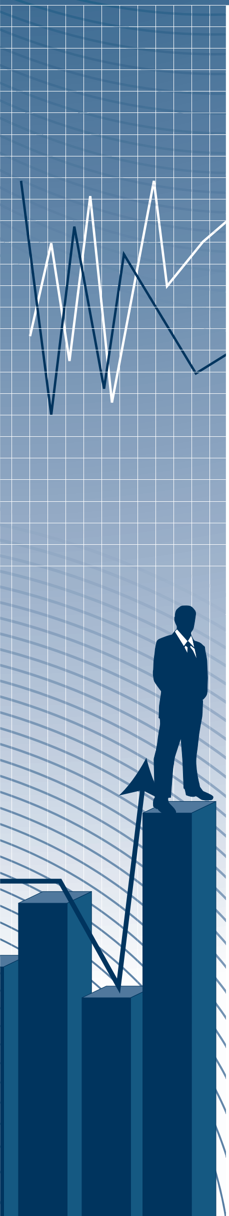
PART 1

1

THE CREDIT RISK FRAMEWORK



Definitions and Concepts

Learning objectives

After studying this chapter, you should be able to:

1. Discuss what credit is and the different types of credit
2. Understand the evolution of credit markets
3. Define what credit risk is and the various frameworks for evaluating and managing it
4. Outline the key components of credit portfolio risk analysis and how they are applied in practice
5. Describe methods and systems for measuring portfolio performance

Introduction

"Credit," the English writer Charles Dickens famously said, "is a system whereby a person who can't pay gets another person who can't pay to guarantee that he can pay." The near collapse of the U.S. financial system in 2008 under the weight of an enormous and growing pile of bad housing loans suggests that Dickens had a point. Extending credit to anybody or any business or group entails risk.

To be successful and stable, any bank needs to have a clear understanding of the risks it is taking with each loan or extension of credit, evaluate those risks, and manage them as a portfolio. The aim is to take on only as much risk as the financial institution can sustain, given the capital it has available.

In this chapter,[1] we discuss the basic frameworks and concepts of credit risk management—what credit is, the various types of credit, and the many ways and means of evaluating and managing credit risk. We will also examine the fundamental components of credit portfolio risk analysis and performance measurement. This will lay the necessary groundwork for deeper discussions in later chapters of credit instruments including credit derivatives and structured credit products and the wide range of credit risk management tools.

What is Credit?

Credit is usually defined in terms of the borrowing and lending of money. The most basic form is a loan granted to a borrower, who may be a consumer or a company. Credit can also take the form of a financial instrument that entails fixed payments determined up front and made over a set time period.

These traditional credit instruments include fixed-coupon bonds and floating-rate loans. The coupon payments are determined by adding a spread, or interest rate differential, to an underlying benchmark rate such as the U.S. Treasury rate or the London Interbank Offer Rate, or Libor, the rate at which large banks lend to each other.

Types of Obligors

Lending to ***consumers***—individuals taking out home mortgages, putting on credit card balances, and asking for consumer loans—is expanding across Asia, especially in China and India, where economic growth is expanding the ranks of the middle class. Economic growth is also driving the rise in corporate borrowing.

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[1] This chapter draws from *Active Credit Portfolio Management in Practice* (2009) by Jeffrey R. Bohn and Roger M. Stein, with permission from publisher John Wiley & Sons.

In addition to direct borrowing, corporations are also the most frequent issuers of the types of debt instruments referenced here. They are not the only borrowers, also referred to as obligors, in the financial system. Other borrowers include governments (commonly referred to as sovereigns) and supranational organisations such as the World Bank.

The credit risk of all these instruments depends on the ability of the sovereign, corporation, or consumer to generate enough cash flow through earnings, operations, or asset sales to meet the future interest and principal payments of the outstanding debt.

As innovative financial instruments have been developed in recent years, the definition of credit has expanded to cover a wider variety of exposures including those involving derivative contracts, whose risk and payoffs depend on the credit risk of some other instrument or entity. The obligors of these instruments are usually investment banks and other financial institutions (the protection seller, which is effectively the borrower) that isolate the credit risk of a reference obligor by linking the value of the debt instrument to the solvency of that reference obligor and to that alone.

A credit default swap (CDS) is an example of such an instrument. The contract requires the protection buyer (effectively the lender) to pay a regular fee (or spread) to the protection seller. In the event the reference obligor defaults as specified in the CDS contract, the protection seller is required to make the protection buyer whole, or pay compensation or whatever obligations are required by the terms of the contract.

While a CDS refers to a single named reference obligor, derivative contracts on indexes of many named such obligors can also be purchased as contracts on a specific basket of assets. These instruments expand the ability of credit portfolio managers to manage a large number of exposures without always having to resort to hedging on a single specific obligor's risk or selling assets outright.

Credit Exposures

The bank exposes itself to credit risk when it lends money directly, buys debt instruments issued by corporates, sovereigns, and supranational organisations, and invests in CDS and other derivatives.

Sometimes a credit exposure does not reflect actual cash being loaned right away. Instead of a straight term loan, a bank may extend a commitment to lend with a variety of conditions on the borrower. We typically refer to loans where cash is actually disbursed as funded and commitments to lend as unfunded. A contractual commitment to lend exposes the bank to risk even if funds have not actually been transferred to the obligor.

Credit exposures like these can be deconstructed into a risk-free debt instrument and a collection of other options including default, prepayment, and interest rate adjustment, among others. Most credit instruments represent a portfolio of options.

