Determining the fair level of economic capital for credit and market risk in commercial banks

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Abstract

Banks play a strategically important role in the machinations of both global finance and the global economy. Ensuring the stability and good governance of the banking milieu falls within the ambit of the Bank for International Settlements (BIS) which recognised the importance of banks and established the Basel Committee on Banking Supervision (BCBS) in 1974. The BCBS has engineered and distributed two accords – Basel I and Basel II – over the last two decades since 1988 with the goal of promoting adequately and *appropriately* regulated banks. The latest of these – Basel II – embraces three risk components namely market, credit and operational risk. The most significant aspect of the current (Basel II) accord is the determination of the *appropriate* amount of regulatory capital, i.e. an amount which is not so lenient that it allows banks to regularly fail and yet not be too onerous as to impede the day to day operations of a bank. The assessment of bank capital adequacy and the enforcement of sufficient retained capital are important functions undertaken by banking supervisors.

Basel II requires that banks retain sufficient capital, at given confidence levels, to prevent insolvency. Banks must also satisfy local regulators (who may interpret and impose more stringent aspects of the accord) that additional risks have been adequately and appropriately addressed and the requisite capital has been reserved for these. The ultimate aim of the BCBS is to align banks' regulatory capital (the amount required to keep banks solvent as decided by the BCBS) with banks' internal (or *economic*) capital. The former is estimated via equations which are based on several economic assumptions, but are by definition highly conservative. The equations comprise several inputs, some of which are determined by banks using the most advanced approaches but many of which have been deliberately *fixed* by the BCBS as a means of introducing and establishing the perceived austerity into capital requirement formulas. The rationale behind the choices of fixed parameters has never been publicly released and this opacity obscures the *fairness* of the capital requirements; *fairness* in the sense of "do these fixed parameter restrictions make for capital requirements that are *too onerous* or *too lenient*?" Without details of how to estimate these fixed parameters, banks using the BCBS-specified equations must simply accept that the requirements are "fair" or at least *appropriate*.

This thesis establishes measurement methodologies of the opaque, fixed variables of Basel II's capital equations using banks' own empirical data. Using these methodologies, banks (of any size and complexity) may determine their own unique parameters from their own internal loss experience and thus assess the fairness of the imposed regulatory capital charges. If these are deemed too lenient, banks can increase their capital reserves and if too onerous, banks can adjust the pricing of risky securities. In either case, banks using these methodologies will be able to establish precisely their unique, *empirical* capital requirements without blind acceptance of obscured parameters in the capital calculations of Basel II.

Uittreksel

Banke speel ‘n strategiese rol in die internasionale finansiële stelsel en is noodsaaklik vir die handhawing van wêreldwye ekonomiese stabiliteit. Die Internasionale Verrekeningsbank (IVB) is verantwoordelik vir stabiliteit in internasionale bankwese en om toe te sien dat goeie bestuur in hierdie sektor gehandhaaf word. Die IVB het die erns en noodsaaklikheid van bankrisikobestuur besef en gevolglik die Baselkomitee oor Banktoesighouding (BKBT) in 1974 tot stand gebring. Die BKBT het sedert 1988 twee belangrike akkoorde (riglyne vir banke en toesighouers), naamlik Basel I en Basel II, saamgestel en gepubliseer. Die mees onlangse akkoord – Basel II – fokus op drie verskillende risiko’s waaraan banke blootgestel is, naamlik mark-, krediet- en operasionele risiko. Die belangrikste aspek van Basel II is die bepaling van genoegsame regulatoriese kapitaal wat nie so toegeeflik is dat verliese op gereelde basis lei tot insolvensie nie, maar moet ook nie so streng wees dat dit die bank se dag tot dag aktiwiteite nadelig beinvloed nie.

Die raming van genoegsame bankkapitaal (teen gegewe sekerheidsvlakke) sowel as die regulering van vereiste kapitaalvlakke is belangrike verantwoordelikhede vir banktoesighouers. Verder moet banke ook plaaslike toesighouers (wat die akkoord strenger kan interpreteer) daarvan oortuig dat alle addisionele risiko’s voldoende aangespreek is en dat voldoende kapitaal daarvoor gereserveer is. Die uiteindelike doelwit van die BKBT is om banke se regulatoriese kapitaal (soos voorgeskryf deur die BKBT) te sinkroniseer met banke se interne (of *ekonomiese*) kapitaal. Eersgenoemde word bepaal deur die gebruik van vergelykings (gebaseer op ekonomiese aannames) wat per definisie baie konserwatief is. Hierdie voorgeskrewe vergelykings bestaan uit verskeie insette in die vorm van vaste parameters wat doelbewus deur die BKBT so vasgestel word dat dit strenger kapitaalvereistes tot gevolg het. Die beweegrede vir die BCBS se gekose parameters is nog nooit bekend gemaak nie en hierdie vaagheid (vanaf die BKBT) wek twyfel op die regverdigheid van regulatoriese kapitaalvereistes. Met ander woorde: Is kapitaalvlakke, gebaseer op die BKBT se vasgestelde parameters, te toegeeflik of te streng?

Hierdie proefskrif bied ‘n vereenvoudigde metodologie wat banke (ongeag grootte of kompleksiteit) instaat sal stel om geregverdige ekonomiese kapitaalreserwes te kan bereken (gebaseer op die inividuele blootstelling van die bank). Banke kan, deur hierdie metododologie te gebruik, hul unieke verliesgeskiedenis gebruik om self die regverdigheid van voorgestelde, regulatoriese kapitaal te bepaal. Indien dit te toegeeflik is, kan banke hul kapitaalreserwes verhoog. Indien dit egter te streng is, kan banke die pryse van meer riskante effekte aanpas. Bowenal sal banke wat hierdie metodologie gebruik instaat wees om hul eie, empiriese kapitaalvereistes akkuraat vas te stel sonder blindelingse aanvaarding van die obskure parameters soos voorgeskryf in Basel II.

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List of Abbreviations

AFMA	-	The Austrian Financial Market Authority
AIG	-	Accord Implementation Group
AIRB	-	Advanced Internal Ratings Based approach
AMA	-	Advanced Measurement approach
APRA	-	Australian Prudential Regulation Authority
ATF	-	Accounting Task Force
BCBS	-	Basel Committee of Banking Supervision
BIA	-	Basic Indicator approach
BIS	-	Bank for International Settlement
CDF	-	Cumulative density function
CEBS	-	Committee of European Banking Supervisors
CGFS	-	Committee on the Global Financial
CI	-	Confidence interval
CPSS	-	Committee on Payment and Settlement Systems
CVaR	-	VaR for credit risk exposure
EAD	-	Exposure at default
ECA	-	Export Credit Agencies
ECAI	-	External Credit Assessment Institution
ECIM	-	European Commission: Internal
EI	-	Exposure indicator
EL	-	Expected losses
EPE	-	Expected positive exposure
FDIC	-	Federal Deposit Insurance Corporation

FED	-	The Federal Reserve Board
FIRB	-	Foundation internal ratings based approach
FSA	-	Financial Services Authority
FSF	-	Financial Stability Forum
HVCRE	-	High-volatility commercial real estate
IAIS	-	International Association of Insurance Supervisors
IBM	-	International Business Machines Corporation
ICAAP	-	Internal Capital Adequacy Assessment Process
IDR	-	Incremental default risk
IFRS	-	International Financial Reporting Standards
ILG	-	International Liaison Group
IMF	-	International Monetary Fund
IOSCO	-	International Organization of Securities Commissions
ISDA	-	International Swaps and Derivatives Association
LGD	-	Loss given default
M	-	Maturity
MDB	-	Multilateral development banks
MVaR	-	VaR for market risk exposure
NUL	-	Nett Unexpected Loss
OECD	-	Organisation for Economic Co-operation and Development
OTC	-	Over the Counter
PDF	-	Probability density function
PDG	-	Policy Development Group
PIT	-	Point-in-time
PR	-	Price risk
PSE	-	Public sector entities
RWA	-	Risk-weighted assets

SA	-	Standardised approach
SAS	-	Statistical Analysis System
SL	-	Specialised lending
SME	-	Small- and medium-sized entity
SRC	-	Specific risk charge
SREP	-	Supervisory Review and Evaluation Process
TTC	-	Through-the-cycle
UL	-	Unexpected losses
US	-	United States of America
VaR	-	Value at Risk
VCV	-	Variance-covariance
α	-	Alpha
β	-	Beta
ρ	-	Correlation

Chapter 1

Introduction

Life has always involved risk and those who are best able to weigh risks and make appropriate decisions have always been the most successful (SAS, 2002:1).

1.1 Background

Measuring and managing risk capital in a bank is critical in maintaining global financial stability – especially when large losses occur or in times of high market volatility. It is, therefore, vital that regulatory capital frameworks (which are designed to measure and estimate the requisite retention of risk-sensitive capital) are constantly adapted and improved.

Ensuring the stability and good governance of the banking milieu falls within the ambit of the Bank for International Settlements (the BIS) which recognised the strategic importance of banks and established the Basel Committee on Banking Supervision (BCBS) in 1974. The BCBS has engineered and distributed two accords (known as Basel I and Basel II) over the last two decades (since 1988) to assert that sound (i.e. adequately and appropriately regulated) banks are critical to the maintenance of global financial stability. Since the introduction of Basel I risk management has evolved from a completely novel and immature concept into a highly-defined and strictly-regulated process (Saidenberg and Schuermann, 2003:1). The current (Basel II) accord – which was launched in January 2008 – is more risk-sensitive than its predecessor and sets out *inter alia* advanced modelling techniques for use by qualifying banks. These methodologies are intended to improve the ability of banks to quantify and manage their risk (Proctor, 2006). The implementation of Basel II helped to correct numerous weaknesses of Basel I, although the economic crisis (which began in 2008) revealed several areas where the accord could be further improved to strengthen the global banking sector (Financial Stability Forum (FSF) and BCBS Working Group, 2009:5).

Basel II embraces, in some detail, three significant bank risk components namely market, credit and operational risk. The framework comprises three pillars with which all Basel-compliant banks must comply. The first of these pillars requires banks to retain *at least* an amount of capital specified by their adopted (and regulatory-approved) approach. Banks must, in addition, also satisfy local regulators (who may interpret and impose more stringent aspects of the accord) that other risks have been adequately and appropriately addressed and the requisite capital has been reserved for these over and above that required under the first pillar. This second pillar embraces capital required for concentration risk, legal risk, liquidity risk, interest rate (in the banking book) risk and others, including capital required for severely adverse market conditions (i.e. for the results of stress testing). It is the aim of the BCBS that the sum of the banks' capital under pillars one and two will ultimately equate to banks' internal (or *economic*) capital requirements or, stated differently, that the amount of capital required to keep banks solvent as decided by the BCBS is as closely aligned as possible with what banks themselves believe this amount of capital to be.

The most prominent aspect of Basel II is the determination of the *appropriate* amount of regulatory capital, i.e. an amount which is not so lenient that it allows banks to regularly fail and yet not so onerous as to impede the day-to-day operations of a bank. The assessment of bank capital adequacy and the enforcement of sufficient retained capital for this purpose are important functions of banking supervisors or regulators. Regulators that perform these assessments compare banks' available capital (held for protection) with the bank's capital needs (based on its overall risk profile). Bank management must also continuously evaluate internal capital adequacy in relation to risk faced by a bank (Federal Deposit Insurance Corporation (FDIC, 2004)).

Banks must comply with regulators' demands: they do not have any choice in implementing the supervisory rules. Several banks, however, face numerous obstacles in order to comply with and effectively implement the Basel II capital requirements (Callaghan, 2006). At the time of writing (November 2009), most banks follow the Basel II Standardised and Basic Approaches for all risk types (Van Roy, 2005:7).[1] To satisfy the requirements required for the advanced approaches as set out in Basel II, banks must have rigorous procedures in place for data collection, model validation and backtesting. Even though this is expensive and complex, banks that qualify are rewarded with a risk management system which provides a competitive advantage as it enables them to raise their ratings and calculate fair regulatory capital charges (Callaghan, 2006). Many banks, however, have neither the resources not the expertise to construct and implement Basel II's Advanced models (see Strand, 2000:1, Yao, 2003:23 and Whalen, 2006:2). All banks, however, also require their own internal (economic capital[2]) models and prior to the introduction of Basel II, these were designed with varying levels of sophistication (Wong, 2008:1). Since Basel II aims to calibrate regulatory capital models with internal economic capital models,[3] many banks simply employ Basel II Advanced *models* for their own (internal) use (Wong, 2008:3). The values of *economic* capital model parameters, however, are chosen completely at the bank's discretion.

Large international banks are increasingly comfortable to use their economic capital frameworks in discussions with stakeholders and to use it for Basel II solutions. Singh and Wilson (2007:19) expect economic frameworks to continue to improve and, in particular over the next few years, to be more widely accepted by the market and regulators in assisting banks to determine their capital management requirements. The determination of economic capital is – and will in future be – increasingly important for all

[1] Several large developing countries – such as China and India – have announced that they will not adopt the Basel II framework (*The Economist*, 2003).

[2] Economic capital can be defined as the amount of capital a bank needs to cover losses arising from the unique risk exposure at a specific confidence level. This capital requirement is calculated based on the bank's own dynamic, internal measures, not prescribed by any external parties (Smithson, 2008). Economic capital is discussed in more detail at the beginning of Chapter 2. Economic capital has reached an advanced level of maturity, and is now more widely accepted than ever before (Singh and Wilson, 2007:19).

[3] The Basel II framework, titled the *International Convergence of Capital Measurement and Capital Standards*, has a clear objective to increasingly improve international convergence for capital adequacy for supervised banks (BCBS, 2006a:1). Accurate and more risk sensitive economic capital models, which can, in future be implemented to improve the BCBS's frameworks, are therefore supported by regulators who are increasingly interested in banks' economic capital modelling.

banks, an undertaking that requires intensive modelling and analysis that is not always possible for all global banks due to a wide variety of resource issues (Sherris and Van der Hoek, 2006:39).

Despite the retention of capital to protect banks from financial crises, the 'credit crisis' has affected almost every segment of the financial system. Indeed, banks were the hardest hit by the crisis (which was arguably caused by the banks themselves) as billions in mortgage-related investments had to be written down, equity market values losses were considerable and exposure to exotic credit derivatives (such as CDOs[4] and CDSs[5]) resulted in many bank failures. Investment banks that once dominated the financial world have either disappeared, been absorbed or have been reinvented as commercial banks (The New York Times, 2009). Although some signs of tentative recovery have been noted recently, at the time of writing (November 2009) the crisis continues unabated. Therefore, understanding a bank's economic capital is currently the focus of all banks, including the BIS and local regulators as the credit crunch revealed that pre-credit crunch regulation was ill prepared for the crisis that followed and that it must be addressed in a holistic and comprehensive manner in order to evolve from the crisis (Morrison, 2009:2).

1.2 Problem statement

Under Basel II, banks are (and will in the future be) regulated by a similar set of rules (with different levels of complexity) in order to ensure that banks have sufficient capital for future events. The BCBS established equations that are part of these rules, based on several broadly sound economic assumptions, for calculating the requisite capital. These assumptions are by definition highly conservative. The equations comprise several inputs, most of which may be determined by banks themselves using the most advanced approaches. The remaining parameters, however, have been deliberately *fixed* by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas. These fixed parameters may not, however, reflect the individual and unique risk exposures and experience of a bank.

The BCBS have presented detailed documentation regarding the choice of model and most of the steps which lead to the capital requirement equations, but the rationale behind the choices of fixed parameters has not been publicly released. This opacity obscures the *fairness* of the capital requirements; *fairness* in the sense of 'do these fixed parameter restrictions make for capital requirements that are *too onerous* or *too lenient*?' Without details of how to estimate (empirically or theoretically) the fixed parameters, banks using the BCBS-specified equations must simply accept that the requirements are, indeed, 'fair' or at least appropriate.

Currently (November 2009), sophisticated banks calculate their economic capital requirements independently of the BCBS while smaller, less sophisticated banks – which often lack the quantitative resources of their more complex peers – rely heavily on Basel II for guidance on the estimation of economic capital (Wong, 2008: 3).

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[4] Collateralised debt obligations.
[5] Credit default swaps.

1.3 Research goals and objectives

To address this problem, primary and secondary goals were identified.

- The primary goal of this study is to address the above mentioned problem statement by establishing methodologies to empirically estimate some of the opaque, fixed variables present in Basel II's equations. The methodologies allow banks (of any size and complexity) to determine empirically their own unique parameters (for credit and market risk) from their own unique loss experience. Knowing these empirical values will allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed too lenient or too onerous (i.e. determine a *fair* capital charge). If the former, banks can increase economic capital reserves appropriately and if the latter, banks can judge for themselves whether or not prevailing economic conditions warrant such capital requirement severity. In either case, banks using the suggested methodologies are able to establish precisely their unique, *empirical* capital requirements without blind acceptance of obscured parameters in Basel II's capital calculations.
- The secondary goal of this study is to summarise the calculation methodologies introduced in this study into implementable applications which may be employed by any bank. These applications will allow banks (of any size and complexity) to determine empirically their own unique market and credit risk parameters from their unique loss experiences.

This study does not seek to discredit Basel II; rather it acknowledges the necessity for banks to ensure that key elements of the Basel II risk management governance structures, policies, processes and systems are robust and integrated within banks' day to day activities. This is especially important in the light of the ongoing (November 2009) credit crisis (Griffin, 2008).

1.4 Thesis outline

This study comprises the following chapters.

- **Chapter 2: Literature survey**

  Chapter 2 presents a literature survey which introduces the three essential role-players of global capital regulation namely: the BIS, BCBS and the Basel II framework. These protagonists are discussed to provide a better understanding of the global regulation of bank capital. The concept of economic capital is also explored in more detail. Historical developments, functioning and status quo of the components is detailed and Basel II's three pillar framework is summarised. Under the first pillar (minimum capital requirements) of Basel II, credit, operational and market risk is introduced briefly. This is followed by a brief introduction of the second pillar (supervisory review) and the third (market discipline).

- **Chapter 3: Fair credit risk capital using empirical asset correlations**

  Chapter 3 focuses only on Basel II's first pillar, namely minimum capital requirements for credit risk (chiefly under the Advanced Internal Ratings Based (AIRB) approach). The primary purpose of this chapter is to introduce a calculation methodology which will enable banks to determine a fair level of economic capital.

  The first parameter which has deliberately been *fixed* by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas is asset correlation and this is investigated in Chapter 3 with the purpose of determining a fair level of economic capital for credit risk, specifically for retail assets. Asset correlation was specifically identified as a potential problem since an incorrect measurement of this parameter could be detrimental in estimating a bank's capital requirements (Laurent, 2004:23).

  Chapter 3 comprises three sections: a literature study (which covers the relevant credit risk definitions and focuses on the capital calculation framework prescribed by Basel II. As this chapter investigates asset correlations and their impact on credit risk capital charges, a thorough description of this topic is required in order to contextualise the subject and draw accurate conclusions on this topic), a methodology for extracting empirical asset correlations using empirical data (which is employed in the calculation methods of the prescribed Basel II framework (introduced in Section 1) to also calculate the capital charge for credit risk) and a summary of the application which may be employed by banks to extract the empirical asset correlation from a set of retail empirical loss data. Banks may use these derived asset correlations to calculate fair levels of economic capital (using the Basel II framework and equations for credit risk). Section 3 also presents the results obtained from the methodology by applying it to US retail loss data.

- **Chapter 4: Fair trading book capital using empirical unwind periods**

  Chapter 4 extends the investigation beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book) and investigates the incremental default risk charge (IDR) which was recently introduced by the BCBS to take account of credit risk embedded in the trading book. This chapter thus investigates another parameter which has been deliberately fixed by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas, namely the credit *holding* (or unwind) *period.*

  The holding periods refers to the length of time required to unwind a financial position without materially affecting underlying asset prices. It is one of the few components of contemporary risk models which may be altered subject to the practitioner's whim. Most others are *calculated* and hence manipulation of their values is more difficult. Chapter 4 therefore introduces a calculation methodology, which may be applied by any bank, to determine the empirical holding period for credit risky instruments in the trading book.

Chapter 4 comprises of three sections. Section 1 is a literature review which covers all the relevant trading book concepts and developments.[6] Section 2 is a methodology section (as well as an exploration of the required parameters needed)[7] while Section 3 is a summary or application section which may be used by banks to calculate their own fair holding period of trading book credit exposures, based on their own data. This fair holding period is an important value and could be of strategic interest to banks who wish to establish fair levels of economic capital for market risk.

- **Chapter 5 - Contribution and results of investigated data**

Chapter 5 presents the results obtained in this analysis and comprises two sections. Section 1 is an application section which summarises the capital calculation methodologies from Chapter 3 which may be used by banks to extract the empirical asset correlation from a set of retail loss data. Banks may then use the *empirical* asset correlation to determine a fair level of economic capital using the Basel II credit capital equations. This is followed by a summary of the methodology introduced in Chapter 4 which may be used by banks to calculate their own fair holding period of trading book credit exposures, based on their own loss data. This fair holding period is an important value and

could be of strategic interest to banks who wish to establish fair levels of economic capital for market risk. Section 2 then applies these capital calculations (one for credit risk and one for market risk) to specific datasets and presents the results. The results show – in both cases – that the capital charges calculated by applying fixed BCBS parameters result in highly conservative (even punitive) levels of capital when compared with empirically calculated (based on unique loss experience) capital charges.

- **Chapter 6 – Conclusion and recommendations**

Chapter 6 concludes the study and makes some key recommendations for future research.

1.5 Scope

This study is aimed at banks of any size and complexity that have adopted Basel II and introduces calculation methodologies which will allow them to determine empirically their unique parameters for capital calculation from their own loss experience. The study does not intend to discredit Basel II nor its conclusions, but rather aims to provide banks with methodologies to determine empirical (based on banks' own data) economic capital. Those results may be used in economic capital calculations which are – and will become – more important for banks, regulators and investors in future.

[6] This section also introduces and discusses credit risk embedded in the trading book, a new development in the Basel framework. A thorough description about this topic is needed to make a proper analysis and develop an accurate methodology for capital calculations.

[7] All the background mathematics is presented in this section. This section also applies the mathematics to a specific set of bond data. The properties of the underlying data are described in detail. The modelling procedures and evidence for the assumptions used in the calculation of empirical holding period are also presented.

In Chapter 2 Basel II is discussed along with the three pillar framework of which it comprises. Under the first pillar, credit, operational and market risk are introduced, but this study focuses only on capital calculation methodologies for credit and market risk. Operational risk was not covered.

For credit risk, the capital calculation methodology is specifically aimed at *retail* credit exposures which have not received sufficient attention in recent years as industry and regulatory resources have always focused far more on *corporate* lending (Ghosh, 2005:3).

For market risk, the capital calculation methodology was based on bonds (specifically plain vanilla, corporate bonds). The idea was to isolate the effects of credit-risky instruments from other types of instruments (such as equities) in the trading book. Using simple debt instruments (plain vanilla corporate bonds) the application of the methodology introduced in this study could be effectively demonstrated. Complex debt instruments (such as CDSs and CDOs) are intricate and this unnecessarily obscures the effective application of the introduced methodology. However, banks which do hold complex instruments may still apply this methodology provided they can accurately determine both the market and credit risk capital charge components.

The literature study follows in Chapter 2.

Chapter 2

Historical development of International Capital Regulations and the New Capital Accord (Basel II)

The banking industry is probably the most regulated sector in the history of civilization (Bentulan, 2001:4).

