

Introduction

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Economic capital is a measure of risk. It is a single measure that captures unexpected losses or reduction in value or income from a portfolio or business in a financial institution. The risk arises from the *unexpected* nature of the losses as distinct from *expected* losses, which are considered part of doing business and are covered by reserves and income. Economic capital covers all unexpected events except the catastrophic ones, for which it is impossible to hold capital. Economic capital is a common currency in which all risks of a financial institution can be measured, enabling comparison of risk across different risks, across diverse businesses and across different financial institutions. A precise definition of economic capital is not attempted in this Introduction, since such a definition can be found in more than one place in the book.

The most important conceptual distinction between expected loss and unexpected loss is that the expected loss of a portfolio is simply the sum of expected losses for each of the constituent transactions within the portfolio. In that sense, expected loss is similar to variables such as revenue and expense. But the same does not hold true for unexpected loss. Unexpected loss in a portfolio has to take an important additional variable into account: namely, correlation. Correlations can exist between one transaction and another or between one portfolio and another. Typically, correlations are much lower for retail portfolios than for commercial portfolios. Another way of saying this is that retail portfolios are much more diversified than commercial ones. Economic capital models

often use the term *granularity* in referring to the proportion that each transaction represents of the portfolio. The extent of underlying granularity has a profound impact on intra-portfolio correlation and consequently on unexpected loss or economic capital.

The term “unexpected loss” is used by practitioners in two different ways. Unexpected loss may be defined as the standard deviation of the portfolio loss distribution. It may also be defined by subtracting the expected loss from the loss level at a high percentile.

A portfolio may have a higher expected loss than another but this does not necessarily imply that it will have a higher economic capital. For example, a highly granular and diversified credit card portfolio may have an expected loss of 4.0% while a commercial real estate portfolio concentrated in a particular region may have an expected loss of 1.0%. The economic capital required to support the credit card portfolio may be less than the economic capital required to support the commercial real estate portfolio.

Since its introduction in sophisticated financial institutions about a decade ago, economic capital has become an important tool for:

- measuring and managing risk;
- risk-adjusted pricing, so that the bank is adequately compensated for the risk taken;
- strategic use and optimum allocation of capital;
- performance measurement for shareholder value creation; and
- a driver of compensation.

In other words, economic capital now plays a significant role in major functions performed in a sophisticated financial institution, both at the corporate level and at the lines of business. Yet there is a paucity of good literature on economic capital. There are published models on economic capital and occasional papers on applications of economic capital. But it is hard for a practitioner to find an easy source providing both an overview and in-depth understanding. The objective of this book is to fill this void. The subject of economic capital has developed sufficiently that it would be presumptuous to claim this book to be comprehensive. But an attempt has been made to cover a fairly wide range of issues regarding economic capital in the book.

The book is divided into three sections. The first section deals with concepts and applications of economic capital. The second section deals with economic capital methodologies for specific risks pertinent to a financial institution. Mathematical treatment of issues in economic capital methodologies comprises the third section.

The four major categories of risk in a financial institution are credit risk, market risk, counterparty risk and operational risk. Issues relating to economic capital for each of these risks have been covered in the book, though economic capital for credit risk takes the lion's share. Balance-sheet interest rate risk and risks such as strategic risk and reputation risk have not been covered. Balance-sheet interest rate risk is managed at the corporate level through discretionary activities, typically by the use of interest rate derivatives and mortgage-backed investments, coupled with a transfer pricing mechanism. It is the residual risk that is of concern and not the interest rate risk in each transaction or portfolio. This obviates the need for allocating economic capital to each transaction. Risks such as reputation risk are too qualitative to attempt an economic capital calculation.

The chapters in the *first* section, although general for the most part, have a reference to economic capital for credit risk and in particular, credit risk in corporate portfolios. This is no surprise, as some of the models of portfolio credit risk and the concept of economic capital were first developed in the corporate credit world.

Chapter 1 provides a broad introduction to economic capital dealing with all risks relevant to a financial institution. While it introduces economic capital in the special setting of a particular bank, the topics covered provide a conceptual and non-mathematical background for any financial institution.