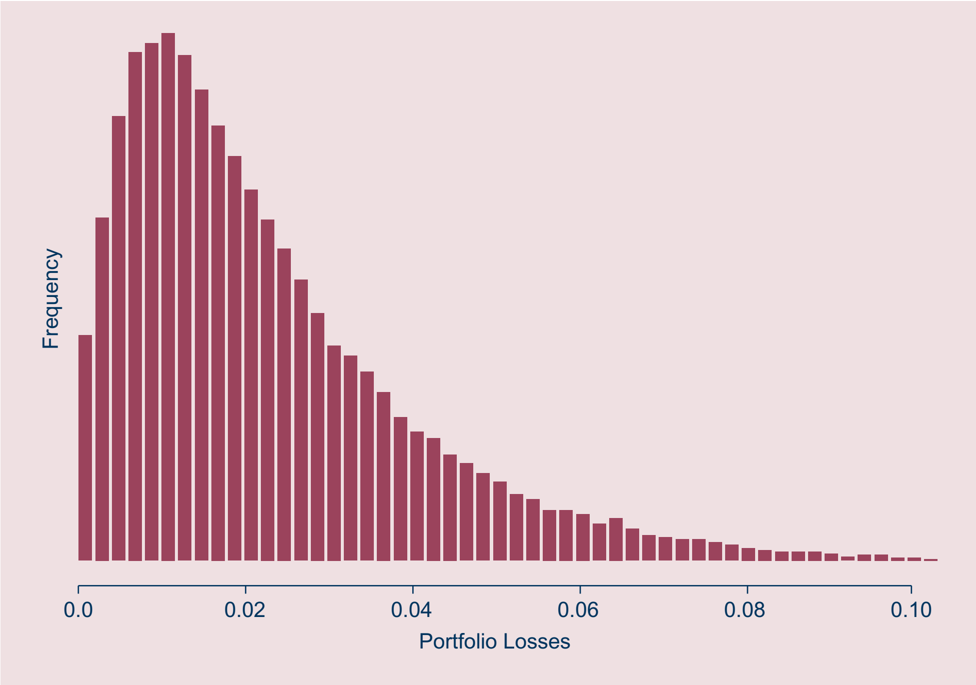
Credit exposure also arises in the case of more traditional derivative transactions such as equity options and interest rate swaps. When such a derivative is in-the-money, or can be exercised at a profit by one part to the contract, the market risk—the risk arising from changes in quantities driving the value of the derivative—must be considered separately from the credit risk. The implicit credit risk may become significant when systemic events impact the entire market.

The main feature of these different types of credit exposure is the shape of the distribution of losses. Credit exposures are typically characterised by skewed, fat-tailed return distributions. That is, the lender or originator of an exposure has a high probability of receiving its principal back plus a small profit over the life of the exposure and a low probability of losing a significant portion of the exposure. Figure 1.1 shows a sample credit loss distribution.

What this means is that there is a high chance that many borrowers will repay, but that if they do fail to repay, they tend to do so severely. The correlation or interconnection among credit exposures tends to be quite low compared with, say, the correlation of equity exposures.

This low correlation coupled with the chance of losing a substantial amount on any one exposure makes these securities particularly well suited for management in the context of a large, well-diversified portfolio. If a bank's portfolio contains only small bits of each exposure, the occasional extreme loss for any one exposure will tend not to affect the portfolio's overall performance. Thus, diversification can buy stability in the portfolio's loss profile.

FIGURE 1.1 Simulated loss distribution[2]



[2] Jeffrey R. Bohn and Roger M. Stein, *Active Credit Portfolio Management in Practice* (Hoboken, NJ: John Wiley & Sons, 2009), 6.

Credit Asset Classification

There are credit asset classifications that are employed to assess credit risk:

- **Sovereign exposures:** These include credit extended to governments or sovereign states, regional groupings such as the European Community, central banks such as the U.S. Federal Reserve Bank or the European Central Bank, and international or regional financial institutions such as the International Monetary Fund, the World Bank, the Asian Development Bank, and the Bank for International Settlements (BIS), which acts as something of a bank for central banks.
- **Bank exposures:** These are exposures to banks and financial institutions including securities firms that are subject to supervisory and regulatory frameworks such as risk-based capital requirements similar to those that apply to banks. In other cases, securities firm exposure is treated as a corporate asset.
- **Corporate exposures:** These include exposures to companies, both those with or without a credit rating, including insurance firms.
- **Residential mortgage loans:** These are credit exposures secured by residential or rental properties and include second mortgage insurance. In Hong Kong, the HKMA requires homebuyers to make a down payment of 30% of the purchase price (40% for homes valued above HK$20 million) to secure a mortgage.
- **Regulatory retail exposures:** These include exposures that meet or are subject to a range of market-specific qualifying criteria or regulatory requirements set by the Hong Kong Monetary Authority (HKMA) relating to:
    i. orientation – These include exposures to individuals or small businesses, defined as enterprises with a turnover of less than HK$50 million
    ii. product – These include retail products such as a revolving line of credit but exclude securities including bonds, equities, and mortgage loans
    iii. granularity – To ensure diversification of risk, no aggregate exposure to one counterparty can exceed 0.2% of the entire regulatory retail portfolio
    iv. value of individual exposure – Aggregate single counterparty exposure must be less than HK$10 million
- **Classified debts:** These include such exposures as past due loans including unsecured portions of loans and those overdue by over 90 days, claims on corporations rated below BB−, claims on sovereigns, non-central government public sector entities (PSEs), banks and securities firms rated below B−, and securitisation tranches rated between BB+ and BB−.

Evolution of Credit Markets

The modern notion of credit began in pre-industrial Europe in the context of commercial payments. Credit was typically extended by deferring payment for goods sold or advancing payment for future delivery of goods purchased. Over time, these debts began to be treated as fungible or exchangeable for similar instruments and could be assigned to other merchants.

Eventually, settlement systems evolved. Deposit banking developed in response to the need for assignment of third-party debt among strangers. Since the bank became the counterparty for multiple transactions, it could net a large number of payments without resorting to final cash settlement.

This enabled pre-industrial banks to offer a solution to the problem faced by merchants, that of liquidity risk, a short-term lack of cash preventing completion of a particular transaction.

Since depositors in the bank found it convenient to leave their money with the banker so that settlement of transactions could be done without having to lug around actual coins, the bank now had a store of deposits to use as the basis for making an overdraft loan. The bankers discovered that they could extend credit beyond the quantity of actual coins or gold on deposit since most depositors did not demand access to all of their deposits most of the time.

Rise of Leverage

This is how leverage in financial institutions began. Since the banker knew his clients well, the bank could use its knowledge of the capacity of a potential borrower, who is likely to be a depositor, to repay a loan and allow this individual to periodically overdraw his account. Eventually, these short-duration, relatively small overdraft loans were supplemented and then overtaken by longer, larger commercial loans.

Credit has evolved in many different ways. It can now be extended not only in the form of loans, but also in the form of bonds traded in a global capital market. Computers have replaced written ledgers and money has become virtual, represented as digitised bits stored in computer hard drives. Along with technological progress came the capacity for higher volume lending.

But a number of difficulties emerged as the institutions and markets developed for the extension and management of credit, including bank runs, the difficulty of managing potentially large losses on a bank's loan book, and inefficiencies in the market for corporate credit. Despite these challenges, debt markets continued to mature.