2.1 Introduction

During the past four decades (since 1970) bank risk management has evolved from a completely new concept into a highly defined process of the modern global financial milieu. The principal driver of this process has been the regulation of bank risk capital.

The primary goal of this study is to introduce methodologies to empirically estimate some of the fixed variables present in Basel II's equations. The methodologies allow banks (of any size and complexity) to determine empirically their own unique parameters (for credit and market risk) from their own unique loss experiences. Knowing these empirical values may allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are too lenient or too onerous. The calculation methodologies introduced should enable banks to estimate the fair level of economic capital for credit and market risk. This is important for banks as *understanding banks' economic capital* is currently (November 2009) a critical focus in the global banking sector (Morrison, 2009:2).

If a bank finds that (based on its own empirical experience) the Basel II-prescribed capital requirements are too lenient, it may choose to increase economic capital reserves appropriately. If, on the other hand, the capital charge is too onerous, it may judge for itself whether or not prevailing economic conditions warrant such capital requirement severity. In either case, a bank using the suggested methodologies is able to establish precisely its unique, *empirical* capital requirements (a fair economic capital charge)[8].

It is the aim of the BCBS that the regulatory capital required to keep banks solvent be as closely aligned as possible with what banks themselves believe this amount of (economic) capital to be. At present, sophisticated banks decide their economic capital requirements independently of the BCBS while smaller, less sophisticated banks – which often lack the quantitative resources of their more complex peers – rely

[8] Knowing the accurate levels of economic capital is critical for banks as it is used to better understand the level of bank solvency. Economic capital is crucial for banks' strategic decision-making processes as it provides information on issues such quantitative risk reward trade-offs and where risk mitigating investments are needed. Banks furthermore rely on accurate levels of economic capital to make better pricing decisions (e.g. for credit securities in their trading book). Accurate levels of economic capital also facilitate better understanding of relative returns on risks across banks and supports portfolio optimisation by providing a good understanding of the combinations of return for risk across different business lines. Finally, economic capital is important for investment assessment used when taking decisions about new investments. When a bank considers investment opportunities it must not only look at the return on the investment, but also the risk adjusted return which can be determined by empirical economic capital (Lang, 2009).

heavily on Basel II for guidance on the estimation of economic capital. Economic capital differs from regulatory capital as the latter refers to the minimum capital required by the regulator to maintain an adequate level of liquidity based on the bank's exposures. In this study *regulatory capital* refers to the capital charges stated by Basel II (Elizalde and Repullo, 2004:1).[9]

Banks and regulators are continuously working together to improve international convergence of these two concepts (a principal Basel II aim). In particular, numerous discussions preceding the publication of Basel II have highlighted the objective of bringing regulatory capital closer to economic capital (Elizalde and Repullo, 2004:1).

From a theoretical perspective, economic capital does not receive as much attention in the literature as the extensive regulatory capital processes and requirements. By definition, the determination of economic capital is proprietary: banks are understandably unwilling to share processes, procedures and methodologies that may provide them with a competitive edge. The BCBS (2009a:5) clearly acknowledges economic capital[10] and notes that economic capital modelling continues to evolve. There are significant methodological, implementation and business challenges which are associated with the application of economic capital in banks. This is particularly true if economic capital measures are to be used for internal assessments of capital adequacy. Banks are encouraged to address economic capital issues be exploring methodologies to improve the overall architecture of economic capital modelling and to the underlying building blocks (BCBS, 2009a:5). However, even though the BCBS recognises and encourages the development of economic capital, banks are still required to calculate their capital based on Basel II, hence regulatory capital.

There are generally two sets of motivations for capital regulation in banks. Firstly, these regulations protect bank customers from exploitation by establishing sounder and better-informed financial institutions (Saidenberg and Schuermann, 2003:1). For banks this means that clients' savings and investments must be protected from losses. Secondly, systemic risk is minimised. Banks are often considered a source of systemic risk because of their central role in financial intermediation. The Reserve Bank of Australia (2001:1) defines systematic risk as:

> *The risk that the failure of one participant in a financial system, to meet its required obligations when due will cause other participants or financial institutions to be unable to meet their obligations (including settlement obligations in a transfer system) when due. Such a failure may cause significant liquidity or credit problems and, as a result, might threaten the stability of financial markets.*

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[9] The onset of the credit crisis (which began in 2008) has focussed attention on bank's economic capital. The computation of risk capital based on a comprehensive and all-inclusive approach is critical, not only for the recovery period which will follow the crisis, but also to ensure sustained levels of financial stability (Morrison, 2009:1).

[10] The BCBS (2009a:1) defines economic capital as: The methods or practices that allow banks to consistently assess risk and attribute capital to cover the economic effects of risk-taking activities. Economic capital was originally developed by banks as a tool for capital allocation and performance assessment. For these purposes, economic capital measures mostly need to reliably and accurately measure risks in a relative sense, with less importance attached to the measurement of the overall level of risk or capital. Over time, the use of economic capital has been extended to applications that require accuracy in estimation of the level of capital (or risk), such as the quantification of the absolute level of internal capital needed by a bank. This evolution in the use of economic capital has been driven by both internal capital management needs of banks and regulatory initiatives, and has been facilitated by advances in risk quantification methodologies and the supporting technological infrastructure.

Banks are, amongst others, the providers of liquidity, credit and several types of other financial services. These important contributions make banks the most important financial intermediaries in virtually all economies. The hard work conducted by the international community to adopt global capital standards is motivated by the important role bank capital plays in global banking soundness (Santos, 2001:3).

Three essential role-players regulate global bank capital. These are: The Bank for International Settlements (BIS), The Basel Committee on Banking Supervision (BCBS) and the document: *International Convergence of Capital Measurement and Capital Standards* (referred to as "Basel II" in this study). These are discussed in this chapter in order to provide a better understanding of global bank capital regulation. This theoretical overview is required by the financial community to eventually have better insight into the calculation methodologies introduced in this study which will enable any bank to calculate fair levels of economic capital for credit and market risk (and the main goal of this study).

The BIS acts as a global regulatory entity. It fulfils this role of international risk regulating facilitator through several representative bodies or committees with the main body (with reference to capital regulation) being the BCBS. The BCBS is the second most important global role-player in the regulation of capital. The BCBS has produced *inter alia* two unique documents or accords, known in the market as Basel I and II. In 1988, the original Basel Accord (Basel I) was produced and was eventually replaced by Basel II (also named the *International Convergence of Capital Measurement and Capital Standards: a Revised Framework* (BCBS, 2006a:1)) in 2008. These accords have been widely consulted, actively revised updated and amended and may be thought of as the most important tool in global capital regulation.

2.2 Chapter layout

This chapter comprises two parts. Firstly the three role-players (the BIS, the BCBS and the Basel Accords) are discussed more thoroughly. In this discussion, the focus is on the historic developments, and the functioning and the status quo of these role-players in the process of global capital regulations.

The second part focuses on Basel II which currently (November 2009) serves as a guide to local regulators worldwide. Specific reference is made to developments and revisions since the publication of Basel I. Basel II is also discussed – along with the three pillar framework of which it comprises. Under the first pillar, credit, operational and market risk are introduced. The second and third pillars are also discussed here. Since the latest (2006) version of Basel II runs into many hundreds of pages, this chapter does not aim at providing a detailed discussion of Basel II, but rather a summary of the main ideas.

2.3 Three essential role-players in global capital regulation

A discussion regarding the three role-players in the process of global capital regulations follows.

2.3.1 The Bank for International Settlement (BIS)

The historical development of the BIS and the BIS as an organisation are detailed in this section.

2.3.1.1 Historical development of the BIS

The original negotiations that would lead to the formation of the BIS began in 1929. Members from Belgium, France, Germany, Great Britain, Italy, Japan and the United States developed a framework to assist in German war reparations. This work eventually led to the creation of the BIS (Fratianni and Pattison, 1999:7). War reparations were, however, not the sole motive as the BIS was also designed to address the threatening failure of capital markets at the end of the 1920s (Simmons, 1993:401). Central bankers also began to realise that a central financial institution was necessary to avoid future financial crises. Such an institution would serve as a coordinator of central bankers and financial regulatory authorities (Felsenfeld and Bilali, 2004:14). On January 20, 1930 the BIS was formally constituted at the Hague Conference and it began its activities in Basel, Switzerland where the headquarters were established. (Scheller, 2004:149).

The BIS had the responsibility to collect, administrate and distribute annuities payable by Germany to the victorious allied nations for reparations after the war. This function had previously been performed by the Agent General for Reparations in Berlin, Germany which no longer existed (Felsenfeld and Bilali, 2004:13).

Another responsibility of the BIS was to improve international financial cooperation among global financial parties. It also had to nurture public sentiment of resistance against the disturbance of harmony. However, the BIS did not intend to have superior authority over central banks and therefore did not have, and still does not have, any legal or political authority (Felsenfeld and Bilali, 2004:3). As a result of the declining economic situation in Europe during the 1930s, further BIS initiatives were hampered. European activities were temporarily suspended during World War II and the BIS could only operate in Basel, Switzerland. In 1944 the Bretton Woods Conference, supported by the US government requested the liquidation of the BIS (Felsenfeld and Bilali, 2004:5). This was motivated by accusations of gold laundering by the BIS, allegedly stolen by the Nazi's from occupied Europe. This resolution, however, was never passed as the BIS nearly instantly assumed an integral role in the international payment systems in the post-war era, helping the European currencies to restore convertibility (BIS, 2009a).

In the years that followed World War II, the BIS focussed on monetary policy cooperation among its member countries. Furthermore the BIS also had an integral role in implementing and defending the Bretton Woods system[11]. In the early 1970's, however, the Bretton Woods system collapsed. This was the main result of a fixed exchange system that failed to accommodate the needs of international trade (Eichengreen, 2004:6). This was replaced by a system known as the *managed floating* system which recog-

[11] The Bretton Woods system refers to an international monetary system used from 1946-1973 where the value of the dollar was fixed in terms of gold. All other countries held their currencies at a fixed exchange rate against the dollar. When trade deficits occurred, the central bank of the deficit country financed the shortfall with its reserves of international currencies (The Foundation for American Communications, 2002).

nised acceptable exchange rates, but also allowed their flexibility within specified parameters (Felsenfeld and Bilali, 2004:7).

During the 1970s and 1980s the BIS was primarily active in the management of cross-border capital flows as a result of the oil and international debt crisis. The turbulent financial situation in the 1970s resulted in the development of the regulatory supervision concept. This would be developed during the next few years and implemented by internationally active banks (BIS, 2009a).

In 1974 the BIS started an initiative that would eventually be seen as its most significant contribution to ensure international bank risk capital regulation. The BIS and central bank governors of the Group of Ten countries formed a working group in Switzerland. This would result in the formation of the BCBS (Felsenfeld and Bilali, 2004:8). The BCBS – and its activities since 1974 – are discussed later in this chapter.

2.3.1.2 The BIS as an organisation

Established on 17 May 1930, the BIS operates as the world's oldest international financial organisation (Felsenfeld and Bilali, 2004:12). Since then, global cooperation between central banks has taken place through regular meetings by central bank governors and other experts involved in central bank business. Meetings still take place in Basel, Switzerland (the head office of the BIS). The BIS also has two representative offices in Hong Kong and Mexico City (BIS 2006:155).

The activities of the BIS can be divided into three broad categories namely (Fratianni and Pattison, 1999:12):

- international monetary and financial cooperation,
- agent and trustee assistance to central banks and
- financial assistance to central banks.

In its latest annual report, the BIS reported that it acts as an international organisation, fostering international monetary and financial cooperation. The BIS also serves as *a bank for central bank* and it attempts to maintain international representation. As a result, it employs 570 staff members from 53 different countries (BIS, 2009a).

According to the BIS (2006:155) it fulfils its mandate through the following:

- by acting as a forum to promote dialogue and facilitate the process of making decisions among central banks and other authorities involved in financial stability,
- by serving as source of economic and monetary research which makes significant contributions by collecting and distributing economic and financial statistics. As a result, more than 100 documents which provide guidance on a diverse series of supervisory topics are available on the BIS website (BIS, 2009b),
- to act as a major counterparty for central banks in their financial transactions and

- to serve as a trustee or agent in the engagement of international financial operations.

The BIS provides the secretariat for various committees and organisations that seek to promote financial stability (Yoshikuni, 2002:2) and it is these Basel based committees which also serve as forums which collectively form the Basel process.

2.3.2 Basel Committee on Banking Supervision (BCBS)

The second role-player in the process of global capital regulations is the BCBS which is discussed by examining the following aspects: the Basel process, the history of the BCBS and a detailed look at the BCBS as an organisation.

2.3.2.1 Basel process

The integration of domestic financial markets, regulatory authorities and central banks is a direct result of globalisation. This inevitable process requires a collective system to coordinate and standardise participants' activities (Bieri, 2004:4). A global framework for harmonising processes and standards has therefore been developed into what is known as the Basel process (Yoshikuni, 2002:4) which may be described as a collection of supervisory and regulatory initiatives that provide global guidance in the form of different committees based in Basel (Bieri, 2004:4). These committees play an integral role in ensuring better financial stability as they serve as a unique platform for discussion. Discussions are focused on current sources of concern or threats to global financial stability (Bieri, 2004:12).

Each of the four main Basel committees have their own secretariat (Yoshikuni, 2002:5). The responsibilities and activities of the four different committees and their secretariats are well defined and specified. The secretariats have the task of providing relevant and unbiased expert analysis. The four committees are:

i. the Basel Committee on Banking Supervision (BCBS) which deals with commercial banks and specifically capital regulation,

ii. the Committee on the Global Financial System (CGFS) which is responsible for the functioning of foreign exchange and financial markets issues (Bieri, 2004:5),

iii. the Committee on Payment and Settlement Systems (CPSS) and is involved in market infrastructure issues such as the development of cross-border and domestic payment, settlement and clearing systems (Bieri, 2004:6) and

iv. the International Association of Insurance Supervisors (IAIS) which is responsible for regulations and supervision in the insurance sector (Yoshikuni, 2002:4).

Yoshikuni (2002:5) summarises the purpose of the Basel Process as follows:

The Basel Process provides the international financial community with the opportunity to explore good governance in various regulatory and supervisory issues in forums that allow a frank exchange of views with the support of highly sophisticated analysis.

The most important component of the Basel Process is the process of establishing and monitoring capital regulations in banks. This is accomplished by implementing and monitoring Basel I and II (these publications are discussed later in this chapter). The BCBS is the most important and influential committee in the Basel process (Bieri, 2004:5).

2.3.2.2 The history of the BCBS

In June 1974, Bankhaus Herstatt, a small bank in West Germany, had its banking licence withdrawn after a series of losses. The bank – mainly active in foreign exchange dealings – still had $620 million of foreign exchange trades unsettled. As a result, the counterparties involved attempted to collect their outstanding currency without success, hence forcing several parties to default (Yoshikuni, 2002:6). This series of events resulted in the establishment to the Basel Committee on Banking Supervision at the end of 1974 (BIS, 2001:1). The main aim of this initiative was to prevent a repetition of Bankhaus Herstatt by establishing international cooperation between bank regulators. The aim was to bridge gaps in bank supervision internationally. Furthermore the BCBS had to improve the mutual understanding and the quality of bank supervision by encouraging national regulators to work together (Fratianni and Pattison, 1999:19). The BCBS was originally established by the central-bank Governors of the Group of Ten countries as the Committee on Banking Regulations and Supervisory Practices. Since February 1975 the body has held meetings three or four times per annum (BIS, 2009c:1). Over the past three decades this resulted in the formulation and promotion of sound supervisory standards for banks worldwide through its most influential publications, Basel I and II (Esterhuysen, 2003:18).

2.3.2.3 About the BCBS as an organisation

The BCBS today consists of supervisory representatives from Belgium, Canada, France, Germany, Italy, Japan, Luxemburg, the Netherlands, Spain, Switzerland, United Kingdom and the United States (BIS, 2009a). At their meetings the central bankers are accompanied by officials from government agencies that are responsible for prudential bank supervision where this is not the responsibility by the countries' central bank (Fratianni and Pattison, 1999:18).

The BIS' annual financial statements are approved and decisions taken other related business issues at the Annual General Meeting (AGM). At the time of writing (November 2009), 55 institutions have rights of voting and representation at General Meetings which includes the central banks or monetary authorities of Algeria, Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, China, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, the

Republic of Macedonia, Malaysia, Mexico, the Netherlands, New Zealand, Norway, the Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom and the United States, plus the European Central Bank (BIS, 2009a).

During its existence the BCBS has had chairmen from different regions such as the United Kingdom, United States, Italy, Spain and the Netherlands. Currently (2009) it is chaired by Guillermo Ortiz, the Governor of the Bank of Mexico (BIS, 2009d).

Since the formation of the committee the primary objective remained the following: *The improvement of supervisory understanding and the quality of banking supervision worldwide* (BIS, 2001:1). This objective is addressed using three principal approaches. Firstly by exchanging information on national supervisory arrangements, secondly by improving the effectiveness of techniques for supervising international banking business and finally by setting minimum supervisory standards in the areas they are considered relevant (BIS, 2007:1).

The BCBS reports to central bank governors of the member countries and seeks their approval for its main initiatives (BIS, 2007:1). The findings and decisions of the BCBS do not possess any formal supranational supervisory authority. This was, however, never the intention. In the expectation that individual authorities will implement detailed arrangements best suited to their own national systems, the committee formulates general guidelines and supervisory standards (BIS, 2001:1). The result of its activities ultimately became recognised when the 1988 Accord was adopted by over 100 countries (Fratianni and Pattison, 1999:21). In October 2006, the BCBS reorganised its activities to function under four main subcommittees with the following functions:

- the Accord Implementation Group (AIG) which shares information and promotes consistency in implementation of Basel II,
- the Policy Development Group (PDG) whose main objective is to identify and review emerging supervisory issues,
- the Accounting Task Force (ATF) which strives to promote sound risk management at financial institutions by promoting more sound and transparent international accounting and auditing standards and
- the International Liaison Group (ILG) which serves as a forum for strengthening the BCBS's relationship with supervisors worldwide (BIS, 2009a).

De Swaan (1997:2) describes the BCBS as follows:

> *The BCBS has evolved into a rule-making body, whose standards and recommendations are recognised and implemented in legislation on a global scale.*

The BCBS formulated the Basel I and II accords, also referred to as the Capital Accords.

2.3.3 The Capital Accords

The last of the role-layers are the Basel I and II (Capital) accords. The following aspects are explored: historical development, Basel I (1988), the 1996 amendments to Basel I and finally Basel II (2008).

2.3.3.1 Historical development of the Capital Accords

The most prominent aspects in banking regulation are the rules pertaining to banking capital (Santos, 2001:3). The following factors led to the process that ultimately resulted in rules pertaining to banking capital called the Capital Accords (Saayman, 2002:124):

- expansion of international bank operations,
- increased levels of competition between banks and non-bank financial intermediaries,
- deterioration of the asset quality,
- increased product innovations and
- a sequence of international bank crises or scandals.

Even though the BCBS's focus in the 1970s and 1980s was mainly on managing cross-border capital flows as a result of the oil crises and the global debt crisis, the 1970s financial catastrophes raised the matter of regulatory supervision of internationally active banks which led to the Capital Accords (Ceram, 2005).

Figure 2.1 illustrates the development of this influential framework for international regulatory supervision and effective bank risk management.

Figure 2.1: Historical development of the Basel Accords

1974	BCBS officially formed by the G10
1988	**Original Basel Accord (Basel I)**
1992	Basel I becomes effective
1996	**Amendment to Accord to accommodate Market Risk**
1997	1996 Amendment becomes effective
1999	Consultative Package 1 (CP1) as proposal for new framework
2001	Consultative Package 2 (CP2)
2003	Consultative Package 3 (CP3)
2003 (Q4)	**New Basel Capital Accord (Basel II)**
2005	Trading book review and double default
2006	Basel II - Comprehensive Version published
End 2006	Implementation: Simpler methods
2007	Basel II becomes effective
End 2007	Implementations: Advanced methods
2010	End of transition period

Source: Compiled by the author

2.3.3.2 Basel I introduced as the first Basel Accord

Basel I was published in July 1988 and was the result of several years of work by the BCBS to implement international convergence of supervisory regulations. This was specifically aimed at governing the capital adequacy of international banks. The framework set out the details for measuring capital adequacy and the minimum standards to be achieved by countries. The framework was endorsed by the Group of Ten central bank Governors and the BCBS intended to facilitate and encourage the implementation of Basel I in the different countries by the local banking authorities (Altman and Saunders, 2001:1).

The Basel Accord served the purpose of measuring banks' risk levels. The highest level of risk in a bank was then identified as the process of providing loans. The Basel framework therefore required a minimum capital standard of 8% to be adopted by compliant banks.[12] The finalisation of the Basel Accord in 1988 was history in the making as it was the first international accord of its kind (Jacobsohn, 2004:2).

[12] Banks should hold aside total capital equal to a minimum of 8% of their total risk-weighted assets (IBM, 2005:5)

2.3.3.3 The 1996 Amendments to Basel I

At the end of 1991 the original Accord was amended for the first time. This was expected as it was never intended to be a static document. General provisions were included in the calculation of capital adequacy. In 1995 the BCBS furthermore acknowledged the effects of bilateral netting of banks' credit risk exposure and in April 1996 the effects of multilateral netting was defined in more detail (BIS, 2007:7).

The BCBS initiated the groundwork to improve the framework by addressing risks other than credit risk. Market risk was addressed for the first time in 1995 and this led to the committee’s third influential publication in 1996 titled the *Amendments to the capital accord to incorporate market risk* (Styger, 1998).

The newly defined market risk was a result of banks' open positions in foreign exchange, traded debt securities, traded equities, commodities and derivatives (Santos, 2001:3). Similarly to credit risk, the capital requirements for market risk were to apply on a worldwide consolidated basis (BCBS, 2005a:2).

Banks were at first very critical about this because of the insufficient risk assessment methods available at the time (Janson, 2003:20). This, however, improved in the years that followed. The elements of market risk are discussed in more detail in Section 2.7.

2.3.3.4 Basel II replaces Basel I

In order to further strengthen the soundness and stability of the international banking system after the important amendment of 1996, the BCBS developed a process to establish more risk-sensitive capital requirements. Therefore Basel I required further revision.

This publication represented a process of almost six years of challenging inputs. During that time the BCBS engaged in extensive consultation with all member countries as proposals were also circulated to supervisory authorities, banking and other industry groups in order to develop a more risk-sensitive capital requirement framework which would also be conceptually sound (BIS, 2007:3). The BCBS formulated the first proposals for consultation in January 2001 and a second in April 2003. The BCBS also conducted three quantitative impact studies (related to its proposals) from which several important improvements were made. The current framework was eventually agreed upon by all its members in 2004. Basel II and the standard it contains have also been endorsed by the Central Bank Governors and Heads of Banking Supervision of the Group of Ten countries (BCBS, 2006a:1).

The framework explains the details for measuring capital adequacy as well as minimum supervisory standards that ought to be complied with. In the different countries involved, the national supervisory authorities represented of the BCBS is responsible for Basel II in their local markets.

Basel II has been designed to provide a more forward-looking approach to capital adequacy supervision. This framework should therefore have the capacity to develop in future to remain relevant. This flexible characteristic will enable the framework to stay in line with market developments and advances in risk management practices (BCBS, 2006a:4). Although the BCBS's proposals have evolved significantly in the past, the fundamental objectives and the three-pillar approach remain constant at the time of writing.

Basel II is a much more complicated and better defined framework than the one it replaced. The next section focuses on the fundamentals of Basel II.

