nov 24, 1997	-3.8%	0.0%	-1.7%	1.4%	-0.1%	-0.9%
Nov 25, 1997	0.9%	-0.1%	0.4%	2.3%	-0.3%	1.1%
Nov 26, 1997	2.4%	0.0%	0.1%	1.2%	0.3%	0.9%
Nov 28, 1997	0.2%	0.1%	0.4%	0.4%	0.1%	0.4%
Dec 1, 1997	2.7%	0.0%	2.0%	2.8%	0.0%	2.4%
Dec 2, 1997	3.2%	0.0%	-0.3%	0.2%	0.5%	0.5%
Dec 3, 1997	0.3%	0.0%	0.5%	0.0%	0.5%	0.5%
Dec 4, 1997	0.5%	-0.1%	-0.4%	0.1%	-0.1%	-0.1%
Dec 5, 1997	0.3%	0.0%	1.1%	-0.4%	0.2%	0.5%
Dec 9, 1997	-2.4%	-0.1%	-0.8%	0.0%	-0.0%	-0.7%
Dec 10, 1997	-3.9%	-0.1%	-0.6%	-1.3%	-0.2%	-1.4%

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Stress Testing

In addition to calculating the CAR for the current portfolio based on volatility and correlation estimates, we should consider scenarios that have disastrous effects on the P&L associated with the portfolio. We can consider the following alternatives:

- Perfect correlation scenario: This scenario is based on the hypothesis that all variables move together in the same direction. In other words, all the assets in a portfolio will move in the same way, which results in a correlation matrix where all values in the matrix are one.
- Worst CAR: This alternative requires repeating the CAR calculations with the covariance matrices observed throughout the simulation period, thus building a probability distribution for the CAR. We then take either the worst CAR in absolute terms or the one that corresponds to a given confidence level.
- Crisis risk: In some economies, the Government controls the price of certain instruments. This results in very stable historical series that show almost no volatility, with insignificant CAR. However, there is obviously significant risk should the Government decide to change its controls or to allow the price of these instruments float freely. This can result in large losses neither predicted by the model nor captured by earlier scenarios. This requires special attention to and analysis of the macroeconomic indicators of the country in order to develop new indicators that improve crisis prediction.
- Scenarios: This is an attempt to analyze the effect that various unfavorable scenarios may have on the portfolio. For example, we can calculate the change in value of the current portfolio given changes in market variables that occurred in the past, and then selecting the highest loss calculated.

The scenario approach has already been presented (p. 229), while the crisis risk approach is discussed in greater detail in chapter 10, which discusses emerging markets. All that is necessary to use the first two approaches is to change the matrix of volatilities and correlations to the new values appropriate for the approach selected and repeat the CAR calculation. The results for the perfect correlation case are shown below by way of example.

EXAMPLE: PERFECT CORRELATION

In this example, we use the same portfolio shown in the multicurrency portfolio example, with the volatilities and correlations now all equal to one.

Volatility and Correlation Matrix (%)

	Volatility	S&P500	Mexican Bolsa	Bovespa	Peso	Real
S&P500	20	100	100	100	100	100
Mexican Bolsa	45		100	100	100	100
Bovespa	65			100	100	100
Peso	18				100	100
Real	2					100

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If we apply the matrix above to the analysis of currency risk by instrument, we obtain the correlation and volatility matrix shown below, expressed in US$.

Volatility and Correlation Matrix (%)

	Volatility	S&P500	Mexican Bolsa	Bovespa
S&P500	20	100	100	100
Mexican Bolsa	63		100	100
Bovespa	67			100

Thus, the volatility of the portfolio in US$ is equal to 42% and the daily CAR for the entire portfolio is US$ 15,936, calculated as follows:

$$CAR_{daily}^{portfolio} = \frac{200{,}000 \bullet 3 \bullet \frac{42\%}{\sqrt{250}}}{(1+0.055)^{\frac{1}{365}}} = \text{US\$}15{,}936$$

The CAR is higher than the one derived in the section on the multicurrency portfolio (p. 218), where we obtained an amount of US$ 14,532, but the difference is not very great due to the high correlation between the dollar-denominated prices of the assets in the portfolio, which fluctuated between 75% and 88%. However, the effect is substantially greater when there are low or negative correlations.

Back Testing

As shown throughout this chapter, in order to calculate risk/return measurements we must begin with a number of assumptions about the price behavior model. Therefore it will be necessary to perform a series of tests intended to assess the reliability of the results obtained and their validity as an efficient instrument for measurement and risk control. A number of such tests can be performed:

- The first test consists of checking next-day profits and losses for only the transactions used to calculate the CAR against the CAR calculated for each day. To do this, a system based on CAR values must be implemented.
- Another option is to evaluate the historical behavior of the current portfolio by comparing the portfolio's historical profits and losses for one day in the past with the daily CAR values that had been calculated the day before.

A confidence interval of 99.87% is assumed in all the examples when calculating the daily CAR, which means that the portfolio value, including daily profits and losses, will remain above the CAR 99.87% of the time.

Let's analyze the behavior of the portfolio used in prior examples under the second method.

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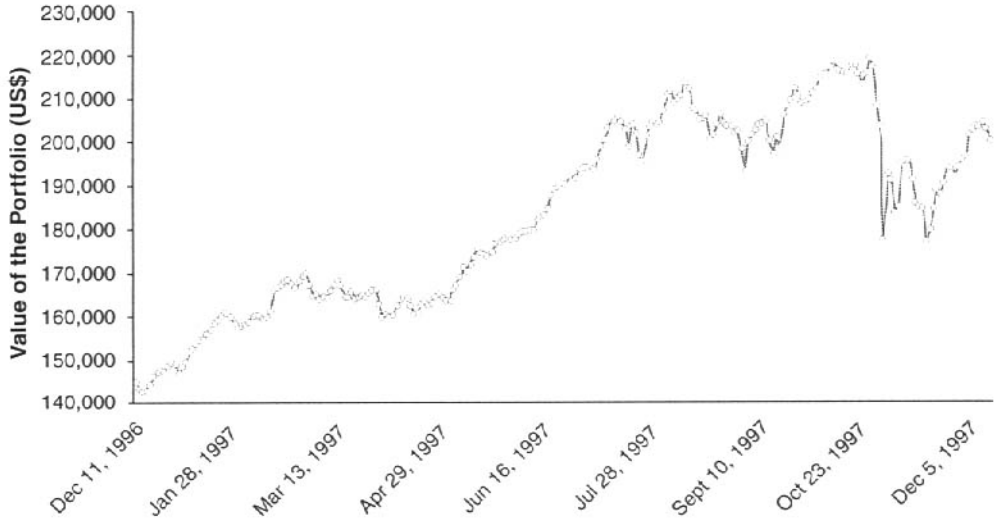
Benchmark Portfolio					
Asset	**Currency**	**US$ Amount**	**%**	**FX (local $/US$)**	**Local $ Amount**
S&P500	US$	100,000	50.0	1.000	US$ 100,000
Mexican Bolsa	Pesos	75,000	37.5	8.125	M$ 609,375
Bovespa	Reales	25,000	12.5	1.112	R$ 27,800

If we assume the same current portfolio composition (as to the number of instruments in the portfolio), the historical closing values that the portfolio would have had can be calculated. They are expressed in US$ in Figure 9-9.

In order to test the model, we will calculate the daily CAR for each date using the historical volatility calculated for the last 60 observations. This amount is then compared to the P&L for the next day. This gives us a graph such as the one in Figure 9-10, in which the lower band represents the CAR while the upper band is the corresponding symmetrical value. The points are the actual changes in the portfolio value.

As we can see, the model adequately shows the maximum potential one-day loss. However, the daily profits and losses have exceeded the limits on more occasions than predicted by the given confidence level, which says that the limits would be exceeded only once every one thousand days. There are two basic explanations for this:

Figure 9-9. Historical Values of the Portfolio



- The actual behavior of prices is not as "normal" as assumed in the analytical approaches and exhibits a phenomenon called "fat tails," which means that the probability of an extreme movement is higher than it would be in a normal distribution. If we take this effect into consideration, the bands widen slightly and some of the points that were previously outside the bands now are within the expected range.
- Even so, there are points that exceed the bands by a lot, which is explained by the fact that a crisis occurred during the period in question and the model is not able to anticipate it. This is especially significant in emerging countries where volatility can vary widely. We should again note the values used in the case of Brazilian reals, where

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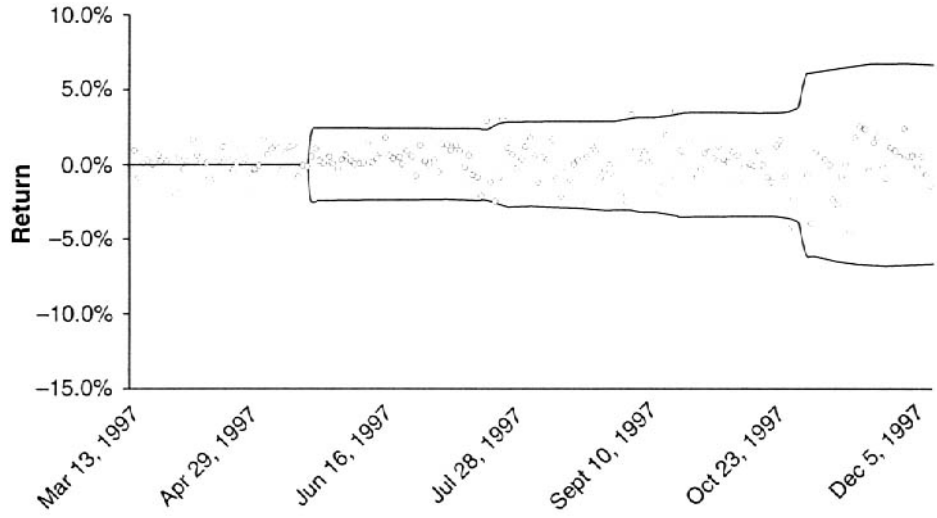
Figure 9-10. Back Testing



historical exchange rate volatility has often been very close to zero due to government controls. This does not mean that there is no possibility of a devaluation of the real. The model (as described so far) is not capable of taking this effect into account. Therefore, we must correct the risk parameters associated with the Brazilian real based on additional information sources. This and other similar topics are discussed in chapter 10, which discusses risk measurements in emerging markets.

We should also note that the width of the bands changes with the return behavior, since it is often mistakenly thought that the loss for one day should never exceed the CAR bottom limit. This approach results in over-allocation of capital and underutilization of funds, when the CAR, combined with the use of RORAC, should really be a measurement that makes it possible to optimize this scarce resource. We must also remember that a confidence interval is used when determining the CAR, so there is not a single CAR for a given portfolio but rather a CAR for each confidence interval. Obviously, the lower the confidence level the more observations will fall outside the range.

Appendices

JUSTIFICATION OF THE PRICE NORMALITY HYPOTHESIS

When calculating the exposure of a portfolio of instruments, we have assumed that the change in value of each asset follows a normal probability distribution. Even though the hypothesis is incorrect from a methodological standpoint (the theory of asset price behavior assumes that prices move on a lognormal basis), this does not cause a significant error from a numerical standpoint.

On one hand, the shorter the time horizon, the closer the various annualized compound return rates will be, such that

$$\ln \frac{V_T}{V_0} \approx \frac{V_T - V_0}{V_0}$$

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On the other hand, the model requires that we estimate a standard deviation, which usually introduces an error that is equal to or greater than the error introduced by the distribution change.

Assuming a confidence interval of 99.87% (3σ) and a time horizon of one day, the table below shows the VAR as a percentage of the market value of the position, assuming that the compounded rate is normal (lognormal VAR), and then shows the VAR, assuming that the daily return is normal (normal VAR). Both have the same standard deviation.

Comparison Between the Normal and Lognormal Hypotheses

Volatility (%)	Lognormal VAR (%)	Normal VAR (%)	Error (%)	NV (%)	Error / Vol (%)
2	0.3	0.3	0.16	2.0	8.00
5	0.8	0.8	0.40	5.0	8.00
8	1.2	1.3	0.64	7.9	8.00
10	1.6	1.6	0.80	9.9	8.00
15	2.3	2.4	1.20	14.8	8.00
20	3.1	3.1	1.60	19.7	8.00
30	4.6	4.7	2.40	29.3	8.00
40	6.1	6.3	3.20	38.8	8.00
50	7.6	7.9	4.00	48.1	8.00
60	9.0	9.4	4.90	57.3	8.17
70	10.4	11.0	5.70	66.3	8.14
80	11.8	12.6	6.60	75.2	8.25
90	13.2	14.1	7.40	83.9	8.22
100	14.5	15.7	8.30	92.5	8.30

The normal volatility column (NV) shows the volatility that must be applied to the normal distribution to obtain a VAR equal to the lognormal VAR. Given that volatility is estimated and there is no single criterion on which its calculation must be based, the error committed in changing the probability distribution is ameliorated by the fact that volatility is nothing more than an estimate.

The error committed when volatility is above 50% ranges from 4-8%. However, situations where volatility exceeds 50% are extremely rare, and in such a situation estimating volatility is actually very difficult. On the other hand, the hypothesis appears to function with a higher degree of precision in the case of low volatility. If we calculate the quotient between the error level and the volatility level, we note that the quotient is around 8%, regardless of the volatility, so the hypothesis appears to be equally applicable for all volatility levels.

CONSTANT RISK ANNUALIZATION

In order to annualize daily results, we assume that the constant risk criterion is followed, meaning that each day the position is closed out and reopened the next with the same risk exposure and market value as those of the preceding day. This generates a result for each day (see Figure 9-11).

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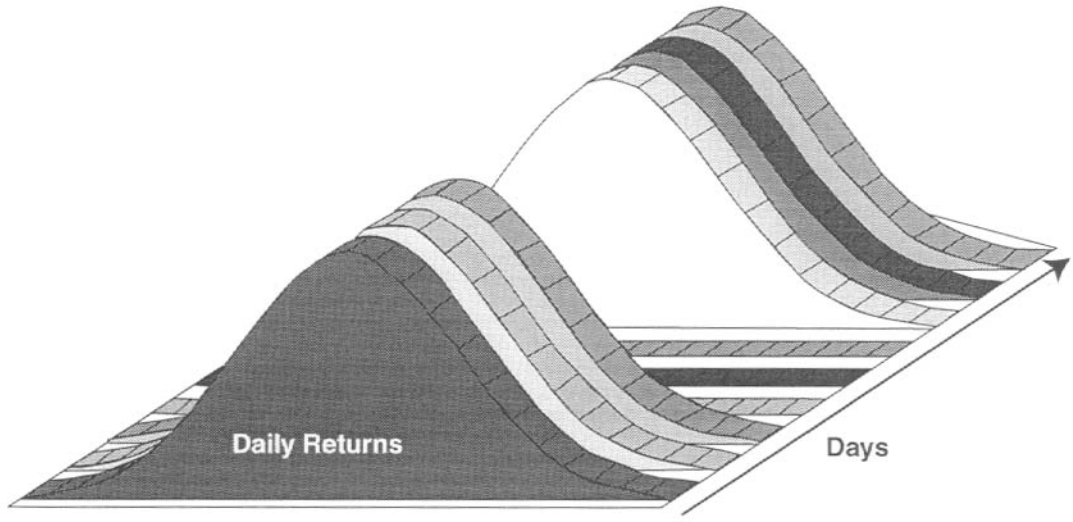
Figure 9-11. Constant Risk Annualization



Of course, losses must be financed and profits may be reinvested. It is assumed that this takes place until the end of the year in question, that the one-day interest rate (z) remains constant throughout the year, and that it is expressed as a compound rate.

Expected Returns and Annualized Volatility

Therefore, the return for day i is annualized by capitalizing interest rate z for 365–i days.

$$return_i^{annualized} = return_i \bullet (1+z)^{\frac{365-i}{365}}$$

This means that the total annual return is the sum of all the daily annualized returns:

$$return^{annualized} = \sum_{i=1}^{365} return_i \bullet (1+z)^{\frac{365-i}{365}}$$

So, the annual return is expressed as the sum of 365 random independent variables that in aggregate tend to behave as an average normal distribution equal to the sum of the averages of the distributions and with a variance equal to the sum of the variances.

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Now, since all of the *return* variables are identical, the average and the volatility of the annualized profit and loss are[24]:

$$return_{expected}^{annualized} = return_{expected}^{daily} \bullet \frac{z}{(1+z)^{\frac{1}{365}}-1}$$

$$volatility^{annualized} = volatility^{daily} \bullet \sqrt{\frac{250}{365}} \bullet \sqrt{\frac{(1+z)^2-1}{(1+z)^{\frac{1}{365}}-1}}$$

We correct by the factor 250/365 because the daily volatility is expressed in business days and the annualization calculation is based on calendar days. This way we begin with a corrected daily volatility and its effect is divided across all the days of the year (not just business days). In fact, if we were not reinvesting (z=0), the annualized volatility could be obtained by multiplying the daily volatility by the root of 250.

Annualized Financial Costs

In order to annualize the financial costs related to position management, we start with the premise that the position is closed out each day and a new position is opened the next with the same exposure and the same market value. This means that we have the same financial costs every day (or returns in the case of liability positions), which must in turn be financed. This means that the annualized financial costs can be expressed as:[25]

$$financing^{annualized} = V_0 \bullet z$$

NORMAL MULTIVARIATE SAMPLING

In order to generate samples of k random variables based on normal multivariate distribution we proceed as follows:

- We take k random samples (x_k) of a variable that behaves like a normal variable with a mean of 0 and a standard deviation of 1, just as we did for a single instrument (see the section on simulations for a single instrument, p. 219).

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[24] Based on the sums that appear in both expressions and assuming that $z > 0$:

$$\sum_{i=1}^{365}(1+z)^{\left(\frac{365-i}{365}\right)} = \sum_{i=0}^{364}\left[(1+z)^{\frac{1}{365}}\right]^i = \frac{z}{(1+z)^{\frac{1}{365}}-1}$$

$$\sum_{i=1}^{365}(1+z)^{2\left(\frac{365-i}{365}\right)} = \sum_{i=0}^{364}\left[(1+z)^{\frac{2}{365}}\right]^i = \frac{(1+z)^2-1}{(1+z)^{\frac{2}{365}}-1}$$

Obviously, for $z = 0$ the sum is equal to 365.

[25] Using the previous premises:

$$Financing^{annualized} = Financing^{daily} \bullet \left(\frac{z}{(1+z)^{\frac{1}{365}}-1}\right) = V_0 \bullet \left[(1+z)^{\frac{1}{365}}-1\right] \bullet \left(\frac{z}{(1+z)^{\frac{1}{365}}-1}\right) = V_0 \bullet z$$

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- These k variables are generated as if they were independent (i.e., with zero correlation), but the actual variables are related and are not independent. Therefore, the next step is to build the actual variables, which we will call y, as the weighted sum of the random samples (x)

$$y_k = \sum_{1}^{k} c_{ki} \bullet x_i$$

- The weighting coefficients are obtained from the correlation matrix. We must keep in mind that:
  - The y variables have a variance of 1, so:

$$\sum_{i=1}^{k} c_{ki}^2 = 1$$

- The y variables must maintain the correlation coefficients of the sample variables, since the x variables are independent (zero correlation). Therefore, the correlation coefficient between elements p and r is expressed as:

$$\rho_{pr} = \sum_{i=1}^{k} c_{pi} \bullet c_{ri}$$

- The first k–1 coefficients are a function of the coefficients of the prior k–1 elements, while coefficient k is a function of the first k–1 coefficients. The process is begun by calculating the coefficients of the first element, then the second, and so on.[26]
- The total final return is a triangular **C** change matrix: $\mathbf{y} = \mathbf{C} \bullet \mathbf{x}$ such that:[27]

$$\mathbf{C} \bullet \mathbf{C}' = [\rho]$$

---

[26] The c_{ki} coefficients are calculated by the following expressions:

- When $k \leq 2$:

$$c_{11} = 1$$
$$c_{21} = \rho_{21}$$
$$c_{22} = \sqrt{1 - \rho_{21}^2}$$

- When $k > 2$

$$C_{ki} = \frac{\rho_{ki} - \sum_{j=1}^{i-1} C_{kj} \bullet C_{ij}}{C_{ii}}, \text{ for all } i < k$$

$$C_{kk} = \sqrt{1 - \sum_{j=1}^{k-1} C_{kj}^2}$$

[27] Keeping in mind that the expected value of the product of vector y and its transposition is equal to the correlation matrix:

$$E[\mathbf{y} \cdot \mathbf{y}'] = [\rho]$$

and that we want to express the y variables as a combination of a series of normal, independent x variables, we have:

$$\mathbf{y} = \mathbf{C} \cdot \mathbf{x}$$
$$E[\mathbf{y} \cdot \mathbf{y}'] = E[\mathbf{C} \cdot \mathbf{x} \cdot \mathbf{x}' \cdot \mathbf{C}'] = \mathbf{C} \cdot E[\mathbf{x} \cdot \mathbf{x}'] \cdot \mathbf{C}' = \mathbf{C} \cdot \mathbf{C}'$$
$$\mathbf{C} \cdot \mathbf{C}' = [\rho]$$

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Chapter 10

An Approach for Emerging Markets

Overview

Commonly used risk measurement methodologies were designed in developed countries for instruments traded in their markets, which typically operate under stable, liquid and deregulated financial systems. When used in an emerging market environment, however, these methodologies yield either worthless results or outright failure, due to the information gaps existing in emerging markets.

Traditional risk measurements, such as duration, must be adapted to the specific features of fixed-income instruments traded in emerging markets. For instance, Brady bonds, created in response to the debt restructurings that took place in Latin America in the 1980s, are partially guaranteed with the US Treasury bonds and therefore have hybrid risk.

As there are no organized markets for trading options on the major indices of the emerging markets, implied volatilities cannot be used to measure transaction risk. Volatility must be estimated through historical price series. However, less developed markets often have lower trading volume and liquidity, and thus lack reliable prices to estimate historical volatilities.

Even when a historical series exists, this does not guarantee that the risk associated with a particular factor will be correctly measured. If we look at the foreign exchange risk associated with a position in Brazilian or Argentine assets, we note that the historical exchange rate volatility of the real or the peso is exceedingly low. Does this mean that there is almost no foreign exchange risk? Hardly. In these countries, government controls over the exchange rate affect risk measurement. If government policies change, if capital flows out of the region, or if the existing exchange system is modified to correct external imbalances, exchange rate fluctuations could be much greater than those projected by using historical volatility estimates.

In this chapter we will discuss the main issues to consider when defining and implementing a risk management strategy adapted for exposure to risk factors specific to emerging markets. The discussion will include three main sections:

- Government-controlled financial markets
- Products specific to emerging markets
- Illiquid markets

In the first section, we will analyze how risk measurement calculations are affected by the significant government intervention in financial markets prevalent in emerging markets. We will review how exchange systems affect transaction exposure calculation and how crisis risk needs to be included in the model as yet another variable.

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In the second section, we will analyze the features of instruments specific to emerging markets, such as guaranteed bonds, floating rate instruments with high spreads, and inflation-linked products.

Finally, we will develop a model to estimate risk parameters for equity and debt instruments traded in illiquid markets.

At this point, we should again note that the methodologies described below are based on reasonable approximations and assumptions. They are presented as a possible solution to issues specific to emerging markets. However, they should in no way be considered as "absolute rules," but rather as guidelines supporting a firm's risk measurements. Management will be ultimately responsible for choosing which methodologies to implement, depending on the firm's specific situation and on the environment in which it operates.

Foreign Exchange Risk

In less-developed financial markets there is a high level of intervention by local authorities as they seek to maintain economic stability. The exposure of businesses operating in this environment is determined by risk factors that cannot be considered "pure" market variables governed by supply and demand; they are government-controlled and dependent on local political decisions. However, the same could also be said, albeit to a lesser extent, of risk factors such as the exchange rates of currencies belonging to the European monetary system or even the US$/Yen or US$/Euro rates. One important difference is that in these instances government controls affect a relatively insignificant share of the market and are accompanied by measures intended to increase credibility.

These circumstances significantly affect the way we must treat the risks inherent in emerging economies when we apply risk measurements based on the concept of Capital-at-Risk. Problems will arise if we attempt to apply the concept with the same assumptions used for developed markets, where it is assumed that market yields will be normally distributed random variables.

Capital-at-Risk is defined as the minimum capital that ensures that there will be no bankruptcy during the period under consideration for a specified confidence level. To calculate it, we start with the overall risk map defined by the probabilities associated with each of the possible profit and loss scenarios and we seek the point associated with the confidence interval in question. Until now, the type of statistical distribution that the overall risk map would have has not been expressly mentioned.

When the model is applied to developed markets with freely moving variables, the underlying theory of price behavior is based on the fact that at each point in time returns behave like a normally distributed random variable. It is assumed that changes in the value of an instrument or portfolio will also follow a normal distribution. Thus, we can calculate, simply and analytically, the Capital-at-Risk from the volatilities and correlations associated with the portfolio. When they are government-controlled, however, changes in market variables are no longer random and free to the extent that we can still reasonably assume normal conditions. The concepts of Capital-at-Risk and the risk map can still be applied, since they are still necessary to consistently combine the risks derived from developed and emerging markets, but must be calculated differently.

Risk factors are divided into two major groups:

- Non government-controlled risk factors, where we would use the same assumptions used for risk factors in developed markets
- Government-controlled risk factors, where we would include additional information in the model to account for eventual changes in the parameters defining government

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control and modify the methodology accordingly. In this chapter, only risk factors associated with exchange rates will be considered to be government-controlled.

This distinction needs to be made only if there are indications or expectations of a change in the conditions affecting government-controlled risk factors, such as a sudden devaluation, a change in the rate of depreciation against the US$, a widening of the fluctuation bands or a switch from a fixed to a floating exchange rate. If the probability of occurrence of this new scenario is practically nil (within the time period under consideration) we will consider all risk factors to be non government-controlled and we will apply the same methodology used for developed markets.

It is important to mention that the indications or expectations leading us to reconfigure the model could derive from information available in the market and thus be reflected in instrument prices, or else could be derived from internal research; firms should focus their efforts on their research, particularly since it is useful to generate profits by taking positions. To construct future forecasts, firms should generate or have access to macroeconomic and market research reports. The forecasts provide a basis for the parameters that should be added to the model for government-controlled risk factors. This would give a more suitable measurement of the risk inherent to the business.

FOREIGN EXCHANGE SYSTEMS

Below we will analyze several foreign exchange systems, this being a major government-controlled risk factor. The trading of a currency in the international financial markets can be regulated by any of the following foreign exchange systems:

- Freely floating: The currency floats freely in the market without government commitment to intervene. However, if they deem it appropriate, central banks may intervene in an effort to prevent deviations from a certain parity level. In this case, the long-term assumption of lognormality will not be fulfilled and some uncertainty about levels will arise.
  Example: Exchange rates between Euro, US$ and ¥.
- Dirty float: The currency floats freely in the market between bands determined by the central banks. Central banks are committed to intervene if the bands are exceeded to keep the currency within the bands around the central parity (in some cases the parity is devalued by the government at certain predefined times).
  Example: Exchange rates of the Chilean peso, the Brazilian real, etc. against the US$.
- Fixed exchange rate: the central bank is committed to keeping the currency at a preset parity.
  Example: Exchange rate of the Argentine peso against the US$.

Currencies operating under the government-controlled dirty float or fixed rate systems will require special treatment. A change in the bands or in the central parity would lead to currency fluctuations higher than the ones initially anticipated had these variables been considered as nongovernment-controlled.

Crisis Risk

In discussing government-controlled risk factors in emerging markets environments using the crisis risk concept, a crisis is defined as a sudden and significant currency depreciation or

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devaluation.[1] To do so, we will take a financial market with foreign exchange control regulations and we will analyze the remaining risk factors.

From a strict viewpoint, given that financial markets have generally become highly integrated, any government intervention over the exchange rate affects the prices of other financial assets. Internal risk factors, such as the local stock market index, are government-controlled to an extent because the return obtained by a foreign investor would clearly be affected by the prevailing exchange rate when he unwinds his investment. As long as investors continue to believe that the government's exchange policy is successful, they will be likely to make investments without hedging exchange rate risk; some of these investments will flow to the financial markets. Given the importance of foreign capital flows to emerging economies, the investment return obtained by a local investor in his or her local stock market will depend significantly on whether foreign investors decide to leave their capital in the local financial system or to withdraw it.

We will consider internal factors other than exchange rates to be non government-controlled since they move freely according to supply and demand forces in the marketplace. These factors, and their associated prices, reflect market expectations about future trends in the local exchange system. If the market begins to discount the possibility of a devaluation brought about by economic pressures, equity prices can be affected as early capital outflows from the stock market generate higher volatility. These internal risk factors bring more exposure to the portfolio even if the exchange rate is still government-controlled. The usual measure of exchange rate volatility would, however, not include the higher exchange rate exposure due to the possibility of a devaluation. Therefore, the model must be corrected so as to capture this effect and to direct that more Capital-at-Risk be allocated to investments in that currency. Viewed in another way, risk factors that are not government-controlled can reflect market expectations in their prices but government-controlled factors cannot.

A firm's internal research reports could also anticipate a potential crisis even if the market does not. In such a case where a firm internally anticipates an eventual increase in exposure to currency risk factors, the volatilities used to calculate the exposure should be increased to reflect a possible change in the foreign exchange system. Thus, the model would behave as if the market itself were discounting this information.

If in the end there was no devaluation, the share of the total exposure attributed to non government-controlled factors would diminish and we would be back at the starting point. But in the meantime the firm would have been aware at all times of its exposure and the Capital-at-Risk committed to the business. Of course, these expectations cannot be considered only from a risk measurement viewpoint; rather, they should also become part of the management of the business. Among possible options, we could consider hedging the position in some way so as to protect the firm's value if the devaluation finally did occur.

In a first approximation, only exchange rates under a directed exchange system (dirty float or fixed rate) will be considered as government-controlled factors, while the remaining risk factors (equity prices, medium and long-term interest rates, etc.) will be treated as non government-controlled factors since they anticipate possible changes in the foreign exchange system.

[1] To be consistent with the general scheme for business risk measurements, the crisis threshold could be considered to be three times the exchange rate volatility. This would take into account movements not picked up by the traditional methodology (based on historical volatilities) and explained by the abrupt end of situations that were maintained in large measure by government intervention.

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Below we will analyze government-controlled exchange systems and how to introduce expectations when calculating transaction risk.

Government-Controlled Exchange Systems

Let us consider the case of government-controlled exchange systems that regulate the exchange rate of the local currency, normally against the US$ or against a basket of currencies heavily weighted towards the US$. In situations of economic instability in international financial markets, currency prices can move suddenly if a government that is facing diminishing reserves decides to change its foreign exchange system, or if a deterioration in the real economy forces the government to increase interest rates to defend its currency.

If this situation were highly probable, future behavior could not be modeled as a normal distribution. Because behavioral trends arise and remain stable in part because of the predictability of government policies, historical volatilities will not accurately reflect future behavior if there is a change of government.

Economic conditions and pressures on the financial system can also affect future government policy. For a currency with a fixed exchange rate against the US$, two possible situations can arise:

- The currency is not under pressure and is expected to stay that way in view of the internal and external macroeconomic environment
- The currency is subject to pressures that force a change in the exchange rate or in the overall foreign exchange system.

In the first case, the business under analysis will have a very low exchange rate risk exposure according to both historical trends and to future expectations. Procedures similar to the ones used in the case of non government-controlled variables will apply.

In the second case, the conditions affecting the risk factor will be expected to change. But, depending on the environment, scenarios positing one outcome will look much more probable than those positing the other. If the currency is under strong pressure from speculative attacks and the central bank's reserves are shrinking, the probability of a devaluation or of a widening of the bands in the system will increase, while the probability of a revaluation will be nil.

Taking a 1-year time horizon, assume that an Argentine investor has a US$100 million position invested for one year at 8.6%, financed with Argentine pesos at 10.3% for one year. Assuming a 1.00 spot exchange rate, this position would be financed with 100 million pesos. Since at the end of the year the principal and interest of the investment will have to be converted to pesos to repay the principal and interest of the financing, the future exchange rate that will generate zero gains in a year is

$$FX_{1\,year} = \frac{1+10.3\%}{1+8.6\%} = 1.0156 \text{ A\$ / US\$}$$

If the exchange rate exceeds this level, the position will generate gains and, if the rate falls below this level, it will generate losses. The profit/loss in million Argentine pesos at the maturity of the position will be:

$$P\&L = 108.6 \cdot (FX - 1.0156)$$

where FX is the spot exchange rate at maturity.

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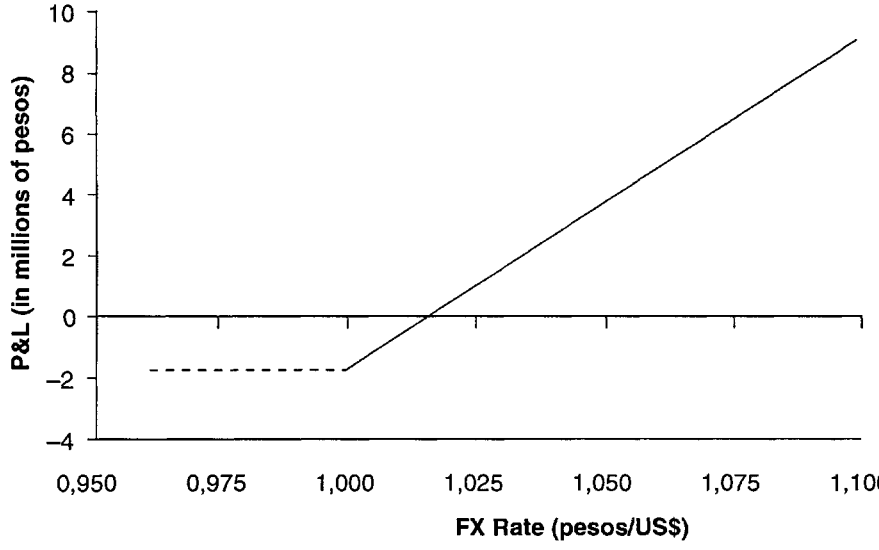
Up to this point, the reasoning would be identical for any pair of currencies where the exchange rate could move in either direction. However, given that the Argentine peso has a fixed parity with the US$, with an exchange rate of 1 peso/US$1, and that the probability of revaluation would be nil, losses would be limited to 1.7 million pesos in the situation where the exchange system does not change. If a crisis led to a devaluation, profits could be very high. Therefore, given the aforementioned starting point and irrespective of the probability of a crisis, this position would not generate losses higher than 1.7 million pesos[2] as shown in Exhibit 10-1, where the zero-probability zone is shown as a dotted line:

Figure 10-1. P&L in Pesos for a Fixed-Parity Currency with Possibility of Devaluation



If we now analyze the opposite position, a peso investment for one year financed in US$, the conclusions will be completely different. The gains will be limited to 1.7 million pesos but if there is a devaluation losses could be very high.[3] Additionally, we cannot use historical volatility to calculate the Capital-at-Risk, as very low numbers would result.

Incorporating future expectations into government-controlled variables skews the risk map. Thus, we cannot use traditional concepts of Capital-at-Risk that assume normal distributions and assign identical volatilities to long or short positions.

Below we will generalize the Capital-at-Risk model, taking into account whether the net position in a currency is long or short and assigning a different volatility in either case. Given the simultaneous existence of long and short positions with positive and negative correlations, the new calculation of the Capital-at-Risk could give a lower amount than the calculation performed without taking into account all the above considerations. From a conservative viewpoint, since crisis probability estimates are arbitrary, the worse of the two Capital-at-Risk calculations would be chosen.

[2] This is analogous to having a call position where the maximum loss is equal to the premium.

[3] Conversely, with regard to the previous note, this could be compared to a put position where the losses are unlimited and the maximum profits are known.

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GENERALIZING THE CAPITAL-AT-RISK MODEL

Here we will present an alternative that includes risk asymmetry effects when calculating the Capital-at-Risk of a portfolio with positions in government-controlled currencies. We will follow conservative criteria, such that introducing subjective expectations into the model will not result in a lower overall business exposure. Thus, we will avoid the occurrence of losses higher than the allocated capital if such expectations are not borne out. From the standpoint of risk, the possibility of a devaluation should only be considered for long positions in the currency under discussion. But if devaluation expectations are combined with the remaining risk factors, there could be cases where we are not being conservative. For instance, a long position in a government-controlled currency combined with a long position in an asset that has a negative correlation with that currency could result in a lower overall exposure. Below we will generalize these considerations so as to maintain the conservative viewpoint and will not consider the positive effects that could derive from combining risk factors.

The final goal of this process is to obtain Capital-at-Risk amounts for individual positions plus the aggregate figure for the portfolio. To achieve this goal, we will assume normal distributions but will adjust the volatilities so as to take into account the asymmetric effect of government intervention on the currency.

To determine individual volatilities and the aggregate portfolio volatility for exchange rates, we must include expectations about changes in the parameters that define the foreign exchange system governing the currencies in question.

Exchange Rate Volatility

To analyze the exchange rate of a government-controlled currency, we will consider two possible behaviors: either a change in the exchange system or no change, and we will assign a probability to each. Several currency fluctuation scenarios will be defined for each case and a probability of occurrence will be assigned to each of them. We will analyze historical data regarding the prior behavior of certain macroeconomic variables during currency crises so as to estimate the probability of a new crisis. This methodology is more fully explained in the section on currency crises in emerging markets, p. 248.

We will assume that the adjusted exchange rate volatility is:[4]

$$\sigma^2_{adjusted} = (1-p) \bullet \sigma^2_{without} + p \bullet \sigma^2_{with}$$

where p is the probability assigned to the devaluation scenario, $\sigma_{without}$ is the volatility assigned to the exchange rate in the scenario without devaluation, which would correspond to the volatility calculated in a recent period with the usual formula for the standard deviation, and σ_{with} is the volatility assigned to the exchange rate in the scenario with devaluation, which could be estimated from the currency's volatilities in past crisis periods. If such history is not available, we could use the average volatilities associated with other markets during crisis periods.

[4] to analyze the adjustment volatility, we will assume that the exchange rate variation is given by the combination of two distributions, one associated with the no-change scenario and the other with the change scenario. Therefore, the probability that a determined variation will occur is equal to:

$$f(x) = (1-p) \bullet f_{without}(x) + p \bullet f_{with}(x)$$

The variance of the combined distribution would approximate:

$$variance = (1-p) \bullet variance_{without} + p \bullet variance_{with}$$

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However, this adjusted volatility would not be used to calculate the foreign exchange risk of all positions but only of those that could potentially generate losses if a crisis does occur. It would be used for long positions in a government-controlled currency, while the volatility corresponding to the scenario without devaluation would be used for short positions. Since the movement could only take place in a single direction and a crisis is assumed, a short position could potentially generate unexpected profits but not losses. Given that losses are limited, no penalty should apply. This position does not affect the adjusted volatility and it would be equivalent to applying a zero devaluation probability.

This circumstance is particularly important when we calculate the aggregate portfolio volatility. On one hand, we will have the individual effects of the instruments comprising the portfolio and, on the other hand, an aggregate effect that incorporates the correlations between assets.

Aggregate Volatility

When considering the portfolio as a whole, we must apply the conservative viewpoint mentioned above. For positions whose risk is reduced by including expectations, we will take the volatility corresponding to the scenario without crisis; for positions whose risk increases, we will take the adjusted volatility that already incorporates the probability that a crisis will occur.

First, assume a portfolio evenly divided into one position in an asset denominated in US$, with volatility σ_A, and a government-controlled currency, with volatility $\sigma_{currency}$.[5] The volatility of the portfolio will be given by

$$\sigma^2_{portfolio} = \sigma^2_A + \sigma^2_{currency} \pm 2\rho\sigma_A\sigma_{currency}$$

where the plus and minus signs correspond respectively to whether both positions have the same sign or opposite signs. If no adjustment for the probability of a crisis is considered, the volatility of the portfolio as a whole will be

$$\sigma^2_{portfolio,\ without} = \sigma^2_A + \sigma^2_{without} \pm 2\rho\sigma_A\sigma_{without}$$

The next step is to determine the portfolio volatility if we take into account crisis expectations. Thus

$$\sigma^2_{portfolio,\ with} = \sigma^2_A + \sigma^2_{currency} \pm 2\rho\sigma_A\sigma_{currency}$$

where

- $\sigma_{currency} = \sigma_{without}$ for short positions in the government-controlled currency, and
- $\sigma_{currency} = \sigma_{adjusted}$ for long positions in the government-controlled currency.

Bearing in mind that introducing crisis expectations should in no case result in a lower CAR, we will take the higher CAR amount or the higher volatility calculated for the portfolio:

$$\sigma_{portfolio} = max(\sigma_{portfolio,without}, \sigma_{portfolio,with})$$

[5] The portfolio value will be given by

$$value_{portfolio} = value_{asset} + value_{currency}$$

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Example

Let's assume an investor whose base currency is the US$ and who has a portfolio evenly divided among an asset in US$ and a cash position in a government-controlled currency against the US$. We have the following information: the volatility of the asset is 15%, the historical volatility of the currency is 3%, the currency's volatility in periods of crisis is 40% and our estimate of the probability of crisis is 35%. Additionally, we will assume three correlation scenarios: positive, negative or nil.

The exchange rate volatility, taking into account the likelihood of a crisis, will be:

$$\sigma = \sqrt{0.65 \bullet 0.03^2 + 0.35 \bullet 0.4^2} = 24\%$$

For each scenario we will consider all the possible combinations of short and long positions in the asset and the currency and we will define the portfolio volatility in accordance with the conservative viewpoint. The last column will show the portfolio volatility resulting from selecting the adjusted or the non-adjusted volatility, whichever is greater. We must choose between these two volatilities only when the net position in the government-controlled currency is long. If there is a positive correlation, we will assume that it is equal to +1 to simplify the calculation.

Volatilities Adjusted for a Positive Correlation

Asset in US$	Currency	$\sigma^2_{portfolio}$ with Adjustment	$\sigma_{portfolio}$ with Adjustment (%)	$\sigma_{portfolio}$ without Adjustment (%)	$\sigma_{portfolio}$ (%)
Long	Short	$\sigma_A^2 + \sigma^2_{without} - 2\rho\sigma_A\sigma_{without}$	12	12	12
Long	Long	$\sigma_A^2 + \sigma^2 + 2\rho\sigma_A\sigma$	39	18	39
Short	Short	$\sigma_A^2 + \sigma^2_{without} + 2\rho\sigma_A\sigma_{without}$	18	18	18
Short	Long	$\sigma_A^2 + \sigma^2 - 2\rho\sigma_A\sigma$	9	12	12

As can be noted in the above table, in the case of a positive correlation when both positions are long, the most unfavorable situation is the crisis probability scenario because all the factors add risk. But in the last case, where the position in the asset is short, the most unfavorable situation is one in which no possibility of crisis exists. This is so because, since the cross term is negative, if the volatility were adjusted we would be reducing the global portfolio risk by assigning a higher volatility to the government-controlled currency. If there were in fact no reasons to justify positing a crisis scenario, we would be assigning a CAR lower than necessary.

Volatilities Adjusted for a Negative Correlation

Asset in US$	Currency	$\sigma^2_{portfolio}$ with Adjustment	$\sigma_{portfolio}$ with Adjustment (%)	$\sigma_{portfolio}$ without Adjustment (%)	$\sigma_{portfolio}$ (%)
Long	Short	$\sigma_A^2 + \sigma^2_{without} - 2\rho\sigma_A\sigma_{without}$	18	18	18
Long	Long	$\sigma_A^2 + \sigma^2 + 2\rho\sigma_A\sigma$	9	12	12
Short	Short	$\sigma_A^2 + \sigma^2_{without} + 2\rho\sigma_A\sigma_{without}$	12	12	12
Short	Long	$\sigma_A^2 + \sigma^2 - 2\rho\sigma_A\sigma$	39	18	39

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In the case of a negative correlation (which we assume is equal to –1 for simplicity's sake), the argument would be similar to the previous example except that the positions in the asset would have the opposite sign due to the negative sign of the correlation, as is shown in the table.

Adjusted Volatilities without Correlation

Asset in US$	Currency	$\sigma^2_{portfolio}$ with Adjustment	$\sigma_{portfolio}$ with Adjustment (%)	$\sigma_{portfolio}$ without Adjustment (%)	$\sigma_{portfolio}$ (%)
Long	Short	$\sigma_A^2 + \sigma^2_{without}$	15	15	12
Long	Long	$\sigma_A^2 + \sigma^2$	28	15	28
Short	Short	$\sigma_A^2 + \sigma^2_{without}$	15	15	15
Short	Long	$\sigma_A^2 + \sigma^2$	28	15	28

If there is no correlation, the risk could not be reduced by the existence of a negative cross term, the portfolio volatility would be obtained directly, and the possibility of a crisis scenario would still be considered.

Thus all the scenarios show that, for the situations that would be most damaging to the portfolio such as long positions in the currency and a positive cross term, portfolio volatility amounts are more than twice what they would be if the adjustment were not used. However, for positions where the cross term is negative and contributes more than the currency volatility term, the possibility of a crisis scenario will not be considered. In those cases, the current situation, in which conditions remain unchanged, is the most unfavorable.

CURRENCY CRISES IN EMERGING MARKETS

The financial and currency crises that shook Asian countries in the second half of 1997 were but the latest manifestations of a phenomenon that has affected many areas in recent years. The 1992-1993 European currency crisis comes to mind, when the breakdown of the European Monetary System resulted in strong speculative attacks against the French franc, the Swedish crown, the Italian lira, the Spanish peseta and the pound sterling. More recently, the 1994-1995 Mexican peso crisis also brought attacks against the Brazilian real and the Argentine peso.