In the 1990s, several trends in corporate credit markets allowed credit to be priced and managed in a relatively efficient way. The first trend involved the successful implementation of objective, quantitative analytic methods for the rigorous evaluation of credit exposures. This arose from the marriage of modern finance and powerful computer technology.

A portfolio manager also needed to be able to use this analysis and then trade at a reasonable cost. This was made possible over the past decade due to the availability of cheap telecommunications, making it easier to trade credit-risky instruments inexpensively. While corporate bonds have always been traded, a market in secondary trading of corporate loans has also developed.

The third step in the evolution of corporate credit markets was to take advantage of the analytical and trading capabilities to diversify portfolio holdings. In recent years, some of the most sophisticated banks have used portfolio analysis technology to devise transfer pricing mechanisms, allowing them to separate the management of the bank's credit portfolio from the creation of valuable services and business lines.

Today, the motivation for trading credit goes beyond avoiding a default and ranges from addressing perceived market inefficiencies to portfolio rebalancing designed to improve the return/risk profile of an institution's entire credit portfolio.

Basel Agreement

Another important trend has been the change in the regulatory environment as financial regulators come to grips with the importance of measuring and managing credit risk. The first global bank accord, known as Basel I, was based on the simple principle that a bank should hold a certain minimum amount of capital, given the credit risk on its loan book. Basel I set those requirements.

Countries are now adopting a more complex set of internationally agreed upon standards known as Basel II, the provisions of which were first published in 2004, and are preparing to implement additional changes under Basel III, which are to be phased in by 1 January 2015. While regulators have now acknowledged the need to employ quantitative measures of credit risk such as probability of default (PD) and loss given default (LGD), the most advanced banks have already been running systems that not only calculate PDs and LGDs but also evaluate the correlations among exposures in their portfolios.

Another trend is the sudden appearance of a deep and liquid market in corporate credit derivatives. In 2009, the Bank for International Settlements estimated that outstanding derivatives totalled US$592 trillion or some 10 times global GDP. Synthetic CDOs have become common transactions in the world of credit management. These instruments create a mechanism for more efficient management and transfer of risk exposure. A portfolio manager can now isolate the credit risk components of price from other types of risks such as market risk and liquidity risk that affect the value of a bond or a loan.

Though still evolving, the markets for corporate credit risk, whether they involve bank loans, bonds, or credit derivatives, are becoming more liquid and more transparent. This does not imply that they are anywhere near full maturity. The development of these markets has not been smooth, as exemplified by the recent credit crisis that resulted in the dramatic reduction in the volume of issues in many sectors of the market for CDOs in late 2007 and the difficulties across most credit markets in 2008.

The challenge lies in choosing the right models and systems to support active corporate portfolio management. More important is to change the way that risk is managed within a financial organisation so that employees are motivated to make decisions that result in efficient allocation of the bank's economic capital. The hope is that proper incentives and insight into credit portfolio management will lead to less risky, more valuable banks.

What is Credit Risk?

The Hong Kong Monetary Authority defines credit risk as "the risk that a borrower or counterparty may fail to fulfil an obligation. The assessment of credit risk involves evaluating both the probability of default by the counterparty, obligor, or issuer and the exposure or financial impact on the AI (authorised institution) in the event of default."[3]

Banks regard counterparties, obligors, or issuers that have a low probability of default (PD) or which have been rated highly by credit ratings agency as relatively safe credit risks. Those with high PDs or low credit ratings are considered relatively risky credits. We will discuss how PDs are measured later in this chapter.

Some financial experts focus only on the probability of default in examining credit risk. The trouble with this approach is that a portfolio could contain "time bombs" that may not be noticed until many other firms in the same industry or geography are defaulting at the same time. By then, it is too late.

Others have argued that credit risk should be defined in terms of a decline in value. But a focus on only downside variance—sometimes called semi-variance—ignores important information about the future. For example, in the late 1990s, Internet firms experienced a few years of skyrocketing growth in value. Their eventual fall went faster than their rise. Focusing just on downside variance in those cases would have led to a severe underestimation of their overall risk.

Since the probability of default of one loan is the same regardless of the concentrations in a portfolio, the potential for large portfolio losses can change dramatically with greater correlation among exposures. Furthermore, the tracking of credit migration or changes in value prior to maturity becomes essential to evaluating the true risk of a portfolio over time. Otherwise, a cluster of sudden defaults will likely surprise the portfolio manager. All this means that considering both the underlying risk and the change in the values of securities within a portfolio is a more accurate way to assess risk than to look just at the risk of defaults.

In credit risk modelling, which we will discuss in Part 3 of this book, much of the change in value of credit-risky securities is attributed to changes in the likelihood that the obligor will pay its coupons and repay the principal. Some models such as structural models rely on specific economic reasoning to describe why an obligor defaults, namely that the market value of the borrower's assets falls to a point at which it no longer covers the total amount of its obligations.

Other more statistically focused models such as reduced-form models do not rely on a specific causal economic relationship but rather focus on default as an unpredictable event that can be determined in a coherent mathematical model that is consistent with financial theory. Even so, reduced-form models tend to focus on processes that drive

[3] Hong Kong Monetary Authority, "Risk Based Supervisory Approach," in *Supervisory Manual,* 19. Refer to "Further Reading" at the end of this chapter on how to download this pdf file.

credit quality. They can also be extended to include processes that drive the state of market liquidity.

What can make this modelling challenge much more difficult is the possibility of a liquidity-based default or liquidity-based change in security value. In a circumstance in which market liquidity has dried up, a firm with sufficient market value may still default because it cannot roll over its short-term debt as it comes due. The claims represented in the issued loans and bonds of a particular obligor may still relate to that obligor's valuable assets, but the absence of liquidity in the market would prevent a portfolio manager or credit trader from finding new financing or selling positions in its portfolio to cover existing claims.

Such liquidity-driven difficulties may result from different processes than the ones driving changes in credit quality, although the credit problems and liquidity difficulties are often related. In modelling, we attempt to separate whenever possible the effect of credit factors from the effect of liquidity factors on estimates of relevant metrics of risk and value.

Regulation

Given the importance of banks to most national economies, governments have an interest in ensuring their prudent management. Efforts to reduce systemic financial risk often focus on regulations. At the international level, the Basel Committee on Banking Supervision, which is housed in the Bank for International Settlements (BIS) in Basel, Switzerland, has been coordinating proposals for bank regulations. While these proposals may not be implemented in every country, the ideas contained in them spark discussion among regulators worldwide.