2.4 The Basel II Accord

> *Basel II introduces a far more comprehensive framework for regulatory capital and Risk Management than we have ever known.* (Temenos, 2007:2)

2.4.1 Introduction to the 3 pillar approach

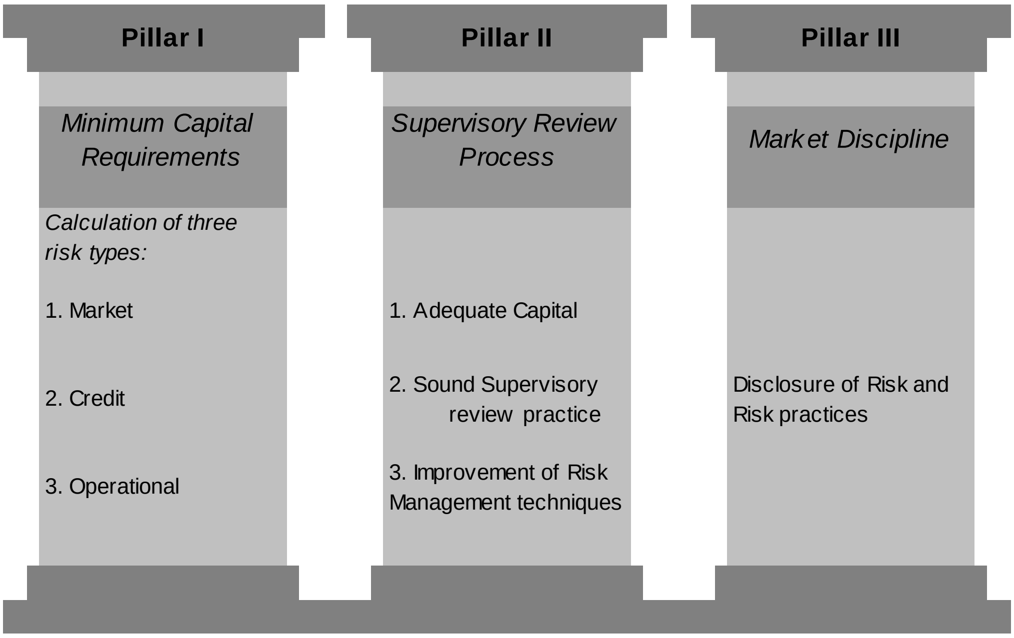
> *The Basel II framework is designed to permit a more risk-sensitive and comprehensive coverage of banking risks. It consists of three complementary and mutually reinforcing pillars*. (Thoraval, 2006:68)

The main features of Basel II – accepted in June 2004 – include:

- Basel II capital charges focus on the quality of assets and banks are permitted to choose an approach from among several acceptable approaches (Heid, 2007:2)
- Basel II aligns risk and capital requirements more effectively than Basel I (IBM, 2005:5) and
- the three pillar approach to capital adequacy which is seen as the backbone of Basel II (Saidenberg and Schuermann, 2003:5).

Figure 2.2 summarises the pillars.

Figure 2.2: The different elements in the 3 Pillars of Basel II



Source: BCBS (2004:2)

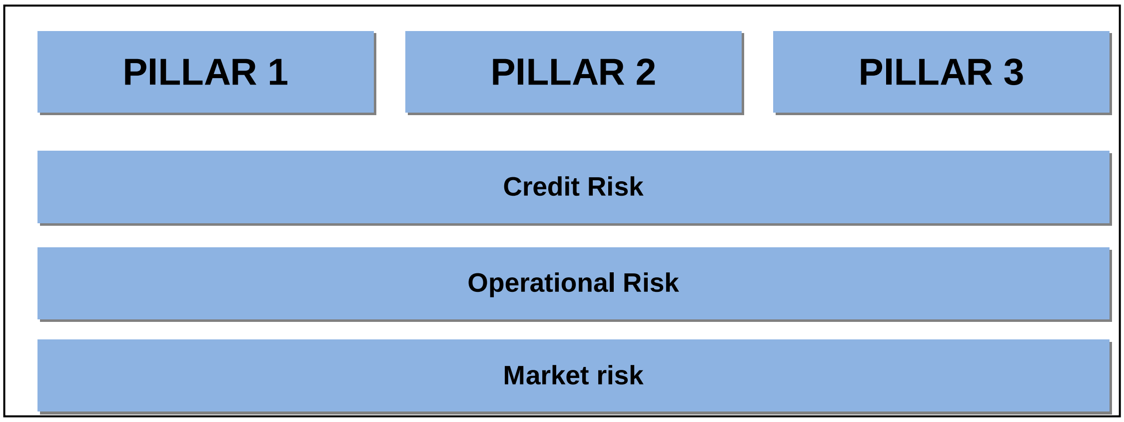
The first pillar stipulates the minimum capital requirements to be held by banks and is designed to ensure that banks hold adequate capital to support risks inherent in their business. Under Pillar 1, the calculation of the capital requirements covers credit, market and operational risks (Varghese, 2005:3).

Pillar 2 is concerned with the supervisory evaluation of risks not captured in Pillar 1. These include: interest rate risk in the banking book, concentration risk, liquidity risk, settlement risk, reputation risk and strategic risk (Kaufman, 2003:7). These risks tend to be more subject to interpretation by local regulators and are therefore less likely to lend themselves to quantitative measurement (CEBS, 2005:21). Local regulators are expected to assess how well banks measure their capital needs relative to the risks they face and are expected to intervene where they consider it appropriate to do so (Kaufman, 2003:7).

Pillar 3 embraces market discipline – or market disclosure – which should contribute to the creation of sound information standards among all market participants. Pillar 3 focuses on such aspects as the publication of information on a bank's capital adequacy and its risk profile (Oesterreichische Nationalbank, 2007).

Figure 2.3 is used throughout the chapter to indicate the relevant section focus. This figure is used to indicate the discussion progress.

Figure 2.3: Structure of the Basel II discussion



Source: Compiled by the author.

As the main goal of this study is to determine a methodology to estimate the *fair* level of economic capital for credit and market risk (covered under Pillar 1) in commercial banks, the literature covering these requirements needs to be understood. Even though a calculation methodology to estimate the fair level of economic capital for operational risk will not be covered in this study, it is nevertheless discussed for completeness. This is also true for Pillar 2 and 3 which will not be used in the capital calculation methodology, but is introduced as part of the literature study.

2.4.2 Pillar 1

> *The most important pillar, Pillar 1, consists of minimum capital requirements - that is, the rules by which a bank calculates its capital ratio and by which its supervisor assesses whether it is in compliance with the minimum capital threshold* (Ferguson, 2003).

Critical elements that need to be understood with respect to Pillar 1 are: the calculation and definition of capital requirements, defining capital, the basics of capital adequacy and the approaches to calculating risk under Pillar 1 (Mars, 2008). These elements are also crucial as the calculation methodologies introduced in this study are based on the principles and requirements of Pillar 1.

2.4.2.1 Calculation and definition of capital requirements

Banks take risks by investing third party deposits into loans which might not be repaid. The depositors, however, generally expect to receive back their deposit. Banks therefore need capital to protect depositors from losses when the quality of an asset deteriorates. Banks hold capital as a buffer in order to protect depositors and other creditors against these losses (Mars, 2008).

2.4.2.2 Defining capital

Since many definitions of capital exist, the BCBS developed standard definitions for different types of capital known as Tier I, II and Tier III capital. The different tier categories indicate the quality of each instrument. Tier I instruments (which include permanent capital, paid-up share capital and disclosed reserves (Chaudhary *et al*, 2005)) have the highest quality. Tier II capital refers to supplementary capital (and includes undisclosed reserves, general provisions, asset revaluation reserves, hybrid capital instruments and subordinated debt) and Tier III capital (which includes short-term subordinated debt and is only affected by market risk (Zaher, 2007) is not referred to as frequently in Basel II as the other tiers.

2.4.2.3 The basics of capital adequacy

The key concept of capital adequacy is that banks must maintain capital at a level that reflects the risk contained in their balance sheet assets. Basel II considers three separate components when referring to capital adequacy: the capital ratio, risk-weighted assets (RWA) and the capital base. A bank's risk-based capital ratio under Basel II (similar to Basel I) has a numerator representing the capital available to the bank (capital base). It also has a denominator that measures the risks faced by the bank, referred to as the RWA (Ferguson, 2003).

$$\text{Capital ratio} = \frac{\text{Capital base}}{\text{Risk weighted assets}} \tag{2.1}$$

Where:

- the *capital ratio* is the relationship between RWA and the capital base and is calculated using the definition of regulatory capital and risk-weighted assets. The total capital ratio must be larger than 8% (BCBS, 2006a:12),
- *risk-weighted assets* are calculated by multiplying the value of each asset category by a conversion factor. The different conversion factors reflect the risk attached to that category of assets. The calculated values of the different asset categories are then added together. In practice this means cash is risk-free and is assigned a conversion factor of zero (Mars, 2008), and
- the *capital base* which refers to the different tiers of capital developed by the BCBS. These tiers indicate the quality of each instrument (The Federal Reserve Board (FED), 2006a).

2.4.2.4 Approaches to calculating risk in Pillar 1

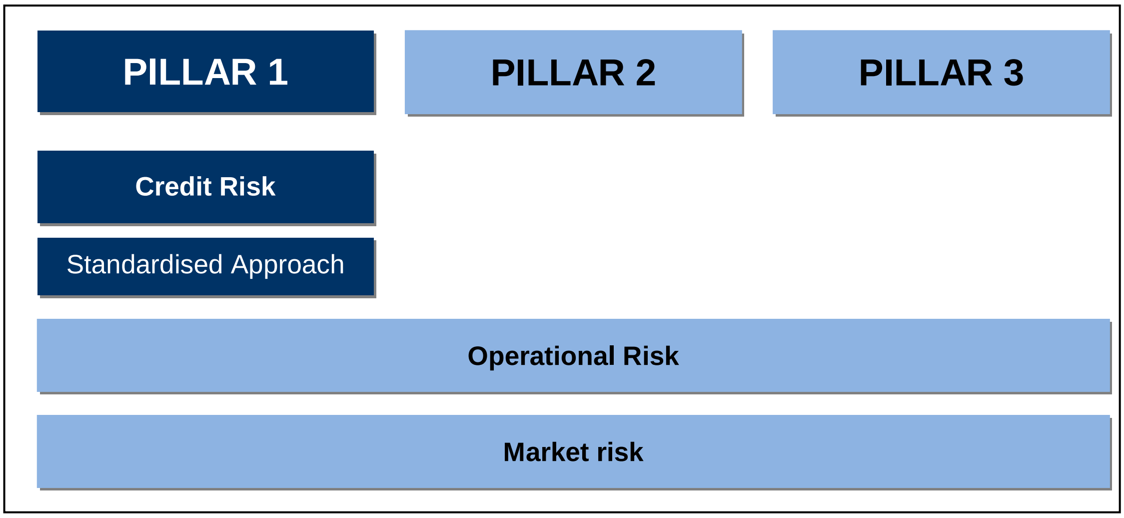
Basel II requires banks to calculate capital requirements for exposure to credit, operational and market risk. Pillar 1 therefore provides banks with different approaches with different degrees of *complexity and flexibility* to calculate the capital requirements for these three different risks. The different approaches are discussed next.

2.4.2.5 Pillar 1 – Credit Risk: Standardised Approach

> *The standardised approach is the simplest of the three broad approaches to credit* risk (BCBS, 2001b:1).

The first area of the Pillar 1 to be explored is the Standardised Approach (SA) for credit risk (illustrated in Figure 2.4 below).

Figure 2.4: Structure of the Basel II discussion: Standardised approach for credit risk



With the revision of Basel I, the BCBS realised that a balance between accuracy and simplicity needed to be achieved. As with market risk, the BCBS proposed a range of approaches for banks to calculate credit risk. By so doing, the BCBS opted to achieve an optimal balance between simplicity and accuracy among different banks. This implies that banks should calculate regulatory capital in such a way that it best reflects the position of their risk measurement and management practices (BCBS, 2001a:1).

The SA is the simplest approach and relies entirely on the use of external ratings. The BCBS, however, do not see this as the perfect solution as banks should know their borrowers better than rating agencies. However, where external ratings exist and banks are not able to develop internal ratings, these external ratings provide a more accurate differentiation of risks. The other two approaches namely: *Foundation Internal Ratings Based approach* **(**FIRB) and the *Advanced Internal Ratings Based approach* **(**AIRB) (which is discussed later in this chapter) are based on banks' internal rating systems. The simplicity, cost and compatibility of the SA makes it one of the most attractive approaches to credit risk assessment (Nouy, 2003:6). Since 2003, the number of Basel compliant banks increased and the SA has been favoured as the compliance process is complex and can be extremely expensive (Beaton, 2007)

The BCBS (2001a:1) furthermore describes the SA as an approach that aligns regulatory capital requirements more directly with the key elements of banking risk. This is achieved by the offering more diverse risk weights and also a wider recognition of credit risk mitigation techniques. When compared with Basel I, the SA in Basel II produces capital ratios that are more in line with the actual economic risks faced by banks. The current SA, therefore, should improve incentives for banks to improve their risk measurement and management capabilities and should furthermore reduce the incentives for regulatory capital arbitrage[13] (BCBS, 2001a:1).

Banks are required to group all credit risks into 13 exposure classes when using the SA. The required capital for each class is determined by a risk weight (Smith and Kaveripatnam, 2005:49). In the case of sovereign, bank and corporate exposures, the risk weights are assigned to the credit rating of the underlying asset as decided by an External Credit Assessment Institution (ECAI).

The following sections explain the SA for credit risk in Pillar 1 in more detail by examining different types of asset classes and some implementation issues experienced in the SA.

2.4.2.5.1 Asset classes

In contrast with Basel I, the SA recognises more asset classes in Basel II. Furthermore, the link to external credit ratings results in weights that change in line with credit risk (Smith and Kaveripatnam, 2005:49). Another difference from Basel I is that local regulators have discretionary options for categorising asset classes and applying risk weights. The applicable rules should, therefore, be properly communicated and well understood by local banks using the SA (Mars, 2008).

The SA increases the risk sensitivity by recognising the individual classes for counterparties. This is done as entirely different risks may exist within similar loan categories (Walsh, 2003:1).

The BCBS (2006a:19) identifies individual claims on:

- sovereigns (Basel II paragraph 50-56)
- non-central government public sector entities (PSEs) (Basel II paragraph 57-58)
- multilateral development banks (MDBs) (Basel II paragraph 59)
- banks (Basel II paragraph 60-64)
- securities firms (Basel II paragraph 65)
- corporates (Basel II paragraph 66-68)
- those included in the regulatory retail portfolios (Basel II paragraph 69-71)
- those secured by residential property (Basel II paragraph 72-73)
- those secured by commercial real estate (Basel II paragraph 74)
- past due loans (Basel II paragraph 75-78)
- higher-risk categories (Basel II paragraph 79-80)
- other assets (Basel II paragraph 81) and

[13]Regulatory capital arbitrage is the practice of taking advantage of the regulatory framework to reduce the level of capital required according to regulators (Mars, 2008).

- off-balance sheet items (Basel II paragraph 82-89)

2.4.2.5.2 Implementation of the SA

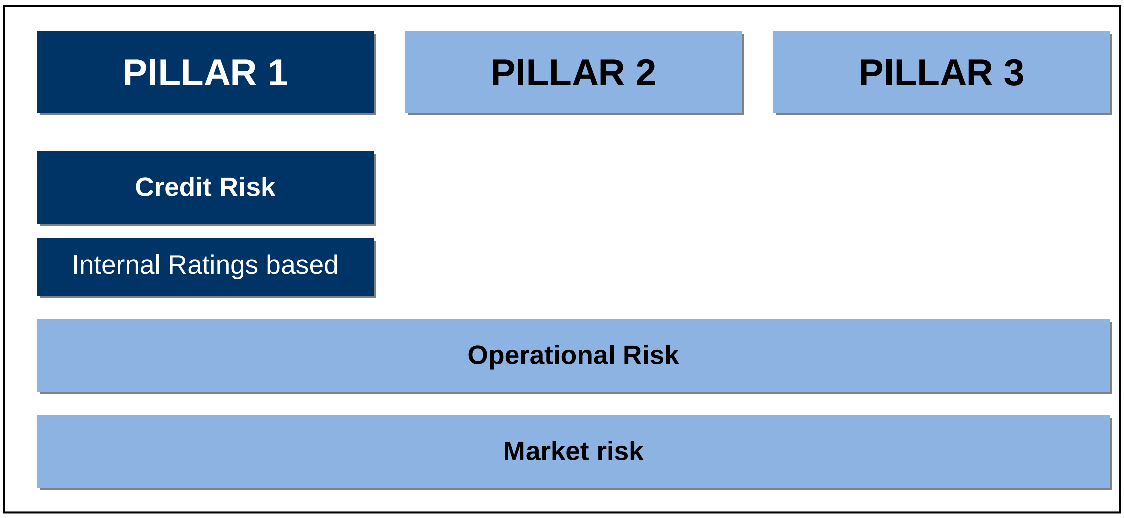
The SA can be summarised as an approach based on a set of defined categories and external ratings. Banks must map this framework across their own business. Each individual risk exposure must be assigned to one of the 13 classes of individual claims in Basel II. A risk weight is then calculated by applying external credit rating to each risk exposure (Basel II paragraph 90-91). By employing these two important elements (a set of defined categories and external ratings), the required capital may be calculated under the supervision of local regulators. Even though local regulators are interested in the correct capital figure, the methods used (to calculate capital) by banks under their supervision are equally important (Smith and Kaveripatnam, 2005:49).

For the first time, vast numbers of smaller banks are using risk sensitive capital calculations by adopting the improved SA as prescribed by Basel II (Isle of Man Financial Supervision Commission, 2006:13). However, more sophisticated banks rarely use the simplified SA opting instead for more advanced approaches (which usually (but not always) results in reduced capital charges). These are discussed in the next section.

2.4.2.6 Pillar 1 – Credit Risk: Internal Ratings Based Approach

The SA – discussed in the previous section – is the simplest approach for calculating minimum capital requirements and mostly used by smaller, less sophisticated banks (BCBS, 2001a:1). In this section, a more advanced approach is introduced, the Internal Ratings Based Approach (IRB) as illustrated in Figure 2.5 below.

Figure 2.5: Structure of the Basel II discussion: IRB approach for credit risk



Banks qualify for the IRB approach if they meet certain minimum conditions and disclosure requirements prescribed by Basel II. These banks should also have their systems for risk assessment evaluated and approved by local regulators. This means that they are allowed to use their own internal estimates to determine certain risk exposures which are needed to calculate the minimum capital requirements for credit risk (BCBS, 2006a:52). The risk exposures required by the BCBS are the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the effective maturity (M). In the IRB approach the categorisation of exposures into different asset classes is the responsibility of banks' internal risk assessors (Jackson, 2001:56). Furthermore, the IRB approach is based on measures of unexpected losses (UL) and expected losses (EL) which are discussed later in this chapter as part of the IRB approach (BCBS, 2004:48).

2.4.2.6.1 Asset classes

Similar to the SA, the IRB also uses asset classes for different risk exposures. However, in calculating capital requirements under the IRB approaches, risk exposures can be divided into five asset classes namely: sovereigns, banks, corporates, retail and equity. For the corporate asset class Basel II identified five separate sub-classes of specialised lending. For the retail asset class, three sub-classes are separately identified. Provided that certain conditions are met, Basel II also allows distinct treatment for purchased receivables (BCBS, 2006a: 52). The classification of exposures in this way is generally consistent with traditional bank practice. However, Basel II also allows banks to use different definitions in their internal risk management and measurement systems. Basel II does not require banks to change the way in which they manage their risks, but states that banks are required to apply appropriate treatment to exposures in order to calculate the capital charge for credit risk. Banks should however be able to demonstrate their methodology to local regulators (BCBS, 2006a: 52).

The rules and guidance applying to the different asset classes are documented in detail in the Basel II document and consists of 159 paragraphs (214-373).

The next important elements on which the IRB approach is based, UL and EL, are discussed next.

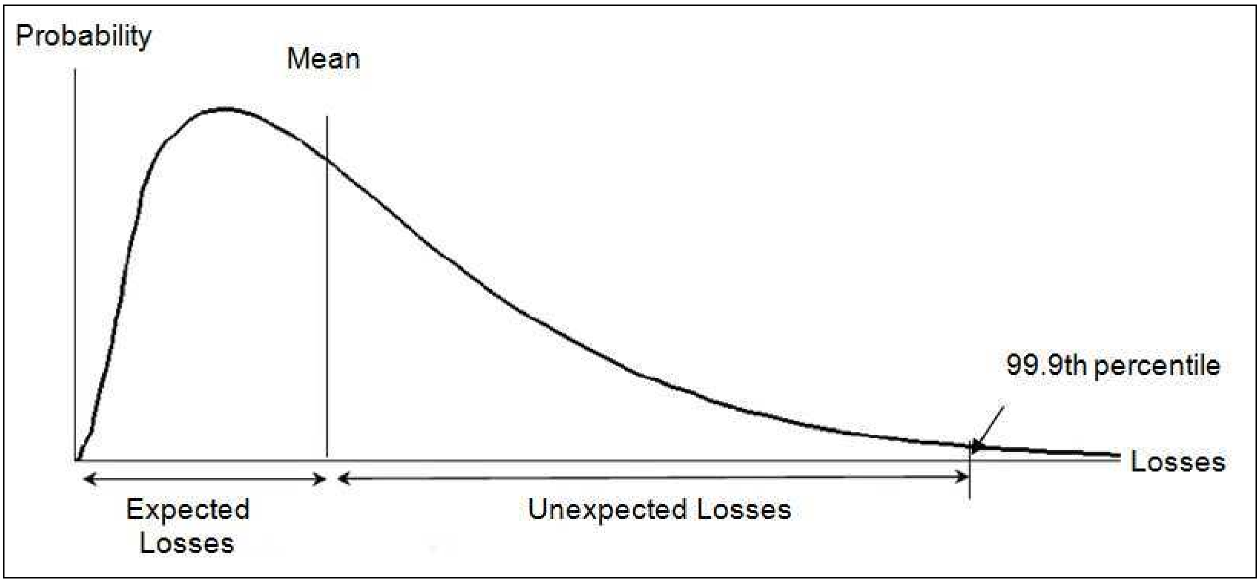
2.4.2.6.2 Expected and unexpected losses

The IRB approach introduces two credit risk concepts: expected and unexpected losses. It is important to understand the fundamental difference between these two for the calculation of regulatory capital.

The European Commission Internal Market (ECIM) (2003:1) defines expected loss as a statistically established loss that is expected to occur on an exposure. This is calculated by multiplying the estimates for the probability of default with the estimates of the loss which will arise should default occur. However, unexpected loss refers to a risk greater than the expected losses. Unexpected losses arise from uncertainties in the estimates of expected loss (ECIM, 2003:1).

Bank capital models assume that expected losses are covered by effective pricing and provisions (Jackson, 2001:61). Figure 2.6 illustrates the probability distribution of potential losses associated with a specific time horizon, usually one year.

Figure 2.6: Probability distribution of potential losses[14]



Source: FED (2006b)

Figure 2.6 shows the statistical mean of the loss distribution – equivalent to the loss amount expected over a specific time horizon. It can also be seen that there is a high probability that expected losses is relatively low (FED, 2006b).

Banks require sufficient capital to protect themselves against losses up to a certain level. This level is referred to – in statistical terms – as the confidence level. A confidence level of 99.9% has been selected by Basel II for credit risk losses implying that there is a 0.1% chance that losses will exceed the bank's capital. Losses greater than this are referred to as catastrophic losses (Van Vuuren, 2007).