These crises have a high economic cost not only for the country involved but also for the ever more interconnected global economy. Domestically, the fiscal and monetary adjustments imposed as a consequence of such crises cause significant production drops and lead to job losses and social problems. However, there are also global effects since crisis events in many cases affect the banking sector and spread when debt repayment problems appear, concerning either principal or interest, and the financial markets lose confidence.

We will not present below the viewpoint of a regulator or an international economic institution concerned with the economic situation of a developing country or group of countries and focused on economic policies to correct internal imbalances and prevent crisis events. Rather, we will adopt the viewpoint of a bank, company or international risk manager who faces the issue of managing the exchange rate risk for currencies that yield very high interest but that on occasion suffer speculative attacks and can generate significant losses for the holders when sudden devaluations occur.

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In these markets, there is a high cost of hedging the exchange rate risk,[6] but not hedging underlying positions can be even more costly if crisis scenarios occur and the currency weakens. Properly timing the introduction of the hedge is key, and for this reason there must be a mechanism to warn of the probability of occurrence of these crisis scenarios. This mechanism will enable us to make the decision to hedge underlying positions when the probability is high or to keep them naked when the probability is minimal.

We will also seek to determine the probability that a currency will remain within certain margins. This means the probability, for instance, that in a month it will depreciate against the US$ more than 30% below the current level, between 30% and 20% or between 10% and 0%; or else that it will appreciate against the US$ between 0% and 5%, between 5% and 10% or more than 10%. Knowing this probability distribution would enable us to determine the CAR by looking for a level that could only be reached with a 0.14% probability, for a 99.86% confidence level.

The goal will be to develop an anticipation model to estimate the probability of occurrence of a particular crisis scenario. We present below several general models, grouped into two broad categories[7] according to the variables that are thought to be most important in determining the existence of a crisis involving either economic fundamentals or global financial contagion.

- Economic fundamentals: According to first-generation models, currency crises are caused by economic policies that do not support the nominal exchange rate for an indefinite period. These models focus on the performance of fundamental macroeconomic variables. Strong monetary expansion and loose fiscal policies can cause credit expansion, excessive indebtedness and strong investment in real assets, thus bringing equity prices and real estate prices to unsustainable levels. If policies are tightened to contain inflation and correct external imbalances, economic activity drops, debt repayment problems arise, the assets used as collateral lose value and the volume of bad debt increases. All of this threatens the creditworthiness of the banking system and the economy of the country in general. In addition, changes in external macroeconomic conditions and higher interest rates in industrialized countries have increasing importance for the economies of emerging countries.
- Global financial contagion: In some cases speculative attacks against a country do not seem to be directly related to its economic fundamental trends. Another type of model is based on speculative attacks caused by financial contagion phenomena. A key factor in recent crises was that the speculative attack against one currency automatically extended to other currencies that on principle had sound economic fundamentals. The probability of a crisis event in a country increases when crises arise in other countries. Apparently, cross-border business relationships can explain the global spread of crisis conditions in some cases better than the macroeconomic conditions prevailing in a single market.

Another issue that should be addressed by this crisis detection mechanism is the fact that financial markets tend to overreact. Therefore, the mechanism must be able to anticipate changes in the current situation, including warning signs suggesting the end of the overreaction. In other words, the model must warn about the possibility of crisis while the current

[6] The cost of hedging the exchange rate is given by the positive spread between interest rates in the local currency and interest rates in US$ (the customary financing currency). The rate spread determines the future price of the currency forward.

[7] The modern literature on currency crises began with an article by Krugman (1979) where these crises are connected with problematic balance of payments situations.

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situation is still positive or, on the other hand, must warn about the end of the crisis while the situation is still negative.

To define this crisis detection mechanism, we have focused on developing countries in two broad geographic zones: Latin America and Asia. The model presented here spans 11 countries (Chile, Argentina, Brazil, Mexico, Peru, Venezuela, Indonesia, Korea, Malaysia, Singapore and Thailand) and a 10-year period (1988-1997) with monthly data. The model calculates the probability of crisis for each country one month in advance.

Defining the Term "Crisis"

Until now we have discussed this term from an abstract viewpoint, but the need to define a model to determine the probability of a crisis scenario compels us to define and quantify the term crisis. Finance literature defines crisis as a significant nominal devaluation of the currency. This definition could, however, exclude times when the currency is subject to strong pressures but is successfully defended by the monetary authorities through intervention in the foreign exchange markets with reserves or interest rate increases. That is why another approach, also used in the literature, defines an index that takes into account not only the nominal devaluation of the currency but also fluctuations in the reserve level or interest rate movements.

For the purposes of this section we will follow another definition of crisis. Since the goal of the model is to time the implementation of the hedge on the underlying positions, and because any hedge has a cost, the traditional definitions of currency crisis are not useful. Thus, we will define currency crisis as the time during which the nominal devaluation of the currency exceeds the devaluation implicit in the forward exchange rates by a predetermined percentage. In emerging markets the interest rate spread over the US$ rate implies a forward exchange rate depreciation, which is the cost associated with implementing the hedge. Therefore, the underlying positions would have to be hedged only if the expected profit derived from the nominal devaluation of the currency exceeds the cost of the hedge—in other words, if we expect that the nominal devaluation will be greater than the one reflected in the interest rate spreads.

Methodology

The goal of this methodology is to define an econometric model able to quantify the relationship between past currency crises and a series of explanatory variables, and then evaluate the probability of occurrence of future crises. The model must be easy to use and incorporate variables whose information is available.

The econometric technique used involves defining a model enabling us to calculate the probability of a crisis at a particular point in time depending on the value of the explanatory variables in the previous period. If monthly periods are established, the model will estimate the probability of a crisis one month in advance. To do so, we will take as a sample a set of countries where currency crises have occurred. Since the number of crises in each country is small, we will include all the countries in the sample required for the historical analysis and then add a series of binary variables, one for each country, that enable us to capture the individual characteristics of each country.

Mathematically, the model is as follows:

$$P(y_i = 1) = F\left(\sum_{j=1}^{k} \beta_j x_j\right)$$

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where

- y_i is the dependent variable that has value 0 if no crisis has occurred and 1 if a crisis has occurred.
- F is a standardized normal distribution function; this ensures that the values obtained are within the interval [0, 1], as should happen for a probability.
- x_j (j = 1, 2 ...) is each of the explanatory variables, including binary variables for each country.
- β_j is the coefficient associated with each of the explanatory variables.

The reason for using this type of model is that the dependent variable, the probability of devaluation at each point in time, is not observable. The only thing that would be observable is whether an actual devaluation occurred.

$$\begin{cases} y_i = 1, & \text{if there is a devaluation} \\ y_i = 0, & \text{if there is no devaluation} \end{cases}$$

If we only have this binary variable, an estimation using ordinary least squares would make no sense, and so we have to use a model like the previous one, called a probit model, which uses a normal distribution function to calculate the probability of occurrence of a binary event. The model uses the maximum likelihood method, in which the β parameters are estimated maximizing the probability of obtaining the initial sample.

The sensitivity of the probability to each of the variables is obtained by calculating the partial probability derivative for the related explanatory variable. Thus, if we define the X variable as

$$X = \sum_{j=1}^{k} \beta_j \bullet x_j$$

the sensitivity of the probability to each of the independent variables is:

$$\frac{\partial P(y_i = 1)}{\partial x_j} = \frac{\partial X}{\partial x_j} \bullet f(X) = \beta_j \bullet f(X)$$

where $f(X)$ is the density function of the standard normal distribution. The β coefficients indicate by their sign whether the probability increases or decreases when the explanatory variables change but are not representative of the size of the change.

Choice of the Explanatory Variables

Given the high cost of a currency crisis for international banks, industrial or management companies, there is great interest in identifying economic variables that could serve as early indicators of a crisis event. It is, however, difficult to detect future crises precisely and early enough with a limited set of variables.

Potentially there are many variables that could serve as crisis indicators. Which ones to choose will depend on what the researcher thinks are the causes of the crisis and on how much data is available for each variable:

- For instance, if we think that currency crises are fundamentally caused by problems related to current account imbalances, we should use variables such as the fiscal deficit or government spending figures.

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- If we think that the currency weakness is due to the condition of the financial system, useful variables could be the rate of increase of loans to the private sector, financial deregulation measures, changes in equity prices or the structure of local interest rates.
- If the most important factors are external problems, we may consider variables such as the real exchange rate, the current account deficit, the maturities of foreign capital inflows or the debt volume in foreign currency.
- We can also use variables pertaining to the real economy, such as the GDP growth rate or unemployment rate, or variables that represent structural or political changes.

When these models are designed for developing countries, there is the additional problem of obtaining data frequent enough to use in predicting crises. This prevents the use of some variables that in principle could be of interest, such as the current account deficit/GDP ratio, because data for these indicators are not available monthly and are not disclosed on a timely basis. There often are no reliable and frequently available data regarding short-term debt volume or the amount of debt in a specific currency.

Given these limitations, the proposed model includes both types of explanatory variables mentioned in the literature, basic macroeconomic variables and variables that represent financial contagion effects.

The theoretical idea underlying the model is that a currency has a greater probability of suffering speculative attacks when it is very overvalued in real terms, or when the country's international competitiveness is dropping. The timing of the speculative attack caused by the overvaluation would be determined by two factors:

- Credibility of the monetary authorities' defense of their currency. The currency's first line of defense is Central Bank intervention in the spot or futures markets, depending on the available reserve level. Factors such as M2 variation or domestic debt also affect the credibility of the monetary authorities.
- Global financial contagion. The second variable that can influence a speculative attack is a crisis in another currency with global repercussions.

According to this simple theoretical idea, the variables to be considered in designing the model are:

- The real effective exchange rate, which represents the appreciation or depreciation of a currency taking into account commercial relationships with other countries and relative inflation levels. Specifically, the variable that we would include is the level of appreciation or depreciation over the long-term trend.
- Variation in the foreign currency reserves held by the Central Bank. This variable attempts to represent, in a simplified form, the credibility of the monetary authorities' defense of their currency. The lack of data availability prevents the analysis from being as complete as the theory recommends for two key reasons:
  - The monetary authorities' ability to defend their currency does not solely depend on the volume of the reserves because other assets can also be used.
  - Thoroughly analyzing whether the monetary authorities will stand by their commitment would require analyzing the on- and off-balance sheet transactions: futures, options embedded in certain deposits, etc.
- Variables that reflect the performance of the monetary policy: loan growth rate and M2 growth rate.

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Prior papers have shown both figures to be relevant, as they represent the timing of eventual speculative bubbles that could lead to a crisis given the application of more restrictive monetary and fiscal policies.

- Variables that represent the effect of wider contagion on the risk aversion level of market participants.
- A way to measure contagion is to count the number of crises that have occurred recently in the sample countries. Each crisis event will be weighted in accordance with the time elapsed since the crisis and the geographic zone where it occurred. The general rule to calculate this variable is:

$$W_i = \sum_{j=1}^{k} \frac{n_{ji} b_i}{j}$$

where

j indicates the number of months elapsed since the crisis

b_i is a weighting coefficient that will depend on the geographic zone where the crisis occurred

n_{ji} is the number of crises that have taken place in the i geographic zone j months prior to the current month

- While the above variable can be used to predict crises after the first one has occurred, it cannot forecast the first crisis event. Thus, we will use a new variable to represent the level of market participants' risk aversion or risk appetite regarding these emerging markets. An appetite for risk will increase capital inflows to emerging countries; their currencies will strengthen and crisis scenarios will become less probable. This variable, representing the risk aversion or risk appetite level, can be defined as the difference between the average stock market yield for prior months in each country (from the point of view of a US$ investor who has not hedged the exchange rate risk) and the yield of the Dow Jones index. If this variable is negative, an increased probability of crisis should be expected, because it reflects a lack of investor interest in these emerging markets.
- Finally, as we already mentioned, since the crisis model generates estimates by handling all the countries simultaneously, we will define as many binary variables as there are countries in order to represent characteristics specific to each. Each variable will be assigned a β coefficient.

Results

The model's results are satisfactory in two ways. First, the signs of the explanatory variable coefficients are what the theory and prior papers would lead us to expect; furthermore, all variables are statistically significant at a 90% confidence level:

- For instance, the variable representing the volume of reserves has a negative coefficient, indicating that a drop in the reserves increases the likelihood of a crisis
- The variable that represents past crises has a negative coefficient, reflecting the contagion effect
- The variable that refers to the appetite for risk has a negative coefficient, indicating that a lessening appetite for emerging country risk increases the likelihood of a crisis

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- The coefficient for the variation in M2 is negative, indicating, as shown in several IMF papers, that this variable reaches its peak about 6 months prior to a crisis
- The coefficient accompanying the actual appreciation or depreciation level for each currency is positive, as real currency appreciation increases the likelihood of a devaluation.

Second, the model's predictive ability is acceptable. It was able to anticipate the recent crisis events in Asia as well as the 1994-1995 Mexican peso crisis. In both cases, while the crisis was actually underway, the model indicated that a crisis event had an above 60% probability of occurring—a figure much higher than the one for prior months. During periods when there was no crisis, the probability was below 15%.

Figures 10-2 and 10-3 show the model's results for Mexico.

Figure 10-2 shows the appreciation/depreciation (in %) suffered by the Mexican peso against its one-month forward exchange rate and the probability assigned by the model one month in advance. Positive (negative) values of the difference between the real devaluation and the one indicated by the forward exchange rate indicate a devaluation/depreciation (revaluation/appreciation). We can see that the probabilities assigned by the model increase sharply during currency crises.

Figure 10-3 shows the times when the crisis was at its peak, indicating the size of the currency devaluation measured against the devaluation indicated by the forward rate, and the exact probability assigned by the model one month in advance.

Although the results are satisfactory, we must pursue the analysis in two directions:

- Analyze the model's ability to predict crises in time horizons other than the one-month timeframe considered above.
- Determine the probability level that optimizes the user's benefits, taking into account both the costs incurred in case of error and the profits derived from implementing a successful hedge.

Figure 10-2. Test of the Validity of the Model for the Mexican Economy

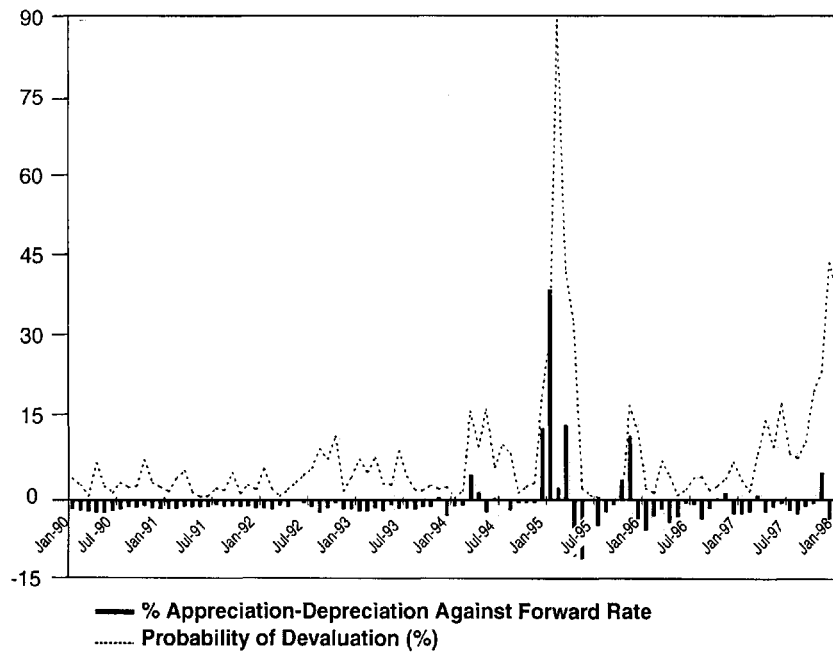

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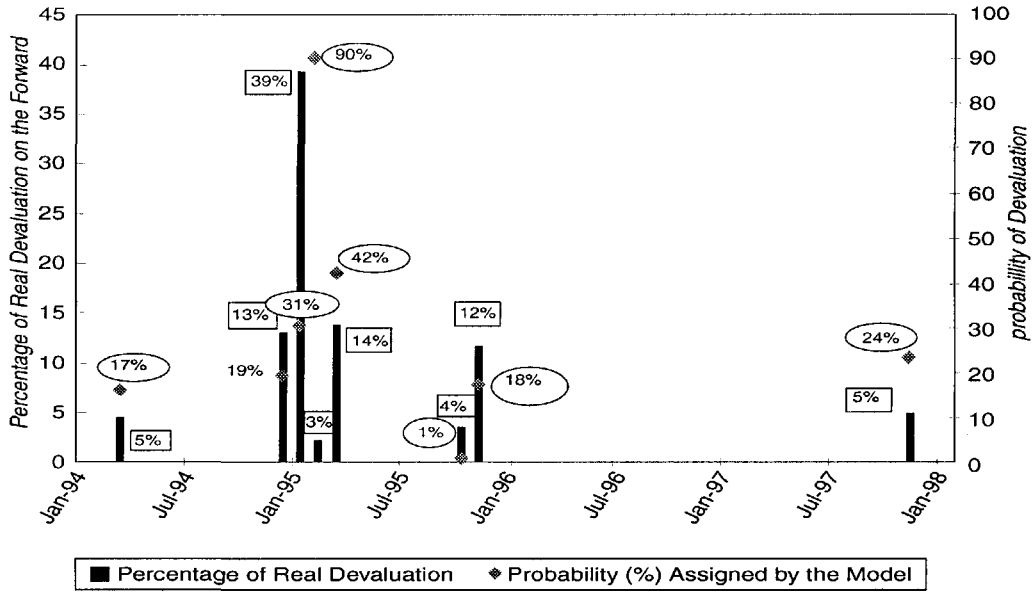
Figure 10-3. Model Results during the Mexican Economic Crisis



Special Products

Characteristics specific to the emerging market environment created a need to develop specific products adapted to past conditions in these economies: low credit ratings, high inflation rates and monetary crisis risk.

In this chapter, we will analyze the major features of specific products developed for emerging market environment to ensure investment quality and attractiveness for local and foreign investors. We will also analyze the peculiar performance of some traditional instruments under the conditions prevailing in emerging markets.

The debt crisis in the 1980s forced the major Latin American countries to restructure their external debt and led to the appearance of external financing instruments with built-in guarantees. The best examples of these instruments are the bonds issued under the Brady Plan.

Also, a dependence on external financing combined with the high spreads paid by local issuers can cause some products to behave in surprising fashions. Such is the case of US$-denominated floating-rate instruments that can end up having negative duration, so that their value increases when the benchmark interest rates go up.

Finally, we will analyze instruments denominated in local currencies but linked to inflation to guarantee the purchasing power of the investment.

In any case, denominating instruments in US$, including guarantees and linking future payments to inflation trends have but a single purpose: to create an investing environment that will be attractive to investors by reducing the exposure suffered by investments in the past and guaranteeing the stability of capital flows.

This section discusses fixed-income instruments. The related appendix (p. 297) discusses basic concepts such as risk measurement, sensitivity and volatility for these types of instruments.

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BRADY BONDS

During the Latin American external debt crisis in the 1980s, a series of fixed-income instruments were designed under a plan coordinated by the US Treasury Secretary, Nicholas Brady. Their purpose was to restructure bank loans granted to Latin American institutions whose ability to repay had become doubtful.

To solve the crisis, in that as Latin countries had very low credit ratings at that time, these products were denominated in strong currencies, mainly the US dollar,[8] and their credit features were enhanced with guarantees. A contingency plan was built into the Brady Plan whereby principal repayment and some interest payments would be secured by zero-coupon US Treasury bonds and high-quality assets deposited in offshore accounts. In this way, if the bond defaulted, the principal and some interest would be guaranteed by collateral, thus reducing the credit exposure of these instruments.

Because of this arrangement, we must differentiate between secured and unsecured cash flows to value these instruments. Each has a different credit risk and consequently the overall product risk is a blend between issuing country risk and United States risk. Therefore, as we will see below, separating the risks helps us understand clearly the risk premium that the market assigns to these bonds.

Not all bonds issued under the Brady Plan have the same payment structure or guarantee features. Brady bonds include fixed and floating rate bonds, bonds with and without principal guarantees, with and without interest guarantees, with and without grace periods, etc. Since the method for dealing with guarantees, if any, is the same in all cases, we will discuss these bonds in general without considering specific cash flow structures.

We will first analyze guarantees and their types, then their impact on bond prices, and finally we will develop a methodology to calculate the risk measurements associated with Brady bonds.

Guarantees

Basically, there are three kinds of guarantees: a guarantee on the principal, a guarantee on interest or a rolling guarantee on interest. This last guarantee is methodologically the most complex.

- Principal guarantee: The bonds that have this guarantee are secured by zero-coupon US Treasury bonds deposited with the Federal Reserve.
- Interest guarantee: Some issues secure part (normally a fixed dollar amount) of the future interest. In the case of fixed-rate instruments the secured part covers the next 2 or 3 semiannual payments, and in the case of variable-rate instruments it covers a number of payments that depend on the rates set from time to time. This guarantee can be of two kinds:
- Fixed guarantee: Secures the payment of some specified coupons. After these coupons are paid, the guarantee disappears.
- Rolling guarantee: Secures the payment of a number of upcoming coupons up to a certain amount, so that the guarantee keeps rolling over as long as there is no default.

[8] Most Brady bonds were issued in US dollars, but some of them are denominated in yen, German marks, Canadian dollars, British pounds, French francs, Swiss francs, Italian lira and Dutch guilders.

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Logically, the existence of guarantees will translate into a higher bond price as investors accept lower yields in view of the lower credit risk.

Valuation

As mentioned above, a key feature of Brady bonds is the existence of collateral securing part of the issuers' future payments. These instruments have a hybrid risk profile that is like an average between the sovereign risk of the issuer and the US Treasury risk. The hybrid risk is in any case always lower than the issuer's risk: how much lower will depend on the guarantee structure put in place for each issue.

If we calculate a Brady bond's internal rate of return, it will not be representative of the return required of another issue from the same issuer and with the same maturity. The same thing will happen if we calculate the Brady bond's spread over a US Treasury bond with a similar cash flow structure. To separate the risks blended into the bond's cash flow structure, we will use the concepts of stripped yield and stripped spread, which more accurately measure the risk premium that the market demands of the issuer. These two variables measure, respectively, the IRR for products that are denominated in US$ but that have the risk level associated with the issuer, and the spread over a similar investment with US Treasury risk.[9]

Below we will discuss the problems posed by guarantees when assessing Brady bond risk. A more rigorous methodology is discussed in the related appendix (p. 263).

Internal Rate of Return

Brady bonds can be considered as a traditional fixed-income product, and their internal rates of return (IRR) can be calculated. However, as we will see below, this IRR is not a reliable measure of comparison with other instruments due to the hybrid risk that is inherent to these bonds.

The IRR to maturity would be calculated, taking into account market conventions, using the traditional formula:[10]

$$P = \sum \frac{CF_i}{(1+IRR)^{t_i}}$$

As we mentioned above, calculating the conventional IRR is not a reliable measure of comparison with US Treasuries or with other Brady bonds, because we are not comparing returns associated with standardized risk levels. Rather, the returns measured by the conventional IRR calculation correspond to an issue with an intermediate risk between the issuer risk and the US Treasury risk.

Therefore, our goal is to isolate each risk and analyze the contribution of each to the final bond price.

---

[9] Throughout the chapter it will be assumed that the instruments under analysis are denominated in US$, as most Brady bonds were issued in this currency.

[10] For purposes of this section, the calculated returns will be stated as compound rates, as this is how they are usually quoted in the market. However, in the appendix they will be stated as continuous rates because these provide more analytical data.

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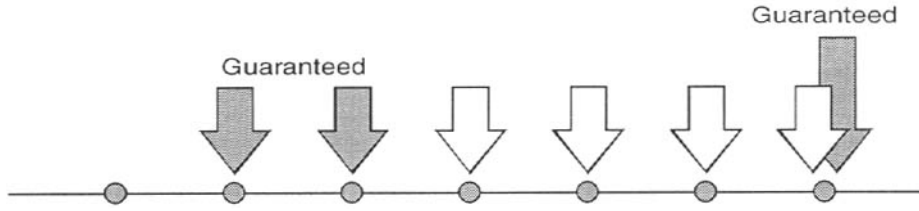
Stripped Yield and Stripped Spread

Due to the existence of guarantees on some payments, a position in a Brady bond is similar to a portfolio holding two fixed-income instruments. This portfolio would have the same overall market value as the bond but would carry two different risks, one related to the risk-free cash flows (secured) and another to the cash flows with issuer risk (unsecured). We will classify cash flows as follows:[11]

CF^*_i = secured cash flow at time i.
CF_i = cash flow with issuer risk at time i.

Assuming that the bond's guarantees are applied to the next two interest payments and to the principal repayments, we obtain the cash flow structure shown in Figure 10-4.

Figure 10-4. Total Cash Flow Structure



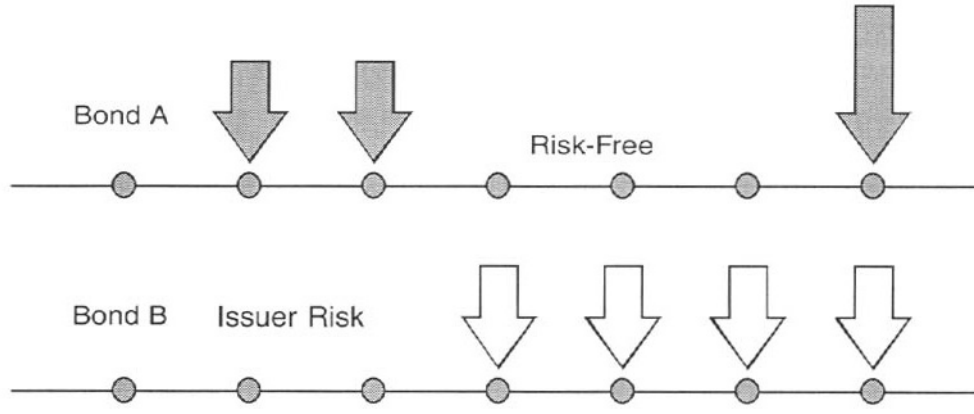
The bond can be broken down into two fixed-income instruments: a risk-free one, with secured cash flows, and one with issuer risk, with unsecured cash flows as shown in Figure 10-5.

Therefore, the bond's market price will be the sum of the prices of the two notional bonds above:

$$\text{price} = \text{price}_A + \text{price}_B$$

The price of bond A can be obtained by discounting its cash flows by means of the risk-free interest yield curve in US$, and the price of bond B can be obtained by discounting its cash flows at the US$ interest rate that would apply to an instrument with a risk level similar to the issuer's.

Figure 10-5. Risk Breakdown



[11] As will be seen below, these could be the bond's real cash flows or equivalent flows if there are rolling guarantees.

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As discussed above, the goal is to clearly identify the risk level associated with the issuer (stripped yield) and the spread over the risk-free rate (stripped spread). Thus, we will follow the inverse procedure. Given the price of the bond as a whole and the price of bond *A*, which can be calculated easily because the risk-free curve is known, we will calculate the price of bond *B*:

$$price_B = price - price_A$$

From the price of bond B we can easily obtain its internal rate of return, or stripped yield, and its spread over the risk-free curve.

The stripped yield is defined as the bond's internal rate of return constructed from the cash flows subject to issuer risk:

$$price_B = \sum \frac{CF_i}{(1+SY)^{t_i}}$$

where *SY* is the stripped yield and the CF_i are the cash flows—in this case only the unsecured ones—that are being discounted.

The stripped spread is the spread that would have to be applied over the risk-free curve so that we would obtain identical prices if we valued bond B with the spread curve [i.e., the risk-free zero curve plus the spread] or with the stripped yield.

$$price_B = \sum \frac{CF_i}{(1+ZC+SS)^{t_i}}$$

where ZC_i would be the risk-free zero coupon rates[12] associated with the US$.

This spread would already be a measurement of the risk level that the market assigns to the issuer, because bond B is a bond with "pure" issuer risk. Since the Bradys are sovereign bonds, one could interpret the stripped spread as the country risk spread that would apply to a US$ investment with similar maturity in that country.

Bonds with Rolling Guarantee

Above we have introduced the concepts of stripped yield and stripped spread in reference to a cash flow structure where the secured flows are known. This would be the case for an issue with a fixed guarantee on the interest or a principal guarantee. However, many Brady bond issues were structured with rolling guarantees that secure a specified interest amount for the next few interest payments as long as there is no default. All the coupon payments have hybrid risk since they could potentially be protected by this guarantee. In this case the methodology becomes more complex, because a coupon that originally was not covered by the guarantee can become covered over time if there is no default, as can be seen in Figure 10-6.

[12] The zero coupon rate associated with a given future moment in time is the internal rate of return of a discounted instrument that would mature at that future moment. The reason for using zero coupon rates as the basis over which to apply the spread instead of using the IRR of a similar US Treasury is simply that it is easier. Indeed, it is difficult to choose a benchmark US Treasury because the cash flow structure that is being discounted (unsecured flows) is not homogeneous and in many cases does not have principal repayments.

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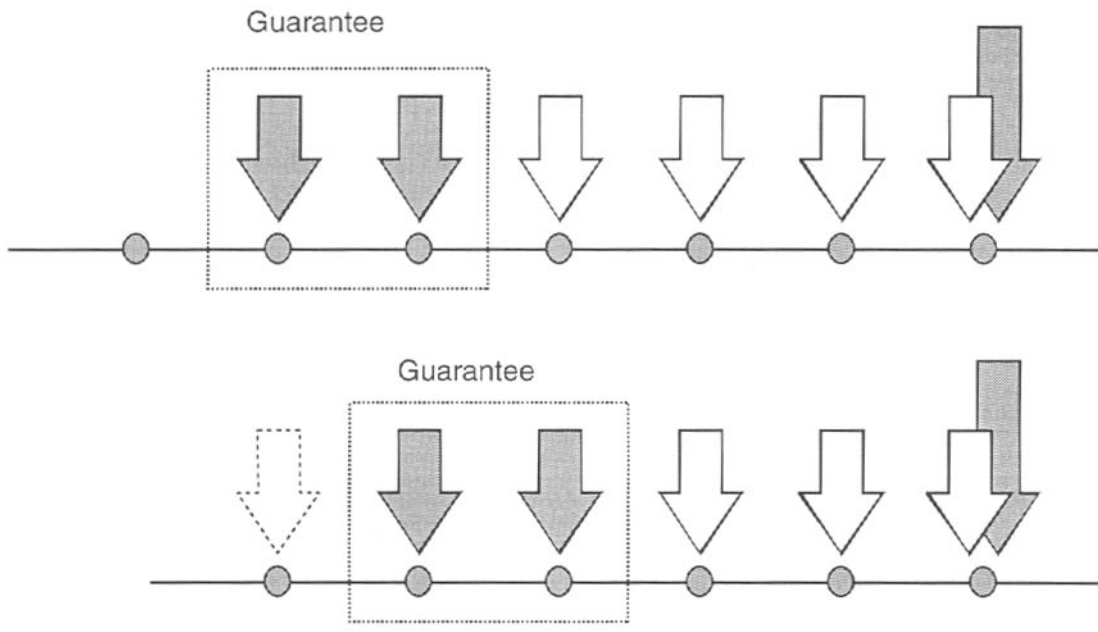
Figure 10-6. Rolling Guarantee



The risk associated with each coupon would range from country risk to risk-free depending on the point in time considered. Let us analyze this situation for a single future coupon payment, assuming that the guarantee covers the next two coupon payments.

As can be seen in Figure 10-7, prior to the penultimate period before the coupon payment (the point in time *T*) the cash flow would have country risk, while beyond that point the cash flow would be risk-free.

Therefore, a cash flow with hybrid risk is equivalent to a cash flow with issuer risk associated with time *T*. Taking into account that the cash flow is risk-free from *T* to *T*+2, the equivalent flow is obtained by discounting the real flow between *T*+2 and *T* using the risk-free curve (Figure 10-8).

We will calculate the implicit rate associated with the period between *T* and *T*+2, or, which amounts to the same thing, we will discount from *T*+2 back to today and capitalize up to *T*, using in both cases the US$ risk-free curve.

$$CF_{modified} = \frac{CF_{T+2} \bullet DF^{\$}_{T+2}}{DF^{\$}_{T}}$$

where $DF^{\$}$ are the discount factors associated with the points in time *T*+2 and *T* for the risk-free curve and *CF* is the hybrid risk cash flow that we intend to modify in order to isolate the issuer risk effect.

When this approach is generalized to all the cash flows[13] that have hybrid risk at the time of valuation, the original bond with a rolling guarantee is converted to an equivalent bond with a fixed guarantee, and the stripped yield and stripped spread concepts can then be applied.

[13] This correction would not be applied to the principal if it were not guaranteed because it would have only issuer risk.

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Figure 10-7. The Effect of a Rolling Guarantee on a Cash Flow

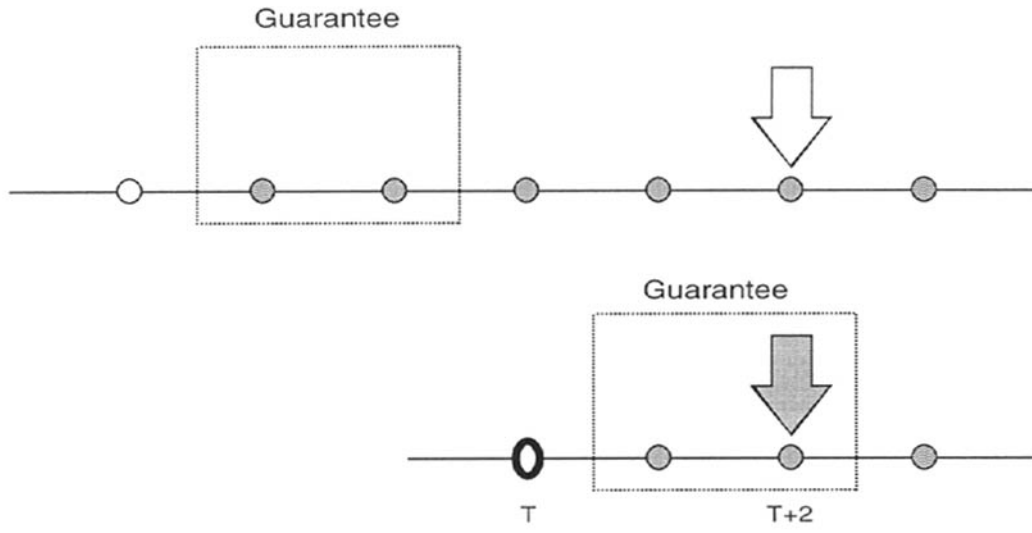


Figure 10-8. Equivalent Cash Flow Due to the Rolling Guarantee

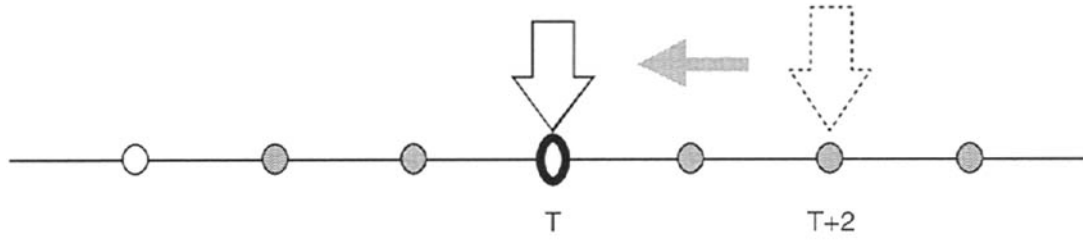
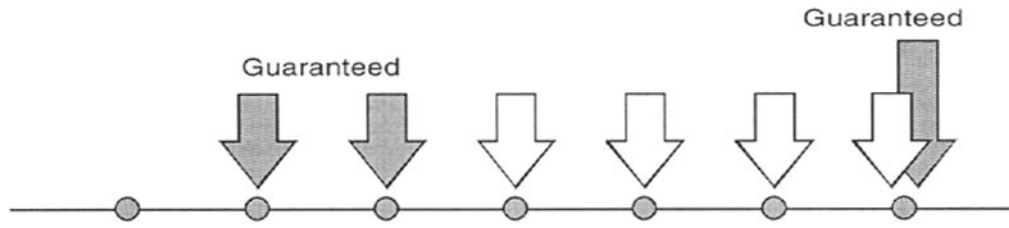


Figure 10-9. Total Cash Flow Structure



To analyze the bond as a whole again, assuming it has a rolling guarantee that covers the next two coupon payments and that the principal is secured, we would use the structure shown in Figure 10-9.

Any cash flows that were not originally secured can become secured later on. At that point, they would have to be corrected as shown above. Thus, the bond would be broken down into a bond A and a bond B that are different from the ones in the general case (Figure 10-10).

Correcting the coupons, by using the same rates of return as for fixed guarantees, causes the price of the bond taken as a whole to be higher. If we used the same price as in the case

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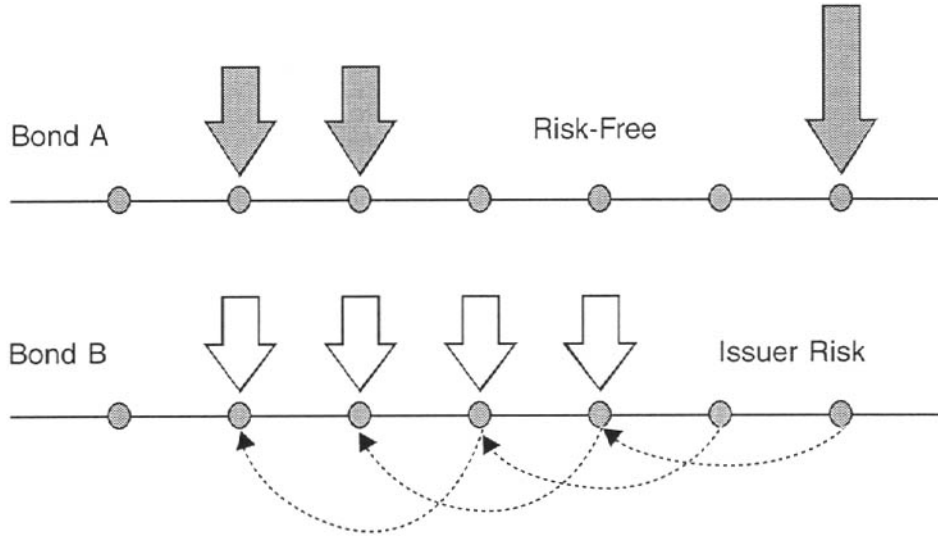
Figure 10-10. Decomposition of Risks with a Rolling Guarantee



of the fixed guarantee, the instrument's implicit returns would be lower. In either case, the higher price or lower implicit return would be explained by the higher credit rating attributable to the instrument with a rolling guarantee.

Floating-Rate Bonds

Up to this point the discussion has assumed that the instrument has a known cash flow structure. However, guarantees can also be applied to floating-coupon instruments whose rates are set throughout the bond's life by reference to the risk-free rate associated with the period in question.

Logically, the worse the instrument's credit rating, the lower its price or the higher the return demanded by investors. Including guarantees in the bond's structure enhances its credit features and increases its price.

But to be able to apply to these bonds the same methodology used in prior sections, we must convert them to a fixed-payment structure. Thus, we must estimate a value for the rate used as a benchmark for the calculation. We will do so by means of the risk-free yield curve, determining its implicit rates.

Assume that the bond pays annual coupons equal to the one-year risk-free rate. The first payment is known, as its rate is equal to the current one-year risk-free rate. The problem arises when we attempt to estimate what the one-year rates will be in one year, two years, etc. These rates will be estimated by means of the risk-free yield curve.

If we want to estimate what the one-year rate will be in two years, we will have to calculate the present value of one dollar two years and three years hence, and then extract the implicit return of a one-year investment starting two years from now. The present value of a dollar two years hence corresponds to the value of the discount factor associated with that point in time, or DF_2, while the value of the US$ in three years will be DF_3. Thus, the implicit interest rate in two years will be:

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$$Implicit\ rate_2 = \frac{DF_2}{DF_3} - 1$$

so that, generalizing for other points in time:

$$Implicit\ rate_T = \frac{1}{t} \bullet \left[\frac{DF_T}{DF_{T+1}} - 1 \right]$$

Once all the necessary coupons have been estimated, we will calculate the associated coupon payments, after which we can determine the stripped yield and stripped spread in accordance with the above methodology.

Risk Measurements

After analyzing the Brady bond valuation procedure, it is necessary to understand how bond prices change when market conditions determining them change. We have seen that the price of guaranteed bonds, which have hybrid risk, is determined on the one hand by the risk-free curve and on the other hand by the value that market participants assign to the issuer's risk by means of a spread over the risk-free curve (stripped spread).

However, it is not sufficient to know the bond's sensitivity to each of these two risk factors. Since they do not move independently, we must know the relationship between them to obtain the bond's overall volatility and then to apply the CAR concept properly.

Sensitivity

Brady bond prices are defined by the variations of the risk-free zero-coupon rates associated with the US$ and by the variations of the stripped spread. When determining their sensitivity to each of these two factors, we must keep in mind that, due to their special nature, Bradys have been analyzed by breaking them down into two bonds that no longer have hybrid risk. Thus, the overall bond's sensitivity to each risk factor includes the sensitivities of the risk-free bond (bond A) and the issuer risk bond (bond B). Obviously, bond A will only be influenced by the variations of the risk-free zero-coupon rates while bond B will also be influenced by the movements of the stripped spread.

We will calculate a Brady bond's sensitivity like any other fixed-income instrument and will represent it as the sum of first-order terms such that:

$$\frac{\Delta P}{P} \approx \sum [-D_i \bullet \Delta ZC_i] - D_{SS} \bullet \Delta SS$$

where D_i would be the first-order contributions of the zero-coupon rate associated with a time i and D_{ss} would be the first-order contributions of the stripped spread.

The value of the D_i and D_{ss} coefficients can be numerically determined[14] by modifying independently the value of each interest rate used in the valuation process and calculating the variation in the bond price.

[14] In the appendix (p. 311) we show formulas for each of the D_i and D_{ss} coefficients. They are obtained by calculating the bond price in relation to each of the variables that determine its market price. In this section we only discuss how to calculate it numerically so as not to introduce more methodological complexity than necessary.

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To determine the D_i coefficient, we will assume that only the zero-coupon rate associated with point in time i varies, and by only a small amount (for instance, 1 basis point), while the remaining zero coupons and the stripped spread remain the same. These new conditions will result in a new bond price such that

$$D_i = -\frac{\Delta P / P}{\Delta ZC_i}$$

If the bond has a floating coupon, a variation in the value of the risk-free curve rates does not affect only the present coupon. Because it impacts the implicit rates, all the coupon payments also have to be recalculated. In this case there is a double effect because both the coupon payments and the discount factors change. If the spread is zero and the coupon payments have no additional spread, these two effects fully offset each other.

We can follow the same procedure to determine the D_{ss} coefficient associated with the stripped spread. We can change the spread by a small amount while keeping the risk-free curve unchanged. Thus,

$$D_{SS} = -\frac{\Delta P / P}{\Delta SS}$$

Once all the coefficients are determined, we can easily simulate the behavior of the bond under various scenarios. To do so, we have to specify only the variation associated with each zero-coupon rate and with the stripped spread, and then apply the relative price variation formula.

The next step is to calculate the combined effect of all the variables by incorporating the relationships existing among them. The zero-coupon rates that are close in time will behave similarly, as they are highly correlated, while the stripped spread will be affected by other factors more closely linked to the financial conditions in the issuing country.

Volatility

As we have seen, variations in Brady bond prices can be approximated by:

$$\frac{\Delta P}{P} \approx \sum [-D_i \bullet \Delta ZC_i] - D_{SS} \bullet \Delta SS$$

Assuming that both the risk-free rates and the stripped spread behave as normally distributed random variables, the bond's relative price variation will also behave as a normally distributed variable, and its volatility will be defined by:

$$\sigma^2 = \{D_1\sigma_1 \quad D_2\sigma_2 \ldots D_n\sigma_n \quad D_{SS}\sigma_{SS}\} \begin{bmatrix} 1 & \rho_{12} & \cdots & \rho_{1n} & \rho_{1S} \\ \rho_{21} & 1 & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \rho_{n1} & \cdots & \cdots & 1 & \rho_{nS} \\ \rho_{S1} & \cdots & \cdots & \rho_{Sn} & 1 \end{bmatrix} \begin{Bmatrix} D_1\sigma_1 \\ D_2\sigma_2 \\ \cdots \\ D_n\sigma_n \\ D_{SS}\sigma_{SS} \end{Bmatrix}$$

Therefore, after calculating the bond's volatility, all we have to do is use the formulas for calculating the CAR that are explained in the chapter on pricing market risk.

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Example

The following example analyzes two bonds: one has a fixed coupon and the other has a floating coupon, but both are denominated in US$ and are issued with the fixed and rolling guarantee structures peculiar to Brady bonds. Assume that the market is pricing the risk level associated with the issuer as a 400 basis point (4%) spread over the risk-free curve in US$ (for all maturities). The discount factors (DF) for each maturity will be as shown below.