Chapter 2 addresses the issue of allocation of portfolio economic capital to individual transactions in the portfolio at a conceptual level. The strengths and weaknesses of two well-known approaches of capital allocation to individual transactions have been presented in a simple way with numerical illustrations. These approaches are: risk-contribution approach and tail-risk approach. Chapter 13 addresses the same problem of allocation of portfolio economic capital to constituent sub-portfolios at a much more mathematical level.

Chapter 3 focuses on the inputs to economic capital calculation for wholesale credit portfolios. While some of the results presented are

based on data from one particular bank, the chapter provides a broad conceptual framework for credit capital at a practical level. Chapter 4 is concerned with loss-given default or recovery and its modelling and impact on economic capital. Intuitively, in an economic downturn not only are the defaults higher but also the values of the defaulted firms' assets are lower, increasing loss-given default. This issue has been addressed with empirical evidence in both Chapters 3 and 4. Chapter 4 seeks to show how true effects of loss-given default need to be incorporated in an economic capital model.

Modelling of economic capital for credit portfolios comes after and depends on modelling of credit risk. There are three fundamental approaches to modelling credit risk: *intensity-based models*, *structural models* and *empirical models*. Intensity-based models describe default as an unpredictable event and do not assume any economic reason for default. They are based on a stochastic process called intensity of default, which describes the instantaneous probability of default. Correlation between default events is described by the correlation between intensity processes. Empirical models are based on econometric estimation from historical data. Structural models, on the other hand, describe default as an event that arises from the financial situation of the borrower. The first useful structural model of default is described in the seminal work of Merton (1974). Merton assumed that a firm has a stock and a single non-amortising debt obligation. The firm's asset value is described by a geometric Brownian motion. The firm defaults if, at maturity of the debt, the value of the firm's assets falls below the face value of the debt. Stock price in the Merton model is a call option on the firm's assets with the debt face value being the option strike price. Many refinements and extensions of the Merton model have subsequently appeared from both academic and practitioners' perspectives. All of these structural models are based on Merton's framework and are often called Merton-type models.

From the economic capital perspective, the most important adaptation of Merton's model has been done by Vasicek (1987, 1991). Vasicek applied Merton's model to a portfolio of borrowers. As in Merton's model, each borrower is characterised by a lognormal asset value process. A borrower defaults when its asset-value falls below a threshold defined by its liabilities. Correlations between

borrowers' defaults arise from correlation between their asset values. Correlations between asset values, in turn, are described by a common dependence of asset returns on a single systematic factor, representing the state of the economy. Thus the asset return for each borrower has a systematic component, reflecting the effect of the economy on the borrower, and an idiosyncratic component, describing fortunes and misfortunes unique for the borrower. Assuming homogeneous portfolio of loans with zero recoveries, Vasicek derived the distribution function for the portfolio loss. The Vasicek model has also been refined and extended to include non-homogeneous portfolios and non-zero stochastic recoveries. The term "Vasicek model" is often used to include these extensions of the original Vasicek model.

To describe different systematic effects for firms belonging to different industries and/or different geographical regions, the single systematic factor in the Vasicek model was replaced by a set of correlated systematic factors. This multi-factor extension of the Vasicek model lies in the foundation of such industry models as KMV's PortfolioManager™ and RiskMetrics' CreditMetrics™. Not all models of portfolio credit risk are of the Merton-Vasicek type (eg, CSFB's Credit Risk Plus™).

Chapter 5 enumerates the applications of economic capital in a financial institution. It argues that the significance of economic capital to a financial institution arises more from these applications than from any theoretical consideration, many of which are possible only with the advent of economic capital methodology. It also shows how the concept of economic capital for a financial institution is a departure from the traditional corporate finance approach for industrial organisations.

The chapters in the *second* section of the book address issues related to economic capital for specific risks: namely, retail credit risk, counterparty credit risk, credit risk in securitisation, market risk and operational risk. Each chapter focuses on economic capital methodology for the particular kind of risk and discusses issues specific to that application.