The Basel Committee was created in 1974 by the central bank governors of what was then known as the Group of Ten or G10 countries, industrialised economies that were making funds available to the International Monetary Fund (IMF). The Basel Committee is now composed of 27 members including both developing and developed economies.

In the 1980s, under the Committee's coordination, central bank governors from around the world engaged in a round of talks that led to an accord published in 1988 that set minimum capital requirements for banks. The agreed set of standards, referred to as Basel I, outlined for banks the appropriate levels of capital they should hold for given classes of risk. It did this in broad terms, with the goal of creating a common language for regulatory capital risk rather than set out any detailed risk management strategies.

In recent years, the Basel Committee has finalised the next generation of banking regulatory standards. Published in 2004, Basel II is intended to create more sensible guidelines within which banks can develop systems for credit risk assessment and economic capital allocation. The promise of Basel II lies in aligning the regulatory guidelines with the way in which decisions are actually made at financial institutions. It is meant to address the regulatory arbitrage issue that arises when capital requirements diverge from economic capital allocation.

Basel II does not deal as much with correlations within a portfolio as it does with estimating PD and loss given default (LGD). Regulators tend to focus more on establishing rules that reduce systemic risk in the financial markets. But they have become more sophisticated in their understanding of quantitative risk management than at the time Basel I was introduced. Over time, there is likely to be better coordination and cooperation among banks, regulators, and industry organisations to implement new credit risk management systems and structures.

In 2010, new provisions known as Basel III were adopted in response to the global financial crisis of 2008. Among the package of reform measures, the minimum requirement for common equity of international banks, which is regarded as the highest form of loss-absorbing capital, will be raised from the 2% level to 4.5% of risk-based assets from 1 January 2015. The Tier 1 capital requirement, which includes common equity and other financial instruments that will qualify for inclusion based on more strict criteria than under Basel II, will be increased from 4% to 6%.

Credit Models

Veteran loan officers often complain that credit risk modelling is destroying relationship banking. Many of them argue that no computer model could ever match an experienced banker's capability for assessing a company's credit quality. But this opinion may be due to a simplistic view of how models are used and how they work. In fact, several studies by banks show that on balance subjective credit risk assessment alone is decidedly inferior to quantitative-based approaches.

Rather than destroying relationships, quantitative models change the way a bank can be organised and, more importantly, change the way credit analysts and relationship managers can do their jobs. Well-implemented systems improve the development of relationship banking and increase the efficiency and accuracy of credit analysts. Good models can provide a means to reduce some of the more tedious aspects of credit analysis and focus the analyst on the obligors, data, and processes that need attention as the bank manages its risk.

With quantitative models at the foundation of a bank's credit assessment process, qualitative assessment can then be overlaid when appropriate. Qualitative assessment becomes more important when evaluating borrowers where market observable information is lacking. Even in these circumstances, a quantitative model can assist in directing the focus of the assessment process to exactly what drives the borrower's risk. In many ways, these models become a common basis for risk discussions throughout the bank and transaction discussions outside the bank.

The most successful institutions benchmark internal models on a regular basis to ensure that the language of risk carries the same meanings from transaction to transaction. Models are best used in environments in which the organisation maintains a balance of healthy scepticism, regularly reviewing the models it uses and the assumptions that support them.

Ideally, there should also be a healthy enthusiasm for the efficiency and insights that quantitative approaches to credit risk management bring to credit processes and internal communication about risk. If implemented correctly, this language of risk can be used to transform a financial institution's business, moving it from origination of single exposures to active credit portfolio management.

Overall Portfolio Risk

The stand-alone risk of a particular exposure tends to be the easiest to understand and act upon. The industry tends to remember the analyst who identified a deteriorating credit well before this deterioration was reflected in that obligor's loan, bond, or CDS price. A financial professional who might have identified problems at WorldCom, Enron, or Lehman Brothers before they became newspaper headlines would certainly emphasise this as proof of his abilities as a credit analyst.

The problem with citing such isolated examples is the lack of focus on the overall performance of the portfolio. If an analyst is consistently negative about all obligors, he will surely identify the handful of big names that default. But that analyst has not necessarily helped his financial institution. Anyone can recommend avoiding all prospective borrowers. A similar situation will arise with an analyst who is always optimistic.

Stand-alone risk assessment should clearly distinguish strong borrowers from weak ones. The ability to make this distinction should be regularly benchmarked and tested regardless of whether the assessment is done by a model, an analyst, or both. Yet by itself, on average qualitative stand-alone risk assessment typically does not lead to better-performing portfolios. Few analysts can successfully separate winners from losers in high volume.

More importantly, from a bank's perspective, the risk of any particular exposure is less useful than the performance of the portfolio as a whole. Thus, single exposures should be evaluated in the context of a portfolio, which requires the assessment of credit exposure correlations. The framework emphasised in this book enables an analyst to calculate a portfolio value distribution that reflects the likelihood of different value outcomes over a specific time horizon.

Japanese banks in the 1990s tended to hold portfolios heavily concentrated in large, Japanese companies. Some of these companies such as Toyota were quite safe on a stand-alone basis. Yet the risk contribution of a safe, large company such as Toyota to a Japanese bank portfolio would likely have been larger than the risk contribution of a moderately risky mid-size European company. The stand-alone measure for Toyota might have implied that it was a good addition to the portfolio, but from a portfolio perspective, the risk measure would have suggested that a riskier, non-Japanese company could have been a better choice.

The portfolio perspective accounts not just for an exposure's stand-alone risk, but also the correlation and concentration of that exposure in the context of a given portfolio. Typically the correlation across geographies is lower than the correlation across industries within any particular geography.

Building Blocks of Portfolio Risk

Understanding the portfolio framework requires definitions of the key components used for credit portfolio analysis:

- **Probability of default (PD):** The probability that an obligor will not meet a stated obligation. In the case of a loan, the obligor is the borrower and the obligation is to pay a regular coupon and repay the principal at maturity. A PD will have a time horizon attached to it.
- **Loss given default (LGD):** The amount lost when an obligor fails to meet a stated obligation. Many times the focus is on recovery, or 1-LGD.
- **Time horizon of analysis (H):** Meaningful credit portfolio analysis requires the specification of a time horizon over which the analysis is made. Most analyses begin with the assumption that H is one year. Note that we often refer to time with the letter T. But in this book, we distinguish the time to maturity, or T, from the time horizon of analysis, which is H.
- **Default correlation:** The correlated movement into default of two obligors.
- **Value correlation:** The correlated movement in the value of the credit-risky securities within a portfolio.