Discount Factors as a Function of Risk Level

	Risk-Free		Issuer Risk	
Maturity	Zero-Coupon Rate (%)	DF	Zero-Coupon Rate (%)	DF
1	5.25	0.9501	9.25	0.9153
2	5.30	0.9019	9.30	0.8371
3	5.34	0.8555	9.34	0.7650
4	5.37	0.8112	9.37	0.6989
5	5.40	0.7688	9.40	0.6381
6	5.42	0.7284	9.42	0.5825
7	5.45	0.6898	9.45	0.5316
8	5.47	0.6530	9.47	0.4848
9	5.50	0.6178	9.50	0.4420
10	5.52	0.5843	9.52	0.4028

Fixed-Coupon Bond

Assume a 10-year US$ denominated bond paying a 5% annual coupon. The following table shows the real cash flows associated with this bond.

Bond Flows

Year	Coupon (%)	Principal (%)	Total (%)
1	5	—	5
2	5	—	5
3	5	—	5
4	5	—	5
5	5	—	5
6	5	—	5
7	5	—	5
8	5	—	5
9	5	—	5
10	5	100	105

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In the following paragraphs we will analyze this bond under four alternative structures: risk-free, issuer risk, fixed guarantee and rolling guarantee.

- Risk-free or issuer risk: Regardless of whether the bond is unsecured (pure issuer risk) or all its cash flows are secured (risk-free), we obtain the price by directly calculating the present value of the flows and multiplying each flow by the discount factor (the issuer risk factor in the first case and the risk-free factor in the second case). The results are shown below.

Price without Guarantee

		Present Value	
Year	Flow (%)	Risk-Free	Issuer Risk
1	5	4.75	4.58
2	5	4.51	4.19
3	5	4.28	3.83
4	5	4.06	3.49
5	5	3.84	3.19
6	5	3.64	2.91
7	5	3.45	2.66
8	5	3.26	2.42
9	5	3.09	2.21
10	105	61.35	42.29
	Total	96.24	71.77

- Fixed guarantee: If there is a fixed guarantee, the bond must be split into two bonds equivalent to the original one but without hybrid risk. The same discount factors will then be applied to these two bonds, depending on the risk level, as shown below.

As we can see, when fixed guarantees are added, the price falls between the two prices above that correspond to the extreme cases when the bond has a single risk level.

Price with Fixed Guarantee

		Risk-Free	Bond with	Present Value	
Year	Flow (%)	Bond (%)	Issuer Risk (%)	Risk-Free	Issuer Risk
1	5	5		4.75	
2	5	5		4.51	
3	5		5		3.83
4	5		5		3.49
5	5		5		3.19
6	5		5		2.91
7	5		5		2.66
8	5		5		2.42
9	5		5		2.21
10	105	100	5	58.43	2.01
			Total	67.69	22.73
			Bond Price	90.42	

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- Rolling guarantee: As in the previous case, when the effects of a rolling guarantee are included it will be necessary to split the bond into two bonds equivalent to the original one but with segregated risks. Since the bond's future cash flows can be unsecured at first and subsequently become secured, an additional correction is needed. To calculate it, each flow that is initially unsecured is discounted back to a point in time two periods before its payment date. The risk-free curve is used and the implicit discount factor applied to each cash flow is calculated as the quotient between the discount factor associated with the payment date and the discount factor associated with the point in time two periods prior. The calculations are shown in the following table.

Price with Rolling Guarantee

Year	Flow (%)	Risk-Free Bond (%)	Implicit DF	Issuer Risk Bond (%)	Present Value (%)	
					Risk-Free	Issuer Risk
1	5	5			4.75	
2	5	5			4.51	
3	5		0.9004	4.502		4.12
4	5		0.8995	4.497		3.76
5	5		0.8986	4.493		3.44
6	5		0.8979	4.490		3.14
7	5		0.8973	4.486		2.86
8	5		0.8965	4.482		2.61
9	5		0.8957	4.478		2.38
10	105	100	0.8948	4.474	58.43	2.17
					67.69	24.48
				Price	92.18	

We can see that this price is higher than the price for a bond with a fixed guarantee, because the rolling guarantee offers a better credit hedge. However, this price is still lower than the risk-free bond's. The results obtained are summarized in the following table, which shows how Brady bonds can offer better terms because of the credit enhancement represented by their guarantees.

Summary of Results

	Price (%)
Issuer risk	71.77
Fixed guarantee	90.42
Rolling guarantee	92.18
Risk-free	96.24

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The next step is to analyze bond behavior when the rate curve and the spread fluctuate. To do so, we will assume that the existing volatility and correlation matrix between various maturities in the risk-free curve and the spread is as follows:

Volatility and Correlation Matrix (%)

	Vol.	1	2	3	4	5	6	7	8	9	10	SS
1	0.1	100	90	85	80	75	70	65	60	55	50	5
2	0.2		100	90	85	80	75	70	65	60	55	10
3	0.3			100	90	85	80	75	70	65	60	15
4	0.4				100	90	85	80	75	70	65	20
5	0.5					100	90	85	80	75	70	25
6	0.6						100	90	85	80	75	30
7	0.7							100	90	85	80	35
8	0.8								100	90	85	40
9	0.9									100	90	45
10	1.0										100	50
SS	4.0											100

Proceeding as indicated above (p. 263) we will calculate the D_i and D_{ss} risk coefficients associated with each maturity and with the spread.

D_i and D_{ss} Coefficients

	No Guarantee	Fixed Guarantee
1	0.0583	0.0499
2	0.1066	0.0946
3	0.1460	0.1159
4	0.1777	0.1410
5	0.2026	0.1608
6	0.2218	0.1760
7	0.2360	0.1873
8	0.2458	0.1951
9	0.2520	0.2000
10	5.3537	6.2948
SS	7.0004	1.3785

We can see that the stripped spread's (SS) contribution is significantly reduced when the principal is guaranteed, because in this case the spread does not contribute to determining the arket price of the bond with issuer risk, and the principal is the flow that has the most weight in the final price.

The coefficients determined will be applied to the volatility and correlation matrix to determine the price volatility of the bond taken as a whole. The results for each of the four cases considered are shown in the following table.

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Volatility Summary	
	Volatility (%)
Issuer Risk	31
Fixed Guarantee	11
Rolling Guarantee	9
Risk-Free	7

The stripped spread effect on the bond's principal is eliminated with the guarantees and the volatility is greatly reduced.

Floating-Rate Bond

Assume a US$-denominated bond maturing in 10 years. The benchmark rate is the 1-year risk-free rate that is set every year. Assuming the same market curve as in the previous example, the table shows the estimated coupon payments.

Estimated Variable Cash Flows				
	Market Data		**Bond**	
Term	**Zero Coupon (%)**	**DF**	**Implicit Rate (%)**	**Total (%)**
1	5.25	0.9501	5.25	5.25
2	5.30	0.9019	5.35	5.35
3	5.34	0.8555	5.42	5.42
4	5.37	0.8112	5.46	5.46
5	5.40	0.7688	5.52	5.52
6	5.42	0.7284	5.54	5.54
7	5.45	0.6898	5.59	5.59
8	5.47	0.6530	5.64	5.64
9	5.50	0.6178	5.69	5.69
10	5.52	0.5843	5.74	105.74

Assuming the same 400 basis point spread as in the previous example, the instrument prices for each risk level would be as follows.

Price Summary	
	Price (%)
Issuer Risk	74.81
Fixed guarantee	93.49
Rolling guarantee	95.44
Risk-free	100.00

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If we now want to calculate the bond's volatility (assuming the same volatility and correlation matrix as in the previous example), we will first determine the D_i coefficients, modify the value of each factor and then recalculate the bond price. There is, however, a small difference between this case and the case of the fixed-coupon bond. As market conditions change, the estimated cash flows also change, so that we would have to recalculate not only the new bond price but also the new cash flow payment structure.

Risk Coefficients

	Without Guarantee
1	–0.0448
2	–0.0819
3	–0.1123
4	–0.1368
5	–0.1562
6	–0.1711
7	–0.1822
8	–0.1900
9	–0.1949
10	–0.1970
SS	6.9230

The coefficients for the pure issuer risk case will be the ones shown in the previous table. The results seem surprising because the rates on the risk-free curve have negative coefficients. If the rates go up and the spread remains constant, the bond price also goes up. Yet traditional theory holds that the prices of interest-paying instruments are inversely correlated to rate trends. This apparent contradiction, however, is explained by the issuer's low credit rating and the ensuing high spread. We will discuss this in more detail in the section on floating coupon bonds. The following table calculates the volatilities for each case.

Volatility Summary

	Volatility (%)
Issuer risk	27
Fixed guarantee	7
Rolling guarantee	5
Risk-free	0

As we can see, the volatility of a bond where all cash flows are guaranteed (risk-free) would be zero because, when market conditions change, discount factors and cash flow payments also change and the effects offset each other. When there is issuer risk, discount factors take into account the spread applied by the market and are not offset.

Thus, although it is thought that variable-rate instruments do not give rise to market risk, this is only true if the rate curve used to estimate future payments is the same one used to discount them to present value.

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Aside from this, the volatility becomes higher as the risk level increases, but guarantees reduce risk and thus improve the bond's rating.

FLOATING RATE BONDS

When we analyzed Brady bonds we discussed a feature of floating rate instruments that are priced at a spread over the benchmark. This type of bond does not behave as expected since its price goes up rather than down when benchmark rates increase.

Because coupon payments are variable and are linked to interest rate levels at the beginning of the accrual period, they are valued by reference to the benchmark curve. On the one hand, the curve serves to estimate the future coupons, and on the other, it serves to discount them and calculate their present value. But the discount curve and the benchmark curve are not always parallel, since the former is changed to represent the bond's features, mainly the issuer's rating. Its sensitivity will depend on two risk factors (see the related section, p. 308) so that the relative price variation will be stated as:

$$\frac{\Delta P}{P} = -[D_{ref} \bullet \Delta IRR_{ref} + D_{spread} \bullet \Delta spread]$$

Here, to calculate the sensitivity to benchmark curve fluctuations, it is necessary to account for the fact that not only the discount factors but also the estimated coupon amounts will vary.

Finally, to calculate the real bond exposure, we must take into account the volatilities of the benchmark rate and the spread, along with their correlations; therefore, the price volatility will be:

$$\sigma^2_{price} = D^2_{ref} \bullet \sigma^2_{ref} + D^2_{spread} \bullet \sigma^2_{spread} + 2\rho \bullet D_{ref} \bullet D_{spread} \sigma_{ref} \bullet \sigma_{spread}$$

We will use an example to illustrate this. The appendix (p. 321) reviews in further detail the problems encountered in pricing these instruments and the reasons why negative durations appear.

Example

Assume a 10-year bond that pays the same coupon each year at the risk-free 1-year rate set at the beginning of each period, and repays the principal at maturity. Market conditions are defined by the risk-free zero-coupon curve as shown in the following table.

Risk-Free Zero Coupon Curve

Year	Zero-Coupon Curve (%)	Discount Factor
1	6.00	0.9418
2	6.15	0.8843
3	6.30	0.8278
4	6.45	0.7726
5	6.60	0.7189
6	6.75	0.6670
7	6.90	0.6169
8	7.05	0.5689
9	7.20	0.5231
10	7.35	0.4795

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To price the bond we will estimate the future 1-year rates by using the previous curve and the following formula:

$$CF_i = \frac{DF_{i-1}}{DF_i} - 1$$

The coupon payment structure will be as shown in the following table.

Estimated Variable Coupons and Cash Flows

Year	Coupon (%)	Principal (%)	Total (%)
1	6.18	—	6.18
2	6.50	—	6.50
3	6.82	—	6.82
4	7.14	—	7.14
5	7.47	—	7.47
6	7.79	—	7.79
7	8.11	—	8.11
8	8.44	—	8.44
9	8.76	—	8.76
10	9.09	100	109.09

To calculate the bond's market price, we need to modify the benchmark risk-free discount factor curve to show the risk level that the market assigns to the issuer. We will assume a uniform spread and apply it directly to the zero-coupon rates shown above, thereby determining the discount factors that correspond to the risk curve. This curve will be used only to calculate the present value of the coupons previously estimated with the risk-free curve,"# there is no need to recalculate these estimates.

For each spread we will obtain prices and IRRs (calculated the same as for a fixed-coupon bond) as shown below.

Price as a Function of the Risk Level

Shift (%)	–1.0	–0.5	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Price (%)	107.9	103.8	100.0	92.8	86.2	80.2	74.6	69.5	64.9
IRR (%)	6.4	6.9	7.4	8.5	9.6	10.7	11.8	12.9	14.0

Lower issuer ratings translate into lower bond prices or higher yields. If the market spread widens, the bond price goes down and vice versa. The bond's duration will be positive as the spread fluctuates. This is logical, because the coupons had to be determined beforehand in order to apply the spread, and thus the bond will behave like a fixed-coupon bond.

Up to now, the bond is behaving normally. But peculiarities appear when we analyze its behavior in the presence of reference rate curve fluctuations.

Let's assume that the spread is 3% for this issue. If the risk-free curve fluctuates and the spread remains constant, we would get the following market prices and IRRs.

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Price Sensitivity to Rate Changes									
Rate Changes (%)	**−4.0**	**−3.0**	**−2.0**	**−1.0**	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**
Price (%)	76.9	77.8	78.6	79.4	80.2	80.9	81.5	82.2	82.8
IRR (%)	6.5	7.5	8.6	9.6	10.7	11.8	12.9	14.0	15.1

We see that when the reference rates go up, the bond's IRR and market price also go up and vice versa. This means that the bond has negative duration although it is widely believed that rate increases always mean price declines. However, please keep in mind that the spread remains constant.

If we repeat the above calculations for other spreads and for changes in the risk-free curve, we can graphically represent the price sensitivity as shown in Figure 10-11.

When the spreads are positive, the bond's duration is negative and its price increases as the risk-free rates go up. When the spreads are negative (better risk than the benchmark curve), the bond's duration is positive and its price decreases as the rates go up.

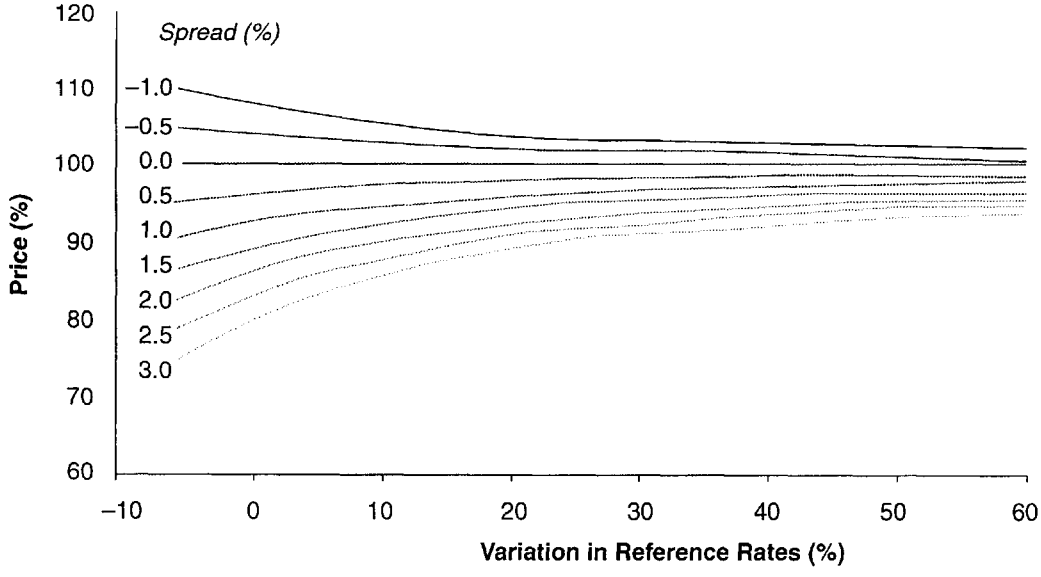
Since coupon payments are linked to variations in the risk-free rates, the coupon will increase if the rates go up. But to calculate the coupon value, we use the modified benchmark curve that adds in the assigned spread, which produces the opposite result since the discount factors drop as the rates go up. When the spread is zero, both effects offset each other and the bond will always be priced at par regardless of the trend of the curve. But when the spread is positive, the first effect has greater weight and the price increases. When the spread is negative, the discount effect has greater weight and the price decreases.

Assuming similar displacement for all maturities in the curve, the bond's sensitivity will be given by:

$$\frac{\Delta P}{P} = -\left[D_{CCC} \bullet \Delta CCC + D_{spread} \bullet \Delta spread\right]$$

where D_{ccc} is the sensitivity to variations in the benchmark curve and D_{spread} is the sensitivity to variations in the spread. Below we show the coefficients calculated for several risk levels.

Figure 10-11. Behavior of the Price of a Variable Rate Bond



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Risk Coefficients Based on the Risk Level									
Spread (%)	**–1.0**	**–0.5**	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**
D_{CCC}	0.291	0.146	0.000	–0.298	–0.601	–0.911	–1.225	–1.544	–1.868
D_{spread}	7.619	7.570	7.521	7.421	7.319	7.214	7.106	6.997	6.885

To see the combined effect of both variables, we will consider the volatilities of the benchmark curve and the spread and their correlations.

The bond's volatility will be:

$$\sigma^2 = \{D_{CCC}\sigma_{CCC} \quad D_{spread}\sigma_{spread}\}\begin{bmatrix}1 & \rho\\ \rho & 1\end{bmatrix}\begin{Bmatrix}D_{CCC}\sigma_{CCC}\\ D_{spread}\sigma_{spread}\end{Bmatrix}$$

Volatility and Correlation Matrix (%)			
	Volatilities	**Risk-Free Curve**	**Spread**
Risk-Free Curve	1	100	70
Spread	6	70	100

Applying this formula to the various spread scenarios and applying the volatility and correlation values from the previous matrix, we get the following values of the bond's volatility.

Constant Volatility for All Spreads									
Spread (%)	**–1.0**	**–0.5**	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**
Volatility (%)	21.1	20.7	20.4	19.6	18.9	18.2	17.5	16.7	16.0

Here we can see how the negative duration effect offsets the spread's volatility.[15] But the above assumption is not very realistic because we are using the same volatility for the spread in all cases. In fact, a 0% spread (lower risk) should not mean higher volatility (higher risk) than a 6% spread for the same bond. If we assume, however, that volatilities are directly proportional to the spread value, higher risk levels will present higher volatilities (as shown below) and will require more capital.

Volatility as a Function of the Risk Level							
Spread (%)	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**
Volatility (%)	0.0	0.5	2.0	4.4	7.6	11.5	16.0

[15] This is so because we used a positive correlation coefficient, which is how the spread usually behaves in relation to the benchmark rates.

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ASSETS LINKED TO INFLATION

High inflation rates in emerging economies have led to the creation of mechanisms to protect investments as well as the public interest. New products and payment systems, alternative currencies and other innovations were designed to guarantee real purchasing power and interest rates. These objectives were achieved by indexing a large share of the economy to a foreign currency (dollarizing the economy for the purpose of stabilizing its variables) or to the local inflation rate. In all cases, the final goal was to ensure that investments would keep their purchasing power and that the country's financial and economic system would remain stable.

We will now discuss inflation-indexed financial instruments. There can be two types of indexation:

- Explicit: Any future payments on the instrument, denominated in the local currency, are corrected by the inflation rate so as to ensure a stable purchasing power.
- Implicit: Another solution adopted by several emerging economies was to create an alternative local currency whose value against the local currency is a function of the local inflation rate. Future interest and principal payments will be denominated in this new currency. Significantly, these inflation-linked currencies are fictitious and only used as a reference. Payments are always made in the local currency after converting the amounts.

The methodology is the same for both types of indexation. We will use the inflation index, called the price index (PI), to allow us to move from past to present purchasing power. The loss in purchasing power between time $-T$ and now (time 0) will be:

$$K = \frac{PI_o}{PI_{-T}}$$

such that the purchasing power of a monetary unit at time $-T$ will be equal to the purchasing power of K monetary units at time 0.

Valuation

These instruments are valued like any other fixed-income instrument but, as they are directly subject to the effects of inflation, the returns will be nominal and will be divided into two components: real return (z_{real}) and inflation (z_{PI}).

$$z_{nominal} = z_{real} + z_{PI}$$

In a traditional fixed-income instrument, the return obtained is nominal because if 7% is generated annually in nominal terms we will have 7% more monetary units. However, if the annual inflation rate is 4% we would need 4% more monetary units to purchase the same item as the year before, and in real terms we would have only 3% more money. If the annual inflation rate were 7%, the real yield would be 0%. The nominal yield obtained would buy the same items as the year before but there would be no cash left over.

Because they are indexed to the price index, instruments linked to inflation guarantee the real return. The nominal return is not known ahead of time and is adjusted in accordance with the price index.

But when pricing any fixed-income instrument, we use the nominal market rates to calculate the present value, such that the present value of any future flow is

$$PV_{CF} = CF \cdot DF$$

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where DF is the discount factor associated to that cash flow. The discount factor will be calculated from the nominal market rates. We will assume that they are expressed continuously:

$$DF = e^{-z_{nominal} \cdot t}$$

where t is the point in time when the flow actually occurs. If the nominal return is broken down into the sum of two yields, the real return and the return due to expected inflation,

$$z_{nominal} = z_{real} + z_{PI}$$

then the nominal discount factor can be defined as the product obtained by multiplying a discount factor based on real returns by a discount factor derived from the price index, which converts future monetary units into current ones on the basis of purchasing power:

$$DF = DF_{real} \cdot DF_{PI}$$

where

$$DF_{real} = e^{-z_{real} \cdot t}$$

$$DF_{PI} = e^{-z_{PI} \cdot t} = \frac{PI_0}{PI_t}$$

where PI_t is the price index expected for future time t. The present value of any cash flow at time t is:

$$PV_{CF} = CF \cdot DF_{real} \cdot \frac{PI_0}{PI_t}$$

Of course, this pricing approach only makes sense if the instrument being analyzed is linked to inflation. As will be seen below, this simplifies the formulas.

Explicit Indexation

Let's assume a fixed-income instrument that pays fixed coupons adjusted for inflation so as not to lose purchasing power as measured from a specified point in time (usually the time of issuance).

The coupon that will really be paid is:

$$CF = CF_{base} \cdot \frac{PI_t}{PI_{ref}}$$

where CF_{base} is the initial flow associated with the instrument and CF is the flow that will be actually received after applying the correction to maintain purchasing power[16] from the reference point of time *ref*.

If we calculate the present value of this flow, we will see that it does not depend on any future inflation estimates but rather on known price indices:[17]

$$PV_{CF} = CF \cdot DF = CF_{base} \cdot DF_{real} \cdot \frac{PI_0}{PI_{ref}}$$

[16] Correcting the flow affects the whole payment, including any principal repayments.

[17] The formula is

$$PV_{CF} = CF \cdot DF = CF_{base} \cdot \frac{PI_t}{PI_{ref}} \cdot DF_{real} \cdot \frac{PI_0}{PI_t} = CF_{base} \cdot DF_{real} \cdot \frac{PI_0}{PI_{ref}}$$

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where point in time 0 is now. The market price of the whole instrument is equal to the sum of all the above:

$$PV = \frac{PI_0}{PI_{ref}} \sum CF_{base} \bullet DF_{real}$$

To price an inflation-linked instrument, we will first price a bond whose flows are equivalent to the uncorrected flows discounted with a real yield curve. The results will be corrected by the relative variation of the price index between the time that serves as the reference point for adjusting the flows (PI_{ref}) and now (PI_0).

If the bond is priced at the time of issue, the last adjustment would not be necessary and the market price would be:

$$PV = \sum CF_{base} \bullet DF_{real}$$

Implicit Indexation

Assume a bond that pays the same fixed coupons as the one discussed above but that is denominated in a fictitious currency reflecting the effects of inflation. Payments would actually be made in the local currency, such that,

$$CF = CF_{base} \bullet FX$$

where CF_{base} is the coupon payment in the fictitious currency and FX is the exchange rate between that currency and the currency used for the payment.

Because the fictitious currency does not fluctuate freely versus the local currency but rather represents the inflation trend, the exchange rate between them at a specified time t is given by the quotient of the price indices between time t and the point in time used to define the value of the new currency:[18]

$$FX_t = \frac{PI_t}{PI_{base}}$$

Thus, the present value of a future cash flow, splitting the discount factors as above, will be:[19]

$$PV^*_{CF} = CF_{base} \bullet DF_{real} \bullet \frac{PI_0}{PI_{base}}$$

Taking into account that

$$FX_0 = \frac{PI_0}{PI_{base}}$$

the bond's market value, stated in the local currency, will be equal to:

$$PV^* = FX_0 \bullet \sum CF_{base} \bullet DF_{real}$$

[18] It should be noted that this base point in time (PI_{base}) does not have to be equal to the reference point in time used in the previous section (PI_{ref}).

[19] The formula is

$$PV^*_{CF} = CF \bullet DF = CF_{base} \bullet \frac{PI_t}{PI_{base}} \bullet DF_{real} \bullet \frac{PI_0}{PI_t} = CF_{base} \bullet DF_{real} \bullet \frac{PI_0}{PI_{base}}$$

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As in the previous case, to obtain the market value of an instrument linked to inflation by means of an adjusted currency, we will assume that the discount curve of the adjusted currency is identical to the real-yield discount curve of the local currency and then apply the current exchange rate between both currencies.

The bond will first be valued in the adjusted currency and then the exchange rate will be applied.

Real Returns

If we generalize the results obtained in the two above cases, we note that the returns negotiated for these instruments are real returns. After determining them, the bond is analyzed like a traditional fixed-income instrument whose payments are the original instrument's non-adjusted or non-converted payments.

Although it does not seem necessary to make estimations about future inflation trends, we must build a future inflation scenario to determine the real return since market prices are based on nominal returns. If both nominal and real returns existed in the market, we would be able to determine the expectations about future inflation trends being discounted by the market by taking the difference between them.

Real Internal Rate of Return

The real internal rate of return for this type of instrument is determined as the constant interest rate that, when applied to the real discount factors

$$DF_{real} = e^{-IRR_{real} \cdot t}$$

will satisfy the following formula (for the implicit indexation case):

$$\frac{PV^*}{FX_0} = \sum CF_{base} \cdot DF_{real}$$

Risk Measurements

The bond price is a function of the real return. The following is the method to analyze a fixed-income instrument whose payments are the original instrument's non-adjusted or non-converted payments. Then, the value obtained is corrected by the current inflation.

The value of the instrument will depend on the fluctuations of the real return and of the price index. In the explicit indexation case, the effect of inflation is represented by the foreign exchange risk. Thus, the sensitivity of the instrument is given by:

$$\frac{\Delta value}{value} \approx -MD_{base} \cdot \Delta IRR_{real} + \Delta FX$$

where the base modified duration is calculated from the unadjusted bond, using the real internal rate of return, and the fluctuation of the exchange rate is determined by the changes in the price index.[20]

[20] In most cases the price index is estimated monthly. It is assumed that, for periods between estimations, the adjusted currency is estimated on the basis of the latest revised inflation rate, which would not cause volatility.

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The overall exposure associated with this type of instrument derives from the volatility inherent in the real returns, the volatility of inflation and the correlation between them. In stable economic environments, price index volatility is practically nil and thus the bond's volatility can be approximated as follows:[21]

$$\sigma_{bond} \approx MD_{base} \bullet \sigma_{IRR\,real}$$

In hyperinflationary periods, however, price index changes can be very significant, and volatilities must always be considered even if the time horizon is very short.

Example

Assume an inflation-linked bond: the face value is 10,000 local monetary units and it pays a 6% base coupon plus the inflation adjustment for 10 years. The adjustment is calculated from the quotient of the price index at the time of each payment and the price index at issuance. Let's assume that the bond was issued 5 years ago and at that time the price index was 107. Real returns are currently 5% and the price index is 130.

The following table analyzes the base bond, with flows identical to the non-adjusted instrument and with a 5% internal rate of return.

Base Bond

Year	Base Coupon (%)	Base Principal (%)	Base Flow (%)	Real DF	Present Value of Base Flow (%)
1	6	—	6	0.95	5.7
2	6	—	6	0.90	5.4
3	6	—	6	0.86	5.2
4	6	—	6	0.82	4.9
5	6	—	6	0.78	4.7
6	6	—	6	0.74	4.4
7	6	—	6	0.70	4.2
8	6	—	6	0.67	4.0
9	6	—	6	0.64	3.8
10	6	100	106	0.61	64.3
				Base Price	106.7

To correct by the inflation rate we multiply by the quotient of the current price index and the price index at issuance. Thus:

$$price = \frac{130}{170} \bullet 106.7\% = 129.6\%$$

giving a market price of 12,963 monetary units.

Now assume an instrument linked to inflation and denominated in an adjusted currency that eliminates the effects of inflation and that pays a 6% annual coupon for 10 years. This instrument is equivalent to the one in the previous example.

[21] If we use historical price series, since the past trend of the price index is known, it will be easy to calculate the real historical returns and obtain their volatilities and their correlation with other securities in the portfolio.

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Let us also assume that the exchange rate was set at par when the price index was 100 and that the market conditions are identical to the ones in the previous example. The base bond price would still be 106.7%, stated in the adjusted currency.

The exchange rate between the adjusted currency and the local currency is

$$FX_0 = \frac{130}{100} = 1.3 \frac{local\ units}{corrected\ units}$$

such that the bond price in the local currency will be

$$price = 1.3 \cdot 106.7\% = 138.7\%$$

Apparently we are not talking about the same instrument because we get two different prices. This difference is not imputable to the bond but to the fact that the differences between the price indices used as benchmarks in both cases affect the principal equivalence between the two bonds. We are comparing two prices on the basis of different principals—the first one based on the local currency and the second on the adjusted currency. If we divide both prices, we note that the quotient is 1.07, which is equal to the quotient of the price indices at issuance and at the time when the base for the new currency was determined.

But, if we analyze the sensitivity, the base modified duration would be the same for both instruments and would be equal to 7.88 years. Thus, assuming that the real rates have 1% volatility, the bond price volatility would be approximately 8%.

Illiquid Markets

Illiquid securities are common in emerging markets. These securities are traded infrequently or at very low volumes, and their prices have to be regarded not as representative of the traders' consensus about their real value but rather as the transaction price arrived at by two counterparties under very special conditions. This represents an obstacle when we seek to measure the risk of these securities with a methodology based in volatilities and correlation matrices. To apply this type of methodology, it is generally necessary to use historical price series,[22] and from them calculate the related volatilities and correlations. A problem arises when the historical series are not available for some securities or, when they are available, they are not fully reliable due to lack of liquidity.

As this situation is very common in emerging markets, it becomes necessary to develop a methodology that will let us estimate the value and the risk parameters (volatilities and correlations) of illiquid assets. In this way we can measure their risk and how much they contribute to the value of the business.

The methodologies discussed below can be applied in all markets where some assets are liquid and others have liquidity-related problems. The basic methodological concept involves segmenting the market into categories or groups in accordance with specified criteria (country, industry, credit rating, etc.) that will be different in each case and will depend on the asset type. After establishing the classification, we will identify liquid assets that are representative of each category and will use them as the basis for estimating the category's risk parameters. For assets

[22] Another possibility involves using implicit volatilities taken from options traded in the market. This method, however, is not very viable for emerging markets whose options markets themselves do not, in most cases, have enough liquidity or trading volume.

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that have liquidity problems or that do not have historical price series, the risk parameters will be estimated from the category's reference parameters.

In the following sections we will discuss both bonds and equities although, since they are different types of securities, they will be discussed separately.

ILLIQUID MARKETS: FIXED-INCOME INSTRUMENTS

As we already mentioned in the introduction to this section, in order to analyze illiquid markets we need to define categories for the classification of illiquid instruments. The individual estimators for calculating risk measurements are constructed from each category's estimators.

We will analyze the yield associated with fixed-income instruments by splitting it into two major components:

- Market interest rate levels: systemic risk
- Features specific to the issue: specific risk

We will show the yield as the sum of a benchmark yield and a specific spread:

$$yield = yield_{reference} + spread_{credit}$$

The spread will be a function of the risk level assigned to the issue by the market. We assume that it is mostly explained by the issue's credit components.

To assist in the understanding and practical application of the methodology, we discuss below two case studies:

- A high-yield bond portfolio
- An emerging market bond portfolio

High-Yield Bond Portfolio

High-yield bonds are fixed-income instruments issued by entities with credit ratings below BB (i.e., non-investment grade). For this reason, they must offer high yields, or be priced at a discount. In the U.S. there is a significant market for these bonds: more than 6,000 issues are quoted. Due to differing degrees of liquidity, there are historical price series for some but none or no reliable ones for others. High-yield bonds introduce a significant exposure into the portfolio: because the credit component has more weight in the yield than the systemic component, their volatility is higher. To measure portfolio risk, at least approximately, a methodology must be developed by firms holding these bonds.

The risk measurement methodology will be based on the assumption that bond yields behave like a normally distributed random variable. A bond's volatility will be estimated by combining two effects: systemic (market) and specific (each issuer's credit rating).

As we mentioned above, a bond's return is equal to the sum of the market return (risk-free) plus a spread attributed mostly to the credit features of the bond.

$$return = return_{market} + spread_{credit}$$

Bond price variations can be stated as the sum of two variables, market interest rate movements and changes in the bond's credit outlook:

$$\frac{\Delta price}{price} = \frac{\Delta price_{market}}{price} + \frac{\Delta price_{credit}}{price}$$

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where the relative price variation is called snapshot return (i.e., the return at a specific point in time).

To calculate the bond's volatility, we use the following formula:

$$\sigma^2_{yield} = \sigma^2_{market} + \sigma^2_{credit} + 2 \bullet \rho_{credit,\ market} \bullet \sigma_{market} \bullet \sigma_{credit}$$

where the credit volatility is the volatility of the snapshot return due to fluctuations in the spread, and the credit correlation is the correlation between the spread-related snapshot return and the market rate-related snapshot return.

Since the volatility due to the benchmark market rates is always the same, whether we are analyzing high-yield bonds or other fixed-income instruments, our efforts should be focused on determining the credit volatility and the credit correlation:[23]

For this purpose we will create a series of categories that will provide risk parameters for illiquid bond issues.

Defining Categories

To begin with, we must create a series of categories covering all high yield bonds. Since the key variable is the credit component, the following criteria could be used:

- Industry of the company that issued the bond
- Bond credit rating

After defining the categories, we will choose a series of representative bonds[24] that are liquid and that have historical price series.

Risk Parameters by Category

After selecting the representative bonds, we will use their risk parameters to estimate the parameters for the category. As was already mentioned, the major risk component for these bonds is the credit component. Our goal is to estimate the following parameters for each category:

- σ_i: credit volatility
- $\rho_{i,M}$: credit correlation with the market
- $\rho_{i,k}$: credit correlation with other categories (k)
- $\rho_{i,X}$: credit correlation with the other assets (X) in the portfolio

where i is the category indicator.

These parameters will first be calculated for each representative bond and then they will be averaged to estimate the total value for the category. Figure 10-12 shows the procedure to determine the parameters for each bond, which will be further explained in the following sections.

---

[23] When the high yield bond is included in a larger portfolio, it will also be necessary to calculate the correlations between its credit component and the other securities in the portfolio.

[24] It is advisable not to choose too many bonds in each category, because that would complicate the calculation. One or two bonds can give a good approximation of the behavior of the remaining bonds in the category.

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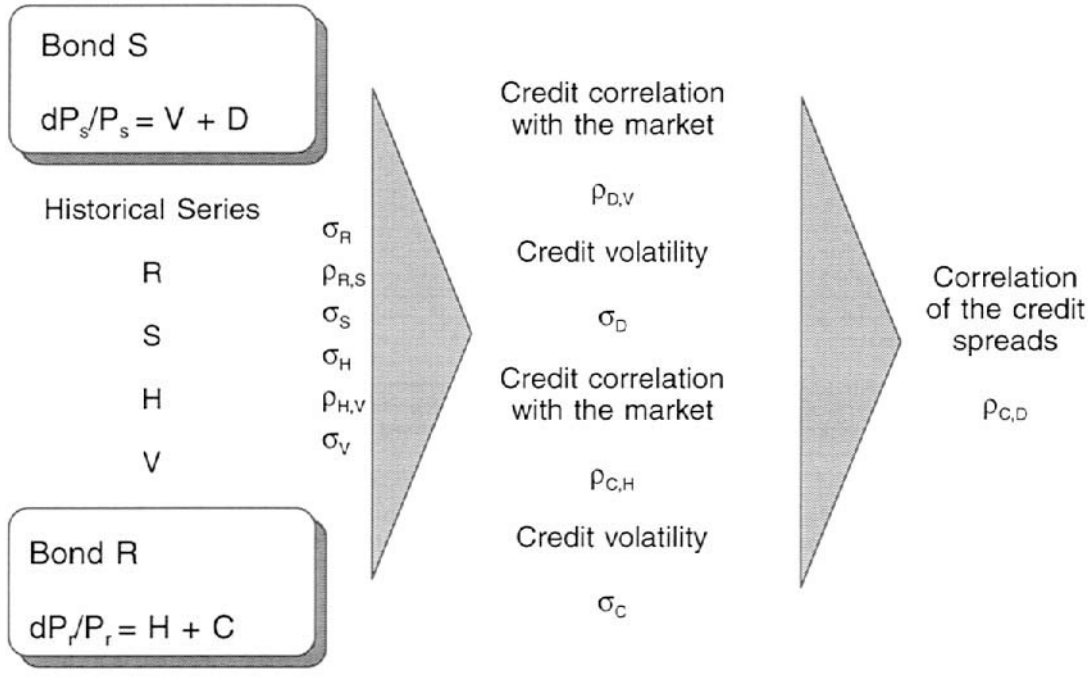
Figure 10-12. Risk Parameters for Representative Bonds Belonging in Different Categories



After the parameters for each category have been obtained, we will assume that all the high yield bonds belonging to the same category have the same credit volatility (σ_i) and the same credit correlation with the market (ρ_{iM}) regardless of their duration.

Volatility of a Category and Credit Correlation with the Market

The credit volatility of a category (σ_i) and its credit correlation with risk-free instruments (r_{iM}) is obtained, respectively, by averaging the credit volatilities and correlations calculated for each bond representative of that category.

We will assume that a representative bond's snapshot returns defined by the sum of two random variables, one related to price fluctuations due to market interest rate movements and the other related to price fluctuations caused by changes in the issuer's credit rating. Thus,

$$R = H + C$$

where R is the bond's snapshot return, H is the snapshot return due to market rate movements of a bond with similar duration, and C is the return due to the credit component that the market assigns to this issue.

Taking into account how the representative bond's price fluctuations are broken down above, the volatility will be:

$$\sigma_R^2 = \sigma_C^2 + \sigma_H^2 + 2\rho_{C,H}\sigma_C\sigma_H$$

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where

- σ_R is the volatility of the bond's snapshot return, calculated from the bond's historical price series for a specified period.
- σ_H is the volatility of a risk-free instrument[25] whose duration today is the closest possible to the duration of the representative bond during the period specified. It will be calculated from the risk-free instrument's historical price series for the same period.
- $\rho_{c,H}$ is the credit correlation between the representative bond and the risk-free instrument. To calculate it, it is necessary to know the direct correlation between the bond and the risk-free instrument, which can be calculated from their historical price series.
- ρ_c is the credit volatility of the representative bond. It will be calculated from the previous correlation.

To determine the credit volatility and correlation, we use the following formulas:[26]

$$\begin{cases} \sigma_R = \sqrt{\sigma_C^2 + \sigma_H^2 + 2\rho_{C,H}\sigma_R\sigma_H} \\ \rho_{H,R} = \dfrac{\sigma_c\rho_{C,H} + \sigma_H}{\sigma_R} \end{cases}$$

$\rho_{H\text{-}R}$ is calculated from the historical yield series for bond R and instrument H. The credit volatility of the representative bond and its credit correlation with the risk-free instrument are calculated from the prior formulas:

$$\sigma_C = \sqrt{\sigma_R^2 + \sigma_H^2 + 2\rho_{H,R}\sigma_R\sigma_H}$$

$$\rho_{C,H} = \frac{\sigma_R\rho_{H,R} - \sigma_H}{\sigma_C}$$

After these parameters are calculated for each representative bond, their average will define the parameters for the category.

Credit Correlation Between Categories

Assume two categories i and k, each of which has three representative bonds. We will calculate the credit correlation for each of the nine pairs of representative bonds, and then we will average the values obtained to determine the credit correlation ($\rho_{i,k}$) between categories i and k. Take one of the nine pairs, made up of two bonds with the following features:

$$R = H + C$$
$$S = V + D$$

where

- R is the current yield of a bond representative of category i that has the following risk parameters:
  - σ_R: volatility of the bond

[25] This instrument can be a US Treasury bond or an interest rate swap.

[26] We must check to see that:

$$\sigma_R^2 = covariance(H + C, H + C)$$
$$covariance\ (H,R) = covariance\ (H,H+C)$$

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- σ_c: credit volatility
- σ_H: volatility of the risk-free instrument with similar duration
- $\rho_{c,H}$: credit correlation with the risk-free instrument

• S is the yield of a bond representative of category *k* that has the following risk parameters:

- σ_s: volatility of the bond
- σ_D: credit volatility
- σ_v: volatility of the risk-free instrument with similar duration
- $\rho_{D,v}$: credit correlation with the market

We will also calculate the correlation between the yields *R* and *S* ($\rho_{R,S}$) and the correlation between the risk-free instruments *H* and *V* ($\rho_{H,V}$) from the historical data series.

Therefore, the credit correlation between the bonds representative of both categories ($\rho_{C,D}$) will be:[27]

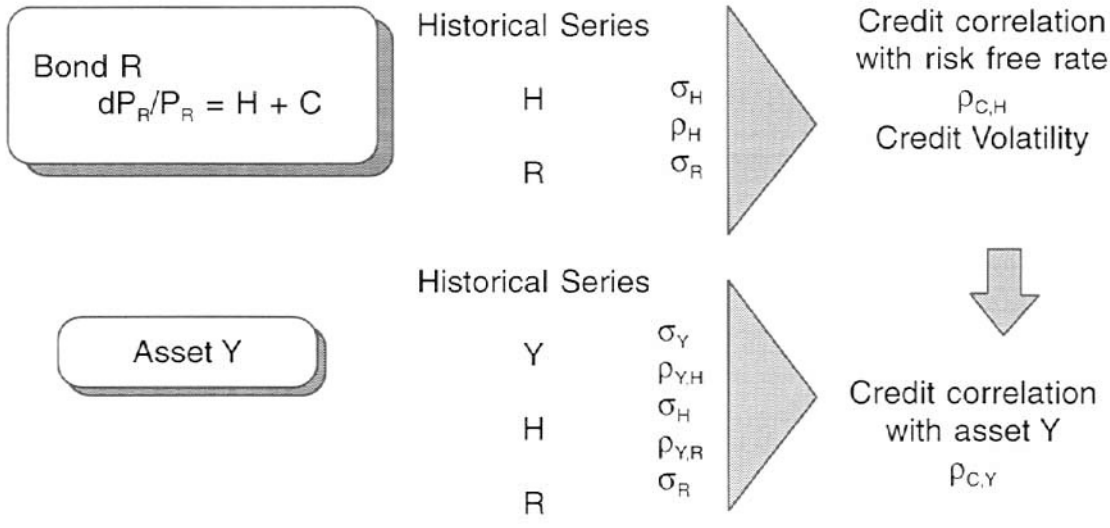
$$\rho_{C,D} = \frac{\sigma_R\sigma_S\rho_{R,S} - \sigma_H\sigma_V\rho_{H,V} - \sigma_C\sigma_V\rho_{C,H} - \sigma_D\sigma_H\rho_{D,V}}{\sigma_C\sigma_D}$$

After obtaining this value for each pair of bonds, we will determine the credit correlation between categories ($\rho_{i,k}$) as the average of all individual values.

Credit Correlation Between One Category and Other Instruments in the Portfolio

Assume an instrument Y in the firm's portfolio. To know the portfolio's overall exposure, it is necessary to know the correlations between instrument Y and each of the defined categories, as shown in Figure 10-13. According to the previous procedure, we would have to calculate

Figure 10-13. Risk Parameters of a Representative Bond vs. other Assets



[27] From

$$\text{covariance } (R,S) = \text{covariance } (H + C, V + D)$$

and assuming that the credit correlation between a bond and the market is independent of its duration such that:

$$\rho_{C,V} \approx \rho_{C,H}$$
$$\rho_{D,H} \approx \rho_{D,V}$$

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the credit correlation between each representative bond and each instrument in the portfolio, average them and then determine the credit correlation between the category and each instrument. This procedure would be very cumbersome. Therefore, we will use only one bond representative of each category and its correlation with the instrument will be the credit correlation assigned to the category.

Assuming that the yield of the representative bond selected is

$$R = H + C$$

the credit correlation with instrument Y will be given by the following formula:[28]

$$\rho_{Y,C} = \frac{\sigma_Y \sigma_R \rho_{Y,R} - \sigma_Y \sigma_H \rho_{Y,H}}{\sigma_Y \sigma_C} = \frac{\sigma_R}{\sigma_C} \rho_{Y,R} - \frac{\sigma_R}{\sigma_C} \rho_{Y,H}$$

To obtain this value, it will be necessary to calculate the correlation between R and Y (ρ_{YR}) and the correlation between Y and the risk-free instrument whose duration is closest to the representative bond (ρ_{YH}). These correlations will be obtained from the respective historical series.