The components of expected and unexpected loss are discussed individually in the next section as they are used in this study to determine a calculation methodology to determine a fair level of economic capital for credit risk.

2.4.2.6.3 Loss components

The calculation of expected loss is based on four key parameters which are used to estimate credit risks under the IRB approach (Saidenberg and Schuermann, 2003:8).

These parameters, defined in Section 2.3.5, are PD, LGD, EAD and M.

[14] The 99.9th percentile is the area to the right of the indicated line, not the line itself.

The PD is the probability that a borrower will default over a one year time horizon. Default occurs when a borrower has not repaid its loan obligations in full (Oesterreichische Nationalbank, 2007). Basel II asserts that default has occurred when a borrower is past due more than 90 days on any material credit obligation. For the calculation of PD, banks must first assign its borrowers to risk categories or risk buckets. Each bucket should contain customers with the same level of risk and is usually done using an internal rating system similar in concept to ECAI's explained in Section 2.4.1. The bank must calculate a PD for each risk bucket over a one year period (Lloyd, 2001:4).

LGD estimates the impact on the institution of a defaulted loan and may be considered as the total loss faced by a bank, net of any recovery the bank has received. The recovery can be in the form of liquidation of collateral or the deficiency judgments made from foreclosure or bankruptcy actions. LGD can furthermore simply refer to the total percentage of the exposure that is lost (Featherstone *et al*, 2004:5).

The EAD is the amount the bank has at risk when the loan goes into default. EAD is usually expressed as a monetary amount comprising the principal outstanding, unutilised commitment and any fees or other expenses the bank made in collecting the default (Featherstone *et al*, 2004:5).

A maturity adjustment is usually applied under Advanced IRB which is discussed in a later section (Aas, 2005:10).

If a bank has a process for measuring expected loss, it will usually set the margin at the origination of the loan to cover the expected loss and to remunerate the capital held to cover unexpected losses (Jackson, 2001:61). This means that a general provision raised to cover an expected loss could also be used to set against unexpected losses through Tier 2 capital (Jackson, 2001:61).

2.4.2.6.4 Capital calculating for IRB Approaches

For a given maturity, the above mentioned elements are used to estimate the EL for the foundation IRB approach (FIRB) and the advanced IRB approach (AIRB) (Schuermann, 2004:3).

2.4.2.6.4.1 The Foundation Internal Ratings Based approach (FIRB)

The FIRB allows banks to use their own internal credit risk estimates as inputs to determine the amount of capital needed. Basel II provides the methodology for calculating the capital requirements. The methodology comprises four inputs: the probability of default (PD), the loss given default (LGD), the exposure at default (EAD) and the effective maturity (M). Of these parameters, only PD directly characterises the specific borrower. LGD may also characterise the client, but more directly refers to the seniority of debt. EAD and M are pure characteristics of the current outstanding credit (Philosophov, 2004:3). The functioning of the FIRB for calculating minimum capital is elaborated upon later in this chapter.

2.4.2.6.4.2 The Advanced Internal Ratings Based approach (AIRB)

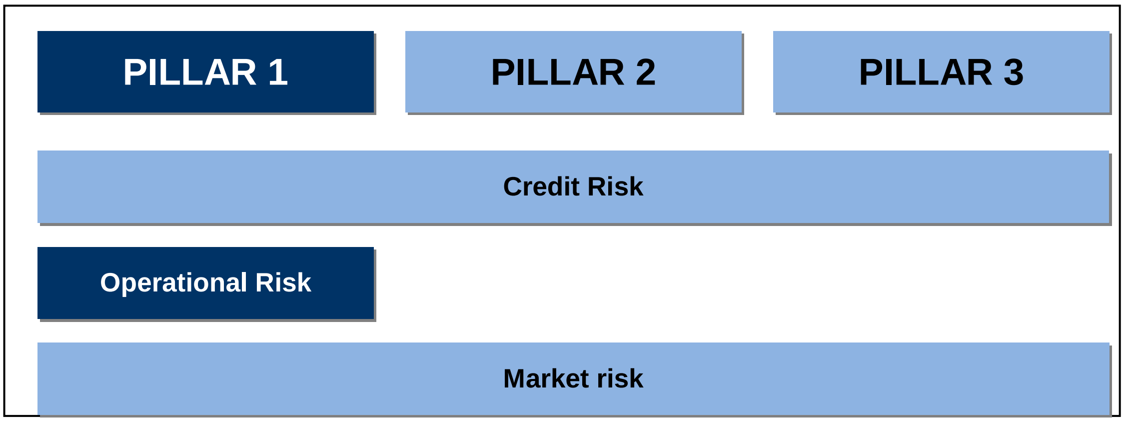
The AIRB is similar to the FIRB, but in this approach banks may use their own internally-modelled measures for the PD, LGD and EAD inputs (Ilako and Stoilov, 2005:35). The more advanced the approach used by a bank to measure credit risk, the more sensitive is the measure to the amount of risk. It is therefore not possible to determine whether banks will require more or less capital under a particular approach. This can only be determined after the full details of a bank's asset collection have been attained (Egan, 2003).The AIRB is discussed in more detail in Chapter 3.

The next section continues the exploration of Basel II (Pillar 1) by examining operational risk.

2.4.2.7 Pillar 1: Operational Risk

This section explores Basel II's (Pillar 1) treatment of operational risk (illustrated in Figure 2.7 below).

Figure 2.7 Structure of the Basel II discussion: Pillar 1: Operational Risk



Even though the main goal of this study is to determine a methodology to estimate the fair level of economic capital for credit and market risk in commercial banks, operational risk is still explored in this chapter as it is part of Pillar 1 investigated in the literature study.

In this section operational risk is discussed by firstly exploring its background and definition, followed by sources and classes of operational risk. The way in which Basel II deals with operational risk and the three different approaches for the measurement of this risk are also discussed in this section. Finally the qualifying criteria for the above mentioned three approaches and the sound practices for the management and supervision of operational risk are discussed.

2.4.2.7.1 Background and definition

Addressing the London Credit Risk Modelling Conference in September 1998, W. McDonough, BCBS chairman and chief executive of the Federal Reserve Bank of New York, first introduced operational risk. At that time the term was only known by a very few delegates (Medova, 2002:2). The BCBS continued to demonstrate increased interest in operational risk by publishing a paper entitled: *Operational Risk Management* in 1998. The reason for this was that the management of operational risk became a vital element of sound risk management practice in modern financial system (Hashagen, 2003:9).

Influenced by the expansion and developments of industry business practices, the BCBS has recommended that operational risk must be defined as a separate risk category, backed by regulatory capital (Hashagen, 2003:9). Basel II specifically defines operational risk and requires that banks reserve capital against risks other than credit and market for this (Medova, 2002:2). In the January 2001 the BCBS defined operational risk as:

> *The risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events.*

During the same year the BCBS also included legal risk in this definition while strategic and reputational risks were later excluded (BCBS, 2001d:2). Today, the BCBS (2006a:144) use the following definition for minimum capital requirements for operational risk worldwide:

> *Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk.*

2.4.2.7.2 Sources and types of operational risk

The complex nature of operational risk is the result of the dynamic risk environment in which banks operate (Walsh, 2003:3). Operational risk does not occur in a vacuum as losses are never the result of single failures in a bank. The challenge for operational risk managers is to determine the contributory factors in an environment in which there is interaction between the five key areas namely: people, processes, systems, business strategies and the business environment (Walsh, 2003:4-5). The BCBS (2006a:305) also identified seven loss event types for operational risk that banks must consider when managing operational risk and calculating capital (Basel II Annex 9). These are:

i. internal fraud,

ii. external fraud,

iii. employment practices and workplace safety

iv. clients, Products and Business Practices and

v. damage to physical assets

vi. business disruption and system failures and

vii. execution, delivery and process management.

2.4.2.7.3 Basel II deals with operational risk

It is not yet clear how Basel II deals with the increasing risk faced by banks. The 8% capital adequacy ratio stated by the BCBS in 1988 refers to the minimum amount of capital that banks are required to hold. Basel I and II require a minimum capital ratio of 8% of risk weighted assets. However, under Basel II the method for calculating this 8% changed (Heinrich, 2006:13).

The new methods under Basel II result in more risk sensitive internal models for banks. This is the result of the globalisation of financial activity, increased sophistication of banking business and best practices developed over time in the banking industry (Fontnouvelle *et al*, 2005:26).

In Equation 2.1, the factor of 8% is built into Basel's capital charge for credit risk. This is not true for market and operational risk so they must be multiplied by 12.5 to scale them back to 1 (since $12.5 \times 8\% = 1.00$). The simplified calculation for calculating the stated 8% is stated below (Heinrich, 2006:13).

$$\frac{\text{Capital}}{\text{Credit Risk} + 12.5 \times (\text{Market Risk} + \text{Operational Risk})} \geq 8\% \qquad (2.2)$$

Where:

- Capital = Tier 1, 2 and 3 capital

Basel II provides banks with three options or methods to determine the capital charges (BCBS, 2006a:144).

2.4.2.7.4 Approaches to calculate operational risk

According to the BCBS (2006a:144) the three methods form a continuum of increasing sophistication and risk sensitivity. These are: the basic indicator approach (BIA), the standardised approach (SA) and the advanced measurement approach (AMA). These three approached are summarised next

2.4.2.7.4.1 The Basic Indicator approach (BIA)

The BIA requires banks to hold a fixed percentage of their average annual gross income (only positive income) over the previous three years.[15] There are no minimum criteria for a bank to adopt the BIA (Egan, 2003).

2.4.2.7.4.2 The Standardised approach (SA)

Under the SA approach, banks are required to divide their business activities into eight different business lines. The SA is similar to the BIA except that banks must calculate the capital requirement for each different business line by multiplying gross income (average over the last three positive years) by fixed factors – determined by Basel II. These factors reflect the different risk weightings of business lines. The total capital required is the sum of the capital required for each of the eight business lines (Medova, 2002:5).

2.4.2.7.4.3 The Advanced Measurement approach (AMA)

The AMA is the most advanced approach available and has no fixed capital calculation methodology in Basel II. This approach involves a more comprehensive overview of operational losses and considers several operational risk types for each business line (Medova, 2002:5). Under this approach banks are required to meet specific minimum quantitative and qualitative requirements. Banks' internal operational risk measurement systems are used to calculate the amount of capital to be held (Balzarotti *et al*, 2002:197). The BCBS ruled that, subjected to certain conditions, the AMA may factor in risk mitigation, such as insurance (Egan, 2003).

The BCBS encourages banks to move along the spectrum of available methods or approaches as they become more sophisticated in their measurement of operational risk. Different qualification criteria are laid down by the BCBS (2006a:144) but local regulators evaluate banks to determine which of the above discussed three approaches should be implemented.

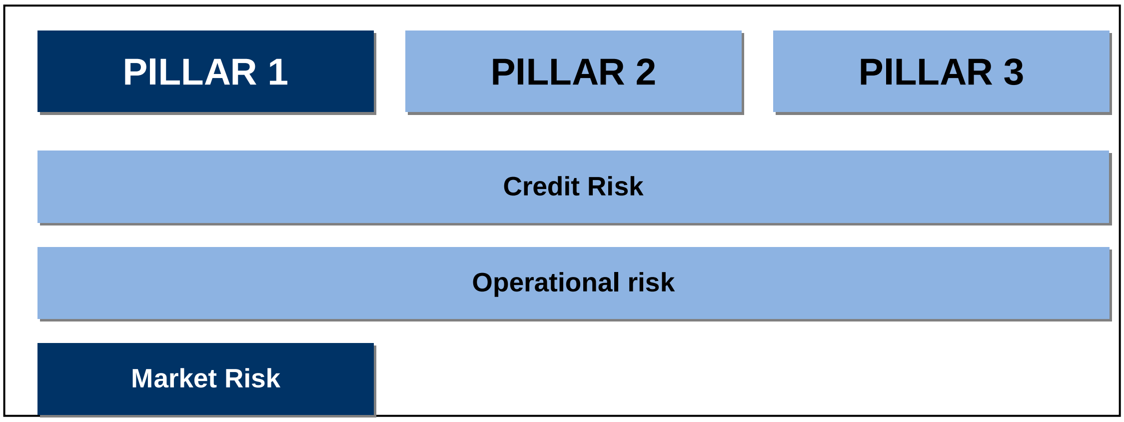
The next section continues to explore Basel II by examining market risk.

2.4.2.8 Pillar 1: Market Risk

Market risk – illustrated in Figure 2.8 below – is discussed in this section.

[15] Gross income is defined as net interest income plus net non-interest income. This measure should: (i) be gross of any provisions (e.g. for unpaid interest); (ii) be gross of operating expenses, including fees paid to outsourcing service providers; (iii) exclude realised profits/losses from the sale of securities in the banking book; and (iv) exclude extraordinary or irregular items as well as income derived from insurance (BCBS, 2006a: 145).

Figure 2.8 Structure of the Basel II discussion: Pillar 1: Market Risk



A background and definition of market risk is presented in this section, followed by the differences (in approaches to market risk) between Basel I and II. This section concludes with an overview of market risk measurement approaches as the fundamentals introduced in this section is applied in Chapter 4 to introduce a calculation methodology which could be used to determine the fair level of market risk capital.

2.4.2.8.1 Background and definition

Market risk is defined as follows:

> *The risk of loss on on-balance sheet or off-balance sheet positions arising from fluctuations in market prices* (Bank of France, 2006:7).

The Austrian Financial Market Authority (2007) (AFMA), defines market risk as the *risk of uncertainty in the market value of a portfolio*. Bank portfolio values may decline in value as a result of unfavourable market price movements. This can result in losses to exposed parties.

Market risk was not originally included in the 1988 Basel I document. The 1996 Amendment of Basel I introduced short-term subordinated debt (or Tier 3 capital) for covering market risk exposures. In 1996 the Basel framework first required capital charges for market risk (Wong, 2006:12). This amendment permitted banks to use their own internal models for determining the required capital charge (Applabs, 2007:2).

2.4.2.8.2 From Basel I to Basel II

The minimum capital requirements remained at 8% of risk-weighted assets in Basel II. The measurement of market risk also remained largely unchanged (Applabs, 2007:2) since the basic concept of market risk has remained the same (AFMA, 2007). There were, however, a few amendments to the Basel I document which appeared in Basel II of which the most significant was the definition of the trading book (Holloway and Grobler, 2005:152).

The definition of the bank trading book was improved in order to be more descriptive on what should be incorporated in the trading book. The trading book's new definition recognises a wider selection of tradable instruments (Holloway and Grobler, 2005:153). The BCBS (2006a:150) defines trading book Basel II as follows:

> *A trading book consists of positions in financial instruments and commodities held either with trading intent or in order to hedge other elements of the trading book. To be eligible for trading book capital treatment, financial instruments must either be free of any restrictive covenants on their tradability or able to be hedged completely. In addition, positions should be frequently and accurately valued, and the portfolio should be actively managed.*

Holloway and Grobler (2005:154) summarise the new requirements relating to the new definition of the trading book as follows:

- positions' intents should initially be identified clearly as being trading or banking book based,
- trading book positions must comply with a well-documented trading strategy and thoroughly defined policies and procedures,
- policies and procedures should be thoroughly defined to cover the following: positions managed on a trading desk, daily market to market valuations, limits structures and procedures, assessment of parameters, independent price verification, position reporting and position monitoring and
- senior management must be aware of the above mentioned elements of the trading book that are subject to mark to model. This includes the actual uncertainty created in the reporting of the risk and performance of the business.

Other amendments include interest rate management in the banking book, valuation requirements in the trading book and disclosure requirements (which are discussed later in this study).

2.4.2.8.3 Measurement of market risk

Market risk covers risks manifest in a bank's trading book and is extremely relevant to market participants. As a result, the BCBS provided banks with two different approaches to measure market risk: the *Standardised Method* (SM) or the *Internal Models Approach* (IMA) (BCBS, 2005a:3). The fundamental difference between these two approaches in that the SM uses a risk bucketing approach to measure general risk and ignores specific risk due to the simplicity of this approach while the IMA allows banks to recognise the effects of correlation across and within risk factors to be taken into account. The IMA also allows the measurement of specific risk for equity and interest rate positions. These two methods are discussed in more detail in Chapter 4 where the IMA is used to introduce a methodology for calculating a fair level of economic capital for market risk.

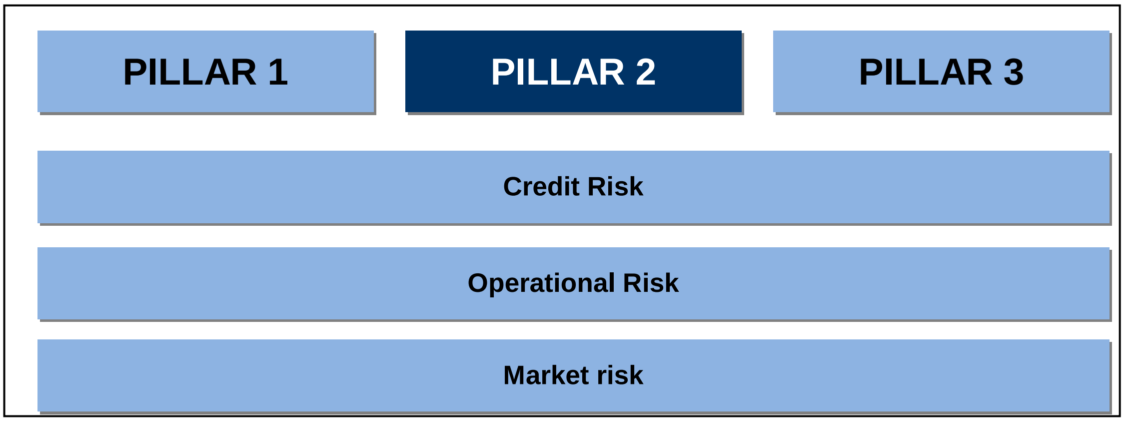
2.4.2.9 Pillar 1: Conclusion

Pillar 1 was explored in this chapter by firstly looking at credit risk by using the standardised as well as internal rating based approaches. This was followed by a discussion on the second risk type, operational risk. The third and final risk type under Pillar 1 was market risk which has been discussed in this section. In the next section, the second pillar (Pillar 2) is reviewed. Pillar 2 and 3 are introduced as they are part of Basel II. They will, however, not be used in the capital calculation methodology.

2.4.2.10 Pillar 2: Supervisory Review

In this section, *Pillar 2: Supervisory Review* is introduced as illustrated in Figure 2.9 below.

Figure 2.9: Structure of the Basel II discussion: Pillar 2: Supervisory Review



This section provides an overview of the background of Pillar 2, followed by an explanation on the importance of supervisory review, which is based on four basic principles (Jackson, 2001:57). These principles will then be discussed as the next section. This is followed by a discussion of the three major components recognised by the BCBS.

2.4.2.10.1 Background

The BCBS views the supervisory review process as a vital component for the support of minimum capital requirements under (Pillar 1) and market discipline (Pillar 3) (Esterhuysen, 2003:29).

Under the supervisory review process, local regulators are required to ensure that local banks adopt effective and sufficient internal processes for the assessment of its capital adequacy. Assessments should be based on a thorough risk evaluation in the bank. Local regulators will intervene if a bank's risks exceed capital held. Pillar 2 thus embraces responsibilities for both the bank and the regulator (Applabs, 2007:2).

2.4.2.10.2 Importance of supervisory review

The BCBS (2006a:204) states that the process of supervisory review is important for the following reasons:

i. the supervisory review process must ensure that banks have adequate levels capital to support the total risks in their banks,

ii. Pillar 2 strives to encourage banks to develop and use improved risk management techniques for monitoring and managing risks in the banks (BCBS, 2006a:204),

iii. Pillar 2 recognises the responsibility of a bank's management to develop internal capital measurement and evaluation processes. Furthermore banks must set adequate capital targets which reflect the bank's risk profile and control environment. Pillar 2 also states that the management of a bank is still responsible for the provision of adequate capital to support the bank's risks *beyond the core minimum requirements* (BCBS, 2006a:204),

iv. local regulators should evaluate the efficiency of a bank's capital assessment in order to calculate their capital needs relative to the risks present in the bank. Local regulators are expected to intervene where necessary (BCBS, 2006a:204) and

v. the Committee of European Banking Supervisors (CEBS) (2005:2), states that the principal aim of Pillar 2 is to improve the linkage between a bank's risk profile, risk management processes, risk mitigation systems and its capital.

The supervisory review is based on four, interlocking, basic principles which are presented in the next section.

2.4.2.10.3 The four basic principles

Basel II prescribes the following principles that must be incorporated in local regulators' policies (BCBS, 2001b:1):

- ***Principle 1***: Banks should have a process for assessing their overall capital in relation to their risk profile and strategy for maintaining their capital levels. (Basel II paragraph 726-745).
- ***Principle 2***: Local regulators should review and evaluate banks' internal capital adequacy and assessment strategies, as well as their ability to monitor and ensure their compliance with regulatory capital ratios. Local regulators should take appropriate supervisory action if they are not satisfied with the results of the process. (Basel II paragraph 746-756).
- ***Principle 3****:* Local regulators should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to hold capital in excess of the minimum. (Basel II paragraph 757-758).

- ***Principle 4***: Local regulators should seek to intervene at an early stage to prevent capital from falling below the minimum required to support the risk characteristics of a particular bank and should require rapid remedial actions if capital is not maintained or restored. (Basel II paragraph 759-760).

2.4.2.10.4 Components

The BCBS (2006a:204) recognises three main components (which may be classified as the core element of Pillar 2 under Basel II) which explain the four principles above which are (Financial Service Authority, 2007:4) the:

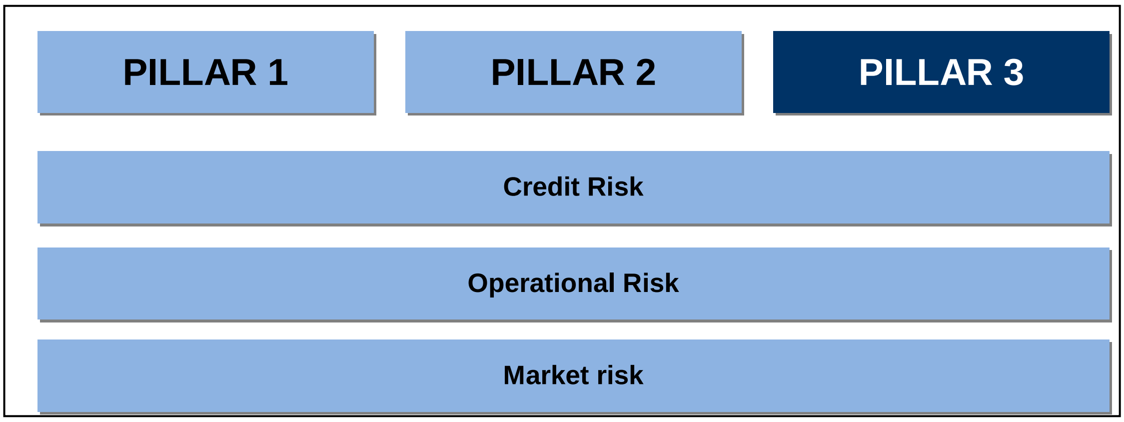
- Internal Capital Adequacy Assessment Process (ICAAP)
- Supervisory Review and Evaluation Process (SREP) and
- Supervisory intervention.