Chapter 6 deals with economic capital for retail credit exposures. The discussion is in the context of credit cards. However, most of the concepts discussed apply equally to any retail portfolio. The three broad methodologies for credit risk capital presented are

the ones prevalent in the wider retail world. The difficulties of estimating loss-given default and particularly exposure at default are unique to revolving credit portfolios.

Chapter 7 presents concepts of economic capital methodologies in general as well as economic capital for counterparty credit risk in particular. Credit risk and market risk intersect in the context of counterparty risk. The chapter indicates that the distinguishing feature of counterparty credit risk from credit risk in general is that the magnitude and direction of the exposure is uncertain. This feature necessitates a distinct methodology for calculating economic capital for counterparty risk. The methodology, in all its details, is presented in the chapter both at a conceptual and a practical level. All derivative portfolios require economic capital for counterparty credit risk as well as economic capital for market risk.

Chapter 8 presents conceptual issues and recent models of credit risk in securitisation tranches. It emphasises the fact that credit risk in a securitisation tranche cannot be modelled in the same way as credit risk in bond or loan portfolios. It also shows that rating of a tranche alone is not enough to compute economic capital attributable to the credit risk in that tranche. On average, highly rated (eg, AAA, AA) senior tranches require significantly less economic capital than similarly rated corporate bonds, while lowly rated junior tranches require significantly more economic capital than similarly rated bonds (eg, BB, B). The chapter describes a couple of models developed recently that address credit risk in securitisation tranches in an appropriate manner. These two models form the foundations of the ratings-based approach and the supervisory formula approach respectively in capital adequacy for securitisation in Basel II (see BIS, 2004).

Chapter 9 is on economic capital for market risk. It describes qualitatively the issues involved in calculating regulatory as well as economic capital for market risk. The most common methodology is to compute value-at-risk (VAR) for the portfolio at a horizon and level of confidence suitable for oversight on trading and then scale the VAR to reflect an annual horizon and a level of confidence corresponding to the desired insolvency standard of the institution. A normal distribution of changes in market value of a portfolio is a reasonable assumption. It is relatively easy to derive the scaling factors under this assumption and that of random walk.

Then the calculation of economic capital rests on the calculation of VAR.

Chapter 10 addresses economic capital for operational risk. It is the discussion around the formulation of Basel II capital adequacy rules that led to a measurable definition of operational risk. While several financial institutions have been allocating economic capital for operational risk prior to that, the methodologies left a lot to be desired. Therefore, unlike other economic capital methodologies, economic capital for operational risk goes hand in hand with the Basel II framework for measurement and management, including precise delineation of the scope of operational risk.

The *advanced measurement approaches* (AMA) constitute the centre-piece of Basel II operational risk capital. As the name suggests, AMA does not refer to a single approach or model, but rather refers to a collection of models that share certain guiding principles, namely incorporating information of (1) internal data, (2) external data, (3) scenario analysis and (4) internal control environment and business environment. AMA models are to be analytic and the capital measure is to reflect a soundness standard comparable to a one-year holding period and a 99.9th percentile confidence interval. As such, AMA provides an appropriate framework to discuss and develop economic capital methodologies for operational risk.

The actuarial technique of modelling the frequency and severity of operational loss events separately is a good starting point. The two are then combined using simulation, or other techniques, to arrive at an aggregate loss distribution. This is typically the analytic core of an economic capital model for operational risk and is known as the *loss distribution approach*. There is an obvious analogy between this loss distribution approach and credit risk modelling. Event frequency is analogous to default and severity is the complement to recovery.

However, scarcity of internal historical loss data necessitates the incorporation of external data and construction of scenarios in order to model frequency and severity. Furthermore, the recognition that operational losses depend on internal controls (in relation to the surrounding business environment), which change with time, necessitates building an explicit dependence of the losses on the state of controls. The “art” of operational risk economic capital consists in estimating the future unexpected loss conditioned on observables,

such as historical losses, historical and current state of controls and accumulated institutional knowledge about potential operational risks. The chapter on operational risk economic capital outlines an AMA-type model, emphasising the aspects related to incorporating information from the controls and business environments.

The *third* section of the book is mathematical. While a strong quantitative background is needed to follow the mathematics, others may find it useful to ignore the derivations and think intuitively about the results presented in these chapters. The issues raised in the chapters in this section are fundamental to the concept of economic capital and risk-adjusted measures.