In the case where the greater part of the representative bond's volatility is due to its credit component and only a very small part is due to the market variable, the following formula will apply:

$$\sigma_R \cong \sigma_C >> \sigma_H$$

and therefore

$$\rho_{Y,C} \cong \rho_{Y,R}$$

Irrespective of the above approximation, the credit correlation between category i and instrument Y will be assumed to be the same as the correlation obtained for the representative bond:

$$\rho_{i,Y} = \rho_{Y,C}$$

Risk Parameters of a High Yield Bond

Each high yield bond in the portfolio will be assigned to one of the categories and will be assumed to have the credit volatilities and correlations determined for that category. This does not mean that the credit correlation between two bonds belonging to the same category equals 1. To fully describe a bond's behavior, we will consider a risk-free instrument with similar duration and add to it a credit spread.

We will calculate the snapshot return of a high yield bond belonging to category i as follows:

$$A = M + i$$

where

- A is the snapshot return of the bond
- M is the contribution explained by a market instrument with similar duration
- i is the credit contribution due to its inclusion in category i

The high yield bond under consideration is assigned the credit characteristics of its category and the market characteristics of a risk-free instrument with similar duration.

[28] Given that:

$$covariance\ (Y,R) = covariance\ (Y,H + C)$$

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Volatility

After defining the two components of the high yield bond's yield, its volatility will be determined as:

$$\sigma_A^2 = \sigma_i^2 + \sigma_M^2 + 2 \bullet \rho_{i,M} \bullet \sigma_i \sigma_M$$

where

- σ_A is the volatility of the bond
- σ_i is the credit volatility of the category to which the bond belongs
- σ_M is the volatility of a risk-free instrument with similar duration
- $\rho_{i,M}$ is the credit correlation of the category with the market

Correlation Between High Yield Bonds

In order to calculate the overall volatility of a high yield bond portfolio, it will be necessary to determine the correlation between the bonds' credit components. To do so, we will follow the procedure indicated in Figure 10-14.

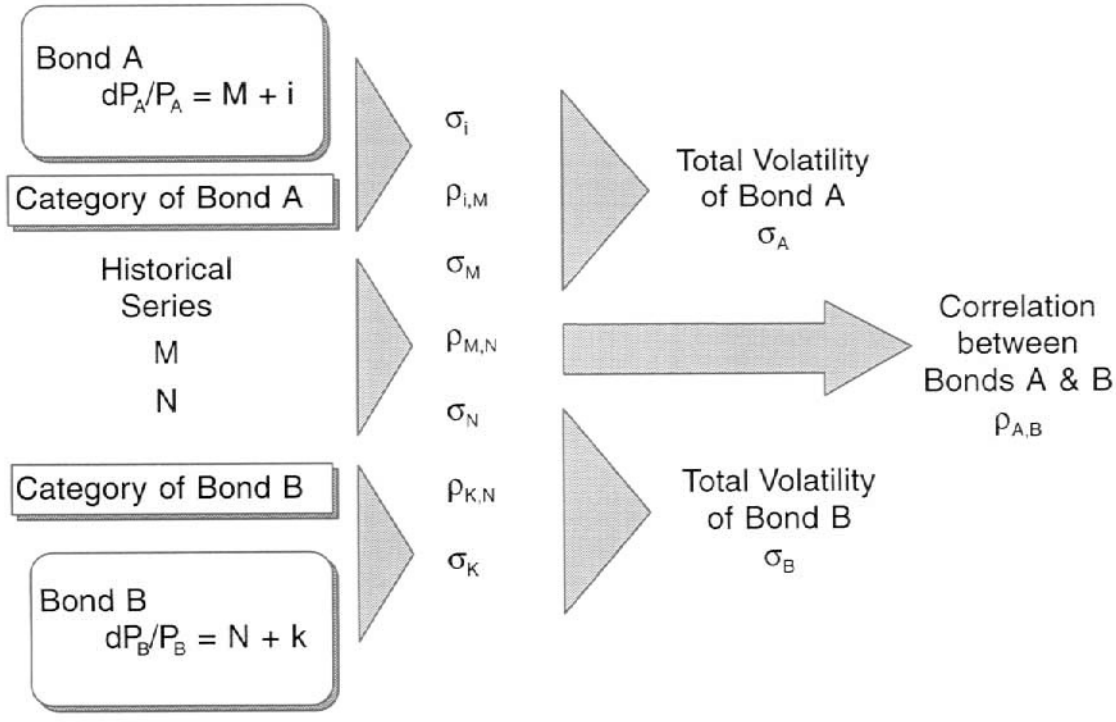
Assume another high yield bond belonging to category *k*, whose snapshot return can be stated as:

$$B = N + k$$

where

- *B* is the snapshot return of the bond
- *N* is the contribution explained by a market instrument with similar duration
- *k* is the credit contribution due to inclusion in category *k*.

Figure 10-14. Correlation between High Yield Bonds



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and its risk parameters are:

- σ_B is the volatility of the bond
- σ_k is the credit volatility of category k to which the bond belongs
- σ_N is the volatility of a risk-free instrument with similar duration
- $\rho_{k,N}$ is the credit correlation of category k with the market

To be able to correlate this instrument with the one above ($A = M+i$), it will be necessary to determine the cross-correlations between all the factors, so that the total correlation between instruments A and B will be given by:[29]

$$\rho_{A,B} = \frac{\sigma_i\sigma_k\rho_{i,k} + \sigma_i\sigma_N\rho_{i,M} + \sigma_k\sigma_M\rho_{k,N} + \sigma_M\sigma_n\rho_{M,N}}{\sigma_A\sigma_B}$$

where the credit correlation between a category and the market is assumed to be independent of the duration, such that:

$$\rho_{i,N} = \rho_{i,M}$$
$$\rho_{k,N} = \rho_{k,M}$$

Additionally, we will have to calculate the correlation ($\rho_{M,N}$) between the two risk-free instruments with durations similar to the bonds under analysis. To do so, we will use their respective historical price series.

Correlation Between a High Yield Bond and Other Instruments in the Portfolio

To calculate the volatility of a portfolio holding other instruments besides high yield bonds, it will be necessary to determine the correlation of each high yield bond with the remaining instruments. To do so, we will follow the procedure indicated in Figure 10-15.

Take an instrument X with volatility σ_X and a high yield bond belonging to category i with credit volatility σ_X, market volatility σ_M, total volatility ρ_A, and a credit correlation between the category and instrument X equal to $\rho_{i,X}$.

The total correlation $\rho_{A,X}$ between the high yield bond and instrument X, taking into account credit and interest rate components, will be:[30]

$$\rho_{A,X} = \frac{\sigma_X\sigma_M\rho_{X,M} + \sigma_i\sigma_X\rho_{i,x}}{\sigma_A\sigma_X}$$

It will also be necessary to calculate the correlation between the risk-free instrument and the high yield bond X ($\rho_{M,X}$).

[29] We will take as departure point the formula

covariance (A,B) = covariance (M + i, N + k)

[30] Given that $A = X + i$, it follows that:

covariance (A,X) = covariance (M + i, X)

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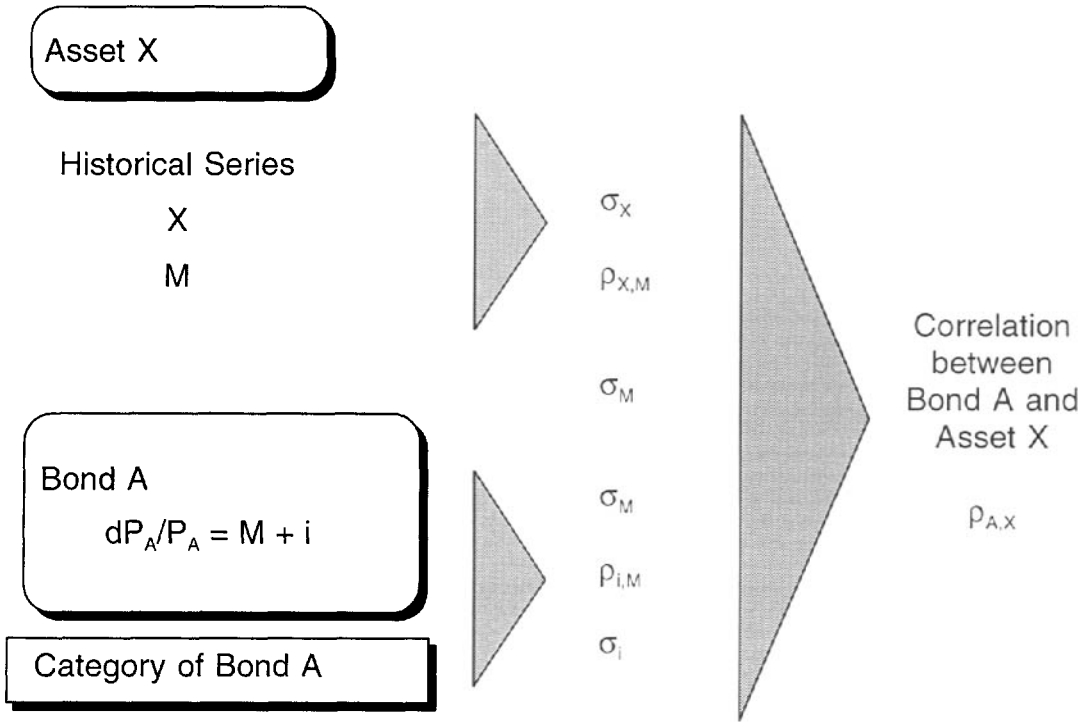
Figure 10-15. Correlation between a High Yield Bond and other Instruments in the Portfolio



Emerging Market Fixed Rate Bond Portfolio

This second section seeks to adapt the methodology described above for a high yield bond portfolio to an emerging market bond portfolio, and to estimate the risk parameters of emerging market government and corporate debt instruments.

Like the high yield bond portfolio, an emerging market government and corporate bond portfolio will hold some securities that have easily available historical price series, while for others there will be no reliable data or no data at all. As in the previous case, the methodology described below seeks to develop a procedure to calculate risk parameters associated with the credit component of any bond, whether or not it has a reliable price series.

Defining Categories

As in the previous case, the goal is to divide the market into categories, calculate all the risk parameters for each category and extrapolate them to the instruments included in each category.

To create categories of emerging market bonds, we will consider the following criteria:

- Country of the issuer
- Currency of the instrument: For the purposes of this analysis, we will consider issues denominated in the local currency and issues denominated in US$.

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- Credit rating of the bond: We will differentiate between local government debt (sovereign rating) and other credit ratings.[31]

For each country we will differentiate between issues denominated in the local currency and issues denominated in US$. Within each of these two categories, we will create other categories according to the credit rating; one of these categories will be government debt.

A firm holding a diversified portfolio of these securities should measure its exposure at two levels:

- First, the firm should measure potential losses in portfolio value as a consequence of interest rate fluctuations[32] and changes in the issuers' credit ratings.
- Second, it should measure potential exchange rate losses when P&L are translated to its reference currency.

The methodology presented below can be used to measure the first level of risk. The exchange rate risk must be measured later as a function of the positions held in each currency at market value, as explained in the chapter on measuring market risk. On this basis, we will differentiate between:

- Issues from each country in local currency; for these, we distinguish between issues with sovereign ratings and other credit ratings.
- Issues from all countries in US$.

Issues in Local Currency

The methodology discussed below must be applied to each emerging market where a firm holds fixed-income assets denominated in local currency. As already discussed in the section on defining categories, we will differentiate between government issues (sovereign rating) and all other credit ratings.

We will determine a bond's yield as the sum of two factors: market benchmark rate (government debt) fluctuations and credit component variations.

$$yield = government\ debt + credit\ component$$

To simplify the analysis, government bonds will be deemed to be risk-free instruments within the issuing country. Within that country the snapshot yield of a government bond depends only on a random variable related to local interest rate fluctuations, without a credit component.

The representative issues selected for each country will be government bonds that are liquid and that have reliable historical price series. The selected bonds will determine the parameters for the category.

First we will calculate the duration and volatility of the yield for each government bond, and then construct a duration vs. volatility curve. The volatility of illiquid government bonds will also be determined from this curve by interpolation, enabling us to determine the price volatility by multiplying the duration by the interpolated volatility.

We will calculate the cross-correlations between all liquid government bonds by using their historical price series and we will assume that the correlations between all the pairs of

[31] Other criteria, such as industry, maturity, etc., could also be included.

[32] The portfolio will be affected by local interest rate fluctuations in the countries of origin of its assets, as well as by US$ rate fluctuations, if it holds US$-denominated assets.

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government bonds are unique, independent of their liquidity and equal to the average of the previously calculated correlations.

We will also create categories for the remaining issues in local currency, using their credit ratings as segmentation criteria. For each category we will choose one or several representative bonds that are liquid and that have reliable historical price series. As in the case of high-yield bonds, the only parameters estimated for each category will be the ones associated with the bond's credit component.

Each bond that is denominated in local currency and held in the portfolio will be assigned to a category and take on that category's credit risk parameters. The component associated with the interest rate risk for that particular bond will then be introduced. This component will be determined from local-currency government debt securities with similar duration.

As the methodology to be applied in this case is almost the same as the one used for high-yield bonds, it will be discussed only in summary form, with a focus on identifying the parameters specific to this case. The formulas will be similar to the ones used for high-yield bonds, so it might be convenient to consult that section (p. 285) before proceeding.

As mentioned above, a bond's yield can be broken down into a return due to market rates and a return due to credit factors. In this particular case, market rates are defined by the return rates on local government debt securities which, as we said, will be assumed to be risk-free within the issuing country.

Thus, we need to develop categories only to estimate the credit component. The risk parameters defining the credit component for each category will be:

σ_i = credit volatility
$\rho_{i,M}$ = credit correlation with local government debt
$\rho_{i,k}$ = credit correlation with other categories (k)
$\rho_{i,X}$ = credit correlation with other assets (X) in the portfolio

where i is the category indicator.

Volatility of a Category and Credit Correlation with Local Government Debt

The credit volatility of a category (σ_i) and its credit correlation with local government debt ($\rho_{i,M}$) will be obtained, respectively, by averaging the volatilities and credit correlations calculated for each bond representative of that category.

We will assume that a representative bond's snapshot return is defined by the sum of two random variables, one related to price fluctuations stemming from local interest rate movements and the other related to price fluctuations caused by changes in the issuer's credit rating. Thus,

$$R = H + C$$

where R is the bond's snapshot return, H is the return due to the market rate fluctuations of a local government bond with similar duration, and C is the return due to the credit component that the market assigns to this issue.

Taking into account how the representative bond's price changes are broken down above, the volatility of the return will be:

$$\sigma_R^2 = \sigma_C^2 + \sigma_H^2 + 2\rho_{C,H}\sigma_C\sigma_H$$

where

- σ_R is the volatility of the bond's snapshot return, calculated from the bond's historical price series for a specified period.

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- σ_H is the volatility of a local government debt instrument whose duration today is the closest possible to the duration of the representative bond during the period specified. It will be calculated from the risk-free instrument's historical price series for the same period.
- $\rho_{c,H}$ is the credit correlation between the representative bond and the market.
- σ_c is the credit volatility of the representative bond. It will be calculated from the previous correlation.

To determine the credit volatility of the representative bond and its credit correlation with the risk-free instrument, we will use the following formulas (see p. 284 in the section on volatility of a category and credit correlation with the market):

$$\sigma_C = \sqrt{\sigma_R^2 + \sigma_H^2 - 2\rho_{H,R}\sigma_R\sigma_H}$$

$$\rho_{C,H} = \frac{\sigma_R\rho_{H,R} - \sigma_H}{\sigma_C}$$

Credit Correlation Between Categories

We will calculate the credit correlation for each pair of bonds representative of categories *i* and *k* (other than the government debt category) by means of the following formula:

$$\rho_{C,D} = \frac{\sigma_R\sigma_S\rho_{R,S} - \sigma_H\sigma_V\rho_{H,V} - \sigma_C\sigma_V\rho_{C,H} - \sigma_D\sigma_H\rho_{D,V}}{\sigma_C\sigma_D}$$

As discussed above, the correlation between government bonds ($\rho_{H\text{-}V}$) will be considered unique and independent of the duration.

The credit correlation ($\rho_{i,k}$) between categories i and k will be the average of the credit correlations ($\rho_{C,D}$) calculated for each pair of representative bonds ($\rho_{C,D}$) between categories.

Credit Correlation Between One Category and Other Instruments in the Portfolio

Assume an instrument Y (other than local government debt). Its credit correlation with category *i* will be calculated as follows:

$$\rho_{Y,C} = \frac{\sigma_Y\sigma_R\rho_{Y,R} - \sigma_Y\sigma_H\rho_{Y,H}}{\sigma_Y\sigma_C} = \frac{\sigma_R}{\sigma_C}\rho_{Y,R} - \frac{\sigma_H}{\sigma_C}\rho_{Y,H}$$

As discussed above, the correlation ($\rho_{i,Y}$) between the return on Y and the local government debt will be equal to the correlation existing between *Y* and the government debt instrument used as benchmark.

To avoid cumbersome calculations, the procedure will be applied only to one asset representative of the category. Thus, the credit correlation ($\rho_{i,Y}$) between category *i* and instrument *Y* will be equal to the credit correlation ($\rho_{Y,C}$) between the selected asset belonging to category *C* and instrument *Y*.

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Correlation Between Government Bonds and Other Categories

For every other asset category,[33] we will calculate the cross-correlations between all liquid government bonds and the instruments representative of that category.

We will assume that the correlation between any government bond (whether it is liquid or illiquid) and an instrument belonging to another category is unique and equal to the average of the previously calculated correlations.

Risk Parameters for Individual Bonds

Each bond in the portfolio will be assigned to one of the categories and will also be assigned the credit volatilities and correlations determined for that category. To complete the required parameters, we will calculate the volatility associated with a local government debt instrument with similar duration.

We will calculate the snapshot return of a bond belonging to category i as follows:

$$A = M + i$$

where

- A is the snapshot return of the bond
- M is the contribution explained by a government debt instrument with similar duration
- i is the credit contribution due to its inclusion in category i

We will assume that the bond has the same credit parameters as category i and the same market parameters as the local government debt instrument with similar duration.

After defining the two components of the bond's return, its volatility will be determined as:

$$\sigma_A^2 = \sigma_i^2 + \sigma_M^2 + 2\rho_{i,M} \bullet \sigma_i \bullet \sigma_M$$

The total correlation ($\rho_{A,B}$) between two bonds A and B (other than government debt), taking into account both credit and interest rate related factors, will be:

$$\rho_{A,B} = \frac{\sigma_i\sigma_k\rho_{i,k} + \sigma_i\sigma_N\rho_{i,N} + \sigma_k\sigma_M\rho_{k,M} + \sigma_M\sigma_N\rho_{M,N}}{\sigma_A\sigma_B}$$

As discussed above, the correlation between government debt instruments ($\rho_{M,N}$) is unique and independent of the duration.

The total correlation ($\rho_{A,X}$) between bond A and instrument X, taking into account both credit and interest rate related factors, will be:

$$\rho_{A,X} = \frac{\sigma_X\sigma_M\rho_{X,M} + \sigma_i\sigma_X\rho_{i,X}}{\sigma_A\sigma_X}$$

The correlation ($\rho_{X,M}$) between the yields of X and the government debt issue will be equal to the unique correlation calculated for that government debt issue and for the category to which X belongs.

[33] Defined as government debt of other countries, fixed-income instruments of that country or another country with a specified rating and, in general, any other category of securities whether or not they are debt instruments.

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Issues Denominated in US$

The procedure to calculate risk parameters for these assets is identical to the one used for high-yield bonds. Additional categories are created to cover emerging market bonds denominated in US$, using the credit rating as a segmentation criterion and the US Treasury bond of similar duration as the risk-free instrument.

For all purposes, these categories will behave exactly like the categories defined for high-yield bonds, except that the industry factor will be replaced by the country of issue. Please see that section (p. 281) for an explanation of the calculations involved.

ILLIQUID MARKETS: EQUITIES

In the market there can be equities as well as bonds that are not traded frequently or whose trading volume is not significant. The price data for these securities can be insufficient or unreliable, forcing us to use other mechanisms to estimate the associated risk parameters. We will apply an analysis similar to the one used for bonds, breaking down the risk into its components. We will select representative stocks and divide the market into categories. Illiquid stocks will be assigned to a category and take on the representative characteristics of that category.

To analyze illiquid equities, we will use the capital asset pricing model[34] where the volatility of a stock is a function of the market volatility and of the β and correlation coefficients between the stock and the market. These last two coefficients can be hard to value for illiquid equities with low trading volumes, although this does not mean that there is no risk associated with them. To estimate the coefficients, we will use the capital asset pricing model. The stock's volatility will be a function of its β coefficient, of the volatility of the market where it is traded and of the volatility of its specific component

$$\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\epsilon_i}^2$$

We will then value the systemic and specific risk components of the illiquid stock. This approach is similar to the one used for illiquid bonds, where the return was broken down into two components, the level of market rates and the credit spread. For bonds, neither component is independent (they are correlated); however, in the capital asset pricing model the systemic and specific variables show zero correlation.

To determine the risk parameters of illiquid equities, we will use an approach similar to the one used for bonds and classify the stocks into categories.

Defining Categories

To analyze the behavior of an illiquid stock, we will use the following assumption: the same industry stocks traded in the same market will be subject to similar business risk. Therefore, each market will be divided into categories by industry: construction, banking, utilities, etc.

[34] Appendix IV (p. 324) develops this methodology to determine an asset's risk parameters. This is not the only model developed in the market; there are generalizations such as the valuation by Arbitrage Portfolio Theory, in which the instrument's risk is broken down on the basis of other risk factors. However we will use this model because it is generally used and it is similar to the approach used for bonds in that it breaks down the yield into a market effect (systemic) and a credit effect (specific).

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Risk Parameters of a Stock

According to the above assumption, companies in the same industry will be subject to similar business risk. Thus, the goal is to determine which variables will represent this risk. If we take the major balance sheet items of any company, assets, liabilities (debt) and equity, and calculate the market value for each, it should follow that

$$assets = liabilities + equity$$
$$A = D + E$$

For a given asset structure (whatever is required to operate the company) there can be several capital structures, in other words, different permutations of debt and equity. Since all companies in the same industry do not necessarily have the same capital structure, not all stockholders are exposed to the same risks. The objective is to differentiate these effects and select the risk measurements common to all businesses.

Calculating the returns of both terms of the equation, we obtain:

$$\left.\begin{aligned}\omega_D &= \frac{D}{D+E}\\ \omega_E &= \frac{E}{D+E}\end{aligned}\right\} \Rightarrow r_A = \omega_D r_D + \omega_E r_E$$

Where r_A, r_D and r_E are, respectively, the returns associated with the assets, the debt and the equity. Irrespective of their capital structure, all companies in the same industry will have similar asset structures since they work in the same business. Thus, we will assume that all the asset structures in a specified industry have similar risk parameters, and we will define these parameters as the assets' volatility and β:

$$\beta_A = \omega_D \beta_D + \omega_E \beta_E$$
$$\sigma_A^2 = \omega_D^2 \sigma_D^2 + \omega_E^2 \sigma_E^2 + 2\omega_D \omega_E \sigma_{DE}$$

If we also assume that the debt component has a very low volatility[35] and is somewhat independent of share price and market fluctuations, it will follow that:

$$\sigma_{DE} \approx \beta_D \approx \sigma_D \approx 0$$

such that

$$\left.\begin{aligned}\beta_A &= \omega_E \beta_E\\ \sigma_A &= \omega_E \sigma_E\end{aligned}\right\} \Rightarrow \begin{cases}\beta_E = \left(1 + \dfrac{D}{E}\right)\beta_A\\ \sigma_E = \left(1 + \dfrac{D}{E}\right)\sigma_A\end{cases}$$

The β and the volatility of the assets are non-leveraged since they do not depend on the capital structure but rather on the asset structure required to operate the business.

The β and the volatility of the equity capital are leveraged since they are determined from the non-leveraged factors and the capital structure. They are the factors applied to the share price.

[35] This assumption should be reconsidered for markets with very high interest rate volatility. The shorter the duration of the debt and the less volatile the interest rates, the lower are the volatility and the covariance associated with the debt.

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Risk Parameters by Category

To define the risk parameters of a category, we will assume that the correlation between a stock and the market is the same for all stocks belonging to the same category, and that the specific risk associated with the stocks is the same for all companies in the same industry.

We will choose a series of liquid stocks i that will be representative of category j, and we can calculate the non-leveraged β and volatility for these stocks using historical price series or any other procedure. Because there could be additional market information available, the leveraged volatility must be the corrected volatility of the representative stock instead of the historical volatility (0).

After performing this calculation, we will define the category's non-leveraged β and volatility as being the average of the non-leveraged betas and volatilities for all stocks.

$$\beta_j = average(\omega_{Ei} \cdot \beta_i)$$
$$\sigma_j = average(\omega_E \cdot \sigma_{i,corrected})$$

where j represents the category and i each of the associated representative stocks.

Correlations Between Same Industry Stocks

We have assumed above that same-industry stocks have similar non-leveraged betas and volatilities, but this does not mean that there is identical non-leveraged correlation between these stocks. Thus, we also need to calculate the average non-leveraged covariance.

Given two representative stocks, i and l, belonging to category j, the non-leveraged covariance between them will be

$$\text{cov}(r_{A_i}, r_{A_l}) = w_{E_i} w_{E_l} \sigma_{i,l}$$

If we calculate all the pairs of non-leveraged covariances between representative stocks belonging to the same category and average them, we will obtain the average non-leveraged covariance for the category. By a similar method, we calculate the non-leveraged correlation coefficient for the industry:

$$\rho_{jj} = \frac{\sigma_{jj}}{\sigma_j^2}$$

where ρ_{jj} is the non-leveraged correlation, σ_{jj} is the average non-leveraged covariance and σ_j is the average non-leveraged volatility associated with category j. Under this approach, ρ_{jj} can have values other than 1.

Thus, the leveraged correlation coefficient between two stocks, u and v, belonging to the same category j, equals

$$\rho_{u,v} = \frac{\sigma_{u,v}}{\sigma_u \sigma_v} = \frac{\omega_u \omega_v \sigma_{jj}}{\omega_u \omega_v \sigma_j^2} = \rho_{jj}$$

The correlation coefficient between two stocks belonging to the same category will be the non-leveraged correlation coefficient for that category.

Risk Parameters between Categories

Since the portfolio contains securities belonging to different categories, we must calculate the average non-leveraged covariance between industries. To do so, we calculate the non-leveraged

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covariance for each pair of representative stocks in each category, as indicated above, and then average them.

We will perform these calculations between all the industries where we hold positions, whether or not they belong to the same market.

Risk Parameters of an Illiquid Stock

An illiquid stock belonging to category j will be assigned the non-leveraged risk parameters associated with that category. These will then be leveraged to obtain the parameters pertaining to the stock's capital structure.

To calculate the β and the volatility of an illiquid stock belonging to category j, we will take the non-leveraged β and volatility of the category and leverage them through the illiquid stock's capital structure:

$$\beta_i = \left(1 + \frac{D_i}{E_i}\right) \bullet \beta_j$$

$$\sigma_i = \left(1 + \frac{D_i}{E_i}\right) \bullet \sigma_j$$

In the case of correlations between stocks belonging to different categories, the correlation between a stock i belonging to category j and another stock l belonging to category k will be equal to the non-leveraged correlation between categories j and k.

$$\rho_{i,l} = \frac{\omega_i \omega_l \sigma_{j,k}}{\omega_j \omega_l \sigma_j \sigma_k} = \rho_{j,k}$$

Simplifying Assumptions

While it is difficult to estimate representative β values, it is even harder to use the capital structures specific to each company. Thus, we propose the following assumptions in order to simplify the above calculations. If the capital structures of each company under analysis cannot be used, it will be assumed that all the companies in the same industry operate under similar financing conditions, so that it will be irrelevant to deleverage and leverage again and it will suffice to consider directly the volatilities and betas of the equity capital.

If a stock i cannot be assigned to any category, it will be assumed to behave like the market, and thus the β and the correlation coefficient will be assumed to equal 1.

Appendices

APPENDIX 1: FIXED-INCOME INSTRUMENTS

Fixed-income instruments are all those that explicitly (bonds) or implicitly (notes) generate a yield that is known at the time the instrument is purchased.

The key feature of these instruments is the existence of a payment timetable known in advance.

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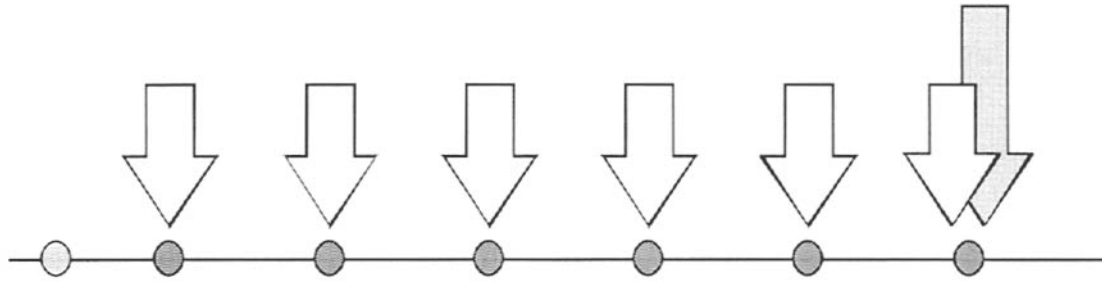
Figure 10-16. Explicit Cash Flow Structure of a Bond



From a risk management viewpoint, our final goal is to apply the risk/return measurements defined above.

To do so, it is important to analyze the following concepts:

- Price: How the price of the instrument is determined, which depends on the interest rate structure existing in the market;
- Sensitivity: How the price changes when interest rates move (duration and convexity);
- Exposure: The maximum unfavorable movement that can occur for a specified confidence level, such that the potential losses associated with a position in the instrument can be calculated.

Below we discuss these concepts in further detail.

Price

The instrument's price[36] or market value must be equal to the sum of the present values of all the future flows pending collection. The present value of a future flow at point in time T is calculated as:

$$present\ value_T = flow_T \cdot discount\ factor_T$$
$$present\ value_{bond} = \Sigma(flow_T \cdot discount\ factor_T)$$

where the discount factor depends on the interest rates prevailing for the term that ends at point in time T. Generally, interest rates will be stated as annual compound rates such that:

$$DF_T = \frac{1}{(1+rate)^T}$$

Internal Rate of Return

We saw in the previous section that to calculate the bond price it is necessary to determine the interest rates used to discount each flow. The usual market practice is to use a single interest rate for all periods, representing an average of the actual interest rate timetable until the maturity date. The rate thus defined is called the internal rate of return (IRR), because it is the

[36] It will be assumed that the price includes at any time the accrued coupon, unlike the stock market price, which usually is stated without the coupon accrued

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rate at which all the future flows must be discounted to obtain the market price sought; it represents the yield associated with the instrument. Thus, it follows that

$$price = \sum flow_T \bullet \frac{1}{(1+IRR)^T}$$

The bond's price is a function of a single market variable, the IRR, which depends on the bond's maturity date and its risk level.[37] Bonds with similar maturities[38] and similar risk levels should have similar returns, so that the market will price IRR levels for various maturities and risks and apply the IRR to all bonds in a given category, irrespective of the actual cash flow structure.

The IRR will be considered as the market factor that determines a bond's risk. Then, the following step is to analyze the effect of the IRR's behavior on the bond price and therefore the P&L associated with a position in that bond.

Example

Let's assume a position in a bond maturing on December 31, 2007, paying a US$60,000 (6%) coupon every December 31 to maturity, with principal (US$1 million) repaid on the maturity date. What would be the market value of this position?

As discussed above, the bond's value will depend on the market IRR associated with that maturity date and the bond's related risk level. Assume that the IRR is 6.5%. Below we show the bond's payment structure and the respective present values for each date, calculating the discount factor (DF) with the 6.5% IRR:

Bond Valuation

Date	Flow (US$)	Years	DF (%)	Present value (US$)
31/12/98	60,000	0.94795	94	56,523
31/12/99	60,000	1.94795	88	53,073
31/12/00	60,000	2.95068	83	49,825
31/12/01	60,000	3.95068	78	46,784
31/12/02	60,000	4.95068	73	43,929
31/12/03	60,000	5.95068	69	41,248
31/12/04	60,000	6.95342	65	38,724
31/12/05	60,000	7,.95342	61	36,360
31/12/06	60,000	8.95342	57	34,141
31/12/07	1,060,000	9.95342	53	566,348

[37] The risk level associated with the bond is given by the issuer's credit rating, the liquidity and trading volume and the bond's specific features.

[38] This statement actually applies to bonds with similar duration, but for explanatory purposes, since this concept has not yet been introduced, the bond's maturity will be considered.

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By adding all the values in the present value column, we will obtain a market value of US$ 966,957.

Repeating the procedure for other IRR values, we will obtain the results shown in Figure 10-17 and in the related table.

We note that when the IRR increases the bond price decreases and vice versa.

Sensitivity

The bond's behavior will be the same whether the position is large or small. Thus we will analyze its sensitivity to fluctuations in the market IRR that corresponds to the bond's maturity and risk level. Using the results of the previous example, we will obtain the graph shown in Figure 10-18.

We can see that, as the IRR changes by small amounts, the return's behavior is linear. As the return moves away from the central point, its behavior becomes nonlinear by a positive amount that is almost symmetrical, such that it can be approximated as:

$$y = ax + bx^2$$

Behavior of IRR vs. Price

IRR (%)	Value (US$)
0	1,600.000
1	1,474,261
2	1,360,582
3	1,257,672
4	1,164,389
5	1,079,724
6	1,002,782
7	932,772
8	868,989
9	810,807
10	757,669
11	709,079
12	664,593
13	623,818
14	586,398
15	552,017
16	520,391
20	416,723
25	325,127
30	261,378
40	182,410

Figura 10-17. Price Behavior as a Function of the IRR

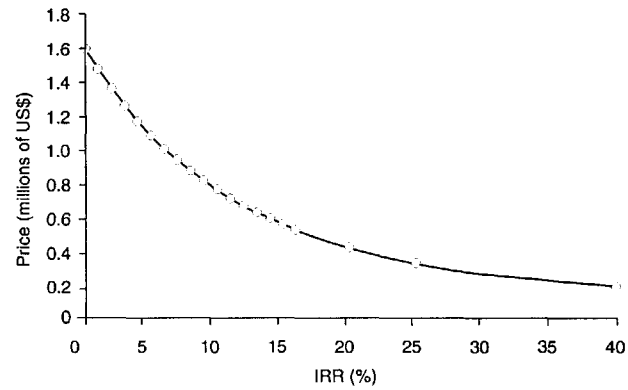

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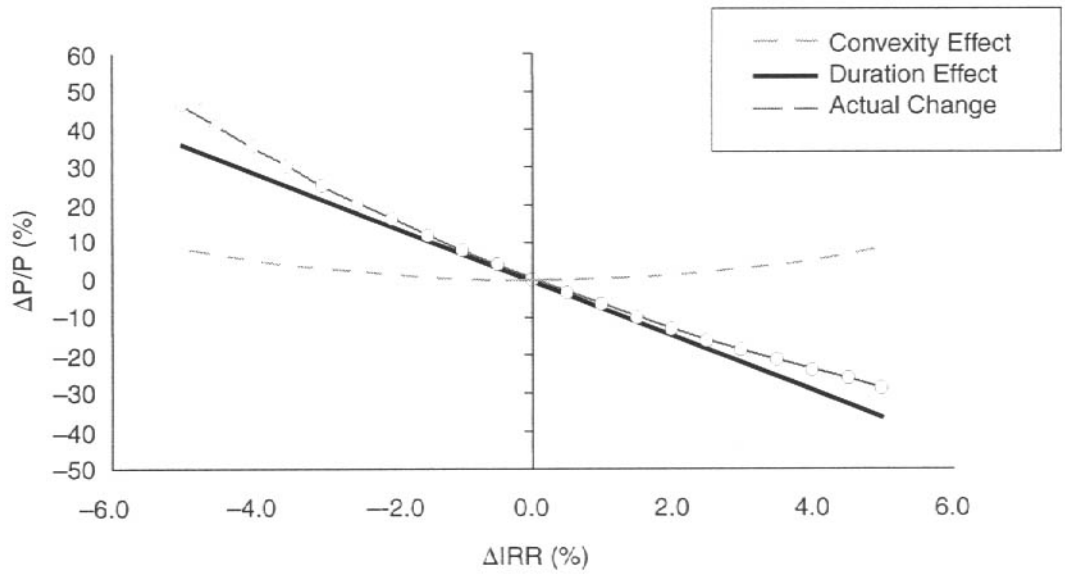
Figure 10-18. Behavior of the Snapshot Return



where y is the relative price variation, and x the IRR variation. Thus, as a first approximation, the relative price variation can be stated as:

$$\frac{\Delta P}{P} \approx -MD \bullet \Delta IRR + \frac{1}{2} \bullet C \bullet \Delta IRR^2$$

where MD is the bond's modified duration and C the convexity, both values being positive.[39]

Modified Duration

The duration of a bond is defined as the weighted average of the present values of each flow where the weight coefficients are the time in years until the payment of the related flow. The present values are stated as a ratio with respect to the bond's total market value. Or,

$$duration = \sum t_i \bullet \frac{PV_i}{PV}$$

where t_i are the years until flow i, PV_i is the present value of flow i discounted using the bond's

[39] According to infinite calculation, MD is calculated as the quotient, with an inverse sign, of the first derivative of the price relative to the IRR and the price itself, and C as the quotient of the second derivative of the price relative to the IRR and the price itself. This can be written as:

$$\frac{\Delta P}{P} = \frac{1}{P} \cdot \frac{dP}{dIRR} \cdot \Delta IRR + \frac{1}{2} \cdot \frac{1}{P} \cdot \frac{d^2P}{dIRR^2} \cdot \Delta IRR^2 + O(\Delta IRR^3)$$

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IRR and *PV* is the bond's present value. From this the modified duration will be defined as the duration divided by 1 plus the IRR of the bond:[40]

$$MD = \frac{duration}{1 + IRR}$$

Convexity

A bond's convexity is defined as:[41]

$$convexity = \frac{1}{(1+IRR)^2} \sum t_i \bullet (t_i + 1) \bullet \frac{PV_{t_i}}{PV}$$

which represents, as in the case of the duration, the weighted average of the present values of each flow. The weight coefficient is the time squared.

Example

Referring back to the previous example, to calculate the modified duration and the convexity given a 6.5% IRR, we will add the factors shown in the following table and obtain a modified duration of 7.24 years and a convexity of 67.859.

Modified Duration and Convexity

Years	Modified Duration (Years)	Convexity
0.95	0.05	0.095
1.95	0.10	0.278
2.95	0.14	0.530
3.95	0.18	0.834
4.95	0.21	1.180
5.95	0.24	1.556
6.95	0.26	1.953
7.95	0.28	2.361
8.95	0.30	2.774
9.95	5.47	56.299
Total	*7.24*	*67.859*

[40] Substituting the present value formula for each flow, the modified duration equals:

$$MD = \frac{duration}{1+IRR} = \frac{1}{1+IRR} \cdot \sum t_i \cdot \frac{PV_i}{PV} = \frac{1}{PV} \sum \left(flow_i \cdot \frac{t_i}{(1+IRR)^{t_i+1}} \right) = -\frac{1}{PV} \cdot \frac{dPV}{dIRR}$$

It is important to note that the proper way to calculate the modified duration is to obtain the first derivative directly. This is because market IRRs depend on the way the number of years between two dates are defined and the way that interest is calculated (simple, compound, continuous) and this will influence the formula related to the discount factor. If the IRR were stated as a linear rate, the above formulas would not be valid as they assume an IRR stated on a compound basis.

[41] As with duration, the proper way to calculate a bond's convexity is to find the quotient between the second derivative of the price relative to the IRR and the price:

$$convexity = \frac{1}{P} \cdot \frac{d^2P}{dIRR^2}$$

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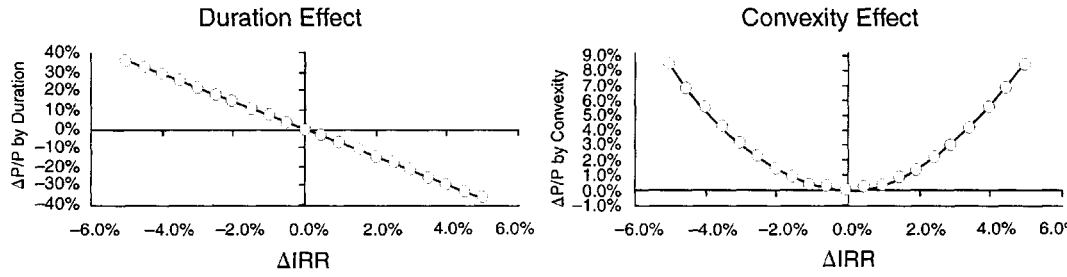
After performing these calculations, we will approximate the variation in the bond's relative value by an analytical equation that is a function of the modified duration and the convexity. Thus,

$$\frac{\Delta P}{P} \approx -7.237 \bullet \Delta IRR + \frac{1}{2} \bullet 67.859 \bullet \Delta IRR^2$$

The effect of each term is shown in Figure 10-19.

Figure 10-19 Duration and Convexity Errors

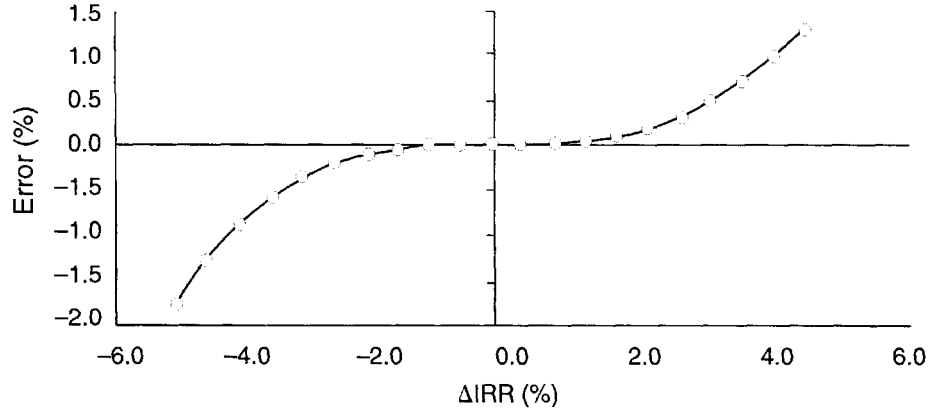


If we also solve for the approximation error, defined as the difference between the variation obtained by means of the approximated formula and the variation obtained by repricing the bond, we get:

$$Error = \frac{\Delta P_{approx.}}{P} - \frac{\Delta P_{real}}{P}$$

We can see in Figure 10-20 that the approximation adequately represents the price behavior for small variations in the IRR value. The convexity effect can be neglected, leaving only the linear component (duration effect).

Figure 10-20. Approximation Error



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Risk Measurements

Up to now we have analyzed only the variables that affect the bond's price and its sensitivity to variations in the variables. But not all possible variations are equally probable, which means that the next step is to obtain a probability distribution profile associated with the variation in the bond's price as a function of the profile of the defining variable. For bonds this variable is the IRR, so we will model its behavior and then apply the behavior to the formula to determine the price variation.

Bond Price Behavior

To determine which method to use in analyzing bond price variations, we must consider the desired time horizon for the calculation. Since bonds have a predetermined maturity, the variables that define their behavior change over time. Thus, the market factor determining the risk for a 5-year bond is the 5-year market IRR, while a year later the term-to-maturity is 4 years and the IRR used is the 4-year IRR.

The value of the bond on the maturity date is known and is equal to the last payment. Therefore, irrespective of its current value, the bond will tend towards its value at maturity, thus reducing the price volatility over time.

Logically, these two effects are important when we are analyzing portfolio trends over a long time horizon, but are less so when the time horizon is short, as in this case. For short horizons, these effects are annualized without taking into account the actual portfolio composition but instead by keeping the risk level constant.

Below we discuss a general approach to dealing with this type of instrument.

Decomposition of a Bond

A position in a bond can be broken down into a purchase transaction with a resale agreement on the end date of the time horizon being considered (simultaneous transaction) plus a forward purchase of the bond on the same date and for the same amount as the resale agreement:[42]

- Purchase of a simultaneous transaction expiring on the same date as the time horizon
- Forward purchase of the bond with settlement date on the expiration date of the simultaneous transaction

In this way, at the end of the period we will still have the same position with the same cash inflows and outflows as if we had held the initial position throughout the period. Figure 10-21 shows that the horizon lies after a coupon payment, which therefore is not lost since it is received in the simultaneous transaction.

The price variation associated with this position over the time horizon considered will be broken down into the price variation of the simultaneous transaction plus the price variation of the forward purchase.

$$\Delta value = \Delta value_{simultaneous} + \Delta value_{future}$$

[42] If the resale price were not equal to the agreed upon forward price, a risk-free arbitrage would be possible. The resale price, or purchase price of the forward transaction, will be determined by the conditions prevailing in the market. See the annex on the forward price of a bond (p. 308).