The BCBS believes that the supervisory review process is fully addressed with the implementation of Basel II (Esterhuysen, 2003:31). This final pillar is called *Pillar 3: Market Discipline* and is discussed in the next section.

2.4.2.11 Pillar 3: Market Discipline

The third and final pillar (Pillar 3: Market Discipline) of Basel II is discussed in this section.

Figure 2.10: Structure of the Basel II discussion: Pillar 3: Market Discipline



Pillar 3 is defined and its background examined. This is followed by an explanation of the purpose of Pillar 3 and a review of the disclosure requirements. This section concludes with a discussion regarding the implementation of this last pillar and a brief summary.

2.4.2.11.1 Background and definition

In recent years there have been several efforts and initiatives to increase and improve the amount of information banks reveal to the public. This has been motivated by a number of both banks and non-banks incidents of major misreporting of balance sheet positions and it serves as a proactive initiative by policymakers to strengthen the role of market discipline in banking supervision (Devine, 2005:199).

Pillar 3: Market discipline may be described as a number of recommendations and requirements set out in Basel II to increase and improve the market disclosure (BCBS, 2006a:226). It is the BCBS's attempt to promote market discipline through improved transparency and it plays an integral role it the success of Basel II (Saidenberg and Schuermann, 2003:13). Pillar 3 underwent several important changes since it was first introduced to banks. However, throughout the revision process, the BCBS maintained that the disclosures should be compulsory for all banks given the increased dependence on the internal assessments of risks (Saidenberg and Schuermann, 2003:13). The requirements for Pillar 3 disclosure are based on the concept of *materiality*. Information would be regarded as material if its exclusion could potentially influence decisions of users relying on that specific information (Danske Bank, 2007). It is, therefore, the responsibility of the bank to determine whether information qualifies as being material or not. However, Basel II also sets out a clear set of disclosure requirements which should be complied with by banks under Pillar 3 (BCBS, 2006a:229).

The definition of Pillar 3 is consistent with that of International Financial Reporting Standards (IFRS). The overlapping of Pillar 3 and IFRS is a large challenge when planning the effective management of these two requirements. The key overlapping element is disclosure and, with effective integration, can be managed with a degree of similarity (Devine, 2005:212). Market participants and local regulators usually focus on Pillar 1, but the significance and value of Pillar 3 should not be underestimated (Gibbons, 2007:6).

2.4.2.11.2 The purpose of Pillar 3

Pillar 3 embraces five main aims. These are:

i. complementing the functioning of minimum capital requirements stated in Pillar 1 as well as the supervisory review process in Pillar 2 (BCBS, 2001c:1),

ii. market transparency achieved by requiring more detailed disclosure of important of risk and capital elements. These disclosures provide market participants such as counterparties and investors with key information required to have an informed view of a bank's risk profile (Saidenberg and Schuermann, 2003:7),

iii. allowing market participants to access the above-mentioned information. Important pieces of information include the scope of application, capital, risk exposures, risk assessment and management processes, and therefore the capital adequacy of banks (BCBS, 2006a:226),

iv. improving the quality and quantity the information it provides. In order to assist market participants to make more accurate and informed judgements on the health of banks they intend to do business with (BCBS, 2006a:226) and

v. enhancing financial stability (BCBS, 2001c:3). The FED (2006b) recognises the significance of market discipline in promoting better risk management practices and systems. Pillar 3 supports the process of improved financial stability in the banking sector**.**

The Basel II prescribed disclosure requirements to determine the relevant disclosures to local regulators which banks should make for market transparency purposes is discussed next.

2.4.2.11.3 Disclosure requirements

Pillar 3 deals with the issue of transparency in banks. Local regulators have diverse measures that can be used to require banks to make the relevant disclosures; they must also ensure that the relevant disclosures provided by banks are timely (BCBS, 2004:175). Basel II provides the main disclosure requirements under Pillar 3 under the following four principles (Basel II paragraph 821-826):

i. general disclosure principle,

ii. scope of application,

iii. capital and

iv. risk exposure and assessment.

Pillar 3 does not only state requirements for regulators and banks, but also provides guidance on implementation. This is discussed in the next section.

2.4.2.11.4 Implementation of Pillar 3

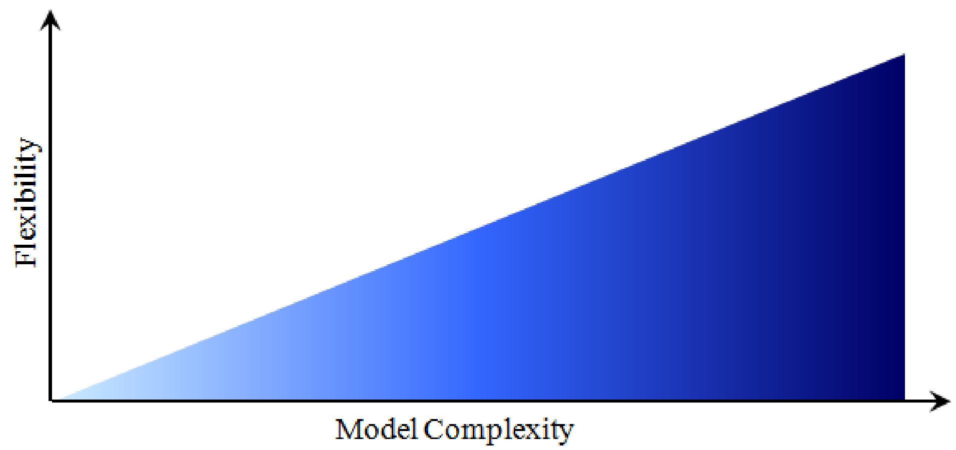
The BCBS (2001c:3) acknowledges that there are differences in the legal authority of local regulators in different countries. It is difficult to set disclosure standards that apply equally well in all countries. Some local regulators have the authority to apply general disclosure requirements directly through compulsory regulations while others may only have the power to use indirect approaches, such as issuing sound practice recommendations. Local regulators have adopted diverse responses for banks that fail to comply with the disclosure requirement under Pillar 3. Therefore the BCBS desires the introduction of strong recommendations or principles. The BCBS will furthermore continue to investigate different approaches to achieve the implementation of these recommendations or principles (BCBS, 2001c:3).

Neither local regulators nor market participants have studied (in the requisite detail) the usability, feasibility or appropriateness of the Pillar 3 disclosures (Gibbons, 2007:6). If the main aim of Pillar 3 is market discipline, then these various disclosures ought to be investigated and stated clearly to ensure proper interpretation by all market participants.

2.5 The relationship between model complexity and flexibility

As a summary of Basel II complexity and flexibility, Figure 2.11 presents a comparison between the Basel II regulatory capital regime and bank's own internal economic capital regime. The different methodologies employed and the distribution of model flexibility and complexity in the methods for calculating bank capital is shown in Figure 2.11 below.

Figure 2.11: Bank capital model complexity vs. model flexibility to determine relevant capital



RISK TYPE	A	B	C	D
Market	**Standardised** approach		**Internal models**	**ECONOMIC CAPITAL**
Credit	**Standardised** approach	**Foundation** internal ratings based approach	**Advanced** internal ratings based models	
Operational	**Basic indicator** approach	**Standardised** approach	**Advanced** models approach	
Models specified by:	BCBS			Bank (*but may employ BCBS models*)
Parameters determined by:	BCBS	BCBS + *some* bank	Bank + *some* BCBS	Bank

Source: Compiled by author

Examining the methodologies discussed in this chapter, it is important to note that only C and D in Figure 2.11 were investigated. A and B refers to the less sophisticated methods in which models are not as complex as in C and D. C (in Figure 2.11) refers to the most advanced capital calculation approached available to banks under Basel II. These approaches (for credit and market risk) are investigated and their parameters investigated in order to determine calculation methodologies which may be used by banks to estimate the fair level of their economic capital. The methodologies introduced should enable banks to determine their own level of economic capital (D in Figure 2.11) which should be sufficient to cover losses arising from relevant risks.

2.6 Conclusion

This chapter introduced two concepts namely economic and regulatory capital. This study will assist banks to calculate their own economic capital for market and credit risk elements. However, the economic capital calculations are based on Basel II's approach which was designed and is currently employed globally for regulatory capital calculations. This chapter aimed at providing an explanatory summation of the literature and theory on the historical development of international capital regulations and Basel II.

This chapter provided an overview of elements and events that led to Basel II as well as the historical development of international capital regulations. A detailed discussion regarding the BIS, the BCBS and the Basel Accords (Basel I and II) was also provided. In discussing these, specific attention was paid to their historical developments, functioning and the status quo.

This chapter also focused on Basel II (which replaced Basel I). The function of Basel II was introduced with specific reference to developmental amendments and revisions that have occurred to Basel I. Some technical functionalities of Basel II were introduced and the framework was discussed in the light of the three pillar framework of which it comprises, namely minimum capital requirements (Pillar 1), supervisory review (Pillar 2) and market discipline (Pillar 3).

This chapter concludes the theoretical investigation. The next chapter builds on this literature to address the primary goal set for this study, namely, to determine a methodology to estimate the fair level of economic capital for credit and market risk in commercial banks.

Chapter 3

Fair credit risk capital using empirical asset correlations

Correlation is the biggest single driving factor of Basel II. It's a critical factor, and banks should really be looking at it much more closely" (Leighton, 2006)

3.1 Introduction

In the previous chapter, the literature surrounding the three essential role-players of global capital regulation was investigated namely: the Bank for International Settlement (BIS), The Basel Committee on Banking Supervision (BCBS) and Basel Accords. These three role players were explored in order to provide a comprehensive understanding of the global regulation of bank capital.

The previous chapter comprised of two main parts. The first part examined the historic developments, functioning and *status quo* of the three essential role-players. The second part summarised the Basel II Accord and the three (minimum capital requirements, supervisory review and market discipline) pillar framework of which it comprises. This chapter focuses only on the first pillar namely the *minimum capital requirements* and specifically on credit risk.

Basel II sets out two approaches to estimate the (regulatory) capital that banks require to provide for credit risk: the Standardised Approach (SA) (in which banks allocate capital according to prescribed risk weights, specified by the BCBS) and the Internal Ratings Based (IRB) approach (in which banks may derive and employ their own credit ratings assigned to obligors). The latter approach is further split into two sub-approaches namely the Foundation IRB approach (FIRB) (in which banks must use BCBS capital formulas, but must use all parameters – other than PDs – specified by the BCBS) and the Advanced IRB (AIRB) (in which banks may determine and employ many of their own parameters, but must still use BCBS specified capital formulas) (Ilako & Stoilov, 2005:34).

This thesis aims to address the *fair* allocation of capital by establishing methodologies to empirically estimate some of the opaque, fixed variables present in the Basel II accord's equations. This chapter focuses only upon capital calculated using the AIRB approach. The introduction of the much-needed analytical methods provided by the Basel II AIRB approach has, among others, two advantages, namely:

- a more efficient and fair overall level of capital to be held and
- a more dynamic and realistic capital adequacy computation (Das, 2006:2).

The primary purpose of this study is to introduce calculation methodologies which will allow banks (of any size and complexity) to empirically determine their own unique parameters from their own unique loss experiences. Knowing these empirical values will allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed accurate. The study will therefore enable banks to determine fair (i.e. not too punitive as to inhibit efficient functioning of the bank and not too lenient as to allow the bank to malfunction in times of stressed economic conditions) levels of economic (i.e. internal) capital which is sufficient to cover losses arising from specifically credit and market risks faced by banks.

If the fixed parameters specified by the BCBS are too lenient, banks can increase their economic capital reserves appropriately and if they are too onerous, banks can judge for themselves whether or not prevailing economic conditions warrant such capital requirement severity. In either case, banks using the suggested methodologies are able to establish precisely their unique, *empirical* capital requirements without blind acceptance of the parameters (the estimation of which the BCBS do not provide much detail) used in the capital calculations of Basel II. Even though the regulatory capital cannot be altered, banks can and do use economic capital in decision making[16]. This chapter introduces a parameter estimation methodology specifically for credit risk.

When modelling the risks to which banks are exposed there are numerous different *scientific* elements that should be considered and investigated in order to model the risks effectively (Currie, 2004:9). In this chapter, asset correlation (a measure of the co-movement of asset return values, which are required in the Basel II formulation) is the scientific credit risk element that is investigated as the incorrect estimation of this parameter could be detrimental (i.e. significantly over or understated) to the management of a bank's capital requirements (Laurent, 2004:23). In order to determine the fair level of economic capital for credit risk, this chapter introduces a methodology for extracting empirical asset correlations using empirical loss data. Empirical asset correlations, instead of the fixed Basel II asset correlations, are employed in the calculation methods prescribed by Basel II to determine the fair level of economic capital for credit risk exposures.

Empirical loan loss data are used to extract empirical asset correlations. For this chapter, empirical loan loss data were derived from retail loans which were chosen specifically as this type of lending has not received sufficient attention in recent years as industry and regulatory resources have always focused far more on corporate lending (Ghosh, 2005:3). Corporate, bank and sovereign credit exposures have been more thoroughly explored as data for these loan types are far more plentiful, leaving retail credit risk less well understood. This lack of data could prove damaging to banks, but it also provides an opportunity to explore and ultimately determine a fair level of credit risk economic capital by investigating empirical retail lending (Helbekkmo, 2006:62).

An investigation into empirical retail lending furthermore adds additional value to the findings of this chapter as there are still vast unexplored opportunities in the retail banking segment as banks with proactive and well understood retail credit risk management strategies should achieve strong growth in terms of both volumes and profitability (Rao, 2005:7).

It is, furthermore, critical that asset correlation is thoroughly understood by banks as it is the biggest single driving factor of Basel II (Lopez, 2005:21).Bank regulatory capital is profoundly affected by the level

[16] See footnote 9 on page 8.

of asset correlation (as is illustrated later in this chapter), so it is critical that banks understand how these values are determined (Chernih *et al*, 2006:2). Banks are being urged to explore this factor more closely and this chapter makes a useful contribution by introducing a methodology which may be employed by all banks to extract empirical asset correlations from empirical loan loss data. After the development of the methodology, the approach is applied to and tested on 22 years of loan loss data – recorded for different retail asset types – in US banks. These data are well-recorded and freely available (U.S. Bureau Economic Analysis, 2008).

3.2 Chapter layout

This chapter comprises three main sections:

- a literature study which covers the relevant credit risk definitions and concepts and focuses specifically on the capital calculation framework prescribed by Basel II. As this chapter investigates asset correlations and their impact on credit risk capital charges, a thorough description of this topic is required in order to contextualise the subject and draw accurate conclusions on this topic.
- a description of a methodology for extracting empirical asset correlations from empirical data. These data are employed in the calculation methods prescribed by Basel II (introduced in Section 1) to also calculate the capital charge for credit risk.
- an application section which may be employed by banks to extract their own empirical asset correlation from their own empirical retail loss data. Banks may use these derived asset correlations to calculate fair levels of economic capital (using the Basel II equations for credit risk). This final section also presents a summary of the results obtained from the application of the methodology to US retail loss data.

A more comprehensive description of each section of this chapter follows at the beginning of each individual section.

3.3 Literature study

The literature study covers all important credit risk definitions and concepts required for this chapter. Specific attention is paid to the capital calculation framework prescribed by Basel II. The literature study commences with a brief introduction to credit risk, followed by the options (provided by Basel II) for calculating the credit risk capital charges: the SA and IRB. Different types of credit exposures are introduced as well as the reasons behind the choice of retail credit exposures. Some discussion on Basel II's treatment of retail credit risk also follows.

The credit risk model chosen by the BCBS for Basel II is the asymptotic single risk factor (ASRF) approach. The credit risk capital requirements (prescribed by Basel II) are based upon the ASRF approach which is explored further by examining reasons *why* it was adopted, *what* a single factor model is and *how* it differs from a multifactor model. The parameters involved in the ASRF approach is also discussed, starting with the most important parameter (Lopez, 2005:21) namely the asset correlation and the set regulatory values of this parameter. The difference between asset and default correlation as well as the difficulties involved in calculating default correlations are also discussed.

Other elements and parameters of the ASRF approach follow the discussion concerning asset correlation as all these elements are required in the capital calculation for credit risk exposures. These elements and parameters include average and conditional probability of default (PD), loss given default (LGD), expected versus unexpected losses (EL and UL), exposure at default (EAD) and risk weighted assets. Maturity adjustments in corporate loans is mentioned, but not discussed in any detail as they are not required for the relevant *retail* exposures of this chapter. The literature study concludes with a discussion on model calibration.

As this chapter introduces a calculation methodology to extract empirical asset correlations to be used in the calculation of a fair level of credit risk capital, a thorough explanation of the elements and parameters involved in this methodology is also presented.

The FIRB allows banks to use the Basel II specified equations for credit risk as well as their own internal estimates of the probability of default. All other parameters required as inputs into the Basel II specified equations to determine the amount of required capital to protect banks against credit risk losses are also specified by Basel II in this approach. Within the AIRB approach, banks may use their own internally-estimated measures for PD, LGD and EAD but not correlations (Ilako & Stoilov, 2005:35) which are specified by Basel II and thus in some sense "fixed". These elements are discussed in this literature section to provide the reader with sufficient background to understand the calculation methodologies introduced in this chapter.

3.3.1 Introduction to credit risk

Basel II defines credit risk as:

> *…the potential that a bank borrower or counterparty will fail to meet its obligations in accordance with agreed terms. The goal of credit risk management is to maximise a bank's risk-adjusted rate of return by maintaining credit risk exposure within acceptable parameters* (BCBS, 2000:1).

Credit risk is one of the three major risks covered in Pillar 1's ambit of Basel II (market and operational risk are the other two). Basel II specifies only these three main risks in the calculation of minimum capital to be held by a bank to ensure adequate capital is held to support all risks to which banks are exposed (Varghese, 2005:3). Banks generally face enormous exposures to credit risk: the most prominent causes of banking difficulties are attributed to negligent/high risk credit provision to counterparties, bad portfolio risk management or the inability to respond sufficiently to economic changes that can lead to an increase in credit risk of the bank's counterparties (BCBS, 1999:1).

3.3.2 Calculating the capital charge for credit risk

The two Basel II approaches to credit risk (SA and IRB) were introduced in Section 2.3.5 of Chapter 2.

When opting for the SA, banks use external ratings to classify all borrowers into seven risk categories with different risk weights. The capital required is then 8% of the risk-weighted total exposure. However, while conceptually the same method is followed, the IRB capital calculations are more complex. The complexity is confined to the risk weight calculation, which becomes a function of several parameters (Lamy, 2006:160).

Unlike the SA, the AIRB allows banks to use more of their own internal estimates as inputs to calculate the capital charge. Basel II provides guidance on this topic and focuses on explaining the risk weight formulas from a non-technical perspective (BCBS, 2005b:4). Basel II also describes the economic foundations as well as the underlying mathematical model (but not in sufficient detail for practitioners to reproduce the parameters fixed in Basel II) and its input parameters which are discussed later in this chapter.

The IRB approaches comprise four main inputs: PD, LGD, EAD and maturity. Of these inputs, only PD directly characterises the specific borrower. This chapter focuses on the AIRB approach which is similar to the FIRB except that for the AIRB approach banks may use their own internally-modelled measures for the PD, LGD and EAD inputs (Ilako & Stoilov, 2005:35). The AIRB approach was chosen as it provides a more sensitive credit risk measure (Egan, 2003) and the more risk sensitive the approach the more effectively (and accurately) regulatory capital can be calculated.

3.3.3 Different types of credit exposures

In calculating the capital requirements under the AIRB approach, risk exposures are divided into five asset classes namely sovereigns, banks, corporates, retail customers and equity (Oesterreichische Nationalbank, 2007). The definitions and details of these exposures have been discussed in Chapter 2 of this study. This chapter explores *retail* exposures and losses in the *retail* credit sector.

3.3.4 Retail exposures and Basel II

Retail credit can be defined as exposures that include, *inter alia*, consumer credits (such as residential mortgages, auto finance and credit cards) and small business loans. Small business loans have characteristics that make them more comparable to consumer loans than to large business loans (Berlin & Mester, 2004:721). Retail credit is a unique from of lending as it involves lending money to individuals which also includes unrated borrowers. Credit amounts are relatively small in size and individual losses on single retail loans will not cause insolvency of a bank, hence calculating the credit risk on each individual loan in not worthwhile. A borrower's PD depends not only on a range of economic factors, but also on their social and personal factors (Ghosh, 2005:3).

The following exposures can be categorised as retail exposures (BCBS, 2004:51):

- exposures to individuals such as revolving credits and lines of credit as well as personal term loans and leases, regardless of size, qualify as a retail exposure,
- residential mortgage loans qualify as retail credit (regardless of exposure size) but with the consent that the borrower is an individual that is an owner-occupier of the financed property
- loans granted to small businesses which are managed as retail exposures are also retail credit exposures. However, the maximum allowed exposure of the bank to this type of borrower is €1 million.

To ensure that retail exposures receive mass-market treatment, these loans classified as retail exposures must form part of a large pool of loans managed on a pooled basis. Local regulators are allowed to set a minimum number of exposures within a pool for exposures in that pool to be treated as retail (BCBS, 2004:51). Furthermore, within the retail asset class category, banks are obliged to identify the following three sub-classes of exposures:

- exposures secured by residential properties which have a similar definition as in SA (Jacobsohn, 2004:23)
- qualifying revolving retail exposures which include overdrafts and credit cards and are allowed a maximum exposure of €100,000. Qualifying revolving retail exposures are revolving, unsecured, uncommitted and must be issued to *individuals* and
- "all other" retail exposures which include loans to small businesses, car loans and consumer credits (BCBS, 2004:51).

For retail credit, like all other defined credit risk exposures, the credit risk capital charge as prescribed by Basel II is based on the ASRF approach, discussed in the next section.

3.3.5 The ASRF approach

> *Ratings-based assignment of capital charges offers significant advantages in regulatory application.* (Gordy, 2003:221)

A bank's credit risk capital requirements are derived from risk weight formulas developed using a portfolio-based asymptotic single risk factor (ASRF) loss model. Although there are no reference documents which detail Basel II's implementation and testing of this model, it is generally believed that the working paper version of Gordy (2003) was the pioneer to the ultimate Basel II credit risk equations (Aas, 2005:10).

Portfolio invariance – defined by the BCBS (2005b:4) as the capital required for any given loan should only depend on the risk of that loan and must not depend on the portfolio to which it is added – of the capital requirements is an essential assumption made in the AIRB approach. The following two requirements apply for portfolio-invariance:

- there is only a single systematic risk factor that drives correlations across obligors, and
- no exposure in a portfolio accounts for more than an arbitrarily small share of total exposures (Gordy, 2003:199).

At the transaction level, the need for stability in business operations favours portfolio-invariant capital charges (BCBS, 2005b:4). Basel II therefore uses single (ASRF) instead of multi-risk factor models to ensure that the contributions to VaR are portfolio-invariant. Unlike single risk factor models, multi-risk factor models cannot be portfolio invariant due to the definition stated above. The use of the ASRF approach assumes that the credit portfolio of a bank comprises a large number of relatively small exposures (i.e. the concentration risk is negligible) (Cox, 2007:160). This implies that the idiosyncratic risk associated with individual exposures tend to cancel out and that only systematic risks, which affect all exposures, have a material effect on portfolio losses (BCBS, 2005b:4).

The most important property of this model is that all systematic (or system-wide) risks that affect all borrowers to a certain degree (such as industry or regional risks) are modelled with only one systematic risk factor. Banks are, however, encouraged to use credit risk models that best fit their internal risk needs when calculating their economic capital. Under the AIRB approach, banks are expected to estimate their unexpected losses[17] for credit exposures. This is achieved by calculating the conditional expected loss for exposures given the appropriate conservative value of the single systematic risk factor (BCBS, 2005b:4).