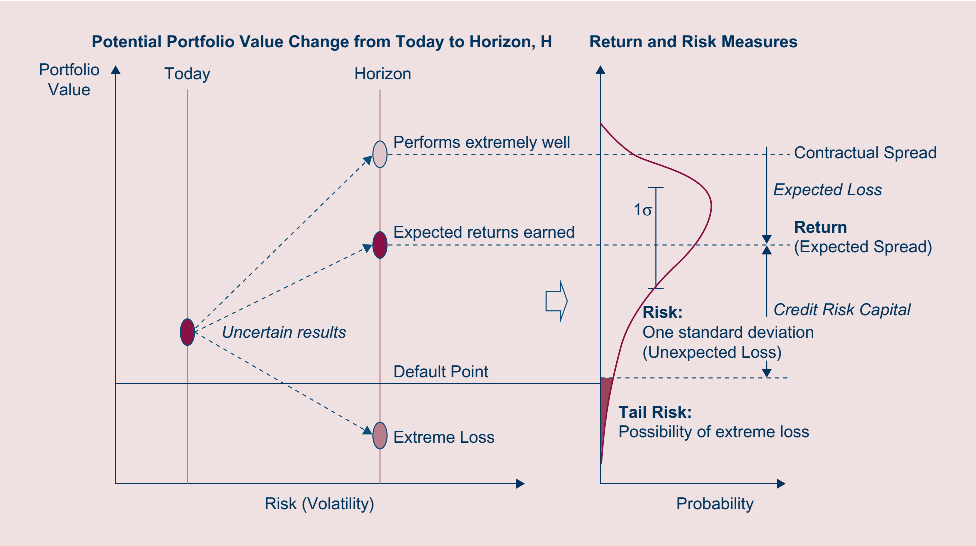
With these definitions, we can sketch out the framework for evaluating a credit portfolio. Initially, we will determine expected loss, which is the primary cost of building a credit portfolio.

- **Expected loss (EL):** PD multiplied by LGD. This quantity is typically calculated over the time horizon, H. In this definition, we assume that the exposure at default (EAD) is par. This definition can be modified for other instrument types.
- **Economic capital:** The amount of value cushion available to absorb extreme losses—that is, to absorb losses after using other sources of reserves such as provisions based on EL and earnings from exposures. The economic capital amount is calculated based on a target probability associated with an estimated portfolio loss distribution (estimated for the time horizon, H). The economic capital corresponds to the present value (of amounts at time H) of the loss level at which the probability of exceeding that loss level equals the target probability.

Occasional surprise losses become the focus of portfolio risk assessment. The two preferred measures of portfolio risk are unexpected loss and tail risk. Figure 1.2 shows a portfolio value distribution with an indication of the UL and TR.

- **Unexpected loss (UL):** A measure of the volatility or standard deviation for a portfolio loss distribution.
- **Tail risk (TR):** A measure of the likelihood of extreme losses in the portfolio (this is similar to the concept of value-at-risk, or VaR, which we will discuss later in this book;

FIGURE 1.2 Portfolio Value Distribution With UL and TR[4]



we will also introduce the concept of conditional VaR, or CVaR, which is sometimes referred to as expected shortfall). Tail risk corresponds to the area of the portfolio loss distribution from which we typically calculate economic capital.

UL and TR in Practice

Unexpected loss tells us something about the variation we expect to see in the size of most losses experienced by the portfolio. Since a large portion of a bank's earnings derive from the financial portfolio, this variation will directly impact the volatility of bank earnings. As such, UL provides guidance as to how the composition of an existing portfolio will impact the volatility of a bank's earnings, which is part of the HKMA's requirement about managing credit risk.

How does a bank avoid holding a portfolio that experiences little volatility, but is occasionally hit with a loss so large that it puts the entire bank at risk? Tail risk is what we measure to determine how a particular exposure contributes to an extreme portfolio loss event at a particular target probability.

Once a target probability is chosen, the amount of capital required can be calculated by examining the quantile, or interval, of the loss distribution corresponding to this probability. Note that this approach assumes that the target quantity is a PD. In some environments, targets are described in terms of expected loss, in which case a more complicated calculation is required.

[4]Jeffrey R. Bohn and Roger M. Stein, *Active Credit Portfolio Management in Practice* (Hoboken, NJ: John Wiley & Sons, 2009), 25.

Once we have determined an aggregate capital amount for a given portfolio, we can next look at how to allocate that capital to each exposure in the portfolio. For example:

- If we are focused on UL or volatility as our measure of risk, we may choose to base capital allocation on a given exposure's contribution to UL, which is sometimes called risk contribution (RC). This approach will favour exposures that do not vary in value much over time, such as loans to large, high-quality corporate borrowers.
- Alternatively, we may choose to allocate capital based on a given exposure's contribution to portfolio TR, which is sometimes called tail-risk contribution (TRC). This approach will favour exposures that do not have correlation with the portfolio or do not represent a large concentration.

Ultimately, the choice of objective function is a management decision, so it is important that the management of a financial institution all share a comfortable understanding of the underlying meaning of each of these measures.

Probability of Default in Practice

When a bank shifts to a quantitative orientation of credit risk assessment (as opposed to subjective risk assessment by experienced bankers), PDs become the foundation for evaluating and monitoring obligors.

Probabilities of default move considerably through the credit cycle: From trough to peak of the cycle, the typical market-based PD of a public firm in a sector or geography may change by as much as a factor of five or six. Probabilities of default also vary considerably across different classes of obligors. For example, Moody's KMV's EDF values, a commonly used measure of PDs, range from one basis point (0.01 percent) to 3,500 basis points (35 percent).

This change over time and change across obligors at any given point make it important to estimate PDs accurately. The first step in doing so is to rank current and prospective obligors in terms of their PDs. In most banks, PDs are converted into internal ratings. This "bucketing" of PDs creates more stability in the estimates and facilitates better communication with non-quantitative employees at the bank, although it also discards a good deal of information on the credit quality of the borrower. By bucketing PDs, however, banks do not have to check each PD every day. We discuss a number of approaches to bucketing PDs in Chapter 4 of this book.

Probabilities of default are an integral, if not the most important, part of a portfolio model. Using PDs, an analyst can not only make a relative statement about obligor risk (for example, that a small manufacturing company is a better risk than a medium-size business services firm), but he can also quantify the differences in risk among obligors (that the small manufacturing company is one-third as likely to default as the medium-size business services firm).