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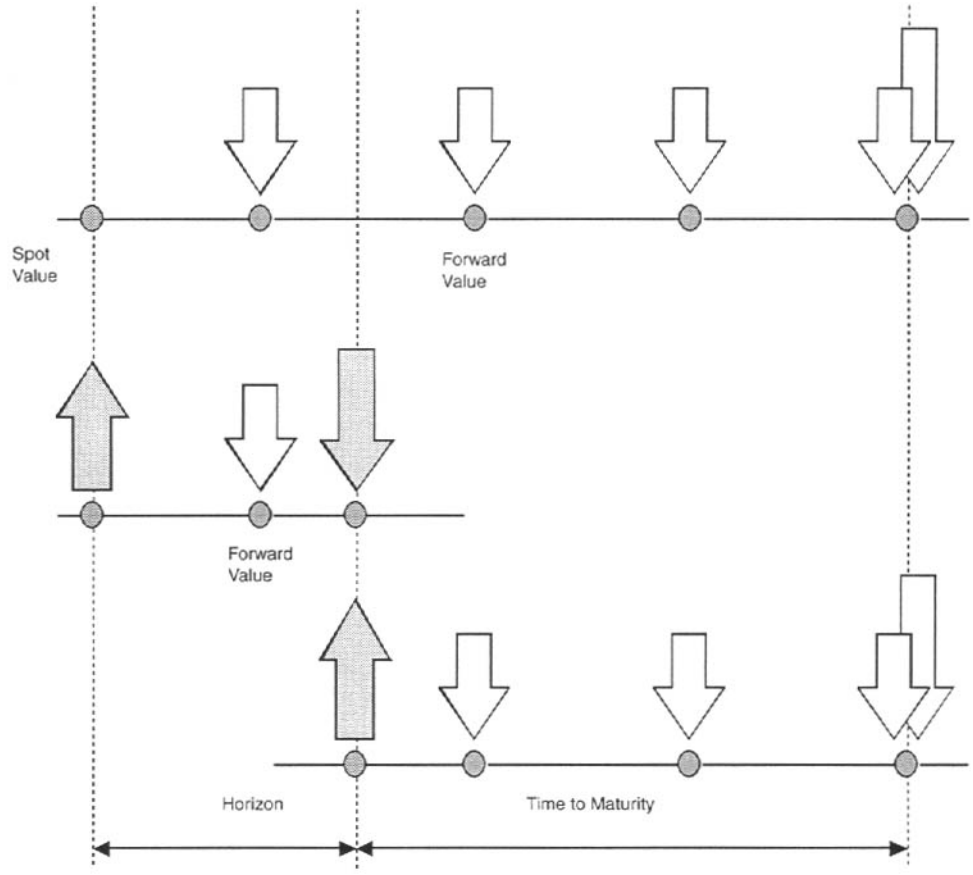
Figure 10-21. Decomposition of a Bond into a Spot and a Forward Transaction



The price variation associated with the simultaneous transaction is equal to the resale value minus the initial value plus any coupons received[43]

$$\Delta value_{simultaneous} = resale\ value + coupons - initial\ value$$

while the price variation due to the forward transaction is equal to the difference between the agreed-upon value of the forward purchase (equal to the resale value of the simultaneous transaction) and the market value at the end of the period:

$$\Delta value_{future} = final\ value - resale\ value$$

such that the total transaction value will be

$$\Delta value = finale\ value + coupons - initial\ value$$

which will be the same as the variation in value associated with the purchase of the bond and with holding it during the period. If this is so, why perform the decomposition? With the variation in value associated with the simultaneous transaction known in advance, the entire volatility component resides in the forward transaction.

[43] If it is assumed that these coupons are reinvested until the end of the simultaneous transaction, the interest generated must also be taken into account.

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The forward transaction also avoids the problems that the passage of time introduces in the analysis of a bond with a predefined maturity, since the bond being purchased in the forward transaction will have exactly the same features at the beginning and at the end of the period, and its behavior will be a function of the fluctuations of the IRR that corresponds to a period equal to the bond's term to maturity.

Modeling the Variation in Value of a Forward Transaction

As discussed above, we will model the IRR associated with the bond's term to maturity. If there are 3 years left from the end of the defined time horizon to the bond's maturity, this is the period we will consider.

To model the IRR's behavior, we will assume that it follows normal trends. If we combine the model with the approximation to analyze bond sensitivities, it follows that[44] the variation in value associated with the forward transaction (the volatility) would also behave according to a normal distribution function equal to the product of the residual bond's modified duration and the volatility of the associated IRR.

$$\sigma_{price} = MD \cdot \sigma_{IRR}$$

We can see that convexity is not associated with price volatility, and the CAR calculation is not affected. Although the convexity effect becomes more significant for large IRR variations, the probability of these movements is very low so that one effect offsets the other.

Example

We will use the same data as in the previous example (p. 302) and will assume that the IRR volatility is 1%. Since the modified duration equals 7.24 years, it follows that:

$$\sigma_{price} = 7.24\%$$

We will then comparatively derive the yield probability distribution by basing the IRR distribution on a normal distribution with volatility equal to σ_{price}. We will reprice the bond for a series of IRR variations around the market IRR (6.5%), and then compare the cumulative probability (normal with 0 mean and 1% volatility) of the IRR associated with each price to the price's cumulative probability for a normal distribution with 0 mean and 7.24% volatility. The results are shown in the following table.

If we represent graphically the two cumulative probabilities vs. the relative price variation, we obtain Figure 10-22.

Calculation of the Historical Volatility of the IRR

As discussed above, we assume that the IRR behaves according to a normal distribution. Thus, to determine its volatility from the historical series we will proceed as for the calculation of the

[44] Further details are given in the annex (p. 309).

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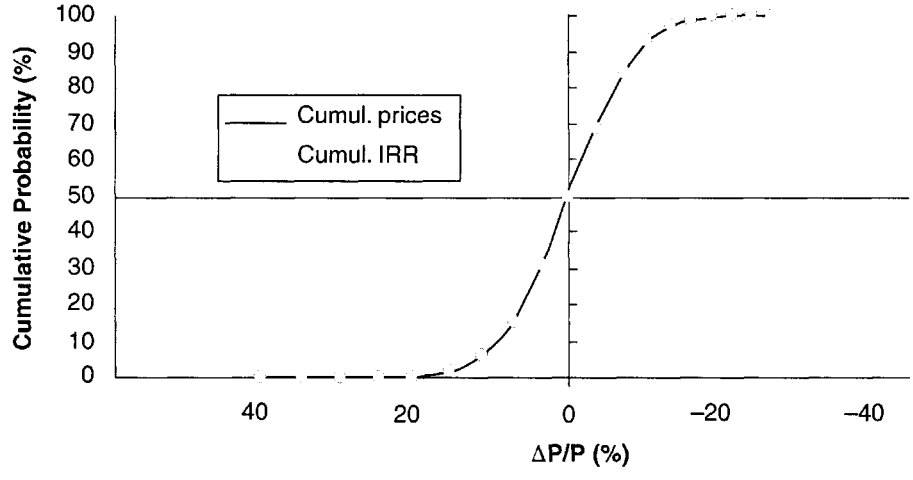
Probability Distribution						
	Cumulative Probability (%) (IRR)	ΔIRR (%)	IRR (%)	Price (US$)	ΔP/P (%)	Cumulative Probability (price)
$-4.5\cdot\sigma$	0.00	−4.5	2.0	1,360,582	40.7	0.00
$-4.0\cdot\sigma$	0.00	−4.0	2.5	1,307,856	35.3	0.00
$-3.5\cdot\sigma$	0.02	−3.5	3.0	1,257,672	30.1	0.00
$-3.0\cdot\sigma$	0.13	−3.0	3.5	1,209,893	25.1	0.03
$-2.5\cdot\sigma$	0.62	−2.5	4.0	1,164,389	20.4	0.24
$-2.0\cdot\sigma$	2.28	−2.0	4.5	1,121,038	15.9	1.38
$-1.5\cdot\sigma$	6.68	−1.5	5.0	1,079,724	11.7	5.35
$-1.0\cdot\sigma$	15.87	−1.0	5.5	1,040,339	7.6	14.72
$-0.5\cdot\sigma$	30.85	−0.5	6.0	1,002,782	3.7	30.43
$0.0\cdot\sigma$	50.00	0.0	6.5	966,957	0.0	50.00
$0.5\cdot\sigma$	69.15	0.5	7.0	932,772	−3.5	68.74
$1.0\cdot\sigma$	84.13	1.0	7.5	900,143	−6.9	83.01
$1.5\cdot\sigma$	93.32	1.5	8.0	868,989	−10.1	91.92
$2.0\cdot\sigma$	97.72	2.0	8.5	839,234	−13.2	96.60
$2.5\cdot\sigma$	99.38	2.5	9.0	810,807	−16.1	98.72
$3.0\cdot\sigma$	99.87	3.0	9.5	783,639	−19.0	99.56
$3.5\cdot\sigma$	99.98	3.5	10.0	757,669	−21.6	99.86
$4.0\cdot\sigma$	100.00	4.0	10.5	732,834	−24.2	99.96
$4.5\cdot\sigma$	100.00	4.5	11.0	709,079	−26.7	99.99

Figure 10-22. Probability Distribution of the Current Yield vs. Probability Distribution of the IRR Variation



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volatility of a price series, except that the variable used to calculate the typical deviation will be the arithmetic difference between IRR values for two consecutive data points:

$$u_i = IRR_i - IRR_{i-1}$$

We should note that the historical series to be analyzed is not the historical IRR of the bond under consideration, because the bond's features vary over time and the IRRs obtained are not homogeneous. If the bond has a 3-year maturity, we will take the historical series of a 3-year IRR for the same risk level. For each past point in time we will calculate the IRR value for a 3-year bond that at that time had the same risk level as the current bond. This market information is usually available and does not have to be generated again.

Daily Capital-at-Risk

The above arguments have been developed under a generic time horizon. However, the risk measurements defined in this document are performed daily. For this reason we can simplify and say that the CAR associated with a bond is

$$CAR \approx \frac{V_o \bullet k \bullet \sigma}{1 + z_{RF} \bullet T_{daily}}$$

where k will depend on the desired confidence interval (3 for a 99.87% interval) and σ will be the daily price volatility, which is stated as

$$\sigma = \frac{MD \bullet \sigma_{IRR}}{\sqrt{250}}$$

where V_0 and MD are the market value and the modified duration associated with a spot position in the bond under consideration. The IRR volatility used will correspond to the maturity associated with the bond of the same risk level.

Example

Assume that the IRR used as reference in the previous example has 1% annual volatility. We have seen that for a 6.5% IRR the bond's market value is US$ 966,957 and the modified duration is 7.237 years. Therefore, the annual price volatility will be

$$\sigma_{price} = 7.24\%$$

Assuming a 5.5% risk-free rate and applying the daily CAR formula at a 99.87% confidence interval, it follows that

$$CAR_{daily} = \frac{966{,}957 \bullet 3 \bullet \frac{7.24\%}{\sqrt{250}}}{1.00015} = US\$13{,}276$$

Risk Factors

In the previous sections we have discussed fixed-income instruments in general, disregarding their risk level, and assumed that each bond's internal rate of return is a function of its specific

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features: issuer, maturity, coupon, liquidity, etc. However, the usual market practice is not to analyze a bond by itself but to relate it to the market instrument with the highest credit rating, which is normally the debt issued by the Treasury. This benchmark instrument sets general interest rate levels, and the bond under consideration is assigned a spread or risk premium on the basis of its specific features, which include liquidity and trading volume.

Therefore the IRR of a bond will be determined as:

$$IRR = IRR_{ref} + spread$$

where the IRR_{ref} corresponds to a benchmark market instrument having a duration similar to the bond under consideration.

In this way, we isolate two effects. The first term represents the behavior of the financial system (systemic risk) and the second is subject only to the bond's specific features (specific risk). Assuming that these two effects move independently of each other, the relative variation of the bond price is given in general[45] by the contribution of each factor:

$$\frac{\Delta P}{P} = -\left[D_{ref} \bullet \Delta IRR_{ref} + D_{spread} \bullet \Delta spread\right]$$

where D_{ref} and D_{spread} are the price sensitivities to variations in the benchmark rates and the spread, respectively.

In a fixed-coupon bond, however, a variation in the benchmark rates has the same contribution as a similar variation in the spread. Therefore:

$$\frac{\Delta P}{P} = -D_{IRR} \bullet \left(\Delta IRR_{ref} + \Delta spread\right)$$

where D_{IRR} is the bond's modified duration as we saw above (p. 302).

As these factors do not move independently, we will have to determine the bond's exposure by calculating its volatility from the volatilities and correlations of the benchmark rates and the spread.

$$\sigma^2_{price} = D^2_{ref} \bullet \sigma^2_{ref} + D^2_{spread} \bullet \sigma^2_{spread} + 2 \bullet \rho \bullet D_{ref} \bullet D_{spread} \bullet \sigma_{ref} \bullet \sigma_{spread}$$

Taking into account that:

$$\sigma^2_{IRR} = \sigma^2_{ref} + \sigma^2_{spread} + 2 \bullet \rho \bullet \sigma_{ref} \bullet \sigma_{spread}$$

For a fixed-coupon bond the following equation will be satisfied:

$$D_{ref} = D_{dif} \Rightarrow \sigma^2_{price} = D^2_{IRR} \bullet \sigma^2_{IRR}$$

Annexes

Forward Price of a Bond

In calculating the forward price of a bond, no arbitrage should be possible. We will use the simultaneous transaction concept.

[45] We have kept the general equation for the sensitivity of a coupon-paying bond, because if the coupons are variable, the contribution of the benchmark interest rate will be different from the spread. The appendix (p. 321) analyzes this in further detail.

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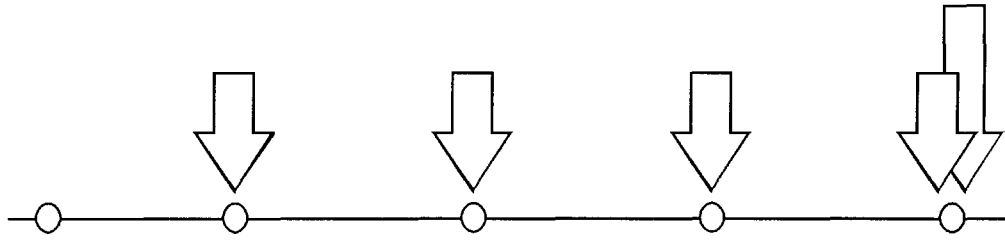
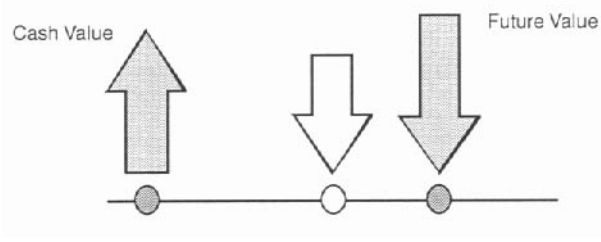
A simultaneous transaction (Figure 10-23) is a transaction in which one party buys an asset from the other party at the market price and commits to sell it back at a future time at a price agreed upon at the beginning of the transaction. This transaction is similar to a time deposit but with two particularities:

- If the instrument used as reference pays any cash flows, they will go to the buyer of the simultaneous transaction.
- If the amount invested plus interest is not returned, the instrument serves as collateral for the transaction.

This feature causes the transaction's yield to be similar to market yields for the time interval between the purchase and the sale. The existence of collateral reduces the yield obtained because it reduces the transaction's credit risk.

Figure 10-23. Simultaneous Transaction





Once the repurchase price has been determined, we will calculate the repo rate (implicit interest rate for the transaction) such that the present value of all the future flows equals the amount invested.

Thus, it follows that:

$$cash\ value = \frac{coupon}{1 + repo \bullet t_{coupon}} + \frac{forward\ value}{1 + repo \bullet t_{final}}$$

If there were more coupon payments during the period, we would just add more terms with their present values. The most frequent case, however, is that there are no coupon payments. The usual market practice is to state rates linearly but to calculate the IRR on a compound basis.

Modeling the Forward Price of a Bond

We saw in the section on bond sensitivity that the bond's relative price variation can be calculated by using the following formula:

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$$\frac{dP}{P} = MD \bullet dIRR + \frac{1}{2} \bullet C \bullet dIRR^2$$

after which the IRR's behavior needs to be modeled. To do so, we will assume that it exhibits Brownian motion with a mean μ and a standard deviation σ_{IRR} such that:

$$dIRR = \mu \bullet dt + \sigma_{IRR} \bullet \varepsilon \bullet \sqrt{dt}$$

where ε is a normally distributed random variable with mean 0 and standard deviation 1. Combining both formulas, we get:

$$\frac{dP}{P} = -MD\left(\mu \bullet dt + \sigma_{IRR} \bullet \varepsilon \bullet \sqrt{dt}\right) + \frac{1}{2} \bullet C \bullet \left(\mu^2 \bullet dt^2 + \sigma_{IRR}^2 \bullet \varepsilon^2 \bullet dt + 2 \bullet \mu \bullet \sigma_{IRR} \bullet \varepsilon \bullet dt^{\frac{3}{2}}\right)$$

Disregarding any terms larger than dt and recognizing that when dt tends toward zero the variable $\varepsilon^2 \bullet dt$ tends to be non-stocastic (its variance is on the order of dt^2), it follows that:[46]

$$\frac{dP}{P} = \left(-MD \bullet \mu + \frac{1}{2} \bullet C \bullet \sigma_{IRR}^2\right) dt + MD \bullet \sigma_{IRR} \bullet \varepsilon \bullet \sqrt{dt}$$

such that the bond price will behave lognormally with a volatility equal to:

$$\sigma_{price} = MD \bullet \sigma_{IRR}$$

From then on the same risk-return measurements used for any other asset will be applied.

APPENDIX II: BRADY BONDS

This section will generalize the conclusions discussed on page 256 and following pages. It will develop a general methodology to price guaranteed bonds and calculate the associated risk measurements. We will assume that the currency of the bonds is the US$ since most Brady bonds are indeed denominated in US$.

To simplify the calculations, we will also assume that all interest rates are stated as continuously compounding rates such that discount factors can be calculated by means of formulas such as:

$$DF = e^{-zt}$$

where z is the interest rate and t is the time stated in years.

Internal Rate of Return

Given a bond price P and a future flow structure CF_i, the continuous IRR (IRR_C) can be calculated by means of the formula

$$P = \sum \frac{CF_i}{e^{IRR_C \bullet t_i}}$$

[46] When converting from one formula to the other, the second term is subtractive but, since it behaves as a normally distributed random variable and such variables are symmetrical, it does not matter whether it is additive or subtractive.

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and it can be transformed into the compound IRR given that

$$IRR_c = \ln(1 + IRR)$$

However, this rate of return is not representative of the risk level assigned to the issuer by the market, as the existence of guarantees makes it a hybrid risk. It will thus be necessary to isolate the risk-free and issuer risk components. To do so, we will calculate only the yield and the spread associated with the issuer risk portion of the bond.

Stripped Yield and Stripped Spread

To isolate the effects of the two types of risk, the cash flows will be divided into:

- CF_i^* : flow guaranteed at time i
- CF_i : flow with issuer risk at time i

To calculate the bond price, each of these flows must be discounted at a different rate. The guaranteed flows are discounted by means of the risk-free curve in US$, while the flows with sovereign risk are discounted at local rates in US$. The related discount factors will be defined as follows:

$$DF_i^{\$} = e^{-Z_i^{\$} \cdot t_i}$$
$$DF_i = e^{-Z_i \cdot t_i}$$

where $z_i^{\$}$ is the risk-free rate in US$ associated with point in time i, z_i is the local rate in US$ associated with point in time i and corresponding to the issuer's risk level, and t_i is the time stated in years up to point in time i.

The bond price is calculated as:

$$P = \sum CF_i^* \cdot DF_i^{\$} + \sum CF_i \cdot DF_i$$

Once the risk-free curve is known, it is necessary to define the interest rates associated with the issuer's risk level to be able to complete the calculation. The interest rates will be determined by shifting the risk-free curve by a specified amount, called the stripped spread, and then obtaining the bond price.

Stripped Spread

The discount rate applied to the unsecured flows will be determined as follows:

$$Z_i = Z_i^{\$} + SS$$

where SS is the stripped spread, which is constant for all time periods. It represents the risk level that the market assigns to the issuer.

If the discount factor associated with the spread is defined as:

$$DF_i^{SS} = e^{-SS \cdot t_i}$$

it will follow that:

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$$DF_i = e^{-(Z_i^{\$}+SS)\bullet t_i} = DF_i^{\$} \bullet DF_i^{SS}$$

Once the bond price is known, we can calculate SS as the value that satisfies the following equation:

$$P = \sum CF_i^{*} \bullet DF_i^{\$} + \sum CF_i \bullet DF_i^{\$} \bullet DF_i^{SS}$$

Stripped Yield

Stripped yield is defined as the internal rate of return of the flows with issuer risk. Its present value is equal to the bond price less the present value of the risk-free flows discounted by using the zero-coupon risk-free curve (US$). Thus if we define SY as:

$$DF_i = e^{-SY\bullet t_i}$$

where SY is the stripped yield, then its value must satisfy the following equation:

$$P - \sum CF_i^{*} \bullet DF_i^{\$} + \sum CF_i \bullet DF_i$$

Bonds with Rolling Guarantee

If a Brady bond has been structured with a rolling guarantee over the coupon payments, then the methodology becomes more complex, as a coupon that initially is not covered by the guarantee can become so over time if there is no payment default. Thus, a coupon's risk level can go from country risk to risk-free depending on the point in time being considered and the probability of default.

This effect will enable us to replace the unsecured real flows with equivalent flows having pure issuer risk, as we will see below.

Equivalent Flows

A coupon may or may not be covered by a rolling guarantee depending on whether there has been a default related to the previous coupons.

Default Tree

Assume a bond with guaranteed principal and a rolling guarantee that covers the next k coupons. If we also assume that, once a bond is in default, only the secured coupons will be collected and the bond will not return to performing status, the possible paths are shown in the tree in Figure 10-24.

where

- n is the number of future payments pending collection
- d_i is the default probability during period i, which can vary over time
- B_i is the real bond associated with path i. It is made up of the real flows that would be collected if there were a default before the payment of coupon i. Since the rolling

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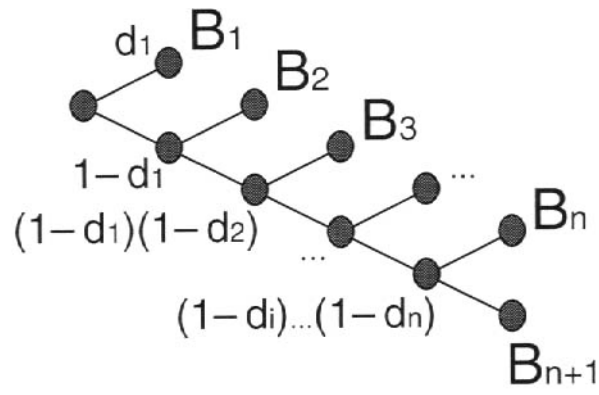
Figure 10-24. Default Tree



guarantee covers k periods, after the point in time n-k all the remaining cash flows will be guaranteed. Therefore,

$$B_i \Rightarrow \begin{cases} \{CF_1, CF_2, \ldots, CF_i, \ldots, CF_{i+k-1}, N\}, \forall i \leq (n-k) \\ \{CF_1, CF_2, \ldots, CF_n, N\}, \forall i > (n-k) \end{cases}$$

where B_{n+1} is the bond made up of all the outstanding coupons

$$B_{n+1} = \{CF_1, CF_2, \ldots, CF_n, N\}$$

Therefore, the bond price will be equal to the average of the values of all the above bonds weighted by the probability associated with their path:

$$P = \sum_{i=1}^{n+1} PV(B_i) \bullet p_i$$

where the probability of path i will be given by the following formulas:

$$p_i \Rightarrow \begin{cases} p_1 = d_1 \\ p_i = d_i \bullet \prod_{1}^{i-1} (1-d_j), \forall i \in \{2,3,4 \ldots n\} \\ p_{n+1} = \prod_{1}^{n} (1-d_j) \end{cases}$$

Since we are analyzing each path separately and are taking the possibility of default into account, the flows of each bond B_i will no longer have issuer risk but will be risk-free:

$$PV(B_i) \Rightarrow \begin{cases} \sum_{1}^{i+k-1} CF_j \bullet DF_j^{\$} + N \bullet DF_n^{\$}, \forall i \leq (n-k) \\ \sum_{1}^{n} CF_j \bullet DF_j^{\$} + N \bullet DF_n^{\$}, \forall i > (n-k) \end{cases}$$

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which becomes

$$V_j = CF_j \bullet DF_j^{\$}$$

with

$$P - N \bullet DF_n^{\$} = \sum_{i=1}^{n-k}\left[p_i \bullet \left[\sum_{j=1}^{i+k-1} V_j\right]\right] + \sum_{i=n-k+1}^{n+1}\left[p_i \bullet \left[\sum_{j=1}^{n} V_j\right]\right]$$

or, equivalently,

$$P - N \bullet DF_n^{\$} = \left[p_i \bullet \sum_{1}^{k} V_j + p_2 \bullet \sum_{1}^{k+1} V_j + \ldots + p_{n-k} \bullet \sum_{1}^{n-1} V_j\right] + \left[p_{n-k+1} \bullet \sum_{1}^{n} V_j + \ldots + p_{n-1} \bullet \sum_{1}^{n} V_j\right]$$

which, taking out the common factor V_j, leaves

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} V_j + \sum_{j=k+1}^{n}\left[V_j \bullet \left[\sum_{j-k+1}^{n+1} p_i\right]\right]$$

Implicit Default Probability

In order to complete the previous formula, it is necessary to calculate the probabilities of default. To do so, we will assume that the spread due to the issuer risk is constant over time. Under this assumption, it will be true that the present value of a flow subject to risk (assumed to be issuer risk) at time i is equal to the product of its present value, assumed risk-free, and the probability of default.

$$DF_i = DF_i^{\$} \bullet \prod_{j=1}^{i}\left(1 - d_j\right)$$

$$e^{-(z_i^{\$} + SS) \bullet t_i} = e^{-z_i^{\$} \bullet t_i} \bullet \prod_{j=1}^{i}\left(1 - d_j\right)$$

such that:

$$\prod_{j=1}^{i}\left(1 - d_j\right) = e^{-SS \bullet t_i}$$

The probability of path i is:

$$p_i = \begin{Bmatrix} p_1 = -e^{-SS \bullet t_1} \\ p_i = e^{-SS \bullet t_{i-1}} - e^{SS \bullet t_i}, \forall i \in \{2,3,4 \ldots n\} \\ p_{n+1} = e^{-SS \bullet t_n} \end{Bmatrix}$$

And the probability of default associated with each period i is:

$$d_i = 1 - e^{-SS \bullet (t_1 - t_{i-1})}$$

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If the periods are of equal length, the probability of default is assumed to remain constant over time. The reason we perform the full calculation is that the periods are not always equal: the first period depends on the value date being considered, and there could be periods without interest payments.

Cash Flow Structure

Going back to the formula to calculate the bond price:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} V_j + \sum_{j=k+1}^{n} \left[V_j \bullet \left[\sum_{j-k+1}^{n+1} p_i \right] \right]$$

Taking into account the definition of p_i and the formulas obtained for the implicit probabilities, it follows that

$$\sum_{j-k+1}^{n+1} p_i = \prod_{1}^{j-k} (1 - d_i) = e^{-SS \bullet t_{j-k}} = DF_{j-k}^{SS}$$

such that the bond price is stated as:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} CF_j \bullet DF_j^{\$} + \sum_{k+1}^{n} CF_j \bullet DF_j^{\$} \bullet DF_{j-k}^{SS}$$

Since a future flow can be discounted in two steps, we can discount it first from time j until time j-k and then from time j-k to today:

$$DF_j^{\$} = DF_{j,j-k}^{\$} \bullet DF_{j-k}^{\$}$$

Substituting the above in the price calculation formula gives the following:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} CF_j \bullet DF_j^{\$} + \sum_{k+1}^{n} CF_j \bullet DF_{j,j-k}^{\$} \bullet DF_{j-k}^{\$} \bullet DF_{j-k}^{SS}$$

Taking into account that:

$$DF_{j-k} = DF_{j-k}^{\$} \bullet DF_{j-k}^{SS}$$

it follows that:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} CF_j \bullet DF_j^{\$} + \sum_{k+1}^{n} CF_j \bullet DF_{j,j-k}^{\$} \bullet DF_{j-k}$$

Therefore, if we define an equivalent flow associated with time j-k as the product of its real value and the risk-free discount factor between times j and j-k

$$CFR_{j-k} = CF_j \bullet DF_{j,j-k}^{\$}$$

we arrive at a formula similar to the one for a bond with fixed guarantee, where we have substituted the unsecured flows by their equivalents to isolate the effect of the rolling guarantee:

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$$P = \sum_{j=1}^{k} CF_j \bullet DF_j^{\$} + \sum_{j=k+1}^{n} CFR_{j-k} \bullet DK_{j-k} + N \bullet DF_n^{\$}$$

The above formula shows that the existence of a rolling guarantee over k periods eliminates the issuer risk component during k periods prior to the coupon payment. A coupon with hybrid risk in year j becomes a coupon with issuer risk in year j-k by discounting from j to j-k at the rates implied by the risk-free curve.

Risk Measurements

The market price of a Brady bond is influenced by the fluctuations of the stripped spread and the movements of the risk-free curve. Its relative price variation can be stated by expanding it in a series and keeping the terms of first and second order:

$$\frac{\Delta P}{P} = \begin{cases} \sum\left[-D_i \bullet \Delta Z_i^{\$} + \frac{1}{2} \bullet C_i \bullet \left(\Delta Z_i^{\$}\right)^2\right] + \\ + \sum\left[C_{i,SS} \bullet \Delta Z_i^{\$} \Delta SS\right] + \sum\sum\left[C_{i,j} \bullet \Delta Z_i^{\$} \Delta Z_j^{\$}\right] \\ + \left[-D_{SS} \bullet \Delta SS + \frac{1}{2} \bullet C_{SS} \bullet \Delta SS^2\right] \end{cases}$$

where

$$-D \bullet P = \frac{dP}{dZ_i^{\$}}$$

$$-D_{SS} \bullet P = \frac{dP}{dSS}$$

$$C_i \bullet P = \frac{d^2P}{dZ_i^{\$^2}}$$

$$C_{SS} \bullet P = \frac{d^2P}{dSS^2}$$

$$C_{i,SS} \bullet P = \frac{d^2P}{dZ_i^{\$} dSS}$$

$$C_{i,j} \bullet P = \frac{d^2P}{dZ_i^{\$} dZ_j^{\$}}$$

all of which are obtained by taking the derivatives of the following formulas:

- Fixed guarantee:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} CF_j \bullet DF_j^{\$} + \sum_{k+1}^{n} CF_j \bullet DF_j^{\$} \bullet DF_j^{SS}$$

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- Rolling guarantee:

$$P - N \bullet DF_n^{\$} = \sum_{1}^{k} CF_j \bullet DF_j^{\$} + \sum_{k+1}^{n} CF_j \bullet DF_j^{\$} \bullet DF_{j-k}^{SS}$$

where k is the number of coupons covered by the guarantee.

To analyze the real exposure of a position in Brady bonds, we have to consider the relationships between all the risk factors, as they are interdependent. To do so, we will calculate the volatility of the bond from the volatility and correlation matrix between the risk-free curve and the stripped spread.

Volatility

Let's assume that the zero-coupon rates and the issuer risk spread behave like normally distributed random variables

$$dz_j = \mu_j \bullet dt + \sigma_j \bullet dw_j$$
$$ds_j = \mu_s \bullet dt + \sigma_s \bullet dw_s$$

By generalizing Ito's lemma:

$$dP = \left\{ \begin{array}{l} \Sigma \dfrac{\partial P}{\partial z_j} \mu_j + \dfrac{\partial P}{\partial s} + \dfrac{\partial P}{\partial t} + \sum\sum \dfrac{\partial^2 P}{\partial z_i \partial z_j} \sigma_i \sigma_j \rho_{ij} \\ \Sigma \dfrac{\partial^2 P}{\partial z_i \partial_s} \sigma_j \sigma_s \rho_{j,s} + \Sigma \dfrac{1}{2} \dfrac{\partial^2 P}{\partial z_j^2} \sigma_j^2 \Sigma \dfrac{1}{2} \dfrac{\partial^2 P}{\partial z_s^2} \sigma_s^2 \end{array} \right\} dt + \left\{ \Sigma \frac{\partial P}{\partial z_j} \sigma_j dw_j + \frac{\partial P}{\partial s} \sigma_s dw_s \right\}$$

and substituting the duration and convexity in the above equation

$$\frac{dP}{P} = \left\{ \begin{array}{l} \left\{ \sum D_j \mu_j + D_s \mu_s + \dfrac{\partial P}{\partial t} + \sum C_{js} \sigma_j \sigma_s \rho_{js} \sum\sum C_{ij} \sigma_i \sigma_j \rho_{ij} + \sum \frac{1}{2} C_j \sigma_j^2 + \frac{1}{2} C_s \sigma_s^2 \right\} dt + \\ + \left\{ \sum D_j \sigma_j dw_j + D_s \sigma_s dw_s \right\} \end{array} \right.$$

It follows that the random component of the current yield will behave as a normally distributed variable since it is the sum of normally distributed random variables:

$$\frac{dP}{P} = \{\ldots\} dt + \left\{ \sum D_j \sigma_j dw_j + D_s \sigma_s dw_s \right\} = \{\ldots\} dt + \sigma dw$$

where the price volatility is calculated as:

$$\sigma^2 = \{D_1\sigma_1 \quad D_2\sigma_2 \quad \ldots \quad D_n\sigma_n \quad D_s\sigma_s\} \begin{bmatrix} 1 & \rho_{12} & \ldots & \rho_{1n} & \rho_{1s} \\ \rho_{21} & 1 & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \rho_{n1} & \ldots & \ldots & 1 & \rho_{ns} \\ \rho_{s1} & \ldots & \ldots & \rho_{sn} & 1 \end{bmatrix} \begin{Bmatrix} D_1\sigma_1 \\ D_2\sigma_2 \\ \ldots \\ D_n\sigma_n \\ D_s\sigma_s \end{Bmatrix}$$

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Volatilities and Correlations

Although the formula to calculate volatility must include volatilities and correlations between the zero-coupon rates associated with the coupon payment dates and those corresponding to the spread, the available market data correspond to fixed terms: 1 year, 2 years, 3 years, 4 years, etc.

Volatilities and Correlations between Zero-Coupon Rates

To calculate the volatilities and correlations, we will assume a linear interpolation for the zero-coupon rates. Thus,

$$z_i = x_i Z_m + (1-x_i) Z_n$$
$$z_j = x_j Z_p + (1-x_j) Z_q$$

being the times when the market determines prices and x being the interpolation coefficients.

Therefore, it will follow that

$$\sigma_i^2 = x_i^2 \sigma_m'^2 + (1-x_i)^2 \sigma_n'^2 + x_i(1-x_i)\rho_{mn}$$
$$\sigma_j^2 = x_j^2 \sigma_m'^2 + (1-x_j)^2 \sigma_n'^2 + x_j(1-x_j)\rho_{mn}$$
$$\rho_{ij} = \frac{1}{\sigma_i \sigma_j}\left\{\begin{array}{l}\rho'_{mp}\sigma'_m\sigma_p x_i x_j + \rho'_{mq}\sigma'_m\sigma_q x_i(1-x_j) + \\ +\rho'_{np}\sigma'_n\sigma'_p(1-x_i)x_j + \rho'_{nq}\sigma'_n\sigma'_q(1-x_i)(1-x_j)\end{array}\right\}$$

where σ' and ρ' are the volatilities and correlations between the zero-coupon rates associated with the standard market-pricing times and σ and ρ are the volatilities and correlations we wish to calculate.

Correlations Between the Spread and the Zero-Coupon Rates

In this case we will use the definition of covariance and substitute the linear interpolation

$$\left.\begin{array}{r} Cov(s,z_i) = E[s \bullet z_i] \\ z_i = x_i Z_m + (1-x_i) Z_n \end{array}\right\} \Rightarrow E[s \bullet z_i] = x_i E[s \bullet Z_m] + (1-x_i) E[s \bullet Z_n]$$

therefore,

$$Cov(s,z_i) = x_i Cov(s,Z_m) + (1-x_i) Cov(s,Z_n)$$
$$\rho_{si} = \frac{1}{\sigma_i}\left\{x_i \rho'_{sm}\sigma'_m + (1-x_i)\rho'_{sn}\sigma'_n\right\}$$

Generalized Flow Correction

The above flow correction is valid only when the rolling guarantee covers a fixed number of future payments. However, the guarantee is usually quantified as a total dollar amount stated as a percentage of the principal. If the Brady bond coupon is fixed and constant, it does not matter whether the guarantee is stated as a number of coupons or as a percentage of the

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principal. However, if the coupon is fixed but not constant or is variable, some payments will only be partially covered by the guarantee. In case of default, the guarantee will be used up to its full amount. Under these conditions, the final corrected flow formula cannot be expressed in a closed form, unlike the previous one.

Using the previous formula, we will define g_{ij} as the percentage of flow j that will be received on path i. It will equal 1 if it is covered by the guarantee, and less than 1 if it is only partially covered.

The bond price, stated as the weighted average of the paths, is:

$$PV\sum_{i=1}^{n}\left[p_i \bullet \sum_{j=1}^{n}\left[CF_j \bullet\right]DF_j^s \bullet g_{if}\right] + P_{n+1} \bullet \sum_{j=1}^{n}\left[CF_j \bullet DF_j^s\right]$$

Substituting the equations obtained in the section on implicit default probability (p. 315),

$$P = \sum_{i=1}^{n}\left[\left(e^{-SS \cdot t_{i-1}} - e^{-SS \cdot t_i}\right) \bullet \sum_{j=1}^{n}\left[CF_j \bullet FD_j^{\$} \bullet g_{if}\right]\right] + e^{-SS \cdot t_n} \bullet \sum_{j=1}^{n}\left[CF_j \bullet DF_j^s\right]$$

which can also be expressed as

$$P = \sum_{i=1}^{n}\left[\left(DF_{i-1}^{SS} - DF_i^{SS}\right) \bullet \sum_{j=1}^{n}\left[CF_j \bullet DF_j^{\$} \bullet g_{if}\right]\right] + DF_n^{SS} \bullet \sum_{j=1}^{n}\left[CF_j \bullet DF_j^s\right]$$

Defining

$$P = \left\{\begin{array}{l} \sum_{i=1}^{n}\left[\left(\sum_{j=1}^{n}\left[CF_j \bullet \frac{DF_j^{\$}}{DF_{i-1}^{\$}} \bullet g_{if}\right]\right)DF_{i-1}\right] - \\ -\sum_{i=1}^{n}\left[\left(\sum_{j=1}^{n}\left[CF_j \bullet \frac{DF_j^{\$}}{DF_{i-1}^{\$}} \bullet g_{if}\right]\right)DF_i\right] + \\ +\sum_{i=1}^{n}\left(\sum_{j=1}^{n}\left[CF_j \bullet \frac{DF_j^{\$}}{DF_{in}^{\$}}\right]\right) \bullet FD_n \end{array}\right.$$

Defining

$$\left.\begin{array}{l} CF'_{i-1} = \sum_{j=1}^{n} CF_j \bullet \frac{DF_j^{\$}}{DF_{i-1}^{\$}} \bullet g_{if} \\ CF''_{i-1} = \sum_{j=1}^{n} CF_j \bullet \frac{DF_j^{\$}}{DF_i^{\$}} \bullet g_{if} \\ CF'''_{i-1} = \sum_{j=1}^{n} CF_j \bullet \frac{DF_j^{\$}}{DF_n^{\$}} \end{array}\right\} \Rightarrow P - CF'_0 = \sum_{i=2}^{n} CF'_{i-1} \bullet DF_{i-1} - \sum_{i=1}^{n} CF''_i \bullet DF_i + CF''' \bullet DF_n$$

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such that the value of the coupons is expressed on the basis of flows with sovereign risk. If we subtract CF'_0 from the market value, we are subtracting the contribution of the currently secured flows. Therefore,

$$\left.\begin{array}{l} CFR_i = CF'_1 - CF''_i, \forall i \in \{1,2,3 \ldots n-1\} \\ CFR_n = CF'' - CF''_n \end{array}\right\} \Rightarrow P - CF'_0 = \sum_{i=1}^{n} CFR'_i \bullet DF_i$$

After obtaining the equivalent flows subject to risk, we can apply the stripped spread and stripped yield formulas.

Durations and Convexities

In order to calculate the volatility of the bond, we must find the duration and convexity coefficients associated with this general case. These will be determined by taking the derivatives of the following equation

$$P - CF'_0 = \sum_{i=1}^{n} CFR'_i \bullet DF_i$$

according to the same method used in the section on risk measurements (p. 317 and following pages). This generalization applies to both fixed-coupon and floating-coupon bonds, and in the case of floating-rate bonds its effect must be considered when taking the derivatives of the price formula since in this case the coupon payments depend on the rate curve.

APPENDIX III: FLOATING RATE NOTES (FRN) WITH A CREDIT SPREAD

Assume a note paying floating-rate coupons that are defined at the beginning of each period and are benchmarked to the market rate for the same maturity. To value the note, we must estimate each of these future coupons and discount them to their present value. The curve used for discounting does not have to be the same one used to calculate the coupons, since the discount rate will depend on the risk level assigned to the issuer by the market. In other words, if we assume several issues with identical structures but issued by issuers with different risk levels, the estimated future payments would be the same for all issues but the prices would not. This is so because the market would want a higher yield from an issuer with a higher risk level and this would imply a lower price.

Let us define the benchmark curve as a series of discount factors associated with each point in time.[47] FD_i will be defined as the discount factor associated with time i, which represents the present value of a monetary unit at time i.

After the benchmark curve is known, we will estimate each future flow associated with the FRN.

[47] It is preferable to state the curve as a combination of discount factors. This simplifies the calculation of the future coupon payments because we do not need to know if the interest rates used are simple, compound, etc.

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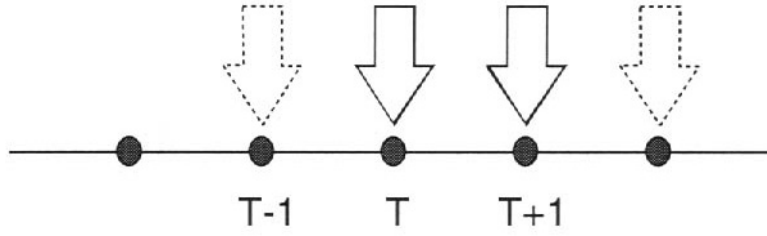
Figure 10-25. Calculation of the Coupon Payable at Time T



The coupon associated with time T (Figure 10-25) can be calculated as:

$$CF_T = N \bullet rate_{T-1,T} \bullet t$$

where N is the principal of the note, *rate* the benchmark rate associated with the period and t the length of the period. In addition, the discount factor associated with the period can be calculated as

$$DF_{T-1,T} = \frac{1}{1 + rate_{T-1,T} \cdot t}$$

Using the benchmark curve, we can calculate the present value of a flow at time T by discounting it first up to *T-1* and then from *T-1* to now. Therefore,

$$DF_T = DF_{T-1,T} \bullet DF_{T-1,T} \Rightarrow DF_{T-1,T} = \frac{DF_T}{DF_{T-1}}$$

And the flow associated with time T will be estimated from the benchmark curve as

$$CF_T = N \bullet \left[\frac{DF_{T-1}}{DF_T} - 1 \right]$$

Once the value of the future flow is known, it must be discounted to present value. To do so, we must take into account the risk level associated with the note. This implies that the curve used for discounting will differ from the benchmark curve, and thus will not be the same for all notes.

To include this effect, we will use a spread over the benchmark curve. The discount factor used will be the product of the discount factor associated with the benchmark curve and a correction factor associated with the spread:[48]

[48] To arrive at the formula, we will assume that the spread is stated as a continuously compounding interest rate. The discount rate associated with time T will equal:

$$z' = z_{reference} + spread$$

and the discount factor will equal

$$DF'_T = e^{-z' \cdot T} = e^{-(z_{ref} + spread) \cdot T} = DF_T \bullet DF_T^{spread}$$

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Therefore, the present value of the flow associated with time T equals:

$$DF'_T = DF_T \bullet DF_T^{spread}$$

If we calculate the coupon corresponding to time $T+1$ in the same way, we get

$$PV_T = CF_T \bullet DF'_T = N \bullet \left[DF_{T-1} - DF_T\right] \bullet DF_T^{spread}$$

Therefore, the behavior of the discount factor associated with time T will affect only the present value of the flows associated with times T and $T+1$. The variation in the FRN value when DF_r varies is calculated as

$$PV_T = N \bullet \left[DF_T - DF_{T-1}\right] \bullet DF_{T+1}^{spread}$$

except for time N associated with the maturity of the FRN, where[49]

$$\frac{dPV}{dDF_T} = N \bullet \left[DF_{T+1}^{spread} - DF_T^{spread}\right]$$

$$\frac{dPV}{dDF_N} = 0$$

At any point in time, the sign of the price derivative with respect to the interest rate associated with that time will depend on the value of the spread. If the spread is positive, the value of the above formula will always be negative. But if the spread is negative, the above formula will have a positive sign. Since when interest rates go up, the associated discount factor goes down and vice versa, the above formula explains why, when rates go up and the spread is positive, the FRN price also goes up.

Behavior of an FRN as a Function of the Risk Level

		Positive Spread	Zero Spread	Negative Spread
	$\frac{dPV}{dDF_r}$	−	0	+
Rates go up	DF goes down	PV goes up	PV unchanged	PV goes down
Rates go down	DF goes up	PV goes down	PV unchanged	PV goes up

[49] A coupon payment and the repayment of the principal are received at time N, which is the maturity date. Therefore:

$$CF_N = N \bullet \left[\frac{DF_{N-1}}{DF_N} - 1\right] + N = N \bullet \frac{DF_{N-1}}{DF_N}$$

and the present value associated with this flow equals:

$$PV_N = CF_N \bullet DF'_N = N \bullet DF_{N-1} \bullet DF_N^{spread}$$

and therefore:

$$\frac{dPV}{dDF_N} = 0$$

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The behavior of the FRN (see table on page 323) with respect to the interest rates will be a function of the risk level the market assigns by means of the spread. The higher the spread the more significant this effect will be. For non-investment grade instruments with very high spreads, the negative durations can be very significant.