The important components and parameters which constitute the ASRF approach are discussed in the next section which commences with an exploration of the most important parameter – the asset correlation – and the regulatory specification of this parameter (Lopez, 2005:21).

3.3.5.1 Asset correlation

The single systematic risk factor needed in the ASRF approach is generally considered to be the state of the economy (BCBS, 2005b:8), either locally or globally, depending on the loan context. The degree of the borrower’s exposure to the systematic risk factor is expressed by the asset correlation: a measure of the degree of co-movement between changes in asset value of one borrower and changes in asset value of another. The asset correlation in the ASRF approach measures the degree of co-movement between changes in a borrower's asset value and changes in the general (either local or global) state of the economy (i.e. the 'single factor'). All borrowers are linked to each other by this single risk factor (BCBS, 2005b:8).

The BCBS determined a series of asset correlation parameters (some fixed, some varying only with PD) for each different credit exposure type in Basel II. Asset correlations were set to ensure that the higher the

[17] Expected losses are “usual” or average losses that a bank incurs in its natural course of business, unexpected losses are deviations from the average that may threaten a bank’s stability (Navarrete, 2006:1). Expected and unexpected losses are discussed later in this chapter as they have a significant impact on capital charges. They are shown in Figure 3.1.

correlation between individual asset values, the higher the probability that assets will default at the same time, hence a higher level of capital is required for different portfolios with the same PD (Gore, 2006).

3.3.5.1.1 Importance of correlation

Credit risk analysis focuses primarily on the shape of the loss distribution for a portfolio of assets, (specifically the tails of the distribution) when determining the adequate amount of capital banks require to cover potential losses. The prominent role that correlation plays in this capital calculation led to an increased focus in importance for academics and professional practitioners (Cassart *et al*, 2007:2).

The importance of asset correlation is rooted in the statistical fact that changes in the correlation between assets transfers some of the risk away from the mean toward the tail of the loss distribution. An increase in the correlation between assets fattens the tail of the loss distribution which results in an increased amount of capital banks need to cover potential losses (Cassart *et al*, 2007:2). Asset correlation is also a crucial input for credit risk management as it has a direct impact on determining the PD of a credit instrument (Chen, 2005:50).

3.3.5.1.2 Asset and default correlation

These two types of correlation are closely related. When two borrowers are part of a homogenous group the default correlation can be determined from the:

> *...time series of defaulted and non-defaulted loans of this group without further assumptions. Therefore, estimating correlation is not a problem of methodology. However, in practice we do not know firsthand which obligors build a homogenous group. In the one–factor model there exists a one-to-one mapping between default correlation and asset correlation for a given probability of default* (Dullmann & Scheule, 2003:6).

Default correlation refers to the phenomenon that the likelihood of one obligor defaulting on its debt is affected by whether or not another obligor has defaulted on its debts (Lucas, 2004:2). In practice, this correlation is difficult, if not impossible, to measure directly. However, the default correlation of two borrowers may be inferred by measuring the individual default probabilities of the obligors as well as their asset correlation. The idea is intuitive and used in the Moody's KMV formulation:[18] an obligor is likely to default when the asset value falls below the value of obligations. The joint probability of two obligors defaulting during the same time period is the likelihood of *both* borrowers' asset values falling below their *respective* default points during that period. This probability can be determined using the correlation between the two firms' asset values and the individual likelihood of each firm defaulting (Zhang *et al*, 2008:6).

[18] Moody's KMV is the industry standard for measuring the credit risk of individual firms. The Moody's KMV provides objective, quantitative solutions that are essential to predict a firm's PD (Moody's KMV, 2009)

In typical *economic* capital calculations, then, each obligor has a unique asset correlation that is used in the determination of credit losses. For the purposes of *regulatory* capital calculations, such a multitude of parameters is infeasible. Instead, Basel II proposed equations that assign asset correlations that are either (a) fixed or (b) a decreasing function of firm probability of default (Lopez, 2005: i).

3.3.5.1.3 Previous studies

Dullmann & Scheule, (2003:21) investigated the determinants of the asset correlations of German firms (clients) and the implications for banks' required regulatory capital. Their results suggest that further research was justified for the estimation of asset correlations as several studies in the past addressed this issue with remarkable differences in their empirical results.

> *The wide range of empirical findings does not only highlight the importance of further empirical research but even more advocates a stronger focus on the economic factors that can explain the observed differences* Dullmann & Scheule, (2003:21).

Chernih *et al* (2006:12) also investigated asset correlation and found that asset correlations are *lower* than those suggested by the BCBS in Basel II. Even though numerous articles (e.g. Lopez (2004 and 2005) and Duchemin *et al* (2003) have reported asset and default correlations based on a variety of different datasets, some issues still remain which require additional exploration as current findings has been inconclusive.

Even though asset correlation is the most important input in the ASRF approach, other parameters must be considered. A review of these other parameters of the ASRF approach follows.

3.3.5.2 Average and conditional PDs

The next important parameter in the ASRF (used for calculating the capital charge under Basel II's AIRB approach) is the PD. Merton (1973:449) defined PD as: *the probability that the firm is unable to satisfy some or all of the indenture requirements*. The PD is usually stated for a fixed assessment horizon such as one year. Merton modelled the asset value of obligors as a variable whose value can vary over time and asserted that the variation in value of the obligor's assets behaves as a normally distributed random variable (BCBS, 2005b:5).

The Basel II capital formulas for the AIRB approach make use of average PDs – estimated by banks – for the implementation of the ASRF approach. The model was developed to reflect expected default rates under normal business conditions (BCBS, 2005b:4). During the last decade, banks have been forced to redesign their PD models in order to develop the most accurate PD under Basel II. To determine an effective PD, banks now distinguish whether different PD measures are point-in-time (PIT), through-the-cycle (TTC) or a hybrid, which incorporates elements of both PIT and TTC, PDs (Aguais, 2008:267).

A PIT PD assesses the likelihood of default over a future period, most often the period one year from the present and sometimes for multiple years forward. An accurate PIT PD anticipates the short term future on the basis of present circumstances by integrating all applicable cyclical developments and individual obligator values with appropriate probabilities. This approach results in a robust short term probability of default. In contrast to the PIT PD, TTC PDs indicate circumstances anticipated over particularly long periods where the effects of the economic cycle, average close to zero. By considering up and downturns in the economy, probabilities of default can be defined as a median of multiple PIT PDs (Aguais, 2008:272).

As far as Basel II is concerned, the BCBS favours the use of TTC PDs although strong emphasis is also placed on the need for an integrated PIT–TTC approach. The Basel II requirements are, however, constantly under discussion and therefore open to interpretation (Aguais, 2008:269). Balthazar (2004:84) predicted that one of the main issues of Basel II AIRB would be that banks would have to prove that the long-term PDs assigned to their clients are indeed correct. In the light of the ongoing credit crisis (November 2009), it remains to be seen how long run average PDs change in the future.

Average PDs are transformed into conditional PDs to calculate the *conditional expected loss*.[19] This is achieved by applying a supervisory mapping function derived from an adaptation of Merton's (1973) single asset model to a bank's credit portfolios (BCBS, 2005b:4). The conditional PD reflects a default rate given an appropriately conservative value (99.9%) of the systematic risk factor (BCBS, 2005b:6). The same value of the systematic risk factor is also used for all instruments in banks' portfolios. Vasicek (2002) proved that, under certain conditions, Merton's model can logically be extended to a specific ASRF credit portfolio model. The BCBS adopted the assumptions of a normal distribution for the systematic and idiosyncratic risk factors following the findings of Merton and Vasicek (BCBS, 2005b:5).

In this section, PD was introduced as parameter in the ASRF. The next parameter used for calculating the capital charge under Basel II's AIRB approach is the LGD and is discussed in the following section.

3.3.5.3 Loss Given Default

LGD is another important parameter in the ASRF approach and refers to the total loss faced by a bank (when a client defaults), net of any recovery the bank has received or will receive. LGD furthermore estimates the impact on the bank when going into default (Featherstone *et al*, 2004:5). Unlike the method used for PDs:

> *the IRB does not contain a specific function that converts average LGDs expected to occur under normal business conditions into conditional LGDs which are consistent with the appropriate conservative value of the systematic risk factor* (BCBS, 2005b:6). *The Basel II framework instead requires that estimated LGD parameters must reflect economic downturn conditions where necessary to capture the relevant risks and that*

[19] The IRB estimate a conditional expected loss, which is a measure of credit VaR as Basel II requires banks to cover EL + UL. However, the product LGD x PD is deducted because the EL should be covered by the bank's loan loss provisions. The capital charge should therefore cover all the *un*expected losses that exceed the EL.

supervisors will continue to monitor and encourage appropriate approaches to this issue (BCBS, 2004:96).

This use of downturn LGD takes into account the fact that the correlation between PD and LGD is ignored by Basel II (Miu & Ozdemir, 2006:2).

The ASRF approach asserts that the total loss for an exposure is equal to the product of a conditional PD and a 'downturn' LGD. In order to derive an economic-downturn LGD, the Basel framework considered two approaches. The first approach is to use bank-reported LGDs and to apply a mapping function (similar to that used for PDs) to them that would provide downturn LGDs. The second option is that banks could be requested to provide downturn LGD information based on internal LGD assessments during unfavourable conditions (BCBS, 2005b:4).

The next important components of the ASRF model are expected and unexpected losses. These are discussed in the next section.

3.3.5.4 Expected versus Unexpected Losses

Expected and unexpected losses are also both important parameters of the ASRF approach which are used for calculating the capital charge using Basel II's AIRB approach. Under the AIRB approach there are two different credit risk concepts: expected loss (EL) and unexpected loss (UL). It is important to understand the fundamental difference between these two.

In Chapter 2, Figure 2.4 illustrated the difference between EL and UL. EL is the mean of a bank's total estimated loss over a specific time horizon and is calculated as the simple mean based on the historical gross losses. Figure 2.4 depicts this statistical mean of the loss distribution. Risk management, however, focuses primarily on managing variability or the uncertain; hence the need to calculate a bank's UL. The only current standard to express UL is that used for regulatory capital and economic capital purposes: a measure to 99.9% confidence[20] over a one-year time horizon (Davies, 2005:31).

From a Basel II perspective, banks are required to cover their EL on an ongoing basis in the form of provisions (bank capital), effective pricing and write-offs. No additional regulatory capital should be set aside for EL under Basel II as it represents another cost component of the lending business. In contrast to EL, UL refers to potentially large losses that may occur; hence regulatory capital is needed to absorb UL (BCBS, 2005b:7).

The next important constituents of the ASRF, namely Exposure at Default and risk weighted assets are discussed next.

[20] The confidence interval is discussed in more detail later in this chapter.

3.3.5.5 Exposure at Default and risk weighted assets

The EAD is an important parameter in the ASRF approach and describes the losses to which the bank is exposed when the loan transitions to default. EAD is usually expressed as a monetary amount comprising the principal outstanding, unutilised commitment and any fees or other expenses the bank made in collecting the outstanding part of the loan (Featherstone *et al*, 2004:5). The capital requirement as laid out in Basel II can, however, also be expressed as a percentage of the total exposure (BCBS, 2005b:11). In order to derive a capital charge, risk weighted assets,[21] must be multiplied by EAD and the reciprocal of the minimum capital ratio of 8%, i.e. by a factor of 12.5 thus, since:

$$k = 8\% \times \left(\frac{RWA}{EAD} \right) \tag{3.1}$$

Where:

- k = the capital required (expressed as a percentage of the total exposure)
- RWA = the risk weighted assets

$$RWA = 12.5 \times k \times EAD \tag{3.2}$$

In this section, EAD and risk weighted assets were discussed as parameter in the ASRF. In the next section, the maturity adjustment factor (which is also used in the estimation of capital charges under Basel II's AIRB approach) is introduced.

3.3.5.6 Maturity adjustment

The next important parameter in the ASRF approach is maturity adjustment. A bank's credit portfolio comprises of loans with different maturities. Long-term loans are considered riskier than short-term loans[22] ; hence, the regulatory capital requirement increases with maturity (BCBS, 2005b:4). The maturity adjustment, specified in Basel II, is intended to account for the effect of an loan's maturity on the risk of changes in its fair value (e.g. as a loan's maturity is extended, the risk of it being subjected to a downgrade increases simply as a result of the timeline (Cornford, 2006:4)).

The risk of default (or downgrade), however, decreases with a decrease in a loan's maturity (BCBS, 2005b:10). The Basel II maturity adjustment is the product of two terms: one corresponding to a standard maturity and the other applying to exposures with maturities not compliant to this standard. The second term has a minimum maturity, which restricts the potential capital reduction due to maturity adjustment

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[21] The assets of a bank multiplied by a risk weighting prescribed by the regulatory authorities. The risk weighting representing the relative risk of the underlying assets. Based on the amount of risk-weighted assets, the amount of minimum capital required by the bank can be calculated (ING, 2009)

[22] The empirical evidence found that long-term bonds have higher yields than short-term bonds. Investors seem to earn higher expected rates of return on average in long-term bonds, because these bonds are riskier (Financial planet, 2009)

(Cornford, 2006:4). This study, however, focuses on retail portfolio's for which Basel II's AIRB capital equation has no maturity factor[23] (BCBS, 2006a:76).

3.3.5.7 Model calibration

Within the ASRF approach, two key parameters are also set by Basel II: the confidence level (deemed to be sufficient when using the AIRB approach) and asset correlation (which indicates the dependency of borrowers on the overall state of the economy) (BCBS, 2005b:11).

Banks require sufficient capital to protect them against losses up to a certain confidence level, referred to as the statistical confidence level. The equation used in the ASRF approach is calibrated to ensure a confidence level of 99.9% (BCBS, 2004:73). This confidence level has been designed to protect banks against a 1:1 000 year default event. It is also designed to protect against 1:1 000 banks defaulting in a single year, a far more likely event in the global financial system (Van Vuuren, 2007), particularly in the current (November 2009) economic environment**.** This confidence level is high – much higher than the 99% confidence interval used for market risk capital estimation – but it was deliberately chosen to be high to ensure more protection against potential estimation errors in internal PD, LGD and EAD estimations as well as other model uncertainties (BCBS, 2004:69).

All the different parameters discussed above are used in the ASRF approach to determine the regulatory capital for credit risk under the AIRB approach.

The actual calculations and how these parameters are used to eventually determine regulatory capital are discussed in the next section. This is important to understand as the methodology (in the next section) and parameters (discussed above) are used to achieve the primary purpose of this chapter, namely to introduce a calculation methodology which will enable banks to determine fair level of economic capital which is sufficient to cover losses arising from the credit risk faced by banks.

3.4 Methodology and parameters

For banks using the SA, the capital required is determined by calculating the percentage of the weighted total exposure (Lamy, 2006:160). The following equation explains this simple calculation:

$$\text{Capital Required} = EAD \times \text{Risk Weight} \times 8\% \tag{3.3}$$

The more complex AIRB capital calculation uses these parameters in the capital calculation where the risk weight is a factor of the PD, LGD, asset correlation (ρ) and maturity (M). The risk weight is multiplied by EAD and 8% to determine the required capital. This is indicated in the equation below:

[23] The BCBS (2002) states that, for retail loans, no explicit maturity adjustment is required. This decision was based on the consideration that the introduction of a separate maturity adjustment for retail loans would be too complicated since this would require a separate analysis of prepayment risk and transition behaviour of loan counterparties, etc.

$$\text{Capital Required} = EAD \times \underbrace{f(PD, LGD, \rho, M)}_{\text{Risk Weight}} \times 8\% \tag{3.4}$$

3.4.1 The mathematics of the ASRF approach

The Basel II capital charge equation for retail portfolios is given by:

$$\text{Capital Required} = EAD \cdot LGD \cdot \left(N\left(\frac{N^{-1}(PD) + \sqrt{\rho} \cdot N^{-1}(0.999)}{\sqrt{1-\rho}} \right) - PD \right) \tag{3.5}$$

Where:

- N = a standard normal distribution applied to threshold and conservative value of the systematic factor,
- N^{-1} = the inverse of the standard normal distribution,
- retail loans do not have a maturity adjustment factor and hence this is not taken into account,
- *LGD* = the loss given default. When using historical LGD and loss data, in order to achieve a relevant downturn LGD,[24] results show that the LGD should be increased by between 35% and 41% (Miu & Ozdemir, 2006:44). These findings are sufficiently conservative (and research in this field is sufficiently lacking) to have been widely accepted[25] by the major rating agencies (e.g. S&P and Fitch) and other academic research. For this reason, the increase in the LGD used in this study was chosen as 37% (the average of the empirical LGD *increases* measured by Miu and Ozdemir, 2006). This is the *increase* in the historical LGD (derived from the QIS5 Basel study) and it is applied to the net losses in order to calculate empirical asset correlations. Since Basel II specifies that the downturn LGD calculation methodology should be principal-based, banks are free to use whichever downturn LGD they believe appropriate.
- *PD* = the probability of default and in this study the *average* PD for the loss portfolio is used,
- ρ = the asset correlation which has been specified by Basel II. In Basel II, different correlations have been determined for different types of retail exposures. Basel II specifies the following correlations for retail exposures:

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[24] This increased LGD compensates for the lack of correlation between PD and LGD. Basel II adopts a principles-based approach which requires (a) the identification of downturn conditions and the adverse dependencies between default rates and recovery rates and (b) the incorporation of adverse dependencies between default rates and recovery rates so as to produce LGD parameters consistent with identified downturn conditions (BCBS, 2006a:103).

[25] S&P (2008:21) states that there is little consensus regarding the appropriate methods for incorporating downturn conditions in LGD estimates. Some banks are concerned about potential over-conservatism and take the view that default-weighted average LGD should be sufficiently conservative. As neither Basel II nor commonly used off-the-shelf EC models capture PD and LGD correlations, there is a risk that under-estimation of capital requirements can occur. S&P, however, accepts the findings from Miu and Ozdemir for quantifying the downturn LGD and have been using it in several S&P publications such as: (a) benchmarking/validation of internal ratings systems, (b) GARP 2007 Recent Research in Basel (2007), (c) LGD Estimation Tools, Services and Data from Risk Solutions (2008) and (d) Basel II Validation Webinar: Estimation of Downturn LGD and long run probability of default (2008). The findings of Miu and Ozdemir (2006) are further supported by Sabatoa and Schmid (2008:10) who followed Miu and Ozdemir's downturn LGD findings (also used in this study) to *estimate a conservative LGD.*

i. Residential Mortgages: $\rho = 15\%$

ii. Qualifying Revolving exposures: $\rho = 4\%$

iii. For *Other Retail* exposures a similar methodology is used as used for corporate, bank and sovereign exposures where the supervisory asset correlations were derived by the analysis of data sets from G10 supervisors. Based on both empirical evidence and intuition the analysis revealed two important systematic dependencies. Firstly, asset correlations decrease with increasing PDs and secondly, asset correlations increase with firm size. Therefore, the asset correlation function used by Basel II considers both these dependencies.

The asset correlation function comprises of two limit correlations of 3% for very high (100%) and 16% for very low (0%) PDs. Correlations between these supervisory limits are modelled by an exponential weighting function that represents the dependency on PD. The rate at which the stated exponential function decreases is determined by the "k-factor" (k) (BCBS, 2006a:77).

$$\rho = 3\% \cdot \frac{(1-\exp(-k \cdot PD))}{(1-\exp(-k))} + 16\% \cdot \left[1 - \frac{(1-\exp(-k \cdot PD))}{(1-\exp(-k))}\right] \tag{3.6}$$

Where: k = 35 for these loan types

A final retail exposure, not covered by the *Other Retail* classification is *High Volatility Commercial Real Estate* (HVCRE). The correlation for HVCRE loans is calculated by using the same method as in *other retail*, however, with different limit correlations and a higher k-factor.

$$\rho = 12\% \cdot \frac{(1-\exp(-k \cdot PD))}{(1-\exp(-k))} + 30\% \cdot \left[1 - \frac{(1-\exp(-k \cdot PD))}{(1-\exp(-k))}\right] \tag{3.7}$$

Where:

k = 50 for these loan types

The fixed correlations prescribed by Basel II (and discussed above) are compared with empirical correlations derived from US Federal Reserve retail loss data. The empirical results are compared with the Basel II asset correlations (stated above) to ascertain whether they agree with the empirical evidence. The Basel II capital charges are calculated using both the Basel II prescribed asset correlations as well as the empirically derived asset correlations, from the results obtained from this comparison, the fairness of the Basel II capital charge is evaluated. This is useful in the calculation of bank's economic capital.

Having introduced the mathematics of the ASRF approach, the fitting of a suitable distribution to the empirical loss data is the next step in the process of determining the empirical asset correlation. This is explored in the next section.

3.4.2 Distribution fitting

In the previous section the mathematics of the ASRF approach was introduced. This section explains the fitting of a suitable distribution to the empirical loss data which is a crucial step in the process to determine the empirical asset correlation from empirical, retail loss data (discussed later in this chapter). From this distribution, the average loss and 99.9th percentile loss can be evaluated (and hence the UL from UL = Total losses – EL).

To select the relevant distribution, this study followed a robust statistical approach to determine the best statistical fit for empirical loss data. The analysis indicates that the Beta distribution provided the best fit and was therefore selected as the preferred distribution for this analysis (see Appendix I for the statistical analysis results).

Using the Beta distribution is also in line with the views of Tasche (2008:4) who found that when fitting different distributions to the same mean and standard deviation, the Vasicek, Kumaraswamy and Beta distributions do not differ considerably. The Vasicek distribution however, is not well-known and it is difficult to locate literature on its implementation. Vasicek distributions also require numerous inputs of different variables which complicates implementation. The Kumaraswamy and Beta methods are simpler, but the Kumaraswamy distribution has some implementation problems as moment matching for these distributions requires complex numerical solving of a two-dimensional optimisation problem. For Beta distributions, moment matching is straightforward which makes for the least complicated (yet most accurate) and implementable distribution (Tasche, 2008: 4). The use of the Beta distribution is not new: it has also been used in the Basel II formulation of AIRB securitisation exposure calculation (BCBS, 2006a:140). The Beta distribution is, in addition, characterised by only two parameters, α and β which are obtained from parameters which are easily measured, namely the mean and standard deviation of underlying empirical losses. The goodness of fit of the Beta distribution to the underlying loss data was consistently confirmed for all retail classes in this study. This is an important characteristic as it enables any bank to apply the capital calculation methodology introduced in this chapter.

The Beta distribution was therefore chosen as the preferred distribution for estimating empirical retail asset correlations for this study.

Calculating these two values from loss data, α and β may be obtained as follows (Wolfram Research, 2009):

$$\alpha = \mu \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right) \tag{3.8}$$

$$\beta = (1-\mu) \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right) \tag{3.9}$$

Where:

- μ = the mean gross loss, and
- σ = the standard deviation of the gross losses.

With α and β calculated (in Equations 3.8 and 3.9) for all the used asset types and the following probability density function for a Beta distribution (Wolfram Research, 2009):

$$P(x) = \frac{\int_0^x (1-t)^{\beta-1} \cdot t^{\alpha-1} dt}{\mathrm{B}(\alpha,\beta)} = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\cdot\Gamma(\beta)} \cdot \int_0^x (1-t)^{\beta-1} \cdot t^{\alpha-1} dt \qquad 1 \geq x \geq 0, \quad \alpha,\beta > 0 \tag{3.10}$$

Where:

- x = the distribution variable, and
- Γ = the standard Gamma function evaluated at the relevant parameters;
- the total amount of losses are equal to x where $P(x)$ equals 99.9% and
- B(α,β) = the incomplete Beta function a generalisation of the Beta function and is defined by:

$$B(x;\alpha,\beta) = \int_0^x (1-t)^{\beta-1} \cdot t^{a-1} dt \qquad \alpha,\beta > 0 \tag{3.11}$$

The empirical loss data were fitted to the Beta distribution using the parameters defined by Equations 3.8 and 3.3 and the definitions of μ and σ introduced above.