The final piece of the puzzle concerns return: How much will a bank earn from each credit exposure? Valuation helps sort out this question. We can use PDs in the context of a valuation model to determine how much an exposure is worth today and how much we expect it to be worth at a particular date in the future.

This expected gain or loss can be added to the expected cash flow stream to determine the overall expected return from holding a particular credit security. We can also incorporate these models into simulation engines so that we determine values conditional on the realisation of various factors that reflect a particular state of the economy. Probabilities of default are the threads that run throughout the fabric of all these risk models.

Risk-neutral PDs

When assessing risk, we estimate the actual, physical PDs. When we estimate a credit instrument's value, we also use PDs. In both these operations, we first convert these actual PDs into ***risk-neutral PDs***.

While the physical PD represents the estimate of the expected rate of default for a particular entity, this conversion to risk-neutral PDs for the purpose of valuation reflects the inherent risk aversion of investors. This adjustment also reflects the fact that risk-averse investors require an extra premium beyond payment for expected loss to compensate them for the risk associated with purchasing a security that may lose value in excess of everyone's expectations. In other words, investors require additional compensation for accepting a gamble versus a sure thing with the same expected payout.

The change from measuring physical to risk-neutral PDs can be accomplished in many ways, but the key objective is to adjust the probability for the extra risk that needs to be implied to adjust for risk aversion. We should be careful to distinguish actual from risk-neutral PDs.

Value, Price, and Spread

When we discuss ***value***, we refer to a measure that reflects the model framework's assessment of the present value of the future risk-adjusted cash flows that the asset or security under analysis is expected to generate. ***Price***, by contrast, is the amount at which an asset or security is bought or sold in a market.

The asset or security's value does not necessarily equal the price at which one could buy or sell the asset or security at any given point in time. Instead, value provides an indication, according to a model, of the price at which the asset or security should be bought or sold, but which may not reflect the actual current market price due to various market conditions.

A useful model will generate values to which prices converge over some reasonable time horizon, usually less than a year. In some cases, the asset is not traded (for example, the market value of an entire firm or the bank loans of a small firm) and in some cases the security's price is driven by factors outside a model (for example, market liquidity effects).

Most of the time when we refer simply to a ***spread***, we generally mean the extra premium with respect to a reference benchmark (for example, a risk-free rate). This spread represents a suitable conversion from the benchmark to the security's value or price.

To calculate a spread, we must first specify a risk-free benchmark. Once we have determined the appropriate risk-free benchmark, rf, we can convert a price or value into a spread. We do this conversion in the context of a particular model for the price or value of debt, D. We can sometimes solve for spread analytically (for example, in the case of zero-coupon bonds); but for most debt securities—particularly ones with coupon, C—we must find the spread, s, such that the functional relationship holds: D = f(rf, s, T, C, and so on)

In the context of the models in this book, we are careful to distinguish the following spreads:

- **Total spread (TS).** We usually call the spread to the U.S. Treasury (or some similar reserve-currency sovereign curve) the total spread. If we define TS in this way, the difference between the benchmark and the U.S. Treasury curve can be considered compensation for less liquidity in the corporate debt market.
- **Expected spread (ES).** As we discuss in Chapter 11, we subtract expected loss (EL) from TS to arrive at ES. This spread reflects the premium for holding credit exposures. This spread may comprise both a credit component and a liquidity component specific to the firm under evaluation.
- **Credit spread.** Part of the challenge in credit modelling is isolating that part of the spread compensating credit risk only. Strictly speaking, we define the credit spread as that portion of the total spread related just to credit risk. It is composed of the EL and the premium earned for holding credit risk.
- **Liquidity spread.** Unfortunately, we do not have good models of liquidity, so this spread tends to be the residual of the ES that cannot be explained by the credit model. Conceptually, there is likely to be some premium earned for exposure to liquidity risk. In practice, we may inadvertently characterise portions of the TS or ES as liquidity spread when in fact our model is incorrectly specified.
- **Zero-coupon spread.** When discussing term structures of spreads, we normally characterise the zero-coupon spread as that which would be earned on a zero-coupon debt security at different maturity dates.
- **Par spread.** An alternative way to characterise the term structure of spreads is in terms of the spread earned on a floating-rate bond such that the price of the bond is equal to par—that is, equal to 100. We call this characterisation the par spread.

Default

A simple definition of default is the non-payment of interest or principal on a credit obligation. Another possible definition of default is bankruptcy. There are also different types of payment defaults such as repudiation, in which the obligor refuses to accept a claim as valid. An obligor can also declare a moratorium to stop all payments for some period of time, although only sovereigns can usually afford to do this. And there is the simple credit default, or payment default on borrowed money.

Situations can also arise in which a firm appears to have defaulted in an economic sense, but not in practical terms. Consider a bank that becomes insolvent, but whose country's government continues to inject funds to keep the institution running—Japan in the 1990s, for example. This bank is economically in default while still making good on its obligations.

Default risk and credit risk are straightforward concepts. Default risk is the possibility that a counterparty does not honour his obligation with respect to payments, delivery of goods, or provision of services. Credit risk is the possibility of a payment default in connection to loans, bonds, or other financial transactions—the obligor does not pay when the obligation is due.

The following definitions by the International Swaps and Derivatives Association are helpful in understanding the concepts and various gradations of defaults:

- **Bankruptcy:** The corporate becomes insolvent or is unable to pay its debts. This event does not pertain to sovereign issuers.
- **Failure to pay:** This is the failure of the reference obligor to make due payments greater than the specified payment requirement (typically $1 million), taking into account some grace period to prevent accidental triggering due to an administrative error. A grace period may be specified. This may extend the maturity of the default swap if there is a potential failure to pay.
- **Obligation acceleration/Obligation default:** Obligations have become due and payable earlier than they would have been due to default or other similar condition, or obligations have become capable of being defined due and payable earlier than they would have been due to default or other similar condition. This latter alternative is the more wide-ranging definition and is therefore preferred by the protection buyer. The aggregate amount of obligations must be greater than the default requirement (typically US$10 million).
- **Repudiation/Moratorium:** A reference entity or government authority rejects or challenges the validity of the obligations.
- **Restructuring:** Changes in the debt obligations of the reference creditor excluding those that are not associated with credit deterioration, such as a renegotiation of more favourable terms.