APPENDIX IV: CAPITAL ASSET PRICING MODEL

This model is used to estimate risk parameters, volatilities and correlations for the purpose of ascertaining the risk (to the value of a business) introduced by an equity portfolio.

In the model the value of a stock is affected by two components: one is related to market yield fluctuations,[50] and the other is related to changes in the company that issued the stock, as perceived by the market.

Assuming also that there is a risk-free asset in which market participants could invest, the stock would have to offer an additional return to attract investors.

Combining the three points above, the additional return of stock i will be stated as the sum of a systemic and a specific component, independent of each other:

$$r_i - r_f = \beta_i \bullet (r_M = r_f) + \varepsilon_i$$

where

- r_i-r_f is the additional return of the stock over the risk-free asset
- r_M-r_f is the excess market return over the risk-free rate
- β_i is the linear regression coefficient between the return of stock i and the market return, representing the portion of the stock's return explained by market fluctuations.

$$\beta_i = \frac{\text{cov}(r_i, r_m)}{\text{var}(r_M)} = \frac{\sigma_{i,M}}{\sigma_M^2}$$

- ε_i is the random component of an asset's return that is not explained by the market (specific risk), such that its expected value is zero and it fluctuates independently from the market:

$$\text{cov}(r_M, \varepsilon_i) = E[\varepsilon_i] = 0$$

Logically, the market β equals 1, because the market is perfectly correlated with itself.

$$\sum \omega_i \bullet \beta_i = \beta_m = 1$$

Volatility of a Stock

After modeling the behavior of the stock by means of the two components, and taking into account that both components will fluctuate independently of each other,

$$r_i = (1 - \beta_1) \bullet r_f + \beta_i \bullet r_M + \varepsilon_i$$
$$\text{cov}(r_M, \varepsilon_i) = 0$$

[50] To simplify, we will assume that the market is made up of all the stocks traded in the local stock market. The market return (r_M) is the average of the returns of each stock (r_i) weighted by its relative market capitalization (ω_i):

$$r_M = \sum \omega_i \bullet r_i$$

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the volatility of the stock will be

$$\sigma_i^2 = \beta_i^2 \bullet \sigma_M^2 + \sigma_{\varepsilon_i}^2$$

Therefore, the volatility of the stock is determined by the volatility of the market plus the volatility of the issuing company's specific risk.

Diversification and Specific Risk

Assume an equity portfolio where p_i is the percentage of the portfolio represented by asset i.

$$p_i = \frac{value\ of\ the\ asset_i}{value\ of\ the\ portfolio}$$

The portfolio's return will be given by:

$$r_{portfolio} - r_f = \sum p_i \bullet (r_i - r_f) = \sum p_i \bullet \beta_i (r_m - r_f) + \sum p_i \bullet \varepsilon_i$$

Since, according to the definition of specific risk, the components of *i* are not correlated with the market return, the portfolio's volatility will be given by:

$$\sigma_{portfolio} = \left[\sum p_i \beta_i\right]^2 \sigma_M^2 + \text{var}\left[\sum p_i \varepsilon_i\right]$$

taking into account that the portfolio's β is equal to the weighted sum of the betas of each of the stocks making up the portfolio:

$$\beta_{portfolio} = \sum p_i \beta_i$$

substituting

$$\sigma_P^2 = \beta_P^2 \sigma_M^2 + \text{var}\left[\sum p_i \varepsilon_i\right]$$

If the portfolio being considered were the market portfolio,

$$\text{var}\left[\sum p_i \varepsilon_i\right] = 0$$

Such that then, by constructing well-diversified portfolios that represent the behavior of the market, it is possible to eliminate the specific risk, such that the volatility of the diversified portfolio equals

$$\sigma_{diversified}^2 = \beta_{diversified}^2 \sigma_M^2$$

Diversified Portfolio

The above leads to a very interesting simplification for the calculation of the Capital-at-Risk when the portfolio is diversified within a single market. Each asset will contribute two volatilities, one related to the market and the other related to the specific risk, although when they are added up, the contribution of the specific risks is not significant. Therefore, if we define σ_i' as the systemic risk's contribution to the asset's volatility, then

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$$\sigma_i' = \beta_i \sigma_M$$

the volatility of the diversified portfolio will be equal to

$$\sigma^2_{diversified} = \sum \left[\rho_i \bullet \sigma_i'\right]^2$$

and we will obtain the same formula as above

$$\sigma^2_{diversified} = \sigma^2_M \sum \left[\rho_i \bullet \beta_i\right]^2 = \sigma^2_M \bullet \beta^2_{diversified}$$

However, it should be noted that σ_i' is not the volatility of asset *i* but the systemic risk's contribution to overall portfolio volatility. If we were considering a non-diversified portfolio, the above simplification would not apply. The portfolio volatility would not correspond to the real volatility as it would lack the component related to the combination of the specific risks of each stock in the portfolio.

The advantage of this simplification is that it requires fewer calculations. We need to calculate only the market volatility and the covariance of each asset with the market, and with that we can calculate the β for each asset. If we used the traditional method, on the other hand, we would have to calculate the covariance matrix between all assets to take into account the residual specific risk. Assuming a portfolio with 20 securities, we would have to perform 400 calculations with the traditional method and only 21 with the simplified method.

If the portfolio included a very small number of assets, such as 3, this simplification would take us from 9 to 4 calculations. No appreciable time would be gained with the simplified method and the results would be less accurate as the proper diversification would be lacking.

Real Volatility vs. Simplified Volatility

The correlation coefficient between any stock and the market is defined as:

$$\rho_i = \frac{\sigma_{i,M}}{\sigma_i \sigma_M}$$

If we take the two terms in the volatility equation:

$$\left.\begin{array}{l} \sigma_i^2 \beta_i^2 \bullet \sigma_M^2 + \sigma_{\varepsilon_i}^2 \\ \sigma_{\varepsilon_i}^2 = \sigma_{i_i}^2 \bullet \left(1 - \rho_i^2\right) \end{array}\right\} \Rightarrow \sigma_i = \frac{|\beta_i|}{|\rho_i|} \bullet \sigma_M = \frac{\sigma_i'}{|\rho_i|}$$

The absolute value of the correlation coefficient indicates the percentage of the real volatility covered by the simplified volatility. The lower the correlation coefficient, the higher will be the error committed when applying the simplified assumptions in the previous section. It should be noted that the error is not determined by the portfolio's β but by the correlation coefficient.

The specific risk can be disregarded when the absolute value of the correlation between the portfolio and the market tends toward 1, whatever the value of β.

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Portfolio Diversified Among Several Markets

Assume a portfolio divided into several sub-portfolios, each holding equities from one market and sufficiently diversified within that market. We can use the formulas in the previous section to calculate the volatility of the sub-portfolios. The volatility of sub-portfolio j (σ_j) associated with market M_j (σ_{Mj}) is given by:

$$\sigma_j^2 = \sigma_{Mj}^2 \bullet \beta_j^2$$

such that the return associated with each sub-portfolio, if we consider it as an individual asset, will not have specific risk and can be stated as:

$$r_j - r_f \beta_j \bullet \left(r_{M_j} - r_f\right)$$

If we want to combine the effects of all the sub-portfolios (disregarding at this point the currency problem), we must take into account the correlations between them. The covariance between portfolios j and k is given by:

$$\sigma_{j,k} = \beta_j \beta_k \bullet \sigma_{M_j M_k} = \beta_j \bullet \beta_k \bullet \rho_{M_j,M_k} \bullet \sigma_{M_j} \bullet \sigma_{M_j}$$

where $\rho_{Mj,Mk}$ is the correlation coefficient between market j and market k.

After calculating the betas for each sub-portfolio, we will need to calculate only the correlations between markets. In this way, the number of calculations required is reduced because we only need to cross-correlate the assets against their market indicator and then correlate the markets with each other, instead of correlating every asset with every other asset. But, as in the previous case, the errors introduced by this method can be significant if the proper diversification is lacking.

General Case

In the previous sections we have developed a simplified methodology for diversified portfolios (highly correlated with the market). But, since the effect of the specific risk is not significant for all portfolios, a more general method will be developed below that will also reduce the number of required calculations.

Assume a global portfolio holding assets from several markets. As we did in the simplified method, we will first group the assets on the basis of the market to which they belong. Thus, sub-portfolio j will be defined as the set of assets in the overall portfolio that are associated with market M_j.

We will calculate the volatility of the portfolio at 3 levels—the asset i, the sub-portfolio j, and the overall portfolio. In this way, we will be able to calculate the Capital-at-Risk associated with an individual asset, a position in an individual market or the portfolio as a whole.

Volatility of Asset i

The volatility of asset i belonging to market M_j will be stated as a function of two volatilities, one related to the market and the other to the asset-specific component. Thus,

$$\sigma_i^2 = \beta_i^2 \bullet \sigma_{M_j}^2 + \sigma_{\varepsilon_i}^2$$

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If only historical market information were available, the volatility of the asset would be directly determined by the historical volatility of its historical return series. Occasionally, however, additional information about the market and the environment becomes available, enabling us to better estimate the volatility. Thus:

- The market may be trading instruments that could be used to determine an implicit volatility;
- An analysis of the environment, especially in emerging markets, could give signals enabling us to anticipate a crisis. This would translate into higher expected market volatilities.

In either case, the market volatility will not be the same as the historical volatility. Rather, it will be a corrected volatility that will obviously impact the volatility of asset *i*. Therefore, the volatility of this asset has to be calculated on the basis of the additional information available. This additional information will impact only the systemic risk, and we will assume that the instrument's β and the volatility of its specific risk are not impacted.

The volatility of the specific risk is calculated from historical data pertaining to the asset and the market:

$$\sigma^2_{\varepsilon_i} = \sigma^2_i - \beta^2_i \bullet \sigma^2_{M\,j,hist}$$

Therefore, the corrected volatility of asset *i* will be stated as:

$$\sigma^2_{i,corrected} = \beta^2_i \bullet \sigma^2_{M\,j,corrected} + \left[\sigma^2_{i,hist} - \beta^2_i \bullet \sigma^2_{M\,j,hist}\right]$$

Volatility of Sub-Portfolio j

After calculating the volatilities for each asset, we will calculate the volatility for sub-portfolio *j* made up of all the assets related to market M_j. To do so, we can do the following:

- Calculate the covariance matrix between all assets in portfolio *j*, or
- Consider portfolio *j* as an asset and apply the capital asset pricing model.

The first option will require more calculations, because if we have *n* assets we have to perform n^2 correlations. Any additional market information cannot be introduced directly because these covariances would introduce systemic risk correlations as well as specific risk correlations.[51]

The second option uses the historical price series associated with sub-portfolio *j*, defined as

$$price_j = \sum p_i \bullet price_i$$

[51] A method enabling us to introduce additional market information would be to separate the systemic risk and specific risk portions of the covariances, keeping the specific covariance and correcting the market volatilities. Thus,

$$\sigma^2_{ij,\,corrected} = \beta_i \beta_l \sigma^2_{M_j,\,corrected} + \sigma^2_{\varepsilon_i \varepsilon_l}$$

where

$$\sigma^2_{\varepsilon_i \varepsilon_i} = \sigma^2_{i,l} - \beta_i \beta_l \sigma^2_{M_j,\,hist}$$

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where p_i is the contribution of asset i to the present value of sub-portfolio j. By doing this, we are analyzing the historical trend of the portfolio. Once we have this historical series, we can analyze the sub-portfolio as if it were an asset, including any available additional market information:

$$\sigma^2_{j,corrected} = \beta^2_j \bullet \sigma^2_{M\,j,corrected} = \left[\sigma^2_{j,hist} - \beta^2_j \bullet \sigma^2_{M\,j,hist}\right]$$

Volatility of the Portfolio as a Whole

We calculate the volatility of the overall portfolio, as we did in the case of the sub-portfolio, by choosing between two options:

- Calculate the covariance matrix between all assets making up the overall portfolio; or
- Calculate the covariance matrix between sub-portfolios.

The first option requires many calculations and does not provide significant added value. As in the previous case, it does not let us introduce additional market or environment information that may be available. In the second option, after calculating the historical series for each sub-portfolio as discussed above, we can easily calculate the correlation coefficient between series and apply to it the corrected volatilities of each sub-portfolio to determine the covariance. Thus, given two sub-portfolios j and k:

$$\sigma_{j,k} = \rho_{j,k} \bullet \sigma_{j,\,corrected} \bullet \sigma_{k,\,corrected}$$

After obtaining the covariance matrix for the overall portfolio, we will determine its volatility by the traditional method, taking into account the foreign exchange risk effect.

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Chapter 11

Credit Risk Measurement Methodologies

Introduction

The first three sections of this chapter present a methodology for calculating three basic parameters of treasury credit risk management and control:

- Credit provisions
- Credit risk capital
- Return on Credit Risk-Adjusted Capital (credit RORAC).

The fourth section analyzes how credit losses influence treasury area results (P&L), distinguishing credit results from results due to changes in market rates and/or prices.

Before explaining how to calculate the above parameters, we will review the meaning of these items as they were explained in Chapter 5, Credit Risk Management and Control.

CREDIT PROVISION

The credit provision for a specific transaction is equal to the present value of expected credit losses from the present date through the maturity/expiration date of the transaction.

$$credit\ provision = (1 - p_r) \bullet \sum_{t=1}^{N} \bullet C_t \bullet q_t \bullet D_t$$

where C_t is the expected value of the transaction at time t (credit exposure),[1] q_t is the probability of counterparty bankruptcy at time t, p_r is the recovery rate and D_t is the discount factor from time t through the present.

The credit provision should be considered as a cost,[2] as it is the best estimate of expected losses. The spread that clients are charged on transactions must be high enough to cover the provision and earn a profit (risk premium) to compensate for the capital at risk.

The credit provision must be booked in advance (as a loss) when the entity's positions are marked to market.

CREDIT RISK CAPITAL

Since it affects transaction prices, the credit provision provides protection from expected credit losses. However, if actual credit losses are greater during a specific period than the provision made, and if the entity is not sufficiently capitalized, bankruptcy can occur.

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[1] Credit exposure exists only if the expected market value of the transaction on that date is positive for the entity.
[2] This is reviewed in detail in the last part of this chapter.

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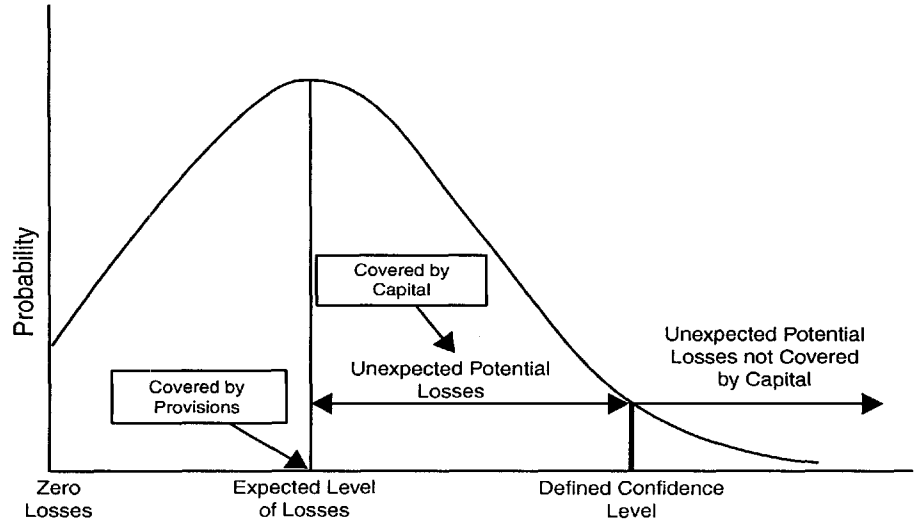
Credit risk capital should cover the maximum estimated credit-related loss in the value of a portfolio (Figure 11-1). This maximum loss should be determined for a certain confidence level and a certain period (one year is generally used as a benchmark period).

The credit risk capital figure is calculated by determining the maximum credit provision for a year, so there is a probability (e.g., a 99.8% confidence interval) that this maximum credit provision will not be exceeded by the actual credit charge that must be made during one year.

The difference between the maximum one-year credit provision and the actual credit provision is the credit risk capital that the entity must have in order to avoid its own bankruptcy (which would be caused by counterparty bankruptcies).

Figure 11-1. Potential Losses from Credit Risk



CREDIT RORAC

The credit RORAC is the internal rate of return (IRR) that shareholders earn from their initial capital contribution and from subsequent withdrawals or further capital contributions, plus profits, throughout the life of the transaction.

To decide whether or not a transaction should be done, the expected credit RORAC should be calculated. The historical RORAC should be calculated in order to evaluate actual results against expected.

The entity must estimate the credit risk capital to allocate throughout the life of the transaction portfolio (not just at a specific time) to be able to calculate the Return on Credit Risk-Adjusted Capital (credit RORAC).

For each transaction, the entity can estimate the return shareholders will earn on the credit risk capital they must contribute as the discount rate that makes the net present value of the following cash flows zero:

- The expected after-tax profits for the transaction.
- Capital contributions or withdrawals[3] that shareholders must or may make throughout the life of the transaction.

[3] If credit risk capital is estimated in annual terms, at the start of the transaction the shareholders must contribute sufficient credit risk capital to cover losses that may be experienced at the end of the first year. Thereafter, shareholders may withdraw capital in years when credit risk capital is lower than the capital contributed the prior year, and must contribute additional capital in years when credit risk capital is higher than the capital contributed the prior year.

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- Capital compensation[4] (after taxes) earned as a result of investing the credit risk capital contribution in risk-free assets.

Calculating the Credit Provision

As noted in the introduction, the credit provision for a treasury transaction is equal to the present value of the losses expected to occur throughout the life of the transaction as a result of counterparty bankruptcy. In order to calculate the credit provision we must know:

- The present value of the expected loss for the transaction in the event of bankruptcy. To do this, we must calculate the positive amount (if any) and the replacement cost of the transaction at different points in time until maturity.

  If the counterparty to a transaction goes bankrupt at a time when the value to the entity is negative, there is no credit loss. Therefore, the loss experienced when a counterparty goes bankrupt is the positive amount (if any) for the entity of the transaction at that time, which is equivalent to the cash flow of an option on the transaction that expires at that future time.

  Therefore, the present value of the expected loss in the event of counterparty bankruptcy at a future time is equal to the value of that payment option, which is the value of an European option on the transaction with an exercise price of zero and an expiration date at that future time.

  This is an asset exchange option, under which—if the counterparty goes bankrupt and exercises the option—it would receive the present value of the cash flows otherwise payable to the entity and it would deliver the present value of the cash flows otherwise receivable from the entity.

  The entity, when it contracts a treasury transaction, is in effect granting its counterparty an option to cancel the transaction if the transaction causes the entity a loss (hence, an option with exercise price of zero), but only in the event of bankruptcy. It has in effect delivered a series of options, each of which can be exercised on a different day prior to and including the expiration of the transaction, but only if bankruptcy occurs at that time.

  The average probability of counterparty bankruptcy for each day indicates the number of options that are expected to be exercised that day. These are European options, which can be exercised only on the expiration date. For the entity, therefore, the present value of the expected credit losses on that day is equal to the value of those European options on the transaction with an exercise price of zero and expiring on that day. When the options value is calculated, the value of any guarantees must be taken into consideration.

  In practice, instead of considering each day up to the maturity of the transaction, the time remaining to maturity is divided into a number of periods; if the options were actually calculated for each day a great number of calculations would be necessary.
- Average probability of counterparty bankruptcy. This probability must be calculated for the different points in time for the time remaining to maturity of the transaction, and will depend on the current credit rating of the counterparty.

[4] This concept was explained in chapter 3, where Capital-at-Risk was described.

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In practice, the probability of bankruptcy is calculated for the same periods chosen in the preceding point for calculating the cancellation options. The probability of bankruptcy for each period can be calculated internally using historical experience as a basis, or the bankruptcy probabilities published by rating agencies such as Moody's, Standard & Poors, etc., may be used.

These agencies publish tables (see Table 11-1) showing bankruptcy probabilities over different time periods (usually years) for entities with different credit ratings.

- Percentage recovery of the transaction value in case of bankruptcy. This depends (in part) on the additional guarantees provided by the counterparty besides those already considered when determining the market value of the options, as explained above. If the entity has a priority right in case of bankruptcy, it will expect to recover more of the value of the transaction at that time than if it did not have such a right.

  For treasury transactions, an average recovery percentage based on the entity's historical experience is normally used.

Table 11-1. Probability of Bankruptcy (in %) as a Function of Credit Rating

	AA	A	BBB	BB+	BB–
Year 1	0.03	0.09	0.31	0.93	2.43
Year 2	0.04	0.15	0.45	1.41	3.25
Year 3	0.07	0.21	0.62	1.76	3.52
Year 4	0.10	0.28	0.78	1.98	3.49
Year 5	0.13	0.36	0.92	2.09	3.32
Year 6	0.18	0.44	1.04	2.12	3.08
Year 7	0.22	0.51	1.13	2.10	2.83
Year 8	0.27	0.58	1.19	2.04	2.60
Year 9	0.31	0.64	1.24	1.96	2.38
Year 10	0.36	0.69	1.27	1.88	2.19
Cumulative	1.71	3.95	8.95	18.28	29.08

- Relationship between the foregoing variables. One assumes that the value of the contract in question has very little influence on the ability of the counterparty to meet its obligations. Therefore, the variables that determine market value and those that influence the potential for bankruptcy of the company are independent. This assumption means either that the contract is a not very significant part of the counterparty's portfolio, or that the risk of the transaction is hedged by the counterparty. This hypothesis is correct for a very high percentage of counterparties, especially in the case of financial entities of a certain size.

Summarizing, we can say that, in order to calculate the credit provision for a specific treasury transaction, one must follow the steps below:

- Divide the period between the current date and the maturity date of the transaction into time periods in order to facilitate calculation of the credit provision. For example, for

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a five-year transaction with semiannual payments, six month periods could be used, which would give ten future dates for which a credit risk analysis would need to be done.

- Calculate the value of the individual cancellation options that expire on the previously defined dates. Guarantees, if any, must be taken into account when calculating the value of the options. To continue with the example, the value of ten options must be calculated, the first of which expires at the end of six months, the second at the end of a year, and so on through the last option, which expires in five years.
- Calculate the probability of counterparty bankruptcy at each set time. Our example would have ten bankruptcy probabilities; the first would be the probability that the counterparty would go bankrupt during the first six months, the second between six and twelve months, and so on, until the end of the fifth year.
- For each defined time, multiply the value of the option that expires at the end of that period by the counterparty bankruptcy probability for that period.
- Calculate the credit provision by adding the above products and multiplying by one less the recovery percentage:

$$credit\ provision = (1 - p_r) \bullet \sum_{t=1}^{N} \bullet C_t \bullet q_t$$

where p_r is the recovery rate, t is the periods into which the transaction term has been divided, C_t is the value of the options that expire in each period t and q_t is the probability of counterparty bankruptcy in each period t.

Let us look at the procedure for calculating the credit provision for a specific example.

Assume that today, February 10, 1998, a financial entity has entered into an IRS with a client with the following characteristics:

- Notional amount: US$ 10 million
- Term: 8 years
- Fixed rate: 6.34% p.a., 365 day basis (the financial entity pays)
- Floating rate: 6 month LIBOR, 365 day basis (the financial entity receives)
- Initial floating rate: 5.81%

We begin by calculating the value of the IRS on the start date, which is US$ 58,807 (see Table 11-2). The fixed rate that makes the value of the IRS zero on the start date is 6.43%, so we can say that the financial entity has made a -9 basis point adjustment in the fixed rate that it intends to pay its client, due to the credit risk it expects to assume.

To test whether the adjustment made by the financial entity (US$ 58,807) matches the credit risk assumed, we are going to calculate the credit provision, i.e., the credit losses that the financial entity can expect based on the characteristics of the IRS and the probability of client bankruptcy at the different points in time until the expiration of the transaction. We must first estimate the credit exposure throughout the life of the IRS, and to do this we must ascertain the value of the cancellation options.

In reality, the client could go bankrupt on any day during the life of the IRS, but to calculate this we would have to break the credit risk down into as many payment options as there are dates in the life of the swap. For simplification purposes, we will use all the dates on which a payment is due under the swap as potential bankruptcy dates. Therefore, we will break the credit risk down into as many European options as there are payment dates.

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Table 11-2. Calculation of the IRS Value

Date	Type (%)	Discount Factor	Pays Fixed (US$)	Receives Floating (US$)	Net Cash Flow (US$)	Discount Net Cash Flow (US$)
10 Feb 98	—	—	—	—	—	—
9 Aug 98	5.81	0.9726	0	282,526	282,526	274,763
10 Feb 99	5.54	0.9476	–633,500	263,626	–369,874	–350,472
9 Aug 99	5.49	0.9233	0	262,453	262,453	242,326
10 Feb 00	5.44	0.8995	–633,500	265,001	–368,499	–331,456
9 Aug 00	5.50	0.8749	0	280,750	280,750	245,632
10 Feb 01	5.56	0.8500	–635,236	292,644	–342,592	–291,216
8 Aug 01	5.67	0.8248	0	306,338	306,338	252,659
9 Feb 02	5.78	0.7987	–631,764	326,362	–305,403	–243,926
10 Aug 02	5.88	0.7733	0	327,958	327,958	253,623
9 Feb 03	5.99	0.7476	–633,500	344,173	–289,327	–216,304
10 Aug 03	6.09	0.7225	0	347,843	347,843	251,310
9 Feb 04	6.19	0.6974	–633,500	359,229	–274,271	–191,284
10 Aug 04	6.30	0.6721	0	375,304	375,304	252,279
9 Feb 05	6.41	0.6472	–635,236	386,003	–249,232	–161,307
9 Aug 05	6.48	0.6245	0	363,870	363,870	227,234
10 Feb 06	6.55	0.6017	–635,236	377,574	–257,661	–155,053
				IRS value		**58,807**

Each of the 15 options[5] into which we have broken down the IRS credit exposure is a European option with the following characteristics:

- Maturity dates (t): Dates between the current date (10 Feb 98) and each of the payment dates of the floating rate cash flows under the IRS; i.e., the first option is at 6 months, the second at 1 year and the last at 7.5 years.
- Exercise prices (K): The present value, on each option expiration date, of the variable cash flows[6] payable. Keeping in mind that the variable cash flows are calculated based on the implicit rates of the zero-coupon yield curve and are discounted using the same curve, their present value will always be equal to the notional amount of the IRS (US$ 10 million). The exercise prices are expressed as a percentage of the notional amount, so each of the exercise prices for the 15 options will be 100 (Table 11-3).
- Future prices (F): The present value, on each of the option expiration dates, of the fixed cash flows[7] that will be due. The future prices are expressed as a percentage of the notional amount (Table 11-4).
- Volatilities (s): We will used the implied volatilities quoted as of the present date (10 Feb 98) for options on IRS in US$ for the expiration dates of the payment options.

[5] The term of the IRS is 8 years and the variable flows are payable semi-annually, so we have 16 potential client bankruptcy dates. We are only using 15 because on the 16th (the maturity date) there are no further payments that will come due subsequently. On the maturity date the only risk is a delivery risk for the final exchange of payments.

[6] For calculation purposes, on the due date of the last variable rate cash flow payment, a flow equal to the notional amount of the IRS is included (which does not really exist), as if it were a floating rate bond.

[7] For calculation purposes, on the due date of the last fixed rate cash flow payment, a flow equal to the notional amount of the IRS is included (which does not really exist), as if it were a fixed rate bond.

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Table 11-3. Calculation of Exercise Prices

Date	Type (%)	Discount Factor	Floating Flow (US$)	Discount Floating Cash Flow (US$)	Cumulative Discounted Floating Cash Flow	Future Value	Exercise Price (%)
10 Feb 98	—	—	—	—	10,000,000	—	
9 Aug 98	5.81	0.9725	282,526	274,763	9,725,237	10,000,000	**100.00**
10 Feb 99	5.54	0.9475	263,626	249,797	9,475,440	10,000,000	**100.00**
9 Aug 99	5.49	0.9233	262,453	242,326	9,233,114	10,000,000	**100.00**
10 Feb 00	5.44	0.8995	265,001	238,362	8,994,752	10,000,000	**100.00**
9 Aug 00	5.50	0.8749	280,750	245,632	8,749,121	10,000,000	**100.00**
10 Feb 01	5.56	0.8500	292,644	248,758	8,500,363	10,000,000	**100.00**
8 Aug 01	5.67	0.8248	306,338	252,659	8,247,704	10,000,000	**100.00**
9 Feb 02	5.78	0.7987	326,362	260,666	7,987,038	10,000,000	**100.00**
10 Aug 02	5.88	0.7733	327,958	253.623	7,733,415	10,000,000	**100.00**
9 Feb 03	5.99	0.7476	344,173	257,307	7,476,108	10,000,000	**100.00**
10 Aug 03	6.09	0.7225	347,843	251,310	7,224,798	10,000,000	**100.00**
9 Feb 04	6.19	0.6974	359,229	250,536	6,974,262	10,000,000	**100.00**
10 Aug 04	6.30	0.6722	375,304	252,279	6,721,983	10,000,000	**100.00**
9 Feb 05	6.41	0.6472	386,003	249,827	6,472,156	10,000,000	**100.00**
9 Aug 05	6.48	0.6245	363,870	227,234	6,244,922	10,000,000	**100.00**
10 Feb 06	6.55	0.6018	10,377,574	6,244,922	6,244,922	10,377,574	

Table 11-4. Calculation of Future Prices

Dates	Type (%)	Discount Factor	Fixed Cash Flow (US$)	Discounted Fixed Cash Flow (US$)	Cumulative Discounted Fixed Cash Flow (US$)	Future Value (US$)	Future Price (%)
10 Feb 98	—	—	—	—	9,941,503	—	
9 Aug 98	5.81	0.9725	0	0	9,941,503	10,222,376	**102.22**
10 Feb 99	5.54	0.9475	633,550	600,316	9,341,186	9,858,314	**98.58**
9 Aug 99	5.49	0.9233	0	0	9,341,186	10,117,049	**101.17**
10 Feb 00	5.44	0.8995	633,550	569,863	8,771,324	9,751,601	**97.52**
9 Aug 00	5.50	0.8749	0	0	8,771,324	10,025,378	**100.25**
10 Feb 01	5.56	0.8500	635,286	540,016	8,231,308	9,683,478	**96.83**
8 Aug 01	5.67	0.8248	0	0	8,231,308	9,980,120	**99.80**
9 Feb 02	5.78	0.7987	631,814	504,632	7,726,675	9,674,019	**96.74**
10 Aug 02	5.88	0.7733	0	0	7,726,675	9,991,286	**99.91**
9 Feb 03	5.99	0.7476	633,550	473,649	7,253,027	9,701,608	**97.02**
10 Aug 03	6.09	0.7225	0	0	7,253,027	10,039,072	**100.39**
9 Feb 04	6.19	0.6974	633,550	441,854	6,811,172	9,766,154	**97.66**
10 Aug 04	6.30	0.6722	0	0	6,811,172	10,132,682	**101.33**
9 Feb 05	6.41	0.6472	635,286	411,167	6,400,005	9,888,522	**98.89**
9 Aug 05	6.48	0.6245	0	0	6,400,005	10,248,335	**102.48**
10 Feb 06	6.55	0.6018	10,635,286	6,400,005	6,400,005	10,635,286	

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- Discount rates (r): These are the current zero-coupon rates for each of the payment option expiration dates.

Each of the 15 options that we must value is a European-style put, which will be exercised by the IRS counterparty only if the future price (present value of the fixed cash flows payable under the IRS) is less than the exercise price (present value of the variable cash flows payable under the IRS). In other words, the IRS counterparty will only exercise the payment options if the IRS has a negative value for it at that time, which means that it has a positive value for the financial entity.

In order to value these options we will use the Black model, which is an adaptation of the general Black-Scholes model. According to this model the value of a put option is:

$$\frac{K \bullet N(-d_2) - F \bullet N(-d_1)}{(1+r)^t}$$

$$d_1 = \frac{\ln \frac{F}{K} + \frac{\sigma^2}{2} \bullet t}{\sigma \bullet \sqrt{t}}$$

$$d_2 = d_1 - \sigma \bullet \sqrt{t}$$

In Table 11-5 we calculate the value of the 15 payment options, using the Black model.

By valuing the payment options we have estimated the credit exposure created by the IRS for the financial entity on each date selected. Now we will calculate the credit provision before recoveries. By multiplying the value of each payment option by the probability,[8] for each option expiration date, that the IRS client will go bankrupt (Table 11-6).

Table 11-5. Option Valuation

Option	Future Price (%)	Exercise Price (%)	Discount Rate (%)	Volatility (%)	Term (Years)	Put Premium (%)
1	102.22	100	5.81	5.17	0.496	**0.600**
2	98.58	100	5.54	5.03	1.000	**2.634**
3	101.17	100	5.49	4.58	1.496	**1.579**
4	97.52	100	5.44	4.42	2.000	**3.509**
5	100.25	100	5.50	4.06	2.499	**2.133**
6	96.83	100	5.56	3.92	3.003	**3.861**
7	99.80	100	5.67	3.53	3.496	**2.252**
8	96.74	100	5.78	3.32	4.000	**3.637**
9	99.91	100	5.88	2.90	4.499	**1.930**
10	97.02	100	5.99	2.62	5.000	**3.061**
11	100.39	100	6.09	2.18	5.499	**1.339**
12	97.66	100	6.19	1.83	6.000	**2.216**
13	101.33	100	6.30	1.36	6.501	**0.557**
14	98.89	100	6.41	0.93	7.003	**1.057**
15	102.48	100	6.48	0.47	7.499	**0.009**

[8] The probability of bankruptcy for the IRS counterparty on each of the dates selected is a function of the credit rating of the counterparty at the present time.

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Table 11-6. Calculation of the Credit Provision for the IRS Before Recoveries

Option	Put Premium (%)	Probability Bankruptcy (%)	Provision (%)
1	0.600	0.0470	0.00028
2	2.634	0.0480	0.00126
3	1.579	0.0730	0.00115
4	3.509	0.0750	0.00263
5	2.133	0.1050	0.00224
6	3.861	0.1080	0.00417
7	2.252	0.1410	0.00317
8	3.637	0.1440	0.00524
9	1.930	0.1780	0.00344
10	3.061	0.1820	0.00557
11	1.339	0.2160	0.00289
12	2.216	0.2210	0.00490
13	0.557	0.2520	0.00140
14	1.057	0.2570	0.00272
15	0.009	0.2870	0.00003
Credit Provision (Before Recovery)			0.04109

As an example, if the financial entity estimates that the recovery percentage is 60%, the credit provision that must be made for this IRS is:

$$0.0004109 \bullet 10^7 \bullet (1-0.60) \cong \text{US\$ } 1{,}644$$

In other words, the financial entity has charged the counterparty a credit risk premium (US$ 58,807) that is greater than the expected credit loss (US$ 1,644). As we will see later, the risk premium covers the credit provision and provides compensation for the credit risk capital that the entity must allocate to this transaction, enabling the entity to earn an adequate credit RORAC.

Calculating of Credit Risk Capital

As stated in the introduction, entities must always allocate credit risk capital to the treasury area to cover credit losses in excess of the credit provisions made for one year's time. This credit risk capital is equal to the present value of the highest credit provision during one year, less the credit provision existing at that time.

An alternative to calculating the highest credit provision for a specific treasury transaction is to use a simulation technique, as described below:

- Define scenarios[9] for the values that the market variables may have in one year and calculate, for each scenario, what the value of the payment options would be in one year (just as we did to calculate the credit provision).

[9] To obtain a distribution of the highest credit provision during the year, many scenarios must be simulated (at least 1,000).

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Continuing with the example we used to calculate the credit provision, after one year's time there will be eight payment options left out of the original ten, as the first two will have expired. Therefore, for each scenario we must calculate the value that those eight options will have in one year. In other words, what was originally the third option, which was originally due to expire in one and one half years, is now the first option to be looked at for the next year, and expires at the end of six months.

- For each scenario defined, and for each credit rating used, calculate the credit provision for one year. If, for example, five credit ratings are used (AAA, AA, A, BBB and BB), each of which has a specific bankruptcy probability, then for each scenario we will have five one-year credit provisions, one for each credit rating.

  In other words, for a specific scenario and a specific credit rating, we will have a one-year credit provision (before recoveries) equal to the sum of the products of the payment option values for each period multiplied by the bankruptcy probability of that credit rating in the respective period. These products must be multiplied by one less the recovery rate to calculate the credit provision after recoveries.
- Starting with the initial credit rating of the counterparty, define credit rating scenarios for the counterparty during the course of the year. For example, if the counterparty has an initial rating of AA, three of the many scenarios that could be defined appear in Table 11-7:

Table 11-7. Credit Rating Scenarios During One Year, AA Initial Rating

	Probability of (%)				
	AAA	AA	A	BBB	BB
Scenario 1	8.0	80.0	9.0	2.5	0.5
Scenario 2	11.0	75.0	10.0	3.0	1.0
Scenario 3	13.0	70.0	11.0	4.0	2.0

In scenario 1, there is an 80% probability that the counterparty, which begins with an AA rating, will continue to have an AA rating during the year. There is an 8% probability that it will move to an AAA rating, a 9% probability that it will drop to an rating, and a 0.5% probability that it will drop to a BB rating.

- By combining the credit provisions calculated for each scenario of market variables and credit rating with the credit rating probability scenarios for the year, we obtain a distribution of credit provisions during the course of the year.
- Now we calculate the highest credit provision. To do this we must select a confidence interval and choose the value of the credit provision distribution that corresponds to that confidence interval.

  For example, if we select a confidence interval of 99%, we will choose the value for the maximum credit provision that is exceeded by only 1% of the values in the distribution.

- Finally, to calculate the credit risk capital for the next year, we discount the maximum one-year credit provision to obtain the credit provision to be made at this time.

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Calculating the Return on Credit Risk-Adjusted Capital

The Return on Credit Risk-Adjusted Capital (credit RORAC) is obtained from the following equation:

$$CF_0 = \sum_{t=1}^{n} \frac{CF_t}{(1+RORAC)^t}$$

where CF_0 is the first cash flow and CF_t is the cash flow each year (cost of capital plus contributions or withdrawals of capital associated with time t), which are calculated by using the expressions below:

$$CF_0 = (ER_0 - CP_0 \bullet (1 - TR) - CAR_0$$

$$CF_t = (CAR_{t-1} \bullet r_{t-1,t}) \bullet (1 - TR) - (CAR_t - CAR_{t-1})$$

where ER_0 is the present value of the expected returns, CP_0 is the credit provision at the outset, TR is the tax rate, CAR_0 is the credit risk capital to be established at the outset, CAR_{t-1} is the credit risk capital to be established at time t–1, CAR_t is the credit risk capital to be established at time t and $r_{t-1,t}$ is the risk-free forward rate from time t–1 to time.

Let us examine a specific example of how to calculate the credit risk capital:

> Assume that we want to calculate the Return on Credit Risk-Adjusted Capital of the IRS that we used as an example to calculate the credit provision. Remember that we assumed that today, February 10, 1998, a financial entity contracted an IRS with a client that had the following characteristics:
>
> - Notional amount: US$ 10 million
> - Term: 8 years
> - Fixed rate: 6.34% p.a., 365 day basis (the financial entity pays)
> - Floating rate: 6 month LIBOR, 365 day basis (the financial entity receives)
> - First floating rate: 5.81%.
>
> The expected return on the IRS (value of the IRS on the start date) was US$ 58,807, and we calculated that the financial entity had to make a credit provision of US$ 1,644.

Using the procedure outlined in the section above, let us estimate the credit risk capital that appears on the second column of Table 11-8. This is the capital that must be contributed by shareholders at the outset of each of the eight years of the life of the IRS.

Based on the expected return of the IRS, the shareholders obtain a credit RORAC of 13.76% (IRR that makes the net present value of the net cash flows shown in Table 11-8 equal to zero) on the risk capital that must be contributed throughout the life of the IRS.

If the financial entity does not think that 13.76% is a sufficient return for this type of transaction, it must quote a fixed rate of less than 6.34%, so that the IRS will earn a return that is sufficient to cover the credit provision and also earn the desired return on the credit risk capital.

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Table 11-8. Calculation of the Credit RORAC of the IRS

Dates	Capital-at-Risk (US$)	Forward Rate (%)	Capital Compen. (US$)	Change in CAR (US$)	Expected Return (US$)	Credit Provision (US$)	Taxes 40% (US$)	Net Cash Flow (US$)
10 Feb 98	93,321			–93,321	58,807	–1,644	–22,865	–59,023
10 Feb 99	98,326	5.33	4,974	–5,005			–1,990	–2,020
10 Feb 00	87,450	5.58	5,484	10,876			–2,194	14,166
10 Feb 01	81,385	6.11	5,346	6,065			–2,138	9,272
10 Feb 02	72,460	6.65	5,411	8,925			–2,164	12,172
10 Feb 03	49,906	7.04	5,098	22,554			–2,039	25,613
10 Feb 04	20,609	7.48	3,735	29,297			–1,494	31,538
10 Mar 04	13,682	7.58	1,563	6,927			–625	7,865
10 Feb 06	0	7.74	1,059	13,682			–424	14,317

Assigning Results Between Market and Credit Risk

In this section we analyze how credit losses influence the returns (P&L) of the treasury area. We distinguish credit returns from returns due to changes in market rates or prices. What we explain below applies mainly to deposits, forwards, and OTC derivatives (FRA, swaps, options, etc.), which are instruments that entities quote prices or rates based on market conditions and the specific credit rating of each of their counterparties.

In general, entities commonly use an assumed-risk criterion to allocate the returns obtained from the management of those risks. In other words, each business is allocated that portion of the return related to the risks it manages. There are two alternatives that may be used to distribute treasury area returns:

- Centralize in the treasury, the management of market and credit risks derived from the positions taken, and then allocate to it all of the returns from these positions (market and credit components).

  According to this philosophy, losses resulting from counterparty bankruptcy would be charged against treasury returns. This focus makes sense when, for example, the treasury invests in assets with low credit ratings instead of obtaining a margin over risk-free rates.
- Make treasury responsible only for managing the market risk of the positions taken, and have credit risk managed by a specialized area. For example, if a treasury transaction is done with a company, the corporate banking area that has the account for that client is responsible for managing the credit risk of the transaction.

  According to this philosophy, credit losses do not affect treasury returns. Instead they are charged to the P&L for the area responsible for managing credit risk. As we will see, that area must be compensated for the risks assumed.

Regardless of the alternative used, what is true is that the P&L of the treasury area is affected by credit losses, according to method 1, due to the possibility of default on contracts by counterparties that go bankrupt when transactions with the entity cause them to suffer a loss.

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The daily P&L for treasury area transactions result from:

- Change in the market value of positions existing at the prior day's close,
- Positive or negative change in credit provisions *vis-à-vis* the prior day,
- Plus market value of new transactions,
- Less credit provisions for the new transactions,
- Plus net cash flows,
- Minus financial costs.

The possibility of credit losses obviously affects cash flows for the period, but so does the market value of the positions.

The market value (MV_{t-1}) of the treasury positions at the end of day $t-1$ can be broken down as:

$$MV_{t-1} = MV^0_{t-1} - P_{t-1}$$

where MV^0_{t-1} is the market value of those positions, without taking credit provisions into account, and P_{t-1} is the credit provision made on that date.

At the end of the next day t, these positions will have a market value that can be broken down as:

$$MV_t = MV^0_t - P_t$$

Therefore, the change in the market value of the positions between days $t-1$ and t will be equal to the change in the market value, without taking credit provisions into account,[10] less the change in the credit provisions:[11]

$$MV_t = MV_{t-1} = (MV^0_t - P_t) - (MV^0_{t-1} - P_{t-1}) = (MV^0_t - MV^0_{t-1}) - (P_t - P_{t-1})$$

In addition, it may happen that during day t the treasury performs new transactions, whose market value (MV_n) can be broken down as:

$$MV_n = MV^0_n - P_n$$

where MV^0_n is the market value of the new transactions, without taking credit considerations into account, and P_n is the credit provision that must be made based on the present value of the expected credit losses on that date.

The net cash flows (F_t) on day t can be broken down as:

$$F_t = F^0_t - PF_t$$

where F^0_t are the net contractual cash flows for the day and PF_t are the cash flows not collected due to bankruptcy of the counterparty (adjusted by the present value of the recoveries expected to occur in the future).

[10] Due to changes in the market variables: interest rates, exchange rates, stock prices, etc.

[11] Due to changes in expectations of movements in the market value of the positions (credit exposure) or the credit rating of the counterparties (probability of default). If the change in expectations results in an increase in the expected credit risk, the credit provision will increase ($P_t - P_{t-1} > 0$); if credit risk drops, credit provisions may be reversed ($P_t - P_{t-1} < 0$).