The main objective of Chapter 11 is deriving a theoretically sound risk-adjusted performance measure. It formally introduces the principle of coherent measures of risk and examines profitability measures such as risk-adjusted return on capital and economic profit added from this perspective. The drawbacks of those measures are examined and a new profitability measure based on the capital asset pricing model is introduced.

Chapter 12 provides the fundamentals of an asymptotic single risk factor framework, which has since become the basis of the Basel II internal ratings based (IRB) approach (see BIS, 2004). General closed-form asymptotic expressions for portfolio VAR and its allocation to individual exposures are derived for the asymptotic single-factor case. According to this allocation, exposure-level capital depends only on properties of the exposure and does not depend on the portfolio composition. This property of the asymptotic single risk factor framework allows ratings-based allocation of capital and paves the foundation for Basel II IRB approach. Going beyond the asymptotic case, the chapter also discusses capital adjustment for undiversified idiosyncratic risk, widely known as *granularity adjustment*.

Chapter 13 looks quantitatively at three established portfolio risk measures: standard deviation, VAR and expected shortfall. Each of these risk measures has its own “native” definition of risk contribution: *covariance-based* risk contribution for the standard deviation measure, *quantile-based* risk contribution for the VAR measure and *shortfall-based* risk contribution for the expected shortfall measure. The chapter argues that using a risk contribution with a “non-native” risk measure (eg, the highly popular covariance-based allocation with VAR risk measure) is likely to lead to counterintuitive results.

A new class of coherent risk measures called *spectral risk measures* is introduced in Chapter 14. Spectral risk measure is a natural extension of the expected shortfall measure. Expected shortfall can be represented as an arithmetic average of portfolio VARs at all levels above the chosen confidence level. It can be thought of as a weighted average of portfolio VARs at all levels between zero and one, with the weight function being equal to zero below the confidence level and being equal to one divided by the insolvency probability above the confidence level. A spectral risk measure is a weighted sum of portfolio VARs at levels between zero and one, with an *arbitrary* weight function satisfying certain conditions. This chapter is an attempt at generalising the theory and modelling of economic capital.

Chapter 15 develops a broad framework for validating an economic capital model. With the introduction of Pillar 2 of Basel II (see BIS, 2004), validation has surfaced as an important issue. Validations are at two levels: validation of the inputs and validation of the ratings or capital models. Not much work has been done in this area. Developing a broad framework, within the parameters of which practitioners and regulators can discuss validation issues, is topical.

The international Basel II capital adequacy rules for financial institutions have been finalised in 2004 (see BIS, 2004). The most important objective of the Basel II capital adequacy rules is to better align minimum regulatory capital requirements to the true risk of the portfolios of the regulated institution. The capital adequacy rules under the present Basel I Accord are more or less “one-size-fits-all”. The second important aspect of Basel II is to allow banks to use internal assessments of risk (up to an extent) to come up with their minimum capital adequacy. The internal economic capital methodologies, developed over the last ten years, enable measurement and assessment of risk in all areas of a financial institution and to attribute it to business units, portfolios and transactions. Under Basel II, regulatory capital will be determined by the very same inputs that go to determine internal economic capital of a bank, while an individual bank’s internal economic capital formulas may be slightly or substantially different from the regulatory capital formulas. Thus, Basel II has not only affected a steady convergence of regulatory and economic capital but has also been a catalyst in

development of economic capital methodologies, particularly for securitisations and operational risk.

The significance of economic capital to a financial institution does not arise from regulatory requirements. Use of economic capital is a prerequisite for good risk management. It is also an essential tool for overall bank management for shareholder value maximisation. The applications of economic capital related in various parts of the book, particularly Chapters 1 and 5, amply illustrate this point. In its initial years, economic capital and its application were limited to large sophisticated institutions. However, in recent years the concept of economic capital is steadily spreading to other financial institutions, perhaps under competitive pressure. It is hoped that the contents of this book will be of value to practitioners, as the use of economic capital becomes more prevalent among financial institutions at large.

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