The total loss can be calculated as the value of x when $P(x)$ = 99.9% as per Basel II's definition of the conservative value of the systematic risk factor.

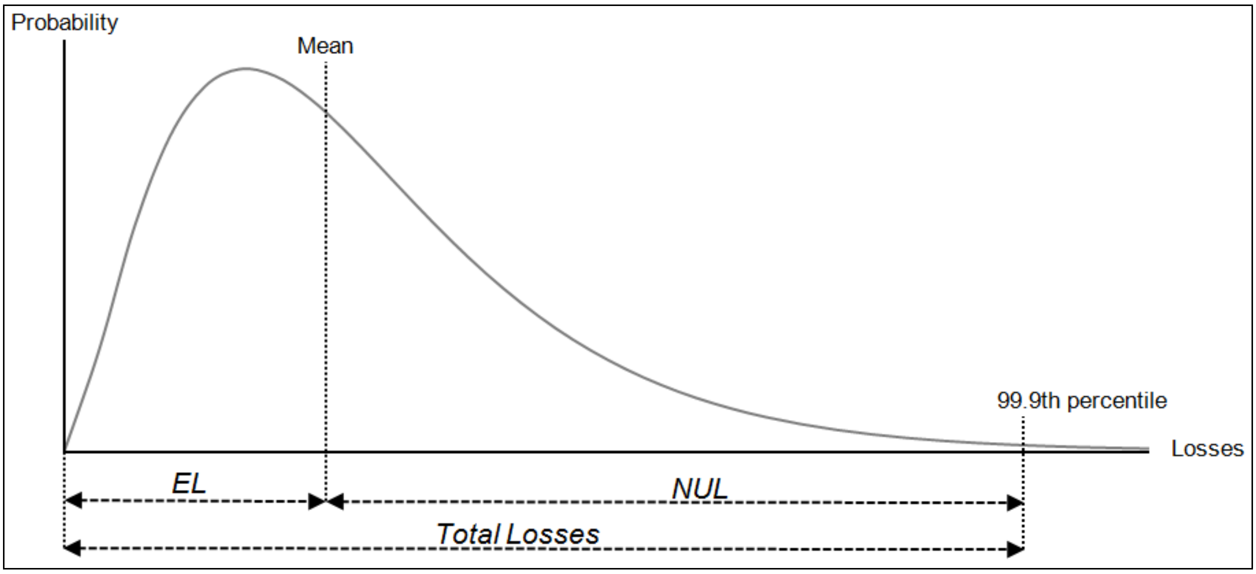
The *Net Unexpected Loss* (NUL)[26] is now introduced and is defined as follows:

$$NUL = \text{Total Loss} - \text{Expected Loss} \tag{3.12}$$

The NUL is illustrated in Figure 3.1 below. The NUL is used in the investigation of the empirical asset correlations later. In order to better understand to what the concepts NUL, EL and Total losses refer, these are displayed in Figure 3.1.

26 This chapter refers to a Net Unexpected Loss instead of an UL as the data used were net losses (and thus these losses do not take the LGD into account in the initial calculation). The application of the LGD is applied in the final step to determine the capital charge.

Figure 3.1: Different losses (NUL, EL and Total losses)



Source: Author

3.4.3 Extracting the empirical asset correlation from loss data

Extracting the empirical asset correlation from loss data is the key step introduced in this chapter. Equation 3.13 is used to determine the asset correlation as defined by Basel II for the different retail asset types. In this crucial Basel II equation, ρ represents the asset correlation: the key unknown element to be determined.

$$NUL = N\left(\frac{N^{-1}(PD) + \sqrt{\rho} \times N^{-1}(0.999)}{\sqrt{1-\rho}}\right) - PD \tag{3.13}$$

$$NUL + PD = N\left(\frac{N^{-1}(PD) + \sqrt{\rho} \times N^{-1}(0.999)}{\sqrt{1-\rho}}\right)$$

$$N^{-1}(NUL + PD) = \frac{N^{-1}(PD) + \sqrt{\rho} \times N^{-1}(0.999)}{\sqrt{1-\rho}}$$

$$N^{-1}(NUL + PD) \times \sqrt{1-\rho} = N^{-1}(PD) + \sqrt{\rho} \times N^{-1}(0.999) \tag{3.14}$$

Squaring both sides of Equation 3.14:

$$\left[N^{-1}(NUL + PD)\right]^2 \times (1-\rho) = \left[N^{-1}(PD)\right]^2 + 2N^{-1}(PD) \times \sqrt{\rho} \times N^{-1}(0.999) + \rho\left[N^{-1}(0.999)\right]^2 \tag{3.15}$$

Setting: $x = N^{-1}(0.999)$

$y = N^{-1}(PD)$ and

$z = N^{-1}(NUL + PD)$

Substituting into Equation 3.15:

$$z^2 \times (1-\rho) = y^2 + 2y \times \sqrt{\rho} \times x + x^2\rho$$

$$z^2 - z^2\rho = y^2 + 2y \times \sqrt{\rho} \times x + x^2\rho$$

$$z^2 - z^2\rho = y^2 + 2xy\sqrt{\rho} + x^2\rho \qquad (3.16)$$

$$-z^2 + z^2\rho + y^2 + 2xy\sqrt{\rho} + x^2\rho = 0$$

$$(z^2 + x^2)\rho + 2xy\sqrt{\rho} + (y^2 - z^2) = 0$$

This is a quadratic in $\sqrt{\rho}$ with solutions:

$$\sqrt{\rho} : \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad (3.17)$$

Where:

$$a = z^2 + x^2$$

$$b = 2xy \qquad (3.18)$$

$c = y^2 - z^2$ so

$$\sqrt{\rho} : \frac{-2xy \pm \sqrt{(2xy^2) - 4(z^2 + x^2)(y^2 - z^2)}}{2(z^2 + x^2)} \quad \text{or}$$

$$\rho = \left[\frac{-2xy \pm \sqrt{(2xy^2) - 4(z^2 + x^2)(y^2 - z^2)}}{2(z^2 + x^2)} \right]^2 \qquad (3.19)$$

Since the components of x, y and z are known these are then substituted into Equation 3.19 to calculate ρ which represents asset correlation.

There will always be two values for ρ when solving Equation 3.19. However, only one of these values can be the 'correct' asset correlation value. The two possible correlations were derived from the actual Basel II Equation 3.14 to calculate the NUL and, having calculated both, these values were substituted into the Basel II equation for NUL.

If the NUL derived from the Basel II equation matches the NUL derived from the Beta distribution, this is taken as the 'correct' asset correlation value. The 'other' asset correlation value, for each of the asset types, resulted in unrealistically high capital charges (> 20%) which do not make economic sense in the Basel capital framework (Güttler and Liedtke, 2007: 3).

3.4.4 Using the empirical asset correlation to calculate economic capital

The empirical asset correlation extracted from empirical loss data (as explained in the previous section) is used to calculate the fair level of economic capital to be held by banks. To demonstrate this calculation method, this study compares the asset correlation provided by the Basel II framework with the empirically extracted asset correlations. A wide range of retail portfolios was used in this chapter to demonstrate the difference between Basel II and empirical asset correlations.

3.4.4.1 Data

In order to demonstrate the calculation of economic capital derived from empirical asset correlation, historical net loss empirical data were obtained from the US Federal Reserve Bank (FED, 2009).

These data span some 24 years (i.e. Q1 1985 to Q12009) and were compiled from the quarterly Federal Financial Institutions Examination Council Consolidated Reports of Condition and Income (data for each calendar quarter become available approximately 60 days after quarter end). The data span the turbulent early and late 90s, the benign credit conditions which characterised the 2003 – 2008 period as well as the recent downturn in the credit environment leading to the 'credit crunch' which began in mid 2007 (which became known as the *Financial or Credit crisis* in 2008) and has yet to run its course. Charge-offs (the values of loans and leases removed from the books and charged against loss reserves) from the 100 largest US banks are measured by consolidated foreign and domestic assets. The US Federal Reserve uses annualised charge-off rates, net of recoveries and outstanding as of quarter-end. The charge-off rates are calculated from data available in the Report of Condition and Income (Call Report), filed each quarter by all commercial banks. Charge-off rates for any category of loan are defined as the flow of a bank's net charge-offs (gross charge-offs – recoveries) during a quarter divided by the average level of its loans outstanding over that quarter. These ratios are multiplied by 400 to express them as annual percentage rates (FED, 2009).

From these data the empirical asset correlation is extracted and then compared with the asset correlation *prescribed* by Basel II. The different asset correlations are then applied to the Basel II prescribed capital calculation equations to ascertain the fair level of economic capital. This study acknowledges that the result of the specific set of loss data does not necessarily reflect the accuracy of Basel II's prescribed asset correlation; however, the methodology can be applied to any set of retail loss data to extract the empirical asset correlation for use in economic capital calculations.

In comparing the Basel II and empirical asset correlations, this section investigates whether any differences between Basel II prescribed asset correlations and empirically observed asset correlations exist.

Data for eight different asset types were available with at least one asset type in each of the four Basel II categories for retail credit exposures namely: residential mortgages, qualifying revolving, high volatility commercial real estate and other retail exposures. The different asset types used are summarised in Table 3.1 below.

Table 3.1: Asset types for which loss data were available and corresponding Basel II classification

Asset type	*Basel II classification*
Single family residential mortgages	Residential Mortgages
Credit card loans	Qualifying Revolving exposures
Commercial real estate loans	High Volatility Commercial Real Estate
Business loans	Other retail exposures
Lease financing receivables	
Loans secured by real estate	
Consumer loans	
Other consumer loans	

Source: Author

US data were used as they were the only available, reliable data for such a long period for all the individual asset types. Furthermore, the current credit crisis (2009) originated in the US credit retail market and therefore these are the most relevant data to explore.[27]

As mentioned in Section 3.4.2, the Beta distribution is suitable for the purposes of this study as it has been acclaimed by practitioners such as Tasche (2008:4) as well as the BCBS (2006a:140) and also proven by this study. These theoretical reviews of Beta distributions were statistically tested (see Appendix I) and it was found to be statistically ranked the overall best fit using the Kolmogorov-Smirnov, Anderson-Darling and Chi-Squared tests. A summary of these fitting results per individual asset type are provided in Table 3.2 (a to h). Also, see Appendix II for the Beta fitting graphs, illustrating the cumulative probability distribution (CDF) function and probability density function (PDF).[28]

[27] Although the US will only fully implement Basel II in 2010, this does not prevent applying the ideas of this chapter to these data.

[28] For a discrete random variable, the PDF at a certain value is the probability that the random variable will have that value. For a continuous random variable, the probability density function is represented by a curve in such a way that the area under the curve between two numbers is the probability that the random variable is between those numbers. The CDF evaluated at a number x, describes the probability that a variable takes on a value less than or equal to x (Brown, 2005).

Table 3.2 (a-h): Goodness of fitting results for each of individual asset types for which loss data were available

a) Single family residential mortgages

Fitting Results		
Rank	*Distribution*	*Parameters*
1	Beta	a_1=0.16403 a_2=1.3287
		a=0.3 b=9.757
2	Log-Logistic (3P)	a=1.6836 b=0.39028 g=0.29088
3	Frechet	a=1.7537 b=0.55983

Summary							
Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07585	2	0.44877	1	3.9584	1
2	Log-Logistic (3P)	0.06971	1	0.58541	6	4.6224	3
3	Frechet (3P)	0.07803	4	0.54084	4	4.749	6

b) Credit cards

Fitting Results		
Rank	*Distribution*	*Parameters*
1	Beta	a_1=6.5315 a_2=33.985
		a=1.7492 b=28.555
2	Nakagami	m=3.7524 W=39.196
3	Burr (4P)	k=6.5391 a=2.8183
		b=7.752 g=2.3858

Summary							
Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06666	1	0.73394	5	2.2283	1
2	Nakagami	0.08186	5	0.7688	9	7.4602	7
3	Burr (4P)	0.08301	7	0.7328	4	8.7255	13

c) Commercial real estate

Fitting Results		
Rank	*Distribution*	*Parameters*
1	Beta	a_1=0.28827 a_2=0.81
		a=-7.8816E-15 b=8.41
2	Frechet	a=0.75406 b=0.26264
3	Pearson 5	a=0.66295 b=0.14586

Summary							
Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07986	1	2.6953	2	4.8467	3
2	Frechet	0.0826	4	2.6576	1	5.9044	10
3	Pearson 5	0.0811	2	2.7657	7	5.6134	6

d) Business loans

Fitting Results		
Rank	*Distribution*	*Parameters*
1	Beta	a_1=0.99801 a_2=1.9721
		a=0.23 b=4.8464
2	Johnson SB	g=0.53685 d=0.86597
		l=4.9533 x=-0.09346
3	Dagum	k=0.14322 a=8.1713 b=3.2594

Summary							
Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07637	3	0.94906	1	8.9241	3
2	Johnson SB	0.07658	4	1.0035	2	9.6924	4
3	Dagum	0.10292	8	1.3568	4	7.7197	2

e) Lease financing receivables

Fitting Results		
Rank	*Distribution*	*Parameters*
1	Beta	a1=1.7917 a2=5.9455
		a=0.04394 b=2.8667
2	Gen. Gamma	k=0.96612 a=2.9741 b=0.22432
3	Dagum (4P)	k=0.14409 a=7.3519

Summary							
Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06212	3	0.46397	1	6.3747	2
2	Gen. Gamma (4P)	0.05918	1	0.48145	2	9.5403	24
3	Dagum (4P)	0.07133	12	0.53953	6	8.6416	14

g) Consumer loans

Fitting Results		
Rank	*Distribution*	*Parameters*

1	Beta	a_1=3.8069 a_2=3.1948E+6
		a=0.88405 b=1.2140E+6
2	Inv. Gaussian	l=22.646 m=2.3299
3	Fatigue Life (3P)	a=0.37679 b=1.8203 g=0.38041

Summary

Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06286	1	0.4082	1	4.5918	3
2	Inv. Gaussian	0.07149	4	0.51551	3	7.5844	12
3	Fatigue Life	0.08083	23	0.52034	4	5.6529	6

h) Other consumer loans

Fitting Results

Rank	*Distribution*	*Parameters*
1	Beta	a_1=2.4593 a_2=5.9691E+6
		a=0.59996 b=2.2560E+6
2	Log-Logistic (3P)	a=3.7133 b=1.0242 g=0.37291
3	Dagum (4P)	k=0.50616 a=3.5854

Summary

Rank	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.04547	1	0.24218	1	2.092	2
2	Log-Logistic (3P)	0.04685	2	0.28838	3	2.0464	1
3	Dagum	0.0483	3	0.28525	2	4.4402	12

With the aspects regarding the data employed introduced above, the discussion about comparing the Basel II and empirical correlations follows in the next section.

3.4.4.2 Comparing Basel and Empirical correlations

Modelling and estimating retail asset correlation remains a daunting challenge and a debatable issue. The best method has not yet been determined by consensus (Lando and Nielsen, 2008:2).

In the previous section, the data used in the process of calculating the empirical asset correlation were discussed. The empirical retail asset correlation results for the different asset classes (derived from the data in the previous section) are discussed in this section. The impact of the different, calculated asset correlation values on regulatory capital is also investigated.

By using loss data it was possible to calculate the empirical asset correlation values for each of the eight asset classes and compare these with those prescribed by Basel II. Statistical analysis was used to compare the difference in asset correlations. The empirical asset correlation is significantly different from the Basel II specified correlation. These differences are significant at the 5% and 1% levels. These statistical findings are summarised in Table 3.3 below.

Table 3.3: Summarising the statistical differences between Basel II and empirical correlations

Significance level	1%	5%
t-stat	-2.58	-1.96

	Single family residential mortgages	Credit card loans	Commercial real estate loans	Business loans	Lease financing receivables	Loans secured by real estate	Consumer loans	Other consumer loans
Observations	79	93	79	93	93	93	93	93
Calculated correlation	4.29%	1.38%	19.18%	4.64%	3.53%	6.95%	1.38%	1.43%
Basel stated correlation	15.00%	4.00%	20.72%	10.05%	12.07%	13.09%	5.67%	9.14%
St Dev	0.11%	1.04%	0.69%	0.52%	0.29%	0.32%	0.57%	0.32%
t-statistic	-862.4	-24.3	-19.9	-100.6	-287.1	-183.4	-73.2	-234.3
p-statistic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Source: Author

The two different sets of correlations are shown in Table 3.4 and Figure 3.3 below. These empirical results clearly indicate that the fixed correlation values specified by Basel are considerably higher than those experienced in the market. On average, the Basel retail asset correlation, for the period of 1985 to 2008, was on average, 3.2 times larger than those derived empirically (i.e. actually experienced) by banks.

Table 3.4: Summarising the Basel II and empirical correlations

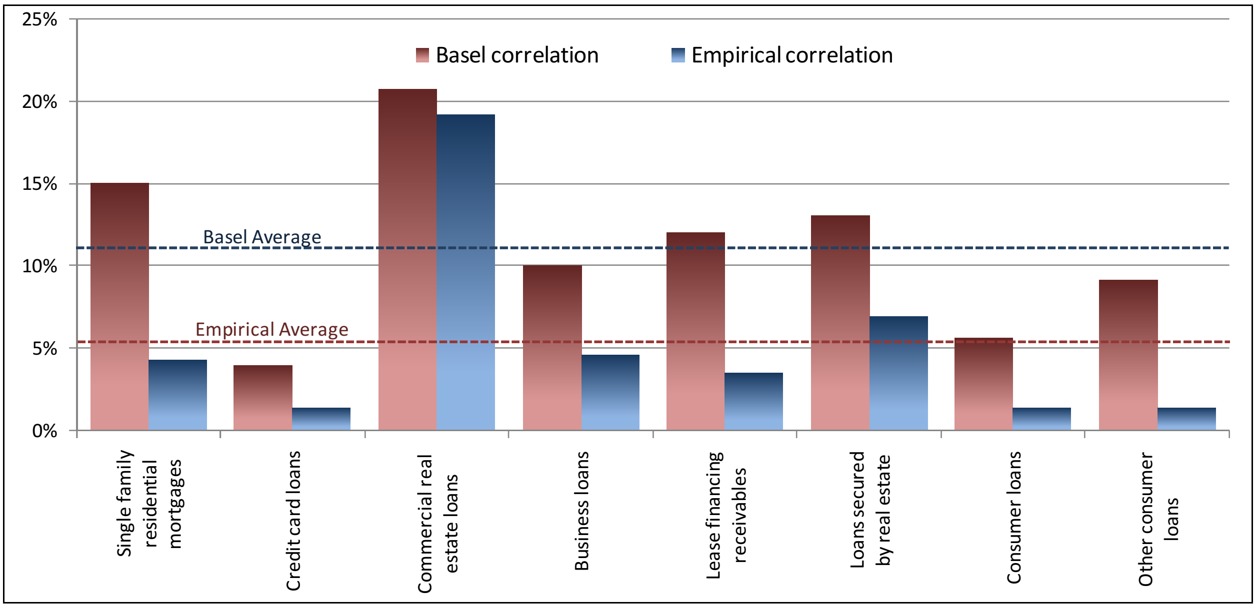
1985-2008	Basel II correlation	Empirical correlation	Ratio a:b
Single family residential mortgages	15.0%	4.3%	3.5
Credit card loans	4.0%	1.4%	2.9
Commercial real estate loans	20.7%	19.2%	1.1
Business loans	10.0%	4.6%	2.2
Lease financing receivables	12.1%	3.5%	3.4
Loans secured by real estate	13.1%	6.9%	1.9
Consumer loans	5.7%	1.4%	4.1
Other consumer loans	9.1%	1.4%	6.4

Source: Author

Note that these results were obtained using Federal Reserve loan loss data and are thus only representative of US retail loans since 1985. The methodology that was used to extract these empirical correlations is applicable to *any* data set of loan losses.

Even though the results derived from these data do not imply that Basel II correlations are consistently higher (see Figure 3.2 below) than empirically extracted asset correlations, the fact that for these data, Basel II's asset correlations were consistently higher (on average 3.2 times more) indicates that this is an important deviation and a factor that requires further investigation.

Figure 3.2: Basel II vs. Empirically extracted correlations - vertical axis=asset correlation; horizontal axis= retail asset class



Source: Author

Under the AIRB approach, Basel II allows banks to calculate inputs to the provided equation for capital calculation. However, two factors are implicitly given by the Basel formula, the confidence interval of 99.9% and asset correlation (Altman & Sabato, 2005:22).

Leighton (2006) asserted that the asset correlation is a critical factor and the biggest single driving factor of Basel II. In addition some academics and risk managers claim that Basel II correlations are overly conservative and could lead to higher capital charges (Gore, 2006). However, in the light of ongoing (2009) credit crisis (elaborated upon in Chapter 4) some participants in the global financial sector raised concerns about the levels of capital required by Basel II and requested a more conservative approach (Griffin, 2008), indeed, Basel II has even been criticised for *causing* the credit crisis (as the average level of capital required by the new discipline is inadequate and this is one of the reasons of the recent collapse of many banks (Cannata & Quagliariello, 2009:6)).

With this difference in opinion about the capital charge, banks can use the methodology introduced here to determine which of the above views apply to their unique situation. However, knowing the empirical level of asset correlation only does not indicate the amount of capital a bank needs to protect it against the risks faced by the bank. The next section therefore explores the impact of different levels of asset correlations on capital requirements.

3.4.4.3 Using asset correlation to calculate the capital requirement

When using the prescribed Basel II equation in estimating the regulatory capital for credit risk, changing correlation assumptions has a significant impact on required capital (Wood, 2008:32). Using the methodology introduced in this chapter, the impact of asset correlation on capital can be empirically determined. By inserting the asset correlations (both Basel II specified and empirical) into the Basel II equations, the different capital charges may now be calculated. Using Equation 3.13 the capital charge for retail loans types as indicated below.[29]

[29] The capital charge was based on an exposure at default of US$1million for each retail asset type.

Table 3.5: Capital charge using Basel II vs. empirical asset correlation

1985-2008	Capital charge using **Basel II** correlations	Capital charge using **empirical** correlations
Average	**63,588**	**23,207**
Single family residential mortgages	23,702	39,135
Credit card loans	105,368	39,135
Commercial real estate loans	72,726	49,727
Business loans	64,443	25,075
Lease financing receivables	53,353	13,610
Loans secured by real estate	45,423	18,371
Consumer loans	75,781	21,597
Other consumer loans	67,911	12,593

Source: Author

These differences in the capital charges indicate that asset correlation (which was the only different input into the results above) have a considerable impact on capital charges. For the loan loss data (discussed extensively in Chapter 5) used, the Basel II asset correlations were found to be extremely conservative. The methodology introduced above could be used as a reference for future research for the way in which empirical asset correlations change in severely adverse economic conditions. More importantly, any bank may employ this methodology to extract empirical asset correlations from their empirical loss data. The empirical asset correlations can then be applied to the Basel II equations to calculate the fair level of economic capital to be held by banks.

The methodology to be applied by banks is discussed in the next section.