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As stated earlier, the daily P&L of the treasury area on day t can be calculated as:

$$P\&L_t = MV_t - MV_{t-1} + MV_n + F_t - CF_t =$$

$$= (MV_t^0 - P_t) - (MV_{t-1}^0 - P_{t-1}) + (MV_n^0 - P_n) + (F_t^0 - PF_t) - CF_t =$$

$$= (MV_t^0 - MV_{t-1}^0 + MV_n^0 + F_t^0 - CF_t) + (-P_t + P_{t-1} - P_n - PF_t)$$

A first breakdown of the returns for the treasury area could be the following:

- Market returns (due solely to rate/price changes, no credit considerations):

$$P\&L_{t,market} = MV_t^0 - MV_{t-1}^0 + MV_n^0 + F_t^0 - CF_t$$

- Credit returns:

$$P\&L_{t,credit} = (P_{t-1} - P_t) - P_n - PF_t$$

If we assume that the treasury area is responsible for managing both market and credit risk, both components of the return are allocated to it. If, on the other hand, we assume that the treasury manages only market risk, it is assigned only market returns. The credit returns are allocated to the area responsible for managing the credit risk of treasury positions.

However, the latter focus creates a problem, in that if the area responsible for managing treasury credit risk receives all the credit returns, each new transaction performed by the treasury introduces a loss equal to its credit provision (P_n). This is the result of attributing a value (MV^0_n) to the new transaction when calculating market returns ($P\&L^0_t$) while not including credit losses in the analysis.

On the other hand, the provision for the new transactions (P_n) is not a credit return, but rather the expected cost of doing the transaction; only when it changes is there improvement or deterioration in the probability of a credit loss. Therefore, the credit provision for new transactions (P_n) should be subtracted from the market returns, and therefore, the breakdown of the treasury returns is as follows:

- Market returns:

$$P\&L_{t,market} = MV_t^0 - MV_{t-1}^0 + MV_n^0 + F_t^0 - CF_t$$

- Credit returns:

$$P\&L_{t,credit} = (P_{t-1} - P_t) - P_n - PF_t$$

Therefore, credit returns are influenced by both movements in the credit rating of the counterparty and the level of exposure, which depends on the transaction's market value (interest and exchange rates) and its volatility. This is a problem with respect to allocating returns to the area responsible for managing treasury credit risk. Therefore, this area should receive additional compensation based on the Return on the Credit Risk Adjusted Capital (credit RORAC) of the treasury transactions. This enables it to offset the risk of change in credit provisions, including the effects of a change in the exposure.

Entities that select the second focus should consider the following issues:

- Managing the market value of positions, while ignoring the credit aspects, is the domain of the treasury area; changes in the market value are what should be reflected in

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this area's returns. However, these returns also capture the initial value of the transactions, and the credit provisions must be subtracted from it.

- The market returns of the treasury (ignoring credit aspects) should be reduced daily by the amount of credit provisions related to new transactions done during the day, and should be increased by credit provisions for paid-out transactions.
- Changes in credit provisions over time affect the total return obtained, yet stem from credit risk, which is not managed by treasury. In other words, losses due to counterparty bankruptcy will not be charged against the treasury area. The only exception is for investment in or trading of corporate stocks, where the treasury takes a credit position in exchange for a margin over the risk-free rates.
- The area responsible for managing treasury credit risk will be charged for the credit losses that occur as a result of counterparty bankruptcy, and in exchange will receive the initial provisions that equate to the expected credit losses, plus some additional compensation based on the Return on Credit Risk-Adjusted Capital to compensate for the risk that credit losses may exceed the provisions made.

Nevertheless, regardless of the focus selected by an entity, it must always have credit provisions for an amount equal to the present value of the credit losses expected from treasury area transactions. This credit provision will lower the return of the treasury area, which must therefore attempt to collect it from the counterparties with which it trades, through either the prices or interest rates quoted.

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Chapter 12

Implementation of Risk Management Information Systems

Introduction

The purpose of this chapter is to outline and discuss the stages and critical points that an entity must consider when defining and implementing systems to support risk management and control. The chapter is divided into three distinct sections:

- The first section discusses the basic elements of a risk management system.
- The second section outlines the stages involved in implementing a risk management support system.
- The third section discusses some critical points about which important decisions must be made during the course of the project.

The chapter proceeds on the assumption that the entity has some overall goals with respect to systems implementation. However, before implementation begins, it is advisable to know the expectations of the different groups involved in the project in order to address the aspects in which they are most interested, and to prevent potential communication problems. In this regard:

- Senior management will be interested mainly in seeing results as quickly as possible in order to demonstrate that the project is moving forward and that work is being done.
- The users will also be interested in obtaining results as quickly as possible, but they will also be interested in the final product, and will want to know the specifications of the system being developed, how it will work, what solutions it will provide, etc.
- The technology and systems area will try to ensure that the project complies with the design, analysis and performance standards of the entity, regardless of the time needed to complete the project. The most important factor for this area is having a quality system from a technical point of view, developed according to the dictates of computer engineering.

In general, the goals and issues of the different groups are somewhat contradictory. Prior to implementing a plan, therefore, it should be very clear which goals are to take priority, which in turn should clarify the problems that are most likely to arise during the course of the project:

- If senior management's interests prevail (i.e., obtaining results as quickly as possible), development may occur in a disorderly fashion without an overall system design and an implementation plan. This style of development can result in a system in which functions developed in isolation are then integrated into the system in a very disorderly fashion. In these situations, the system is difficult and expensive to maintain, and has

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an uncontrolled architecture in which any small change can have unforeseen consequences on processes that are unrelated to the actual changes.

- The attitude of the future system users is normally the most balanced, because they are interested in both quality and rapid results. However, one needs to know whether the users perceive the new system as a tool that will make their work easier or as a threat to their ability to do their work. This negative perception can arise if they do not know the system and do not want to learn it.
- Finally, if the interests of the technology and systems area prevail, the project will almost certainly be a success from a technical point of view. There is the danger, though, that the development process will take so long that, when the project is completed, the system will be obsolete or no longer of interest to senior management or the users.

Before the project begins, therefore, communication channels must be established so that a consensus can be reached on the final goal of the project. The consensus decision should take into account the problems that may arise as a result of overly radical decisions that do not adequately address the preferences and needs of the other areas of the entity.

To summarize, this chapter is intended to be of service to those who decide to implement a risk management system, and proposes a methodology to use in designing and implementing such a system. It also discusses some of the more important issues that may arise during the project.

The Risk Management System

In this chapter we proceed as though the risk management system structure is a single system, but in reality it is a number of sub-systems that provide the functions needed to support the risk management and control function.

Before we describe the phases and critical points involved in implementing a risk management control system, we will discuss the basic elements that comprise the system in order to provide an idea of the magnitude of a project of this type. They include:

- Databases
- Calculators
- Reports
- Interfaces

DATABASES

The definition and design of the databases depend on the functions that the risk management system is going to support. It is not possible to design a general structure that is optimal for all situations.

However, experience shows that most risk management systems contain certain basic types of information, which we outline below. The established groupings should cover the majority of risk management system databases:

- Static databases: This group includes the general information that is used by most risk management processes. This information is considered a group because after it is

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initially loaded into the system, it is not changed, or is changed infrequently, over long periods of time. This group includes databases of counterparties, limits, products, and the organizational structure of the entity.

- Dynamic databases: The information in these databases has a more specific purpose and, consequently, they are updated much more frequently. This group includes databases that store market information and those that store the positions taken and transactions undertaken by the entity.
- Databases used to perform and present calculations. The systems that are purchased or developed to manage the entity's risks perform a large number of calculations with the information contained in the first two types of databases. These processes require databases that can store interim results that are helpful to risk managers.

The technical aspects of the databases should be managed by a single work group that can be part of the technology and systems area. This group must ensure the integrity of the information and its optimum storage. It must also be responsible for ensuring that the databases comply with users' requirements.

We discuss the most common databases below and outline their more general characteristics. How they are designed and created will depend on the entity implementing the system, so these aspects are left to the judgment of the area or person responsible.

Counterparty Database

This database is normally used to store information on all the counterparties of the entity (clients, brokers and issuers), together with an indication of the credit rating that the entity has assigned to each.

A credit rating should be assigned using some standard procedure. Each entity has its own, and we will not discuss this any further here.

Normally, all counterparties and the credit ratings assigned them by the entity are entered into this database. The database is updated to reflect new organizations with which business relationships are established, or to show changes in the rating of entities already recorded.

Most risk management systems take information from this database, so it is important that it be defined and maintained correctly.

In most entities this information is managed by the risk analysis and control area, which is responsible for assigning a credit rating to each counterparty.

Limit Database

All of the limits established for all the deals in which the entity participates are stored in this database. There are two basic types of limits, depending on the type of risk exposure an entity wants to monitor:

- Market risk limits: These limits are imposed on the business units, so that the entity is not exposed to more risk than it wants to assume.
- Credit risk limits: These limits are used to avoid concentration of risk in certain countries, sectors or clients. As a rule, lines of credit are established for each country and then for sectors, clients, etc. In this case the information is closely related to the counterparty database.

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The allocated limits are changed periodically (although not too often), based on the decisions made by management about the activities in which it wishes to concentrate the entity's risk-taking.

A limit database is frequently consulted in order to monitor limits, with the percentage utilization and possible existence of excesses indicated.

The risk analysis and control area should be responsible for management of the information contained in a limit database, as this area is also responsible for proposing and monitoring limits.

Negotiable Securities Database

The purpose of such a database is to store the characteristics of the securities regularly traded by the entity, such as futures contracts or bond issues. Information is initially loaded into this database, indicating all the products that the entity regularly trades, and then is updated on a regular basis to reflect any changes.

The risk analysis and control area and the administrative and back office areas should be responsible for maintaining the information contained in this database, since these areas define the products with which the entity deals.

Business Unit Structure Database

The organizational structure of the different business units is stored in this database. The organization of this database depends on the level at which limits are to be imposed and the level at which the entity wants to see aggregate results and be able to identify functional relationships used to create groupings.

The organizational structure is entered and updated thereafter to reflect the actual organizational structure of the different business units. This enables identification of the transactions done by each unit, and therefore the associated risk exposure, as well as profits and losses. This, together with the use of limits, enables analysis and management of the business units based on the profits earned and the risks to which the entity is exposed.

The information contained in this database should be managed by the risk analysis and control area, which is responsible for ensuring correct application of policies and methodologies, so that the numbers provided by the business areas reflect the economic reality of the entity.

Market Variable Database

Risk management systems need to have current market information, as well as a historical database that is kept current, in order to be able to do calculations. A wide variety of information is needed. Some examples of the data normally contained in market variable databases are:

- Current and historical interest rates for the currencies traded by the entity.
- Exchange rates for the currencies traded by the entity.
- Prices of securities traded.
- Volatility, correlation, etc.

Information is normally loaded into such a database from systems that contain current information (Reuters, Bloomberg, etc.) for almost all markets around the world. Using this basic

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information, the entity's systems calculate much other information that describes the behavior of the markets; this additional information is then stored in this database.

A market variable database is fundamental to a risk management system because such information enables the entity to value its positions and evaluate changes that may occur. Almost all of the sub-systems have access to this database so that they can use the information it contains to perform their own calculations.

The risk analysis and control area should be responsible for managing the information contained in this database, as it is responsible for defining the independent sources to be accessed in order to capture the market variables needed to value and measure risk. It is important for the risk analysis and control area to coordinate with the administrative and back offices so that there are no problems with inconsistent use of market data when making calculations.

Transaction Database

This database contains information about all the existing transactions that expose the entity to market and credit risk. A wide variety of data is stored in such a database; some data is rarely changed, as in the case of long-term investments, while other information is constantly changing, as in the case of transactions done by the treasury trading desks.

Business units enter this information into the database when transactions are done and should subsequently check it to make sure it is correct.

As one might imagine, the content of this database is vital to risk management, since it shows all the transactions that expose the entity to different types of risk. Almost all the other systems have access to it, in order to obtain the information that is needed to do risk measurements.

Database administration should be handled by the administrative and back offices, which are responsible for ensuring the integrity of the transaction database.

Relationships between Different Databases

The information types mentioned are closely related because they all provide information needed to perform the calculations that are part of risk management. All the databases are interrelated in some way, so special care must be taken to ensure consistency among them and to avoid problems such as:

- Transactions performed in markets that they should not have been performed in.
- Transactions or positions allocated to business units that do not exist.
- Counterparties that lack a credit rating.
- Transactions with products not defined in the databases, or for which prices are not available, etc.

CALCULATION SYSTEMS

In our earlier chapters on the methodologies used in risk management and measurement, one can see how, in addition to requiring a great deal of information, many calculations are also necessary to obtain the results sought.

In this section we describe the main calculators that must be implemented in order to put these methodologies into practice.

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Calculating Positions

The sub-system responsible for calculating positions takes as a starting point the transactions done by the entity and the market variables needed to calculate their values. It then values all of the transactions so that the end users of the system know the value of the entity's positions, both individually and based on different aggregation criteria (portfolios, products, profit centers, etc.).

When the number of transactions is very high, it becomes necessary to provide more aggregated information in order to know the entity's positions *vis-à-vis* different risk factors. For this reason equivalent position maps are calculated; they summarize the entity's aggregate position from a group of positions *vis-à-vis* a smaller number of risk factors. The position maps are obtained by calculating, under multiple market scenarios, a portfolio equivalent to the entity's portfolio, such that the change in value of the equivalent portfolio in any given scenario is equal to the change in the value of the real portfolio. This is a complex process that requires the use of simulation techniques involving the use of many calculations.

In many cases, the entity needs to have the equivalent positions of each of the businesses in which it operates in addition to its overall equivalent position. This significantly increases the number of calculations that must be performed.

Calculation of Operating Results

Another important issue involves obtaining operating results. A sub-system is needed to calculate, on a daily basis, profits and losses (P&L) using operating criteria (which are different than accounting criteria).

This module calculates the P&L generated by each transaction and must be capable of performing as many aggregations as necessary so that the results considered most relevant to the risks assumed can be evaluated. The sub-system must also be able to evaluate the P&L for different time periods: daily, month-to-date, year-to-date (calendar or fiscal) and, in general, any other time period.

In addition to calculating historical results, the P&L module must be able to estimate the results the current position is expected to generate in future periods.

Last, it is important for the P&L module to be able to subject the entity's results to sensitivity analyses that incorporate hypothetical changes in various risk factors. This capability enables the entity to explain the results obtained in terms of the positions taken and the movements that have occurred in the markets.

Calculation of Risk and Risk/Return Measures

Risk measurement indicators (VAR, CAR, etc.) and risk/return measures (RORAC) use the results generated by the two modules above, together with market data (volatilities, correlations, etc.), to generate the final results described in the methodologies outlined throughout this manual. The risk measurement calculation model must enable comparison of actual risk assumed to the limits established.

Since the risk measurements cannot be added together directly, we must take into account the correlations that exist between the risk factors. This significantly complicates the calculations, since they must be redone each time a new transaction or position is introduced.

First, Capital-at-Risk is usually calculated for different factors (interest rates, exchange rates, etc.), and then multiple aggregations are done: the total for the entity, the positions in each

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currency in which the entity trades, the total for the business units, the total for each of the positions of the equivalent portfolio, and, in general, for any group of transactions that the entity wants to evaluate.

The RORACs are also calculated for each of these groups. Normally two RORAC values—expected and historical—are provided. The expected RORAC is calculated from the expected P&L and CAR, along with the actual position of the entity. The historical RORAC is calculated using the historical P&L and the CARs that were calculated daily; from these figures, the historical CAR can be obtained.

Simulators

As noted previously, executing a single new transaction requires that all of the risk measurements for an associated portfolio be recalculated, which is a significant complication when deciding how transactions that have not been performed previously will affect the CAR and the RORAC of a portfolio.

Simulators are used to resolve this problem. They make it possible to calculate the approximate change (by using, for example, the concept of CARdelta) that would occur in the CAR and the RORAC of a portfolio if the portfolio's positions were modified.

Simulators make it possible for managers of different business areas to track the approximate risk of their portfolios while doing transactions throughout the day.

REPORT GENERATORS

The risk management system must be able to generate reports for all the areas of the entity, according to the standards outlined in chapter 8.

As a part of end-of-day processing, the system should automatically produce predefined reports that can be consulted by the different areas of the entity according to an appropriate access level scheme.

The system should also have a report generator that can prepare reports selected by the user, using any combination of profit center, risk factor, portfolio type, product type, etc.

In addition, the system should have a consultation module that allows users to easily access the information they want so that they can evaluate their position and the risk/return of the trades that they are monitoring or managing.

INTERFACES

One of the biggest problems that an entity can face when implementing a risk management system is how to create interfaces with the entity's other systems in order to be able to load all the data that the system needs to function.

Basically, interfaces with two types of systems are needed, depending on the information that they provide:

- Market information systems, which supply the information needed by the risk management system to value positions and evaluate the risk embedded in the positions. This type of information is usually provided by specialized companies that provide real-time market information (such as interest rates, foreign exchange rates, stock prices, etc.).

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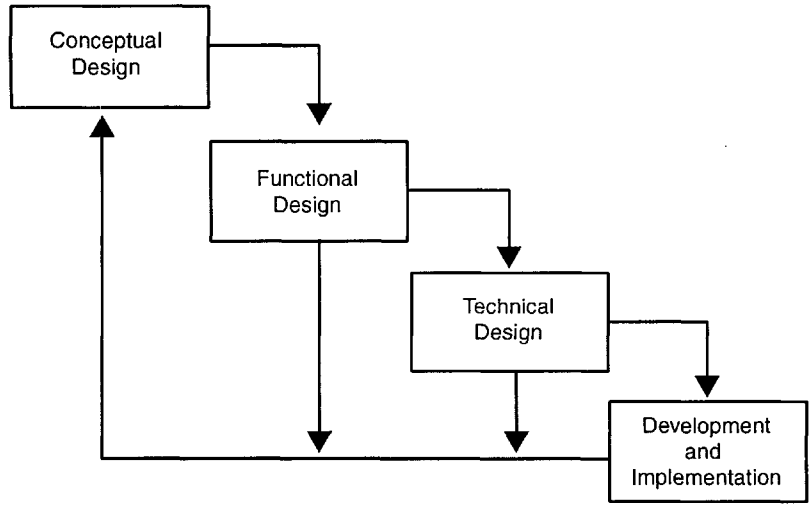
- Position information systems, which store the transactions done by the different business units of the entity. Although this information should be centralized, in most entities it is dispersed among multiple specialized systems that deal with specific products or types of business, which considerably complicates the risk management information system implementation process.

In addition to building input interfaces, the entity may have to develop output interfaces that provide information to other systems of the entity, such as the accounting system (it can use transaction valuations) and the internal auditing system.

Project Stages

In this section we outline the stages that must occur when defining and implementing a structure for a risk management system. Figure 12-1 provides a general scheme of the stages of the project.

Figure 12-1. Project Stages: Design, Development and Implementation of a Risk Management System



Conceptual Design

The objective of the first stage of the project is to develop and obtain approval for a conceptual design for the system that provides the bases on which the Risk Committee can approve starting the project.

The conceptual design establishes the basic goals of the project, and describes the processes that will be included in the system, the computer platform on which it will run, the effect it will have on the organization, etc. It also includes a plan for the analysis and design stage.

The conceptual design consists of three phases:

- Organization of the conceptual design stage.
- Development of the conceptual design.
- Review and approval.

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Organization of the Conceptual Design Stage

In this phase, the computer environment in which the conceptual design is to be done is prepared, the scope of the project is defined, and decisions are made about which areas of the entity are to be involved and what the administrative standards are.

Given the strategic importance of this type of project, it is essential for all the areas of the entity to participate in defining and implementing the structure of the risk management system:

- Leadership: senior management (strategic structure) must commit to the project, ensuring that all of the areas of the entity (operating structure) are committed and cooperate as necessary on the project, in order to achieve the goals established.
- Functional definition: all of the areas of the entity must define the capabilities that the system should provide them with respect to the risk management and control tasks assigned to them.
- Technological definition: the technology and systems area must define the technological characteristics and the structure of the risk management system.
- Coordination: the Risk Committee is responsible for coordinating the execution of the project, either directly or by delegating it to a project management committee presided over by a member of senior management. At a minimum, the following areas should be represented in this committee:
  - All the business areas.
  - The risk analysis and control area.
  - The administrative and back office area.
  - The technology and systems area.
  - The internal auditing area.

Development of the Conceptual Design

The purpose of the conceptual design is to define what the system will do. As part of this process, the current systems are analyzed, the objectives of the new system are established, and possible development alternatives are analyzed. The most satisfactory is selected.

The conceptual design development is usually divided into four phases:

a. Description of the current situation, detailing the status of the entity's current risk management systems from both a technological and functional point of view. In other words, the technological requirements and functions of the potential new system are compared to those of the existing system and to the ability of those existing technologies to meet the needs of the new system.

   This analysis is used to identify the weak and strong points of the current systems, as well as of the existing processes and procedures.

b. Conceptual description of the risk management system. During this phase, the processes that the new system must handle are identified and described. The information required for the execution of each of its processes is identified, as is the information it will provide to the other systems. A preliminary data model is also prepared, reflecting the information needs identified to that point and identifying the areas that will be responsible for entering and maintaining that information.

   When preparing the conceptual description report, it is important to keep in mind senior management's expectations, which are reflected in the risk management strategy approved by the Executive Committee of the entity. It should also include the general

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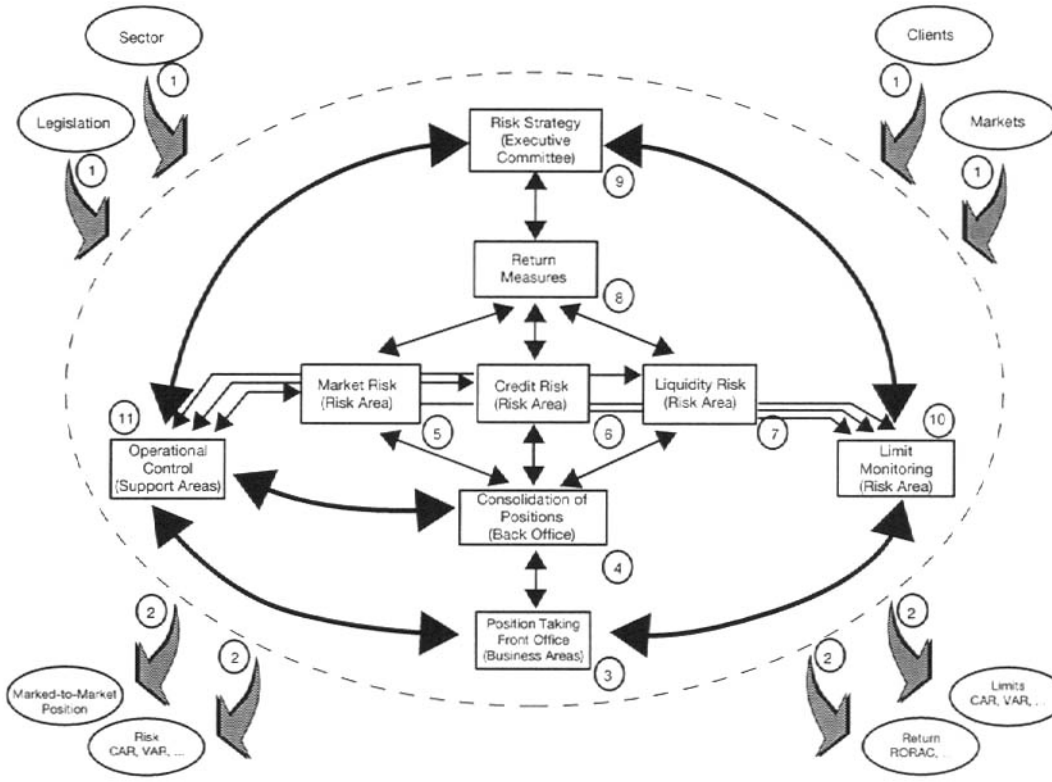
guidelines established by the systems strategy so that no compatibility problems occur in the future.

Finally, this report should be accompanied by a preliminary study of the impact that the implementation of these processes and systems will have on the entity. This report should describe the processes that must be performed by each of the areas defined in chapter 2 and identify the extent of the changes that will occur in each due to the new system.

Figure 12-2 describes the main processes required for risk management and control, as well as the relationships that exist between them.

Figure 12-2. Processes Required for Risk Management and Control



1. The system obtains external information that describes the markets in which the entity operates, its clients, economic sectors and applicable law.
2. The external information that is entered into the system, together with the information describing the position taken by the entity, is used to generate valuation measurements of the entity's position: Capital-at-Risk, Return on Risk-Adjusted Capital, limit control, etc.
3. In the business areas, the entity's risk is managed by performing transactions. In order to perform their functions, the business areas have systems that facilitate decision-making, analysis (simulators), and storage of transaction information.
4. The transactions done in all of the business areas are consolidated and stored in a single database that is run by the administrative and back office area. The information handled by this system is the basis for all subsequent calculations.

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5. The market risk control system reads the entity's positions and calculates the market risk exposure, comparing it to established limits.
6. The credit risk control system calculates the credit risk exposure by counterparty and checks it against authorized lines of credit.
7. The liquidity risk control system enables analysis of incoming and outgoing funds in relation to the entity's balance sheet structure in order to anticipate liquidity needs or excesses at different times in the future.
8. The risk analysis and control area is responsible for integrating and analyzing the risk information generated by these systems. This area reports regularly and in detail to the Risk Committee about the exposure to different risks generated by the businesses in which the entity operates.
9. The Risk Committee reports to the Executive Committee on the overall risk exposure of the entity.
10. The risk analysis and control area checks to see that all the units operate within the limits established, and informs the Risk Committee of any excesses that occur.
11. The purpose of the operating control module is to establish procedures and controls that prevent execution of transactions or processes that do not comply with all established requirements. This module receives information from all the other modules, since it monitors the existence of specific conditions defined as necessary to carry out each of the processes.

c. Preliminary technical analysis. Once a description of the desired system and the functions it must perform has been completed, it is possible to create a rough approximation of the technical environment in which the system is to work. In order for the analysis to be as rigorous as possible, different alternatives should be presented, accompanied by a study of the impact each alternative may have on the organization.

   It would also be interesting to include alternatives regarding the environments that could be used to develop or adapt the sub-systems to be implemented. The appropriateness of using different development tools is studied, based on the training and experience of the team that the entity wants to create to handle this project. In organizational impact studies, it is important to identify the risks involved in carrying out the project, as well as those that the system will face after being implemented.

d. Project plan proposal. With the information obtained thus far, a work plan for the project can be prepared, together with an estimated budget. The main tasks and the cost of each are identified, including the assumptions involved in the estimates and a brief sensitivity analysis.

   In addition to the general planning and budgeting related to the project, a more detailed plan and budget must be prepared for the next phase, during which the system is analyzed and designed from both functional and technical points of view.

Review and Approval

Using all of the information described in the sections above, a report is prepared containing a proposal for the desired system. The report is sent to the Risk Committee for approval.

ANALYSIS AND DESIGN

The purpose of this phase is to establish the functional and technical specifications of the risk management system, which is then presented to the Risk Committee for approval. At the end

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of this phase, the plan, budget and calendar for the development and implementation phase of the system are prepared.

During the analysis and design phase, the functional design personnel designated to collaborate on the project (who come from each of the areas defined in the section on organization of the conceptual design) have an especially important role. Without their approval the functional design cannot be sent to the Risk Committee for approval.

It is imperative in this phase that the functional design personnel be committed to the directives established by the Risk Committee and heed the requests made of them with respect to defining the specifications of the risk management system. Their collaboration is essential to the integration of the risk management processes in their respective areas with minimal impact while optimizing the use of all the established processes.

The analysis and design phase consists of eight stages:

- Organization of the analysis and design phase.
- Definition of user requirements.
- Functional design.
- Evaluation of computer hardware and software.
- Technical design.
- Specification of technical requirements.
- Planning system implementation.
- Review and approval.

Organization of the Analysis and Design Phase

The analysis and design phase is considerably more complicated to manage than the preceding stage; therefore, organizing it well is essential to the overall success of the project. In this phase, the entity must:

- Establish project standards, administrative procedures and administrative tools. Before beginning work, select the computer application that will be used to manage the project, and define all the administrative, progress control and financial control procedures. Also define all the project standards.

  The purpose of this stage is to decide on the methodology to be used to oversee the project, indicating the items about which information must be provided in order to monitor project progress. The nature and frequency of the reports to be provided must also be decided.
- Organize the work team. Using the detailed plan drawn up at the end of the conceptual design phase, establish the activities that must be carried out. Persons must be assigned to perform them, starting and completion dates must be established, and those responsible for functional issues and user area processes must be decided. Finally, the training that will be needed by the team in order to carry out the project must be specified.
- Define the project quality control plan. Define the internal quality controls that will be followed during the project.

Definition of User Requirements

The purpose of this process is to define user requirements in more detail than in the conceptual design. With assistance from the functional design personnel, the processes and their security

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and control requirements are identified, and the impact the system will have on each area is analyzed. In brief, this is a matter of designing a structure of processes and procedures that satisfy the requirements of the Risk Committee, as expressed in the conceptual design, and are acceptable to the functional design personnel of each area involved.

This work can be done in the following stages:

- Identification of information processes and needs. Starting with the conceptual design, and working in concert with the functional design personnel, define in detail the processes that will be created to provide the desired functions. Then analyze the processes that were performed prior to the project, and optimize all of the resulting processes, so as to minimize the effort and cost of the risk management function. Break the processes down into activities and determine what information is required and generated by each process. Then define the data model used by the risk management area, and connect it to the initial outline developed as part of the conceptual design.

As this phase progresses, the functional design personnel develop a sharper awareness of the scope of the project, and can begin to evaluate the project's impact on their areas and the importance of the information that is generated by the new system. The process of defining which pieces of information are relevant to the performance of the risk management function begins in this phase, along with the development of the processes and activities that must be carried out to process the information, and the definition of the results that must be known in order to quantify risk.

The result is a map of optimized processes and activities, and the data model needed for them to function.

- Define the return, security and control requirements. Once the processes and activities that will be performed by the risk management function are known, and an estimate of the volume of information to be managed can be made, it is possible to make a rough estimate of the processing capacity needs of the function. By having a relatively well-developed data model and a process and activity map, we can begin to define the security and control requirements needed to avoid weak points in the systems structure.
- Analysis of the organizational impact. With all of the information generated so far, the functional design personnel cannot but be aware of the changes that the risk management function will undergo when the new processing structure is implemented. A detailed report must be prepared on the impact that the implementation of the new system will have on the function, and the functional design personnel must accept and approve the process structure.

Functional Design

The purpose of this phase is to create a prototype[1] that shows the final process structure that has been developed and the appearance of the systems that will be implemented by the entity. The data model continues to be developed by identifying the inflows and output of the systems, as well as the information flows to be established between them.

In this phase the different methodologies to be used to calculate the entity's risk exposure must be defined. There must be consistency among all of them so that they can be aggregated

[1] The prototype may take many different forms. It may consist of a group of hard copy reports and diagrams that show the flow of information in the system and the time when each of the prior reports appears. Applications might be used that facilitate the preparation of computer application prototypes.

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to obtain total results. This is the time to determine the calculations that must be made to obtain the risk measurements to be approved by the Risk Committee.

It is important to perform all the tests deemed necessary and to ensure that the methodologies developed can be expanded to measure the risk of the different businesses that the entity may enter in the future. If the methods are not sufficiently general or are badly defined, there will be problems that grow as the project moves forward, which makes them much more difficult and costly to solve.

Development of the prototype requires an important decision be made—namely, the methodology that will be used to create it. Two classes of prototypes may be created:

- Simple prototypes. Such prototypes are of a purely experimental nature, and are useful only for learning and showing what the final system could be. As a general rule, they are a series of screens that simulate how the system will finally operate. Development of such prototypes facilitates analysis of the input/output information for each system and the relationships established between them. They have the advantages of being easier and cheaper to build, but after the functional design is approved, they serve only as a reference point for development of the final system. There are many products in the market that facilitate the development of such prototypes, although one must be cautious in selecting them in order to ensure that the result resembles the final result as closely as possible. In this regard, the standards established by the technology and systems area should be followed.
- Intelligent prototypes.[2] In this case the prototype is part of the new system, which will grow larger and be modified as the design progresses. It is much more costly and takes more time to develop, but the work done can be used in the future development of the system.

Whether or not a prototype is developed depends on the entity's cumulative experience and on the results obtained in each case. Therefore, we can make no general recommendation about prototypes.

When a prototype is developed, the screens and reports that will be used by the system are defined. This requires defining the input and output information of each process in greater detail. This work is used to further define the data model that was developed as part of the conceptual design and to specify users' requirements.

In order to finalize the functional design, the prototype is presented to the user, together with all the documentation generated. Any modifications necessary are then made until approval is obtained from the functional design personnel.

Evaluation of Hardware and Software

Although the format of this document requires sequential description of the phases, we should note that the choice of hardware and software is closely related to the technical design, so it is necessary to have an idea of the hardware and software one wishes to use for technical design. However, the selection cannot be considered final because the technical design may not achieve the desired objectives. Therefore, this phase and the next provide important feedback that must be used well.

[2] If there is a possibility that a system will be purchased to perform the functions the entity wants to implement, it is not advisable to develop this type of prototype, since it is very costly, and, as is explained in this point, is of interest only if the system is going to be developed from scratch.

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The choice of software must take into account the following considerations:

- The possible hardware and software combinations that may satisfy the requirements of the new system must be identified, evaluated and recommended. To do this, the technical architecture that best meets the requirements established as of that point must be defined. Then the hardware and software that best work with the technical architecture must be identified. Then information is requested from suppliers and a technical evaluation is performed. When the technical evaluation has been completed, the number of potential systems is smaller. For those still in the running, bids are requested, and after they are analyzed, a final decision is made.
- The hardware and software of the new system must comply with the standards defined by the entity's technology and systems area.
- If a decision were made not to use any of the architectures defined in the entity's standards, the most similar would be taken as a reference. If this cannot be done, the need to create a new standard that covers the situation must be reported.

Technical Design

The purpose of technical design is to create technical specifications so that the system can be implemented. During this phase, there is less communication with the user, although he must be told of any modifications made in the functional design due to technical constraints.

In this phase the methodologies and the mathematical formulas designed to quantify risk begin to be structured in the technical environment. At this point we begin to define how calculations are actually going to be performed in order to obtain the final results.

The technical design can be divided into the following phases:

- Technical architecture design. Based on the functional design, one begins to create the final structure of the software that will be developed. At this time one indicates the processes that can be done in batch mode, the ones that are to be done on-line and the relationships that must exist between them. Interfaces must be described in detail. During this phase one must also determine the security requirements for each process and the related user interfaces. A capacity analysis must be performed to verify that the hardware and software selected are capable of performing the processes just defined.
- Database design. First a logical architecture for the database is created by finalizing the data model that we began to develop in the conceptual design phase. The consistency of the data model is verified, and an architecture is created for the database. Then a physical design is done for the database, a traffic analysis is performed and the database architecture is adjusted based on technical criteria. Finally, documentation is prepared for the physical database.

  Creation of the physical database is done concurrently with the next two phases. It is generally advisable to make some progress on the next two phases while working on this phase to get an overall vision of the system, which is crucial to achieving a complete and coherent physical design that works with the processes proposed.
- Design of system modules. At this point, the processes can be broken out into modules, which give rise to the program structure to be developed. A set of specifications is created for each process, and should contain the following information:
  - Module description.
  - Flow diagram.

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  - Determination of access to database.
  - Input and output.
- Design of the performance, security and control procedures. Before considering the technical design complete, final testing should be done as follows:
  - Performance control. Verify that the system performs as expected, according to the operating needs of the business, the hardware chosen, and the programs to be used. Access to storage devices and to the database management system must be reviewed, as must the communications system and the number of transactions expected. Attempt to find any bottlenecks.
  - Security control. Check to see that the database design and chosen programs comply with security specifications, using the documentation created thus far regarding security needs. Check information input and output.
  - Integrity control. Check to see that the database and program designs fulfill technical and user requirements, and that they are consistent. In other words, make sure that the databases contain all the information needed by the programs to run and ensure that they are not storing useless information.

Specification of Technical Requirements

One of the final stages before beginning the system development phase is to define the technical procedures that will be used in the development phase:

- Test strategy design. Before beginning development, define the tests that are to be conducted on every module before they are deemed ready to go into operation. Create a test environment.
- Conversion strategy design. Once the final data module is ready and we know which existing information the system will store, we can prepare the conversion and data entry strategy.

Planning the Systems Implementation

The purpose of this phase is to plan the execution of the next phase, in which the system goes live. The tasks and work groups responsible for each task must be defined, and the cost of implementing the system is estimated.

In this phase it is important to remember to plan conversion of personnel data and information.

The entire process should be reviewed using project management techniques in order to find the critical path for managing the project appropriately during the execution phase.

Review and Approval

The review process is especially important at this point and should be done very thoroughly to ensure that there is compliance with all of the specifications defined by the Risk Committee in order to achieve the established goals. If necessary, the conceptual and functional specifications must be changed at this point and reported to the functional design personnel and the other units that collaborated on them. The purpose here is to eliminate, or at least minimize, errors, because after this point it will be much more difficult and costly to fix them.

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Finally, a report is prepared for the Executive Committee and the project is presented to it, with special emphasis placed on the functions the system will actually perform, the responsibilities assumed during the development phases by each area, and the final estimated cost of the project.

Modifications requested must be made until final approval is obtained, and then development may begin.

DEVELOPMENT OF THE RISK MANAGEMENT SYSTEM

In this phase we move from the designs completed thus far to the programs, converted data, and procedures needed for the system to begin operating. To efficiently execute this phase, the user must be committed to not modifying the designs already approved, since this would make the project more expensive and increase the amount of time to completion.

In the system development phase the following must occur:

- Organization of the development phase. In this phase the plan for execution of the system development project is prepared. The plan prepared at the end of the previous phase is used as a starting point to determine the following:
  - Organizational structure of the project. The persons to be involved must be specified, and their responsibilities and degree of participation must be established.
  - Organization of work teams. The teams that will perform each phase of the implementation must be established, and the entity must ensure that they are able to do the work entrusted to them.
  - Project standards. The standards to be observed during project development must be set, especially with respect to program codes and documentation.
- Installation of the base hardware and software for the project. The architecture created during the design phase is implemented, so that everything is ready for development to begin.
- Detailed design and programming. Based on the program specifications drawn up during the technical design phase, a detailed design of each program must be prepared. Using these detailed designs, the work teams can begin program code work and documentation, which will result in the final programs. These programs must be tested in accordance with the test plan discussed earlier.
- Data conversion. Existing data must be loaded so that the system can be started up. This process must be done very carefully, with checks to see that the procedures established for the capture, conversion and entering of data are correct and do not alter the information.
- Preparation of the user training plan. With the system nearly complete, it is time to begin preparation of the user training plans for all levels, so that when the system is up, every user knows precisely how it operates and how it affects the functions each person performs.
- Installation support. Finally, the system is installed and starts to operate. All problems that arise during this process must be solved, and tests should be performed to see that the system works on an integrated basis. The users have an important role here, as this is their first contact with the system; they are using it to perform the procedures described in earlier phases.
- System approval. Using the reports prepared in the prior phase on the proper functioning of all modules, and with approval from all the functional design personnel regarding the part on which they worked, the documentation for requesting final approval of the system from the Risk Committee is prepared.

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- Start-up of the system. The system is finally started up. In this phase it is important to specifically establish the responsibilities of each area so that no coordination problems arise between them later that make it difficult to implement the risk management strategy.

SELECTION, INTEGRATION AND IMPLEMENTATION OF APPLICATIONS

Sometimes a system is available in the market that provides a portion of the functions needed for a risk management system. If this is the case, the entity must decide whether it is better to buy the system or develop it internally. The criteria on which such a decision should be based are laid out in the next section.

Here we will discuss the point at which (i.e., at which project phase as described above) the entity should analyze the appropriateness of buying an external system. We will also examine (assuming the entity does decide to buy an external system) how it should be implemented and integrated into the existing risk management system in order to achieve the best result.

The time to begin such a selection is during the creation of the functional design. Once the entity has clearly specified user requirements in hand, it is in a position to analyze whether any of the systems available in the market cover all or some of the functions it needs, and whether its price is attractive enough to lead the entity to prefer not to run the risks involved in internal system development.

After ensuring that the external system meets its requirements, the entity needs to examine the technical design in order to determine whether the system could meet all the performance, security and control requirements of the project. Then the entity could design the interfaces with the other systems that would need to take information from the external system, and the interfaces needed for it to provide information to other systems. This is when the system data model must be carefully analyzed to ensure that the information it handles is complete and not duplicated in other locations. If all requirements are met at this point, the external system can be implemented during the system development phase, during which the entity can modify it and change its parameters as necessary for integration with the other modules.

When the general system tests are run, the purchased application must be fully installed so that it can be part of the integrated testing process. It is important to note that we recommend that the purchase not be made final until the test process is complete and there is no doubt that the system performs in all ways as claimed by the vendor.

Critical Issues

When an entity decides to undertake a project such as the one described in the sections above, it must analyze and make decisions about different critical issues that will affect the execution of the project. Below we state and review the main critical issues that normally are involved in a project of this type:

- Which systems will be developed internally and which will be purchased?
- If systems are purchased, what factors must be taken into account in the selection process?
- Will the existing platform be maintained or will the project be used as an opportunity to change the computer platform?
- What technical architecture is best?
- What operating controls must be implicit in the risk management system structure?
- In what environment will the risk management system be developed?

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WHICH SYSTEMS WILL BE DEVELOPED INTERNALLY AND WHICH WILL BE PURCHASED?

This question must be answered when deciding on the implementation of each of the sub-systems needed to support the entity's risk management strategy. The main factors that must be taken into account when making such a decision are outlined below.

Determining Objectives

Before beginning a study of whether a certain product should be purchased or developed internally, it is necessary to know exactly what the system is intended to do. In this regard, it is important to clarify the following aspects of the issue:

- Functions that are to be supported. It is necessary to know exactly the function that the product will perform within the risk management strategy to be implemented, what information will be input into it, what processes it must perform, and what information it must generate.
- Methodologies to be implemented. The methodologies used to perform the different functions are important factors in establishing the information that the system must handle, the processing capacity required and the storage capacity needed.
- Sources from which data will be taken. It is important to know the characteristics of the system's information sources: the data formats, the technical characteristics of the applications that store information, how information is accessed, etc.
- Sub-systems to which information will be provided. It is also advisable to understand the systems to which information will be provided, the data formats they use, their data storage characteristics, how information is accessed, etc.
- The likelihood of regular expansion or modification in the future. It is necessary to know whether the parameters of the problem that needs to be solved change periodically. Typical examples are the appearance of new products, new payment methods, etc.
- Technical architecture of the environment in which the system is to be implemented. Another important point is the systems architecture used in the environment where the system is to be implemented.

Analysis of the Applications Installed at the Entity

Once objectives are clearly established, make sure that existing applications do not already support the desired functions. The following checks should be carried out:

- Check whether a system exists at the entity that provides the required function but is not currently being used. It may be that a system that has such a function was purchased but never implemented because it was not previously necessary.
- Verify that no new versions exist. New versions that support the functions may have appeared, or the vendor may be developing one.
- If a new version provides a needed function, or is expected to shortly, do a thorough analysis to ensure that what it offers is really what is needed. Special care must be taken if the function has not yet been developed by the entity—while the vendor may offer assurances that the new version will do what is needed, subsequent experience may prove otherwise.

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Analysis of Products Already in the Market

This analysis is used to decide which systems of those available in the market meet the functionality specifications established previously, and whether they fit adequately into the systems architecture of the entity.

The next section analyzes this topic in more detail.

Analysis of the Cost and Implications of Internal Development

Internal development of the different sub-systems is a risky process given the difficulties that appear during the development of any computer application, and especially because of the complexity of the methodologies used to manage risk. Therefore, before deciding that we want to pursue this option, the following steps should be taken:

- Thoroughly analyze the objectives the system is intended to meet. It is necessary to know as exactly as possible the functions that are to be performed by the sub-system so that the main obstacles to its development can be evaluated.
- Analyze the risks assumed by opting for internal development. Internal development is a complicated process that always entails a risk of not meeting objectives related to time periods, budgets and quality. The possibility that objectives will not be met should be analyzed, as well as the impact that this would have on implementation of the risk management strategy.
- Analyze the methodologies to be used. If internal development is chosen, the methodologies defined earlier must be implemented, which can be very complicated. In general, the methodologies used to value the risks to which an entity is subject are very complex and require significant mathematical knowledge. It is also possible that the mathematical models developed will not provide the expected results, in which case it will be necessary to create other models that give better results.
- Evaluate the personnel available to carry out the project. The team that will execute the project must be carefully assembled. It must include people capable of developing the mathematical models used to value risks as well as analyzing whether the results obtained are what was desired. In addition, the analysts and programmers must be able to work with advanced mathematical specifications.
- Evaluate the personnel available to operate the system. After the sub-system is developed, there must be a team to maintain and operate the sub-system, and in general the team must be larger than if an application were merely purchased. The team must also include people who continue to check the accuracy of the results and who propose solutions to problems that arise with the models and methodologies.
- Consider both internal and external development. Another important issue is whether software is to be developed by a team from an area other than the one that will operate it, or whether a team will be added that will subsequently become part of the department. There are various alternatives:

  a) A team consisting of area personnel. This can be a good choice, since, as a part of the department, the team knows the environment in which the sub-system must operate, which will increase the project's chances for success.

  b) A team that is part of the area but is made up of outside personnel. The advantage stated in a) is still valid, although if the personnel are from outside the entity, the knowledge and experience of the department could leave the entity.

  c) A team from within the entity but outside the area. In this case, which may occur when the project is the responsibility of another department of the entity that handles

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new development, the problem that can arise is that the team responsible for development is made up of system development specialists who are not very familiar with the department itself. This lack of familiarity decreases the chances that the project will be satisfactorily completed.

d) A team external to the area and the entity. In this case, the problem noted in c) is potentially exacerbated by the fact that the project knowledge and experience lie totally outside the department and the entity.