Portfolio Performance Metrics

We have touched on a measure of the extra premium or expected spread (ES) earned to hold a risky security in a portfolio. We have also characterised contribution to portfolio volatility, or risk contribution (RC), and contribution to portfolio tail risk (TRC). The RC and TRC can be used to allocate economic capital, usually defined as a capitalisation rate (CR), to a particular exposure. Finally, we characterised the portfolio's stand-alone risk or unexpected loss (UL) and a particular portfolio's target probability–based economic capital (C).

The question remains: How do we use these measures in practice? In the world of credit, notions of return per unit of risk and benchmarks are still quite new. Nonetheless, the Sharpe ratio measure has started gaining popularity for credit portfolios.

Sharpe Ratio

To put the Sharpe ratio in the credit context, analysts make a few modifications. Return is measured in terms of ES: not just the risk-free rate but also expected loss is subtracted from total return. The denominator for the portfolio is UL. At the exposure level, RC replaces UL. (Note that the calculation of the Sharpe ratio for a credit portfolio maintains the concept behind the traditional Sharpe ratio: return divided by risk. However, in our context, we replace the traditional measures of excess return and the standard deviation of returns with measures appropriate to credit risk.)

Once the Sharpe ratio is calculated, a more fundamental difficulty arises in that there is a lack of an appropriate benchmark. While many credit indexes do exist, they tend to suffer from the endemic problem that the market does not originate well-diversified portfolios. Unlike in the equity world, where indexes can be constructed that more or less diversify away idiosyncratic risk, in the credit world, a borrower such as Ford may account for several percentage points of the market portfolio in exposure value terms. Thus the benchmark is overshadowed by the idiosyncratic risk of its largest constituents.

Traded CDS indexes are rapidly developing into benchmarks because they are regarded as suffering from the diversification problems of current bond indexes. That said, the changing liquidity and their relative newness do not always make CDS issues as the most reliable choice at present, though they will likely eventually develop into benchmarks in the future.

Where does this leave us? First, we can begin with the portfolio's current Sharpe ratio as a reasonable target for motivating each transaction within the bank. In this way, each new transaction should earn at least as much return per unit of volatility risk as the current portfolio.

An alternative benchmark is the Sharpe ratio for the "best" possible portfolio that the firm can construct given its constraints. All financial institutions have constraints governing what and how much they can own. This benchmark pushes the institution toward building the best possible portfolio available to it. Each transaction's Sharpe ratio (calculated in this case as ES/RC) is compared to this best-case portfolio's Sharpe ratio (calculated as ES/UL). This approach to decision making works for motivating value-adding transactions.

Vasicek Ratio

An alternative measure of performance to the Sharpe ratio is something we call the Vasicek ratio (named after its developer, Oldrich Vasicek, a pioneer in modern quantitative finance). A Vasicek ratio is analogous to a Sharpe ratio in the sense that it is a measure of return per unit of risk. But in this case, we replace the volatility-based denominator with a capital number reflecting a calculation of the portfolio tail risk. The Vasicek ratio is defined as ES/C, so the estimation effort stays focused on properly calculating the capital, or C.

In the early 1990s, a similar measure was developed at Bankers Trust (acquired in 1998 by Deutsche Bank), called risk-adjusted return on capital (RAROC). The credit-modelling firm KMV introduced a variant of this measure in the mid-1990s called return on risk-adjusted capital (RORAC). There is even something called a risk-adjusted return on risk-adjusted capital (RARORAC).

A related metric to the Vasicek ratio, which can also serve as a common measure for evaluating portfolio and non-portfolio businesses, is shareholder value added (SVA), or economic profit. Shareholder value added is measured by first calculating a net income number adjusted downward for expected loss (similar in concept to the calculation of ES). Next, the cost of capital allocated against a portfolio or business (defined as allocated capital multiplied by the cost of that capital) is also subtracted from the net income. The residual is the economic profit, or SVA, of that activity.

While the Vasicek ratio provides some sense of the percentage return earned on capital allocated, SVA provides a sense of the absolute level of contribution to shareholder value. A business may have a high Vasicek ratio, but it may be so small as to not materially increase shareholder value. In contrast, a business with a lower Vasicek ratio may have a high SVA, given its size. Still, the Vasicek ratio provides a sense of the ongoing opportunity associated with a particular business, as a high growth rate will eventually result in a high SVA, all else being equal. Both the Vasicek ratio and SVA are therefore useful tools for benchmarking performance.

Data and Data Systems

One of the primary factors behind the gap between many models introduced in the financial literature and those used in practice is the difficulty researchers have in finding sufficient data to estimate some academic models. It is true that, over time, the models driving risk analytics have become more widely accepted. However, how the models are implemented and how the organisation changes to make use of the models continue to be debated.

In adopting credit risk management models, it makes sense to have a bias toward market observable information. While private information about management plans or new products and other qualitative analysis can be useful supplements, quantitative, observable data (as long as the historical period is sufficiently long) provide the best starting point and foundation for modelling in almost every case.

What if market data is not available, such as when modelling private small and medium enterprises (SMEs)? Large pools of data from several different sources constitute the best data foundation from which to start. Some banks erroneously believe that their own portfolio is large enough that they have sufficient internal data to build robust credit models. The best approach actually relies on collecting a diverse and large sample of data that usually requires collaboration among several institutions and/or government entities.

Significant investment will be needed in data collection, data cleaning, and data systems. No matter how robust a model appears or how confident an analyst is of a particular approach, bad data will quickly render the model and system useless. Since credit events happen so infrequently, the modelling exercises in this context tend to be focused on outliers. Any system whose calibration is heavily impacted by outliers becomes highly sensitive to data quality.

Risk Control Framework and Governance

The foregoing discussions focus almost exclusively on credit and credit risk, but banks do not focus only on credit in risk management. They also monitor and examine credit's interactions with other risks, including operation, liquidity, market, reputational, fraud, sustainability, and strategy risks. The risk unit of a bank generally embraces functional specialists in these different risk arenas for more effective management of the bank's overall risk position.

In light of the changing market and regulatory environment, banks are aware of the need to set up good risk control and governance framework. These include setting up and implementation of appropriate policies, credit authorities, delegation framework, appropriate reporting layers and control mechanisms among the different risk, business functions/committees, board members, auditors, regulators, and other stakeholders.

Summary

- The definition of credit has expanded to cover a wide variety of exposures including those involving derivative contracts such as a credit default swap (CDS) and structured credit including collateralised debt obligations (CDOs) and asset-backed securities (ABS). Counterparty credit risk has thus become a critical issue as the volume of derivatives has mushroomed.
- The Hong Kong Monetary Authority defines credit risk as "the risk that a borrower or counterparty may fail to fulfil an obligation." Banks regard counterparties, obligors, or issuers that have a low probability of default (PD) or which have been rated highly by credit ratings agencies as relatively safe credit risks. Those with high PDs or low credit ratings are considered relatively risky credits.
- In assessing credit risk, some banks focus on the probability of default. Others have argued that credit risk should be defined in terms of a decline in value. Considering both the underlying risk (PD) and the change in the values of securities within a portfolio is actually a more accurate way to assess risk.

- In credit risk modelling, much of the change in value of credit-risky securities is ascribed to changes in the likelihood that the obligor will pay its coupons and repay the principal. Some models such as structural models rely on specific economic reasoning to describe why an obligor defaults. But is also possible that the change in value is caused by a shortage of liquidity in the market. This complicates the task of credit risk modelling.
- Many veteran loan officers complain that credit risk modelling is destroying relationship banking. Quantitative models actually change the way a bank can be organised and, more importantly, change the way credit analysts and relationship managers can do their jobs. Systems that are well implemented improve the development of relationship banking and increase the efficiency and accuracy of credit analysts.
- The portfolio perspective accounts not just for an exposure's stand-alone risk, but also the correlation and concentration of that exposure in the context of a given portfolio. Typically the correlation across geographies is lower than the correlation across industries within any particular geography; the correlation across company size groups within the same industry is also lower than the correlation across industries for a given company size group. A portfolio perspective requires uncovering such underlying factors.
- The key components for credit portfolio analysis are: probability of default (PD), loss given default (LGD), time horizon of analysis (H), default correlation, and value correlation. These components can be used to determine expected loss (EL, defined as PD multiplied by LGD) and economic capital, the amount of value cushion available to absorb extreme losses.
- Two preferred measures of portfolio risk are unexpected loss (UL) and tail risk (TR). UL provides guidance as to how the composition of an existing portfolio will impact the volatility of a bank's earnings. UL helps a bank avoid a situation where its portfolio experiences little volatility, but is occasionally hit with a loss so large that it puts the entire bank at risk. TR helps in measuring the risk of this extreme loss occurring.
- When a financial firm shifts to a quantitative orientation of risk assessment, PDs become the foundation for evaluating and monitoring obligors. Probabilities of default move considerably through the credit cycle: From trough to peak of the cycle, the typical market-based PD of a public firm in a sector or geography may change by as much as a factor of five or six. Probabilities of default also vary considerably across different classes of obligors.
- When assessing risk, actual, physical PDs are estimated. When we estimate a credit instrument's value, we also use PDs. However, we first convert these actual PDs into risk-neutral PDs. While the physical PD represents the estimate of the expected rate of default for a particular entity, this conversion to risk-neutral PDs for the purpose of valuation reflects the inherent risk aversion of investors.
- When we discuss value, we refer to a measure that reflects the model framework's assessment of the present value of the future risk-adjusted cash flows that the asset or security under analysis is expected to generate. Price, by contrast, is the amount at which an asset

or security is bought or sold in a market. Spread generally means the extra premium with respect to a reference benchmark (for example, a risk-free rate) that represents a suitable conversion from the benchmark to the security's value or price.

- A simple definition of default is the non-payment of interest or principal on a credit obligation. Another possible definition of default is bankruptcy. There are different types of payment defaults such as repudiation. An obligor can declare a moratorium to stop all payments for some period of time. There is also credit default, or payment default on borrowed money. The definitions by the International Swaps and Derivatives Association are helpful in understanding the concept and various gradations of defaults.
- In the world of credit, notions of return per unit of risk and benchmarks are still quite new. Nonetheless, the Sharpe ratio measure has started gaining popularity for credit portfolios. An alternative measure of performance is the Vasicek ratio. A related metric to the Vasicek ratio is shareholder value added (SVA).
- In risk management, banks do not focus only on credit, but also on credit's interactions with other risks, including operation, liquidity, market, reputational, fraud, sustainability, and strategy risks.

Key Terms

bankruptcy
Basel Committee on Banking Supervision
Basel I
Basel II
Basel III
bond
capitalisation rate (CR)
collateral
collateralised bond obligation (CBO)
collateralised debt obligation (CDO)
collateralised loan obligation (CLO)
commercial mortgage-backed security (CMBS)
corporate exposure
correlation
counterparty
credit
credit default swap (CDS)
credit exposure
credit risk
credit spread
default
default correlation
derivative
economic capital
Expected Default Frequency (EDF)
expected loss (EL)
expected spread (ES)
exposure
loss given default (LGD), 1-LGD
marginal risk
model
Moody's KMV
moratorium
obligation acceleration
obligation default
obligor
par spread
portfolio
portfolio loss distribution

portfolio performance
portfolio risk
price
probability of default (PD)
regulatory retail exposure
repudiation
restructuring
return
return on risk-adjusted capital (RORAC)
risk
risk contribution (RC)
risk-adjusted return on capital (RAROC)
risk-adjusted return on risk-adjusted capital (RARORAC)
risk-free benchmark (rf)
shareholder value added (SVA)
Sharpe ratio
sovereign exposure
spread
stand-alone risk
tail risk (TR)
tail-risk contribution (TRC)
time horizon of analysis (H)
time to maturity (T)
total spread (TS)
unexpected loss (UL)
Vasicek ratio

Study Guide

1. Explain why examining both probability of default and the change in the values of securities within a portfolio is a more accurate way to assess credit risk, rather than to look at just one or the other.
2. Some veteran loan officers "argue that no computer model could ever match an experienced banker's capability for assessing a company's credit quality." Do you agree or disagree? Defend your answer.
3. "From a bank's perspective, the risk of any particular exposure is less useful than the performance of the portfolio as a whole." Do you agree or disagree? Isn't it the case that if each stand-alone exposure is measured, the bank will in effect measure the entire portfolio? Defend your answer.
4. If a bank bases its capital allocation decisions on unexpected losses, what kind of exposures will it favour? What about if it focuses on tail risk?
5. Distinguish between Sharpe ratio and Vasicek ratio in the credit environment. Give one situation where a Sharpe ratio is a better way of measuring return per unit of risk, and another situation where the Vasicek ratio is a more effective way.

Further Reading

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