Methodology Used to Develop the Sub-System

Of all the possible ways of approaching application development, perhaps the most suitable in this situation is the incremental development of prototypes. This approach enables the entity to achieve preliminary results in little time, after which functions can be added and existing ones improved. This approach does present the problem that the time periods for development and therefore the costs of development may be longer and higher than hoped, but the probability that the final result will be acceptable is much greater than when classic system development is attempted. In the latter approach to development the specifications are so rigid that modifications cannot be made when problems arise.

Making the Decision: Internal Development or System Purchase?

After analyzing the points outlined above, the entity is in a position to make a decision. Although each case is different, the two alternatives present both pluses and minuses:

- Internal development related to risk management and control is often risky due to the relative newness of the subject and its complexity. However, if the risks are accepted, internal development is more able to adjust to the needs of the entity and does not create dependence on any outside organization. In addition, the actual experience of creating the design will significantly increase the entity's knowledge of this subject.
- The purchase of a system enables resolution of the problem in less time, and causes less upheaval at the entity, provided that a thorough analysis has already been performed. However, purchased systems result in external dependencies, and are less flexible in terms of adapting to the needs of the entity.

If the entity decides to go with internal development, it should not overlook the possibility of purchasing a usage license for some system for a period of time while internal development occurs. In this way the final system is internally developed, and some of the risks that can occur are eliminated. While development is underway, the entity will have a system that provides the risk measurements needed by the risk management strategy. If delivery of the internal system is delayed, the usage agreement for the other system could be extended.

IF SYSTEMS ARE PURCHASED, WHAT FACTORS MUST BE TAKEN INTO ACCOUNT IN THE SELECTION PROCESS?

The process of analyzing a system to decide whether it is appropriate for purchase must be done very carefully. In conducting the analysis, the entity must try to avoid disagreeable

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surprises that hinder implementation of the risk management strategy within the established time periods.

At a minimum, the following should be taken into account in such a decision.

Functionality Provided by the Sub-System

The first requirement is to check that the sub-system truly provides the required functionality under the conditions in which it is going to be implemented by the entity. To do this, the entity should:

- Ensure that the software under consideration can work with all the products in which the entity deals. The system must be a full solution for the entity; i.e., no other systems must be necessary to provide the functions it wants to cover. The system must also permit entering combinations of instruments (equivalent portfolios of a product) and allow users to work with them as if they were a single product. This capability enables the use of replicas of instruments and portfolios until the system can be expanded to deal with the actual instruments used.
- Ensure that the product under consideration provides the risk measurements desired for use in the project. It is necessary to ensure that the system provides the risk measurements that were standardized when the risk management strategy was defined. The applications used for risk management can offer different risk measurements: Value-at-Risk, Capital-at-Risk, RORAC, etc. Therefore, the entity must check that the system generates the desired risk measurements, or that they can be obtained with relative ease.
- Thoroughly examine the methodology used to perform calculations to ensure that it is the one indicated by the vendor. Sometimes, computer systems can include their own versions of the methodologies most often used in the market, such that the results obtained do not exactly agree with those expected.
- Ensure that the system can operate and provide the functions required of it with the data the entity has available. Sometimes the system provides all the functions required but only using data that the entity is unable to provide.

The second requirement is to ensure that the results provided by the sub-system are consistent with the rest of the risk measurements used, so that they can be aggregated to obtain the overall risk map of the entity. Therefore, it is necessary to ensure that the parameters of the sub-system can be easily adjusted, such that if a decision is made to modify a calculation criterion used in the risk measurements of the entire entity, the system can handle it easily. Typical examples of key parameters are the number of volatilities used to obtain risk measurements, or the number of values obtained in a Monte Carlo simulation.

Technical Characteristics

In addition to ensuring that the sub-system is adequate functionally, the entity must assess the technical characteristics of the sub-system in order to ensure that they also are consistent with the systems policy of the entity. Key considerations include:

- The operating systems in which the sub-system is marketed. The operating systems with which the application is marketed must be checked and tested to see if they are reliable and whether there are personnel at the company that know how to run them.

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- Hardware. As a rule, operating systems are provided by hardware vendors, although in some cases the vendor only provides software. In either case, the hardware/operating system combinations recommended by the application vendor must be checked to obtain performance measurements. The entity must also check to see that its software policy does not impose limitations on working with the vendors of recommended hardware.
- Information storage. Another factor to keep in mind is how information is stored. Most applications work with one database management system, while some support several of those that are most common in the market. Other applications use their own storage files, in which case it is impossible to find out which data model is used by the application.

  In general, systems that use database management systems are preferable because they provide relatively easy access to their data modules, which facilitates the establishment of interfaces with other sub-systems.

  Systems that use their own storage files usually offer better performance in terms of execution time, but the access times for queries are significantly higher, and one pays the price for not having access to its data model in the form of increased dependency on the vendor.
- Data entry. Data entry is another of the factors that must be evaluated when analyzing a product. In general, these applications require a wide variety of data that must be taken from other systems. Therefore, the more data-entry help the product provides, the easier implementing the product becomes.

  Some of the applications available in the market have modules that exist only for use in data entry through some database or file. Others leave the user to handle data entry by storing the data in a file with a predefined format, or in a specific table in the database.

  Data entry must be carefully considered when making a final selection since it is doubtless one of the critical points in the implementation of the sub-system.
- Accessibility of information from other systems. As we saw in the model for implementing risk management systems, almost all sub-systems take information from some sub-systems and provide information to others. Therefore, another aspect that must be evaluated is the ease with which information can be extracted from the sub-system.

  We saw before that the ability of the sub-system to work on a standard database facilitates access to the data model used. This is the minimum accessibility the sub-system must provide, although it is advisable to have a module that allows for selective extraction of data in different formats, whether through the use of files or data server processes.
- User interface. This characteristic must also be carefully examined in order to estimate the difficulty that users will have in executing the functions of the application.
- Modularity. It is advisable to have modular architecture, which facilitates the selection of the functions one wishes to implement. This architecture also facilitates the inclusion of new modules that provide specific functions required by the users or by the risk management strategy but that are not provided by the sub-system.

  If the sub-system permits development of new modules that increase its functions, the entity must evaluate the tools provided for use in such development, the programming language used, the manner in which data will be stored, and other such issues. It is also interesting to know whether ownership of the source code is available or not.
- Security. The application must comply with the security standards established for the project. There must be access control by user and user group, mechanisms for recovery of errors, etc.

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- Documentation. Like any other computer system, it is an advantage to have good technical documentation, which includes the installation manual, errors manual, operating manual, etc.
- Technical service. The system is of more interest if it has technical service in the country in which implementation is to occur, so that immediate service is available if problems occur.

Factors to Keep in Mind Regarding Implementation

After completing a preliminary analysis of the applications that may provide the functions needed, we find that they fall into two clearly different groups:

- Closed applications. This group includes all applications that have a group of functions that cannot be expanded (unless the vendor does it in subsequent versions), although their parameters can be adjusted. They follow the classic definition of a system as a black box with various inputs and outputs that can have different parameters set through the values assigned to a group of status variables.
- Group of libraries with functions used to manage risk. The common characteristic of this group is that the products that fall within it are not applications that solve specific problems, but rather groups of complete functions that can be used as the pieces of a puzzle to build a made-to-order application that solves the entity's specific needs. The vendors of this group usually have agreements with consulting companies that provide specific developments for each entity.

The decision about which group to choose depends on how much the entity wants to customize the application to its needs, how quickly the application needs to be up and running, the budget allocated, the training of the users responsible for system development, etc. In general, buying a sub-system from the second group almost always means doing one's own development with outside consultants, although within shorter periods of time and under lower budgets than when the sub-system is built from scratch.

Relationship with the Vendor

The purchase of an application and its inclusion in the systems structure of the entity requires careful assessment of the vendor to ensure that it can provide technical support and keep the application current during the life of the project. Therefore, it is useful to do the following:

- Check that it is a solid company with future prospects and no financial problems. Ideally, it has years of experience providing systems in the sector, and its conduct has been reliable and proper.
- Check to see whether the application has been implemented at other entities. Being the first entity carries serious risks, since there is no proof that the application will function properly.
- Get a commitment from the vendor that the data models of the future releases will be compatible with the data models from former versions. The system will have interfaces with many other systems within the entity, and it is necessary to ensure that the start-up of the new versions will not be delayed by the need to redo many interfaces.
- When formalizing the sales contract, ensure that the vendor keeps the system up-to-date and takes into account all the products the entity normally deals in, or that it may reasonably decide to include in its portfolio of products. Maximum periods will be

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assigned within which the vendor must support the addition of new products to the system, so the entity will not have to delay using a new product for a longer period than established in the contract.
- During the negotiation, keep in mind that it is possible that the vendor may go bankrupt or abandon the activity. Therefore, it is necessary to establish mechanisms by which the source code becomes the property of the entity so that it can at least keep the application up-to-date.

WILL THE EXISTING PLATFORM BE MAINTAINED OR WILL THE PROJECT BE USED AS AN OPPORTUNITY TO CHANGE THE COMPUTER PLATFORM?

Some of the reasons why an entity might decide to change computer platforms are:

- The sub-system that best suits the functional specifications established is not available for the platform that is used in the department or area where it is to be implemented.
- The platform that the entity currently uses is beginning to become obsolete and although the sub-system it plans to purchase is compatible with that platform, the vendor has given notice that within a specific period it will no longer provide support and that it will not do any new versions.
- The platform is out-of-date, and, although neither of the two points above pertain, the implementation of a new system in the department can be a good time to migrate to a new environment.

A change in platform is a very delicate process with many implications, so before proceeding with such a change it is advisable to be sure that it is absolutely necessary, or that the advantages to be gained clearly outweigh the difficulties that can occur during migration. Therefore, before making a decision the following steps should be carried out:

- Be absolutely sure that the potential new platform functions correctly. Do not rely on the fact that other entities have already completed a migration to this platform, or on the promises of the vendor. It is better to do one's own analysis, in which the new environment is subjected to stress tests over a period of time; prior to launching a project of this type, a pilot installation should be done and the platform should run for some selected period of time.
- In addition to ensuring that the hardware and the operating system function correctly, the entity must check to see that the same is true for all the systems and applications used. Special attention must be given to the database management systems, the communications systems and the specific applications used by the entity.
- Another important consideration is whether the new environment provides a solution for the future. In other words, the new platform should provide a certain amount of security that problems with the vendor will not arise in future years because the system is obsolete at that time.

One of the implications that must be kept in mind before changing platforms is the impact such a change will have on end users of the applications. Although this is usually not part of the technical considerations that are reviewed in these situations, it is important to analyze how the change will affect the work done by the users, so that a training plan can be provided to facilitate adaptation to the new environment.

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After carefully analyzing the advantages and disadvantages of the platform change, the entity is in a position to make a decision. It may find itself in one of the following scenarios:

- The tests to which the new platform was subjected did not give the expected results, so the change cannot be made, nor is it even advisable to purchase a sub-system that works on this platform. In this case the entity must go back to selecting the sub-system it will use, rejecting those that work only on the platform that was found to be unsatisfactory.
- The results obtained in the platform analysis were positive, and the decision is made to install the new sub-system on this platform, although the other applications used in the department or area will not be changed. In this case two platforms will co-exist for some period of time, which at the outset is not defined. The disadvantage of this approach is that it increases the complexity of the area's work, but it gains through having actual experience in operating the new platform. In addition, the users will have more time to familiarize themselves with the new environment while continuing to work with the one they already know.
- The results were positive and the decision is made to migrate all the systems to the new platform. This solution is riskier than the former; in particular, the project execution periods can easily stretch out, and users can experience difficulties in adapting to the new environment.

The analysis of the new platforms must be done very carefully. It is a good idea to talk with the providers of the database management system, the communications systems, and the applications so that they can provide information about the experiences they have had with other implementations involving the same platform products and versions.

Finally, if the decision is ultimately made to change the platform, it is advisable to be conservative and follow the second of the scenarios described above. If the results are acceptable, it is always possible to migrate the entire system over to the new platform at a later time.

WHICH TECHNICAL ARCHITECTURE IS BEST?

It is impossible to say which technical architecture is best in all situations, since, as we will show, many factors influence the selection of an architecture, and they vary from entity to entity. Therefore, the purpose of this section is to enumerate the factors that should be taken into account and the most important decisions that must be made.

- Corporate hardware/software strategy. The technology and systems area generally has a strategy into which the architecture to be used must fit. If it cannot be adapted to the strategy, the entity as a whole should negotiate with this area to find an architecture that is more compatible with the area's strategy.
- Types of activities and processes. Most systems used for risk management perform very complicated calculations that consume a great deal of time; this fact, together with the volume of information that is habitually processed, will determine the processing capacity required to obtain results within the periods established.
- Processing frequency. Combined with the preceding point, processing frequency will determine a number of the architecture's characteristics, such as the required storage capacity, processing capacity, characteristics of the channels through which information is transferred, etc.

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- Location of the different processes. This is one of the most decisive factors when choosing an architecture type (centralized or decentralized[3]). The selection of centralized or decentralized architecture has important consequences that will affect almost all variables managed because it characterizes the nature of the system to be implemented.

The main advantages and disadvantages of a decentralized architecture *vis-à-vis* a centralized architecture are presented below.

Advantages

- Local autonomy. Decentralized architecture allows the persons who know the processes and information best to be responsible for them. It may also be the case that the decentralization is physical (e.g., business centers in different countries with different hours), in which case decentralized processing is less expensive and more efficient.
- Better performance. The fact that the persons handling the data are responsible for processing eliminates many procedures needed to resolve problems, since the decisions can be made immediately.
- Improved availability and reliability. The fact that the processes are decentralized means that it is practically impossible for the risk management system to shut down entirely. Even if some modules fail, the others can continue to function.
- Economic advantages. In general, it is cheaper to work with small machines that combine to perform a task than to buy a single machine with sufficient power to do all of the calculations needed.
- Growth. Should more processing power be needed, it is always better to add more machines, or increase the power where it is needed, than to change a single machine as in centralized architecture. However, we should note that with decentralized systems the total power of the whole is not proportional to the sum of the power of all the parts. The reason has to do with the overload introduced by communications.

Disadvantages

- Methodologies. Risk management calculations require use of aggregate information, so even if decentralized calculations are done in order to obtain partial measurements, it will always be necessary to have a centralized database to calculate the overall risk and return measurements.
- Complexity. It is always more complex to maintain a group of computers, even if they are individually not very complex, than a single machine.
- Communications. The communications systems are more complex and expensive in decentralized processing arrangements than in centralized processing.
- Control distribution. There are more problems with synchronization and coordination with decentralized systems.
- Security. Security is more difficult to manage in decentralized systems. This is a direct result of the increased complexity that results from managing many machines.
- Other technical factors. These may include the type of user interfaces used, the validation processes required, etc.

[3] The implementation of centralized architecture presumes that there is a single processing center to which all relevant information is sent for processing and storage. Decentralized architectures are characterized by multiple processing centers, along with procedures that facilitate the integration of the stored information in order to obtain any aggregate statements needed.

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By analyzing the factors above, one can select a technical architecture, which in turn must establish at least the following:

- Type of hardware.
- Operating systems to be used.
- Database management system to be used.
- Communications systems.
- On-line control systems.

The selection of the architecture type will have a significant impact on performance. Therefore, performance tests should be run, and the technical characteristics of the processors, required memory, configuration of various elements, etc. should be defined as precisely as possible.

PROCESSING AND STORAGE REQUIREMENTS OF THE DIFFERENT METHODOLOGIES

Implementation of a risk management strategy requires using complex mathematical methodologies that calculate measurements of the risk to which an entity is exposed. The methodology used in each area depends on the type of activity performed there, which also determines the storage capacity and the processing power needed.

The purpose of this section is to offer a comparative analysis of the different methodologies. We will describe the basic characteristics of each, so as to provide an understanding of the relationship existing between the methodology used and the required storage and processing capacities.

The methodologies can be grouped into two types: simulation and analytical.

Simulation Methodologies

The simulation methodologies are based on valuing the entity's position under multiple scenarios. They provide valuable risk measurements because the user can clearly see the relationship between the different scenarios and the value that the entity's position has in each of them. The method used to select the scenarios determines the type of simulation to be done:

- Historical simulation. The position is valued based on past real scenarios. In order to perform this type of simulation, long time series of data for the parameters that affect the market value of the position must be stored. Quantification of the position depends mainly on the type of activity to be analyzed.
- Stress testing. In this case, the scenarios are generated directly by the users, who can use real situations (past situations in which especially adverse phenomena occurred), or generate specific situations (in order to analyze how the entity's position would react to specific events). This case also requires storage of a high number of scenarios.
- Monte Carlo simulation. In this case scenarios are generated by means of a stochastic simulation model that generates large numbers of potential random scenarios. The scenario generation models also need information on the evolution of market prices.

These methodologies require more processing power and storage capacity than the analytical methods because they require a large number of scenarios to be stored and enough processing capacity to value the entity's position in each scenario.

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Analytical Methodologies

These methodologies are based on the use of models that try to estimate the changes that take place in the value of the entity's position given changes in market variables. Estimates, or at least estimates of ranges, are also made about the values of the market variables in the future.

Although they are not as intuitive as the simulation methodologies, they have the advantage of requiring less data to function and many fewer calculations to obtain results. This enables the user to obtain risk measurements in reasonable periods of time.

Experience shows that the methodologies used to obtain risk measurements—especially the simulation methodologies—require significant processing and storage capacity. Therefore, before making a decision regarding the purchase of hardware, or committing to obtain risk measurements within a specific period of time, it is advisable to do testing to ensure the feasibility of the project.

WHAT OPERATING CONTROLS SHOULD BE IMPLICIT IN THE RISK MANAGEMENT SYSTEM STRUCTURE?

Chapter 6, which discussed operational risk, pointed out the need to establish procedures to protect the information used in risk management systems. In this section we will discuss this topic in more detail, and describe the main dangers to which the entity is exposed. We should remember that the information generated is of strategic importance to the entity and, therefore, its unintentional loss or release could cause significant damage.

The establishment of security procedures should take into account two basic objectives:

- Protecting the information from unauthorized access. The strategic importance of the information makes it necessary to protect it from unauthorized access.
- Avoiding unauthorized modifications of the information. This concept covers unauthorized modifications or deletions of information, ill-intentioned behavior, or failures in the hardware or software used.

In order to keep security breaches from occurring, it is necessary to use all the facilities provided by the basic computer systems that the risk management sub-systems use, i.e., the facilities provided by the operating system, the database management system and the communications system. In most cases, however, this is not sufficient, and additional procedures must be established to ensure security. Sometimes specific systems are used whose only purpose is to manage security.

Today there is general concern with the subject of confidentiality of information and recovery from failures, as shown by the existence of multiple standardized specifications from international organizations or commercial systems that manage procedures intended to increase security. Studying the solutions proposed in these types of standards can be very useful in understanding the related problems, and we therefore recommend that they be reviewed.

We discuss below the main aspects that should be considered when establishing a policy regarding control and management of computer security.

Operating Systems

- Access control. Most of today's operating systems have numerous facilities to control access by users. Users normally have a single path for entry into the system, which requires the

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name of the user and passwords that permit access to directories solely for that user and to another group of directories that can be accessed by many users. If all the facilities are used and parameters are set correctly, a high degree of security is obtained. Nevertheless, operating systems sometimes fail, thereby allowing breach of the controls established. Security features therefore cannot be considered a definitive solution.

- Recovery in the event of failures. Operating systems have changed significantly in recent times with respect to recovery facilities. Architectures have been developed that keep service from being interrupted, even in the event of hardware failures. These are the so-called high-availability architectures, which are characterized by mirroring of the elements that comprise them. In these architectures the operating system is responsible for maintaining the information and functions replicated so that when an element fails it is immediately replaced by its replica. This results in less disturbance to users.

Communication Systems

- Access control. Network connections and their globalization have brought about new problems with unauthorized access. Since almost all computers are connected, it is easy to find ways to access almost any machine, so if all appropriate security measures have not been taken or the security system fails in some way, anyone could theoretically access any site. This certainly occurs regularly today; on the Internet one can find methods for bypassing the security controls of some operating systems or servers.

  In order to solve this problem, systems like FireWall and proxy servers have been developed. They try to place limits on the addresses from which one can enter a computer, or to restrict the services that a specific user can use.

  Another problem with communication networks is that the information that circulates via the network can be tampered with and seen by people that should not be able to do so. To avoid this problem, encryption algorithms are used. They cannot categorically keep information from being taken, but at least they make its interpretation much more difficult.
- Recovery in the event of failures. We can divide failures in communication systems into two groups: those that interrupt service and those that cause the information sent to not match the information received.

  Many solutions have been developed in order to avoid failures involving loss of service; most of these involve replication of channels. These solutions are managed by the network and transportation levels of the ISO reference model. These levels ensure that the information arrives at its destination. In addition, there are communication network management systems that make finding solutions to these problems much easier.

  Transmission failures are of small concern because the majority of existing architectures ensure the existence of error-free, secure, efficient channels with the protocols at the link level of the ISO reference model.

Database Management Systems

- Access control. Most database management systems sold today have many utilities to manage each user's access rights. The general structure of the security architecture is very similar to the operating system architecture. However, here the architecture is working with databases, tables, views, functions, procedures, access types (query, modification, insertion and deletion), etc., rather than directories.

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The person responsible for management of the database enters new users and assigns them a password and access rights. Access profiles are usually used to assign access rights, although they can be assigned on an individual basis.

Some of the database management systems sold today allow encryption of information. In this case, a second password is needed for access to encrypted information.

Another issue in accessing data is the number of users that can access the system at a time. Most database management systems allow concurrent access to data, and are therefore equipped with a control system that ensures that two users cannot modify the same piece of data at the same time.

- Control of consistency and integrity of information. Database management systems carefully protect the information stored in them by means of various techniques. The most important technique is integrity rules, which must be defined during creation of the database. They keep information that does not comply with certain requirements from being entered into the system. By using these rules, the system ensures that the information stored is consistent and is meaningful. Use of the rules is not obligatory, and increases the time spent accessing data, but if the rules are defined correctly they ensure the quality of the information stored.
- Transactional system. Database management systems can work with whole transactions, meaning operations that are either done in full or not done at all. Appropriate use of a transactional system keeps the database from being inconsistent. An example of a situation in which use of the transactional system can be crucial is when a group of transactions is done that make sense only when taken as a whole, so if only some are entered into the database, the parts do not make sense. In this case the group of transactions is defined as one transaction, and if a failure should occur while the whole transaction is being executed, the database management system automatically returns to the point at which it was prior to the beginning of any part of the transaction.
- Tools that facilitate the establishment of procedures to save and recover information. If some event results in corruption of information (e.g., the failure of a hard disk), and a high security architecture is not being used that replicates the information, it is essential to recover the information saved during the last back-up. Database management systems provide numerous utilities to perform this task, thereby facilitating the creation and recovery of total, partial or incremental back-ups. There are also tools that make it possible to recover the transactions done in the database since the last back-up, etc.

To summarize, it is important that we note the need to establish a security management policy and to assign responsibility for it to someone in the technology and systems area. This person will establish appropriate procedures and ensure that they are put into practice. Some of the considerations that should be kept in mind when establishing security procedures are:

- Periodic password changes should be required. Users should be encouraged, and in some cases required, to change their passwords periodically by means of the utilities provided by the different systems. It is important not to require that changes be made too often, which can be a nuisance for users.
- No file should exist that contains the access passwords. In some organizations, the person responsible for system management, or the users themselves, keep the system passwords in files. This is dangerous, since someone else can access one of these files and gain access to many systems. The existence of such files is closely related to overly frequent password updates, as well as to the use of passwords that are too complex and therefore difficult to remember.

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- There should be a back-up plan for all systems. This plan should detail at least:
  - Frequency of back-up for each system. This depends on how much of the information that is stored in the system is modified, and over what period of time the modifications occur.
  - Types of back-up performed. Back-up policies can be very different, and may require incremental, partial, and/or total back-up, or combinations of these.
  - Definition of recovery procedures. Based on the back-up policy chosen, the recovery process can be more or less complex. There should be specifications for back-up recovery for all the systems. All the steps that must be taken to recover the machine's condition as of the last time information was stored must be documented.
  - Back-up storage policies. In addition to establishing a back-up frequency, a strategy must be established for saving the back-ups done. One possibility is to save all of the back-ups done for the last two weeks, the back-up of the last day of each month for the last year, and the last back-up of each year for the last five years.
- There should be a contingency plan. It should outline the steps that must be taken to recover the information stored in the systems, and to restore them to operation, in the hypothetical case that all of the regularly used systems disappear (for example, because a natural disaster seriously damages the entity's facilities).

SELECTION OF THE ENVIRONMENT IN WHICH THE DEVELOPMENT OF THE RISK MANAGEMENT SYSTEM WILL OCCUR

If a decision has been made to develop the system or some of the sub-systems, it will be necessary to choose a development platform that enables the project to be executed within the period established, and that adheres to established quality standards.

If the development is contracted out to a consulting firm, it will be responsible for choosing the development environment. Most such firms have their own development methodologies and platforms, although it is appropriate to suggest to them that they adapt to the platforms used by the entity.

If the project is handled internally, the entity must establish the development environment. The right time for making this decision is after the technical architecture has been decided, but before the schedule and resources for the execution of the project have been set. The importance of this choice must not be overlooked, since it has a significant impact in the following ways:

- Complexity of the design work and system development. Today there are many tools that facilitate system design and significantly reduce the distance between the design and development phases.
- Complexity of system maintenance. When system development is completed, and the system begins to operate, the environment used will play an important role in all aspects.
- System development and maintenance costs. The development platform used determines the time periods required for execution of the project, as well as the number of persons involved and thus has an impact on the final cost of the project.

Some of the factors that must be kept in mind when selecting the development platform are:

- Existing entity standards. The technology and systems area of the entity will have previously established various standards, either explicitly or *de facto,* regarding the

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systems, development platforms, communication protocols, user interfaces, etc., that must be used. It is important to keep them in mind, because adherence to these standards leverages the assistance and resources available within the entity.

- Internal or external experiences with different development environments. Prior to selecting a development environment, the experiences that people have had working with it on different projects should be explored. Internal experience is especially important. One of the selection criteria should be familiarity with the platform on the part of as many people inside the entity as possible. If nobody inside the entity knows the platform, it should be easy to learn, in order to keep training costs down.
- Design and development methodology to be used. The methodology the entity wants to use determines in some ways the development environment that must be used. Although the relationship between methodologies and development environments is not an absolute, it is true that certain methodologies work better in certain environments.
- Up-to-date technology in the development environment. It is important for the environment to be relatively new and widely used. It is not advisable to have to change the development environment halfway through the life cycle of the system, because it would be very costly.

In summary, outlined below are the elements that must be considered when the creation of a development environment is proposed:

- Technical architecture. The architecture designed for the sub-system to be developed largely determines the environment that must be used. The architecture must indicate the modules that need to be programmed and the parameters that need to be set, as well as the platforms on which they reside.
- Operating systems. Once the operating systems that will be used are known, the appropriate tools must be selected in order to be able to write code for them.
- Database management systems. If a decision is made to use such systems, a development environment that integrates the operating system, programming language, communications, database access libraries, etc., must be prepared.
- Communications. The technical architecture must contain a solution for communication among the different parts of the system; in addition, a communications protocol, the type of service to be provided, etc., will have to be chosen. An environment must be created that facilitates development of applications that use the designed solution.
- Programming languages. This is one of the key factors in any development. It may be necessary, or advisable, to use more than one language, depending on the architecture designed. High-level languages should be used if possible (4GL, O.O., etc.), although there are many factors that bear on the final decision.
- Project management, environment management and version management tools. These tools facilitate tracking and control of the project, and their use is advised.

Recommendations for International Standards on Systems

Recommendations of the Group of Thirty

- Entities should have systems that enable them to measure and control the market and credit risk generated by their derivative positions. The characteristics of these systems will depend on the volume and complexity of the transactions performed by the entity.

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- Entities should have systems able to capture, process, and settle transactions, and also generate management reports, efficiently and in accordance with established policies.

Recommendations of the Derivatives Policy Group

- Entities should have systems that efficiently support risk management and control policies.

Recommendations of the Bank for International Settlements

- Entities should have systems that enable them to control and manage both market risk (interest rate, exchange rate, floating rates, commodities, etc.) and credit risk.
- Entities should include security measures in their systems that ensure the integrity of the information contained in them.
- Entities should establish contingency procedures and plans to ensure the restoration of information stored in the event of failure and to control the information entered.

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Chapter 13

Risk Management Training Plan

Introduction

One of the fundamental prerequisites of risk management for an organization is that all of its parts must understand the need for and advisability of proper management of the risks to which it is exposed because of its operations. This then becomes the focal point of the organization's strategy and decision-making process.

Risk management must be woven into the culture of the organization, so that all employees treat it as a priority during the performance of their duties. In order for the risk management philosophy to be adopted by employees of the entity, they must understand its implications.

The key to achieving these goals is the creation of a *training plan* that allows everyone in the organization to acquire the necessary risk management expertise *vis-à-vis* the functions each performs within the organization.

According to the organizational structure defined in Chapter 2, the human resources and development area must be responsible for designing and overseeing this training plan.

The goal of this chapter is to present a risk management training plan based on the following issues:

- General goals.
- Success factors.
- Structure.
- Specific goals and content for training groups.
- Training alternatives.

GENERAL GOALS

The general goals of an organization's risk management training plan are primarily the following:

- Foster professional training and development of its human resources as a strategy to ensure its ongoing competitiveness and to accomplish its risk management goals.
- Encourage employees of the entity to understand its business activities and the products and instruments it trades, along with their inherent risks.
- Publicize the risk management strategy so that everyone understands its content and goals.
- Identify the training needs of different parts of the organization involved in the risk management strategy.
- Educate everyone involved in the risk management strategy so that they have the level of expertise necessary to carry out their responsibilities effectively.

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SUCCESS FACTORS

For the organization to successfully develop its risk management plan, the plan must be:

- Universal: the training plan must reach every member of the staff, especially those involved in the risk management process.
- Comprehensive: the training plan must address each risk to which the organization is exposed and cover all aspects related to the management, assessment and control of these risks.
- Uniform: the training plan must be structured so that within the organization, training groups are created that are as homogeneous as possible with regard to:
  - Various functions within the risk management process.
  - The expertise that all the affected parties need to acquire to carry out their responsibilities.
  - Risk management expertise already acquired.

  The reason for creating uniform training groups is to enable the design of specific training activities (courses, seminars, etc.) adapted as much as possible to the characteristics of each group.

  The fact that the training groups are similar does not mean that they cannot include staff from different areas of the organization. Such diversity can enrich training activities by facilitating an exchange of ideas.
- Gradual: the training plan must be designed so that each training group, starting with its initial knowledge of risk management, gradually acquires more advanced knowledge.

  The training plan must be conceived as a constructive process, whereby employees of the entity absorb basic concepts and then gradually acquire knowledge of more complex ideas.

  It is important that the training activities for a specific group be adequately spaced over time, so that each member of the group has completely absorbed one training activity before moving on to another.

  There are accelerated courses and seminars in which participants with very basic knowledge of risk management learn complex ideas within a short period of time (usually less than a week). Generally speaking, participants in this type of training activity, in the best-case scenario, acquire a general knowledge of the material but do not absorb concepts. The inability to internalize difficult concepts quickly prevents the participants from applying them on the job.

  Therefore, it is preferable to avoid this type of training, and conversely, it is advisable to support training that uses a more gradual approach (basic, intermediate, advanced, etc.).
- Continuous: the training plan must be defined as a continuing process, so that employees of the entity can keep abreast of trends in risk management techniques and control on an ongoing basis.

  To achieve this goal, it is important that the content of training activities be updated to include the most recent trends in risk management and control.
- Flexible: the training plan must be flexible enough so its structure is tailored to the specific reality of the entity and its environment at all times. Additionally, the content of the training activities should be updated to reflect the latest trends in risk management and control.
- Reflective of general consensus: even though, as we indicated before, the human resources and development area must be responsible for designing and coordinating the training plan, it is important that all those involved in risk management participate in the process of developing the plan, because those who actually execute risk management processes are the most knowledgeable about their own training needs.

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- Evaluation: it is essential that the human resources and development area establish procedures to evaluate whether the goals of the various training activities are being met. It must also monitor whether participants in the training plan are absorbing the knowledge and whether it is useful to their job performance.

  It is important to point out that the goal is to evaluate not the participants, but rather the nature of the training plan and its capacity to achieve the goals being pursued. It is crucial that the human resources and development area monitor each of the training activities closely and continuously to tailor and improve the training plan on an ongoing basis.

STRUCTURE OF THE TRAINING GROUPS

The training plan must be structured to create uniform training groups within the organization, to design specific training activities that can be tailored as much as possible to the characteristics of each group.

The goal of this section is to define, for orientation purposes, a possible group training structure, using as a basic guide the organizational chart presented in Chapter 2.

The training group proposal discussed below only identifies the groups that, based on their responsibilities within the risk management process, may have similar training needs in terms of goals and content. Organizations should consider this proposal for training groups as a first step that must be tailored in each case to the organizational structure itself and the level of training in risk management for the personnel affected. We therefore propose the following training groups:

- Senior management: comprises members of the board of directors and the executive committee.
- Technical management: comprises members of the Assets and Liabilities Committee, Risk Committee, and business committees.
- Operating structure: comprises the risk analysis and control areas, the ALCO area, and the business and support areas.

Specific Goals and Content for Training Groups

In this section we propose specific goals to be achieved and content to be covered in the risk management training activities designed for each of the training groups previously defined.

Table 13-1 summarizes the focus of the training activities directed toward these groups.

Table 13-1. Focus of Training Activities

Senior Management	Technical Management	Operating Structure
Overall and strategic view	Technical and strategic view (basic level)	Technical view (advanced level)
Understand and connect ideas and their basic implications	Understand calculation procedures and their technical technical implications	Apply calculation procedures and solve technical problems
Comprehensive analysis	Specific analysis	Detailed analysis
Make and communicate strategic decisions	Make and communicate strategic decisions	Execute specific decisions

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SENIOR MANAGEMENT

Goals

- Acquire a comprehensive, overall knowledge of all risks (market, credit, operational, legal, etc.) produced by the various activities in which the entity operates.
- Understand the significance of the various market and credit risk predictors, as well as the risk limits established, based on the level of risk the entity wants to assume.
- Strengthen the comparative analysis of different business activities *vis-à-vis* their relative risk-reward profiles in order to allocate capital as efficiently as possible.
- Understand the impact of different risk management policies and strategies on the organization and their influence on decision making.

Content

- General characteristics of the financial instruments and products traded by the entity.
- Definition and basic implications of different types of financial risk.
- Interpretation and significance of the following market risk concepts:
  - Return measures.
  - Sensitivity measures.
  - Exposure.
  - Volatility.
  - Correlation.
  - Statistical distribution.
  - Simulation techniques.
  - Value-at-Risk (VAR).
  - Capital-at-Risk (CAR).
  - Return on Risk-Adjusted Capital (RORAC).
- Interpretation and significance of the following credit risk concepts:
  - Credit exposure.
  - Credit provision.
  - Credit risk capital.
  - Return on Credit Risk-Adjusted Capital.
- Analysis of the implications of basic financial risk management and risk hedging strategies.

TECHNICAL MANAGEMENT

Goals

- Know the basic technical characteristics of the products and instruments offered by the entity, primarily those relevant to risk calculation.
- Know the procedures and methodologies used to measure, control and manage the risks (market, credit, operational, legal, etc.) produced by the various business activities in which the entity engages.
- Understand the problems associated with the various predictors of market and credit risk, as well as the techniques for interpreting the significance of these predictors.

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- Understand how the market environment in which the entity operates (i.e., emerging markets) influences the application of risk management and measurement techniques.
- Learn how to translate the risk management strategy into a limit structure consistent with that strategy.
- Learn how to analyze different business activities in terms of a uniform risk-reward framework and how to make proposals for allocating capital based on this analysis.
- Learn how to analyze market and business trends in order to propose alternative risk management strategies to senior management.

Content

- Technical characteristics of the financial products and instruments traded by the entity.
- General characteristics of different types of financial risk measurement and control methodologies and techniques.
- Interpretation and significance of the following market risk concepts:
  - Return measures.
  - Sensitivity measures.
  - Exposure.
  - Volatility.
  - Correlation.
  - Statistical distribution.
  - Simulation techniques.
  - Value-at-Risk (VAR).
  - Capital-at-Risk (CAR).
  - Return on Risk-Adjusted Capital (RORAC).
  - Stress-testing and back testing.
- Interpretation and basic calculation procedures for the following credit risk concepts:
  - Credit exposure.
  - Credit provision.
  - Credit risk capital.
  - Return on Credit Risk-Adjusted Capital.
- Analysis of the basic characteristics of emerging markets and their effect on risk management and control.
- Aspects to bear in mind when defining and analyzing financial risk management strategies:
  - Interpretation of business and market trends.
  - Alternatives for stating positions.
  - Hedging alternatives.
  - Potential of derivative instruments for risk management.
  - Basis risk.

OPERATING STRUCTURE

Goals

As described in Chapter 2, the operating structure includes a group of areas within the organization that have distinct responsibilities in terms of the risk management process. Despite the

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fact that these areas are diverse, we believe that training activities related to the operating structure must enable employees to achieve the following general goals:

- Acquire an in-depth knowledge of the technical characteristics and valuation methods for the products and instruments traded by the entity.
- Know the procedures and methodologies used to measure, control and manage risks (market, credit, operational, legal, etc.) produced by the various business activities in which the entity engages.
- Learn to calculate the various predictors of market and credit risk within the context of emerging markets.
- Learn to calculate the profitability of different business activities and relate them to general risks by expressing their relationship through uniform and comparable measures among different types of business activities.
- Learn to design and execute risk management strategies (business areas) and analyze their repercussions (risk control and analysis area).

The general goals set forth above may be tailored and customized by the entity to the specific situation of each of the areas comprising the operating structure.

Content

Bearing in mind the diverse nature of the areas comprising the operating structure, we will divide the content of the training activities directed to the strategic structure into three groups:

- General content for all areas comprising the operating structure, which are very similar to those previously listed for technical management, but more focused on calculation procedures.
- Specific content for the risk analysis and control area.
- Specific content for the ALCO and business areas.

General Content

- Market operation, technical characteristics and valuation of the financial instruments and products traded by the entity.
- Procedures, methodologies and measurement and control techniques for different types of financial risks.
- Interpretation and basic calculation procedures for the following market risk concepts:
  - Return measures.
  - Sensitivity measures.
  - Exposure.
  - Volatility.
  - Correlation.
  - Statistical distribution.
  - Simulation techniques.
  - Value-at-Risk (VAR).
  - Capital-at-Risk (CAR).
  - Return on Risk-Adjusted Capital (RORAC).
  - Stress-testing and back testing.

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- Interpretation and basic calculation procedure for the following credit risk concepts:
  - Credit exposure.
  - Credit provision.
  - Credit risk capital.
  - Return on Credit Risk-Adjusted Capital.
- Analysis of the basic characteristics of emerging markets and their influence on calculation procedures for risk predictors.

Specific Content for the Risk Analysis and Control Area

- Advanced aspects of risk measurement techniques and their practical application.
  - Models for generating interest rate curves.
  - Simulation techniques (Monte Carlo, historical, etc.).
  - Methods for estimating volatility and correlation.
  - Advanced techniques such as stress-testing and back testing.
  - Risk calculation of non-linear products (for example, options).
- Comprehensive analysis of emerging markets characteristics and adaptation of risk measurement methodologies to their specific problems:
  - Exchange rate interventions.
  - Crisis risk.
  - Hyperinflation.
  - Low-liquidity markets.
  - Specific products: Brady bonds, inflation-indexed assets, etc.

Specific Content for the ALCO and Business Areas

- In-depth analysis of the characteristics and potential of the products and instruments marketed by the entity as well as their specific application.
- The characteristics and potential of new products.
- Advanced risk management strategies and techniques, such as:
  - Analysis of hedging alternatives and calculation of hedging percentages and risks.
  - Portfolio management techniques.
  - Advanced trading techniques.
  - Product and/or market arbitrage.
  - Asset and liability management strategies.
  - Advanced market analysis methodologies, including macroeconomic analysis.

Development of the Training Plan

The objective of this section is to raise some issues that entities must bear in mind when developing a risk management training plan and particularly when designing training activities.

TYPES OF TRAINING ACTIVITIES

Training activities vary, but in general they can be divided into three basic types: courses, seminars and conferences.

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Courses

The Course is a type of training activity where one or more subjects are treated in a comprehensive and structured way.

The Course is an appropriate training activity because all participants, whatever their level of knowledge, can gradually absorb and understand concepts. Courses are especially recommended for training on technical issues, as they usually have a practical orientation.

Seminars

The Seminar is a training activity that provides in-depth coverage of a specific subject and facilitated by many experts who deliver short lectures/presentations on various aspects of the subject.

The goal of seminars is to give a general overview of a specific subject. Furthermore, they are interesting because participants can see how various organizations handle specific problems. The lecture/presentation in the seminar usually cover very specific aspects, though not in depth. Seminars are only recommended for those who have some knowledge of and experience with the subjects to be covered.

Conferences

The Conference is a training activity that generally focuses on current and non-technical issues, and is facilitated by prominent speakers on the topic in question. Conferences usually conclude with a roundtable discussion, including the speaker and participants who present their points of view.

Their purpose is to enable participants to learn and exchange ideas on a specific subject, though from a general viewpoint and without in-depth attention to specific problems. In fact, they are more informative than useful as a training activity and are recommended for managers of the entity with experience in the subjects to be covered.

Others

In the specific case of senior management, who usually cannot attend group training activities, there is an alternative. A group of two or three professionals from the organization with technical and teaching expertise may attend the group sessions in order to transmit the content of the sessions at a later time to senior management, who can then learn the specific aspects necessary for their on-the-job performance. This alternative is very flexible and adapts itself to the needs of senior management.

CUSTOMIZED OR EXTERNAL TRAINING ACTIVITIES

Another important issue for organizations to analyze is the advisability of organizing training activities tailored to the organization, as opposed to participating in external training activities. Generally speaking, seminars and conferences are usually external training activities. Therefore, in the case of courses, these two alternatives must be analyzed.

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It is usually preferable to develop customized training courses if they must be attended by a large number of the organization's employees (this generally applies to basic and intermediate courses). This allows the organization to structure the course, content, dates, time, etc. Moreover, customized courses are less costly, given a certain minimum number of participants, than external courses.

For courses in which a smaller number must attend (generally advanced courses or those on a specific topic), it is usually better for participants to attend external courses. Not only is this less costly, but it offers the opportunity for them to share experiences with participants from other organizations.

INTERNAL OR EXTERNAL TEACHERS

When entities decide to organize customized courses, there is another aspect to decide: whether they should be taught by in-house professionals, external teachers or a combination of both.

External trainers are usually persons who have teaching experience but usually lack in-depth knowledge of the specific problems of the entity. On the other hand, professionals within the organization have less teaching experience but are able to provide a more practical and up-close view of the organization on a daily basis.

Therefore, leaving aside financial considerations, we recommend that courses be tailored to have external trainers responsible for explaining theoretical concepts while in-house professionals are responsible for explaining their practical application to actual situations within the entity.

IMPORTANCE OF A PRACTICAL APPROACH

Although implicit in the previous sections, one aspect that organizations must consider when defining the training activities, especially in the case of courses, is the importance of using the most practical approach possible in presenting the subject matter.

Any explanation of a concept, methodology, technique or procedure is better absorbed when accompanied by examples. It is also advisable for course participants to do practical exercises on problems likely to be encountered on the job. Realistic examples and practical exercises which will resemble actual situations encountered on the job will prove the most useful.

Therefore, when designing customized courses or selecting external courses, entities must emphasize and present the practical element.

TRAINING MATERIAL

Another important issue organizations should consider when designing customized courses or selecting external courses is appropriate training material. Training material must be well structured, easy to understand and contain examples that help to clarify concepts introduced in the material.

One of the goals we have tried to achieve with this manual is to structure it in such a way that it can be used by organizations as training material for internal risk management courses.

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Recommendations for International Standards on Training

Recommendations of the Group of Thirty

- Entities should ensure that derivatives transactions are managed, controlled, administered and audited by appropriate personnel, in number as well as in experience, training and degree of specialization.

Recommendations of the Bank for International Settlements

- Entities should have competent personnel, who have a sufficient level of training and experience to perform the work assigned.

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BANKING/FINANCE

This comprehensive guide is designed to help businesses and financial institutions operating in emerging markets incorporate modern risk management techniques into their decisionmaking. It looks at market, credit, operational and legal risks and proposes solutions to risk management issues as they apply specifically to emerging markets.

Based on a value-at-risk approach, *Financial Risk Management* examines the role of senior management in setting risk guidelines,.the use of information systems for monitoring and communicating risk, and the tools for measuring and managing risk. It also outlines how to implement an objective and systematic risk management program that allows for effective control and evaluation of operations.

Drawing on practical methods used by successful risk managers in emerging and developed markets throughout the world, the book provides specific guidance on establishing a modern risk management framework and developing efficient approaches to increase the profitability of risk management activities in emerging market settings.

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