3.5 Application of the methodology

The previous sections of this chapter explained the Basel II requirements for calculating regulatory capital which refers to the minimum capital required by the regulator to maintain an adequate level of liquidity based on the bank's credit exposures.

More importantly, this chapter introduced a methodology to extract empirical asset correlations from empirical loss data which may be applied to the Basel II equations to calculate the fair level of economic capital to be held by banks. As stated in Chapter 1, economic capital can be defined as the amount of capital a bank needs to cover losses arising from the unique risk exposure at a specific confidence level. This capital requirement is calculated based on the bank's own dynamic, internal measures, not prescribed by any external parties (Smithson, 2008). By definition, the determination of economic capital is *proprietary*: banks are understandably unwilling to share processes, procedures and methodologies that may provide them with a competitive edge. In order for banks obtain such a competitive edge, the introduced methodology can be applied to their own empirical loss data which will enable them to calculate a fair level of economic capital. Applying the methodology introduced in the sections above is summarised as a 12 step process which may be employed by banks to calculate their own economic capital for retail asset types.

Step 1: *Understand the rules*

Banks need to determine the exact local and global requirements. Local regulators use national discretionary rules in addition to Basel II and banks need to know precisely what these discretionary rules are. Banks also need to remain up to date with global requirements as Basel II may change requirements (such as asset correlations) at any time, depending on industry response and whether economic conditions require it to do so. Banks should therefore always examine the most updated version of Basel II for asset correlation requirements.

Step 2: *Determine capital charges for each loan type*

Determine the individual capital charge for each loan type using the correlations specified by Basel II (using Equation 3.13). This step involves simply calculating the regulatory capital charge as prescribed by Basel II. This value will later be used to compare with the empirically extracted asset correlation.

Step 3: *Gather data*

Obtain loan loss data for each category of loan type. This study employed historical net loss empirical data measured on a quarterly basis.

Step 4: *Calculate the mean and standard deviation of loan loss data*

The mean (μ) and standard deviation (σ) of loan losses using standard statistical techniques should be determined.

Step 5: *Calculate Alpha (α) and Beta (β)*

The only inputs required for calculating α (Equation 3.8) and β (Equation 3.9) are μ and σ which are easily obtainable from loss data.

Step 6: *Generate the Beta distribution*

A Beta distribution for the loan loss data is then generated. The Beta distribution is easy to apply and effective for this analysis.

Step 7: *Calculate the loan loss value at the correct confidence interval*

The inverse Beta function (*BETAINV* in Microsoft Excel) allows the user to estimate a value at which 0.1% of loan losses exceed this value (in other words, at which point 99.9% of loan losses are less than this value) – this is the total loss at 99.9% confidence interval.

Step 8: *Calculate the Expected Loss (EL)*

The average PD is the *expected* loss. Knowing μ (i.e. average PD) from Step 4, this is the EL.

Step 9: *Calculate the Net Unexpected loss (NUL)*

The NUL can simply be calculated by subtracting the EL from the total loss (value obtained in Step 8 subtracted from the value obtained in Step 7).

Step10: *Calculate the empirical correlation (ρ)*

Apply the NUL and Equations 3.16, 3.17 and 3.18 into Equation 3.18 and calculate ρ. This is the empirically extracted asset correlation.

Step 11: *Using ρ to calculate the fair level of economic capital*

Use ρ extracted in Step 10 to determine the fair levels of capital to be held for each retail loan class. In this step, the empirical ρ (from Step 10) is simply applied to the prescribed Basel II (Equation 3.13) instead of Basel II prescribed correlations used in Step 2. The values obtained in this step can therefore be seen as the fair levels of economic capital to be held by banks.

Step 12: *Using different capital charges.*

The capital charges obtained in Step 2 and 11 can be compared to determine if the capital charge prescribed by Basel II is too punitive or too lenient for the bank analysed.

This methodology represents the main contribution of this chapter as it is a new application that banks may apply not only extract empirical asset correlations from their loss data, but more importantly to calculate the fair level of economic capital that should be held to protect them against the credit risk faced in different retail asset classes.

3.6 Conclusion

The primary purpose of this study is to introduce calculation methodologies which will allow all banks to empirically determine their own unique parameters from their own loss experiences. Knowing these empirical values will allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed in line with their own experiences. Banks applying the methodologies introduced in this study is able to calculate fair levels of economic capital which is sufficient to cover losses arising from specifically credit and market risks faced by banks.

If banks find that the fixed BCBS parameters are too lenient, they can choose to raise levels of economic capital reserves appropriately. However, if these parameters are or too onerous, banks can judge for themselves whether or not current economic conditions warrant such severe levels of capital. In either case, banks using the suggested methodologies is able to establish their unique, empirical capital requirements without blind acceptance of obscured parameters in the capital calculations of Basel II. This chapter introduced a calculation methodology specifically for credit risk and more specifically for capital calculation under the AIRB approach (in which banks may decide on and use all their own parameters, but must still use BCBS specified capital formulas).

When modelling the risks to which banks are exposed there are numerous different *scientific* elements that should be considered and investigated in order to model the risks effectively (Currie, 2004:9). Asset correlation was the scientific credit risk element explored in this chapter.

This chapter comprised three main sections. The first section presented a literature study which covered the relevant credit risk definitions and concepts and focused specifically on the capital calculation framework prescribed by Basel II. As this chapter investigated asset correlations and their impact on credit risk capital charges, a thorough description of this topic was required in order to contextualise the subject and draw accurate conclusions on this topic.

Section 2 used the literature discussed in Section 1 and introduced a methodology for extracting empirical asset correlations using empirical data. Retail credit loss data for the last 22 years, sourced directly from US banks, was used in this chapter. Retail credit was specifically investigated as this loan type has not received as much attention from industry and regulatory resources as (e.g.) corporate lending. The data were then employed in the calculation methods prescribed by Basel II (introduced in Section 1) to also calculate the capital charge for credit risk.

In Section 3, the methodology introduced in Section 2 was summarised into an application section which may be employed by banks to extract the empirical asset correlation from a set of empirical retail loss data. Banks can use these derived asset correlations to calculate fair levels of economic capital (using the Basel II equations for credit risk). Section 3 also presented a summary of the results which indicated that the required regulatory capital is roughly three times higher than estimated economic capital, reflecting a high – perhaps even punitive – measure of conservatism imposed by Basel II. This finding is, however, reflective of the specific data used and results will vary with each different set of data. A comprehensive discussion about the results obtained from the set of US loan loss data follows in Chapter 5.

With a calculation methodology introduced for credit risk in this chapter, the next chapter extends the investigation beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book). Chapter 4 introduces a calculation methodology which, similar to the methodology introduced in this chapter, can be applied by any bank; however, while this chapter provided a methodology to determine empirical asset correlation, Chapter 4 provides a methodology that will enable banks to determine the empirical *holding period* for credit instruments in the trading book. The empirical holding period may then be employed to calculate a fair level of capital to be held for the trading book, based on the bank's own unique trading book exposures.

Chapter 4

Fair trading book capital using empirical unwind periods

Banks' failure to align Incremental Default Risk guidelines with existing market risk capital rules could have a detrimental effect (Benyon, 2007).

4.1 Introduction

The main purpose of this study is to introduce methodologies which can be used to empirically estimate some of the fixed – yet unclear – variables present in Basel II's equations. The methodologies derived could allow banks to empirically determine their own unique parameters from their own unique loss experiences. The empirically-calculated values will allow banks to determine whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed correct. The methodologies introduced in this chapter may be employed by banks, irrespective of their size and complexity, to determine a fair level of economic capital specifically for the trading book (traditionally dominated by market risk).

Banks use economic capital for risk-based pricing (e.g. for credit securities in their trading book). At many banks, the price includes the cost of the economic capital required (Dvorak, 2005:14). If the capital charge prescribed by Basel II is too lenient, banks can increase economic capital reserves appropriately and if it is too onerous, banks can judge for themselves whether or not prevailing economic conditions warrant such capital requirement severity. In either case, banks using the suggested methodologies is able to establish precisely their unique, *empirical* capital requirements without blind acceptance of obscured parameters in the capital calculations of Basel II. Even though the regulatory capital cannot be altered, banks can and do use economic capital in decision making.

Using actual loan loss data (Chapter 3), regulatory credit risk capital has been shown to be approximately three times higher than empirical economic credit risk capital reflecting a high – perhaps even punitive – measure of conservatism imposed by Basel II. This finding is, however, reflective of the specific dataset used and results will vary with different data. This chapter extends the investigation beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book).

The investigation into – and modelling of – bank risks through empirical loss data embraces many 'scientific elements' (Currie, 2004:9). In the previous chapter, asset correlation was explored as the scientific element of credit risk models. This chapter investigates incremental default risk (IDR) which represents the credit risk present in the trading book. More specifically, the scientific element in this chapter is the length of time required to unwind a financial position (the 'holding period') without materially affecting underlying asset prices. This is one of the very few components of contemporary risk models which may be altered subject at the practitioner's whim. Most other constituents are *calculated* and hence manipulation of their values is more difficult. Estimating accurate, empirical holding periods allows economic capital for market risk to be fairly allocated in contrast to regulatory capital which imposes fixed holding periods for different loan classes.

This chapter introduces a calculation methodology, which may be applied by any bank, to determine the empirical holding period for credit-risky instruments in the trading book. The empirical holding period may then be employed to calculate a fair level of capital to be held for the trading book, based on the bank's own unique trading book exposures.

4.2 Chapter layout

This chapter comprises three main sections. A literature study (which covers all the relevant trading book concepts and developments) is first presented. This section also introduces and discusses credit risk embedded in the trading book, a relatively new development in the Basel framework. A thorough description about this topic is required to make a proper analysis and develop an accurate methodology for capital calculations.

The next section introduces the background mathematics regarding the methodology as well as an exploration of the required parameters. This section also applies the mathematics to a specific set of vanilla bond[30] data. The properties of the underlying data are described in detail as well as the modelling procedures and evidence for the assumptions used in the calculations.

Section 3 summarises the methodology introduced in Section 2 and presents a step by step application process which can be used by any bank to calculate its own empirical holding period for trading book credit exposures (based on empirical data). This empirical holding period for credit risky instruments in the trading book is an important value as it could be of strategic interest to banks who wish to determine fair levels of economic capital for market risk.

4.3 Literature study

This literature study covers a wide variety of concepts, definitions and developments needed to comprehend the methodology presented in this chapter. This section first establishes the definition of market risk within the context of Basel II and then provides a brief history of this risk type from its origin in 1993 to contemporary analytical techniques which are now used to describe and measure it. Since market risk was introduced 1993, the BCBS has made a distinction between trading and banking book activities and has required banks to hold different regulatory capital for these books (BCBS, 1993:5). This, as well a brief history of market risk, is discussed in this chapter.

As this chapter essentially investigates fair levels economic capital for market risk, the concepts of capital requirements are also investigated in this section followed by a theoretical overview of Value at Risk

[30] The reason vanilla bonds were chosen as the "credit risky instruments" in this study was their simplicity.

(VaR) – the most important (and by far the most widely used) measure of market risk (Hartz *et al*, 2006:2295).

This section also covers other important concepts needed to understand and implement methodology introduced in this chapter. These concepts include, the Specific Risk Charge, calculating the market risk charge under Basel II, regulatory criteria for good and bad models as well as the different approaches (from Basel I to II) for calculating *credit risk* in the trading book.

As there have been several developments which impact the regulatory capital charge for market risk since the onset of the credit crunch (which began in 2007), this literature study also discusses credit risk in the trading book before the credit crisis (also referred to as the 'credit crunch' in this study) as well as the credit crunch itself. This is important as the crisis has had considerable impact on the BCBS's proposed capital calculation methods. As a direct result of the credit crunch, the BCBS introduced the Incremental Default Risk (IDR) as part of a proposed Basel II amendment in November 2008. Industry responses to this concept as well as the potential consequences of regulatory changes it will incur is discussed in this chapter. IDR is a critical concept that must be understood in order to follow the methodology to of estimating the empirical holding period, which allows fair, empirical allocation of economic capital for the trading book.

4.4 Definition of market risk

Interrelated economic and political events drive price movements of all securities, including interest rates, exchange rates, commodities and share prices on a daily basis. The IMF (2004:169) defines market risk as the risk of potential losses on financial instruments which arise from these movements in market prices. Variations in value have an effect on the income and capital of individuals and institutions that take positions in these financial instruments. The BCBS (2005a:1) defines market risk as the risk of losses in on and off-balance sheet positions arising from movements in market prices. This includes all risks exposed to interest rate related instruments and equities in bank trading books (which is defined in the next section) as well as foreign exchange risk and commodities risk throughout the bank.

Market risk has a direct effect on capital and return and has thus always been a primary concern for financial market participants (Van de Venter, 2000:2). Regulators also have a particular interest in this risk type which is an important element in the overall financial health of the banks they regulate. Market participants' exposure to market risk is rooted in the probability of an unfavourable movement in the price of an underlying asset. The fundamental measurement technique for this risk type is therefore is based on the volatility of the underlying asset's price. Being the essence behind trading in financial assets, volatility is the most basic statistical risk measure for traded assets as it measures the relative price changes (i.e. the returns) of a single asset or portfolio of assets (Van de Venter, 2000:2).

Measuring the price stability is, however, a complicated activity. The first element of complexity lies in the fact that risk – which drives instability – is determined by infinite possibilities of random events in the world. It is therefore impossible to measure it as single number with no uncertainty. To answer the question 'what is the maximal loss that can be suffered over a specific time horizon?' the only honest and accurate answer is that 'everything can be lost' **(**Wiener, 1997:4**).** However, as the probability of losing everything is very small, the 'very small' must be quantified as accurately as possible. The market risk exposure of a traded asset is derived directly from its volatility, so risk managers have the challenge of estimating volatility and therefore attempt to accurately calculate market risk exposure. The most popular and widely accepted technique to estimate market risk is Value at Risk (VaR) (Van de Venter, 2000:2) and one of VaR's key inputs is the volatility of the underlying portfolio.[31] A detailed discussion of VaR follows later in this literature study. The next section introduces the history of market risk and then distinguishes between the banking and trading books.

4.4.1 A brief history of market risk

In April 1993, the BCBS released a document which dealt explicitly with the regulatory treatment of market risks (BCBS, 1995:1). This was issued for comment by financial participants in the market and was an important improvement on the 1988 Basel Capital Adequacy Accord, which focussed primarily on credit risks and largely ignored market risk (Khindanova & Rachev, 1999:2).

The document formed a regulatory backbone which sets out the original framework requiring banks to set aside capital for the market risks to which they were exposed. The use of a standardised methodology for market risk management was investigated and served as a foundation for applying capital charges to a bank’s open market positions. In the industry responses that followed, some concerns (which the BCBS considered important) surfaced. In brief, the most important comments were that the proposals:

- did not recognise the most accurate risk measurement methodology and hence did not offer adequate incentives to improve market risk management models and
- did not sufficiently incentivise risk diversification as the correlations and portfolio effects across markets and instruments were largely ignored.

In addition, the proposals were too difficult to implement as they did not seem to be compatible with banks' internal measurement systems and that their own risk management methodologies calculated more accurate market risk estimates without any additional cost proposed by the BCBS (1995:1).

To address these problems, the Group of Thirty[32] supported and promoted an approach to measuring market risk in a study called: 'Derivatives: Practices and Principles' in July 1993. This approach was the pre-

[31] VaR may be calculated using one of three different methods: the Variance-Covariance, Monte Carlo and Historical techniques. The historical method does not employ any assumptions regarding the volatility of the underlying portfolio constituents but the Variance-Covariance and Monte Carlo methods do.

[32] Established in 1978, the Group of Thirty is a private, non-profit, international body composed of senior representatives of the private and public sectors and academia. It aims to deepen understanding of international economic and financial issues, to explore the international repercussions of decisions taken in the public and private sectors, and to examine the choices available to market practitioners and policymakers.

cursor to modern VaR approaches.[33] During this prominent year for market risk, the European Union further strengthened the thoughts about market risk by instructing the setting of capital reserves to balance market risks in the Capital Adequacy Directive 'EEC 6-93' (Khindanova & Rachev, 1999:2). A more modern VaR description was developed by JP Morgan in the early 1990s to assess portfolio risk (JP Morgan/Reuters, 1996: iii). The VaR methodology was then introduced beyond Wall Street during October 1994 after its creators started to circulate specific VaR calculations on the internet. The JP Morgan methodology, known as *RiskMetrics*, evolved into the foremost standard for the international VaR description and measurement.

Due to the efficiency and wide industry acceptance of the VaR methodology, the BIS advised the disclosure of VaR numbers in a discussion paper on public disclosure of market and credit risks by financial intermediaries (also known as the Fisher report) in 1994. Discussions and new initiatives which were focussed on internal risk management became very prominent in market risk discussions and was one of the key drivers behind the *Supervisory Treatment of Market Risks* issued jointly by the BCBS and the IOSCO[34] Technical Committee in May 1995 (BCBS, 1995:1). This proposal by the BCBS asserted that banks could use their own internal models in VaR calculations to determine capital requirements (Ito *et al*, 1996:142).

This internal models-based approach, proposed by the BCBS, was not aimed at providing banks absolute discretionary freehold on VaR calculations (and hence capital requirements). Internal models for VaR calculations were to be based on a series of quantitative and qualitative standards set by the BCBS. The *quantitative* standards refer to a number of general risk measurement parameters to be used for internal modelling. A simplified rule for converting models-based exposure calculations into regulatory capital is also included in these standards. *Qualitative* standards were designed with the purpose of ensuring integrity and accuracy in banks' modelling process (BCBS, 1995:2).

Market risk was formally taken to a level of increased importance in January 1996 when the BCBS amended the 1988 Basel framework to include market risk. This new framework called the *Amendment to the Capital Accord to incorporate market risk* stipulated two approaches to calculate regulatory capital for market risks: the *standardised* and the *internal models* approach (BCBS, 2005a:3). However, before discussing these two approaches (and further developments of market risk), the concepts of the 'banking book' and the 'trading book' are introduced as the distinction between the two is very important for this study. The importance of this distinction is explained in the next section.

[33] VaR is the measure of potential change in value of a portfolio of financial instruments with a given probability over a specific time horizon. VaR answers the question: how much can be lost with x % probability over a given time horizon (JP Morgan, 1996:6).

[34]The Technical Committee of IOSCO is a committee of the supervisory authorities for securities firms in major industrialised countries. It consists of senior representatives of the securities regulators from Australia, Canada, France, Germany, Hong Kong, Italy, Japan, Mexico, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and the United States (BCBS, 1995:1).

4.4.2 The banking and trading books

With the introduction of Basel I, banks began to increase proprietary trading considerably. This means that banks began to trade much more for their own account as they were not subjected to a capital charge. This resulted in the BCBS amending Basel I, resulting in the 1996 amendments. The amendments divided bank assets into two parts, the trading and the banking book (Jorion, 2007:60). As banks which comply with Basel II allocate risk positions to either the 'banking book' or the 'trading book', a distinction between the two needs to be established.

The trading book contains positions that are marked-to-market and actively hedged, giving it a more market risk flavour as they would mostly not be held for an extensive period of time, but intentionally for short-term resale (BCBS, 2004:150). Hedge positions refer to positions that offset the component risk elements of other trading book positions. Positions on the trading book should therefore be highly liquid as these positions have to be easy to sell or readily hedged. Basel II also specified the following basic requirements for positions or instruments to qualify for receiving trading book capital treatment (BCBS, 2004:150):

i. a transparent and documented trading strategy, approved by senior management must be available

ii. a bank must have well-defined policies and procedures designed to actively manage positions in the trading book. These policies and procedures should include the following six important functions:

   - positions should be managed on a trading desk,
   - position limits should be determined and monitored for appropriateness,
   - traders should have the right to manage positions within specified limits and according to the approved strategy,
   - all positions should be marked to market on a daily basis. In addition, when marked to model (assets priced according to a market model as some securities such as Over the Counter (OTC) options may not be liquid) the parameters should be assessed daily. An OTC refers to the trading of instruments not listed on any formal exchange and as transactions are individually negotiated electronically or over the telephone (London Stock Exchange, 2009),
   - positions should also be reported to senior management as part of the institution's risk management process,
   - positions should be actively monitored according to market information sources. This includes the assessment of quality and availability of market inputs to the following: *the valuation process, level of market turnover, sizes of positions traded in the market, etc,*

iii. well defined policies and procedures should be in place to ensure that the positions in the trading book are monitored against the banks pre-defined trading strategy. This includes monitoring the turnover and bad positions in the trading book.

The banking book could be described as all other remaining instruments held by the bank of which loans are the largest. Subject to accrual accounting, the banking book more formally refers to positions that could be considered to have the same characteristics as the traditional loan portfolio where assets are normally held to maturity. Capital requirements are therefore associated with longer holding periods. From a regulatory perspective, commercial banks holds more capital for assets in the banking book while securities firms hold more capital for trading book assets (Nazareth, 2007).

The next section explores the two approaches to calculate regulatory capital for market risks namely the *Standardised* and the *Internal Models* approach.

4.4.3 Market risk capital requirements methods

With market risk becoming increasingly relevant to market participants the BCBS gave bank two different approaches in the 1996 amendments. Banks could calculate market risk by using two approved methods namely the *Standardised Model* (SM) or the *Internal Models Approach* (IMA) (BCBS, 2005a:3).

The fundamental difference between these two approaches is that the SM uses a risk bucketing approach to measure general risk and ignores specific risk due to the simplicity of the approach while the IMA allows banks to recognise the effects of correlation across and within risk factors to be taken into account. The IMA also allows the measurement of specific risk for equity and interest rate positions.

4.4.3.1 Standardised method

The SM was originally proposed in April 1993 and is based on a pre-specified, standardised building-block approach (Ho *et al*, 2004:602). The level of market risk in the bank is determined by the exposure to interest rate risk, exchange rate risk, equity risk and commodity risk. This is calculated by using specific guidelines for each type of exposure. Regulatory capital for market risk is determined by a summation of risk charges across the four categories mentioned above (Jorion, 2007:60).

The SM, however, received the following three important industry criticisms:

i. it failed to acknowledge the most accurate risk measurement techniques as it did not provide enough incentive for banks to improve their risk management systems,

ii. it did not sufficiently reward risk diversification as it did not take sufficient account of correlations and portfolio effects across instruments and markets and

iii. banks had difficulties combining this method with their own measurement systems (Gibbons, 2007:2).

As a result, the BCBS developed an alternative option for calculating the capital charge for market risk. This method, the IMA, was introduced in April 1995 (BCBS, 1995:1).

4.4.3.2 Internal models approach (IMA)

The IMA was a major extension to the original standardised approach as this gave banks the opportunity to use their own risk measurement models to determine the capital charge for market risk. The BCBS acknowledged that several banks had developed risk complex management systems. In many banks these internal risk models were far more sophisticated than were prescribed by regulators. Furthermore, the IMA also served as a motivation for banks not to lag behind other institutions and to create more sound risk management systems (Gallati, 2003:97).

The methodology for estimating the empirical holding period introduced in this chapter is based on the IMA. This chapter investigates fair levels economic capital for the trading book so the principles of the market risk capital requirements were necessarily investigated.

With the IMA introduced above, a theoretical overview of Value at Risk (VaR), which is used in the IMA approach and is also the most important measure of market risk, is presented next (Hartz *et al*, 2006:2295).

4.4.4 The VaR approach

As one of the core responsibilities of financial institutions is evaluating the exposure to market risks, a frequently-used methodology for market risks calculations is VaR. (Khindanova & Rachev, 1999:2 216) VaR is a concept designed by the financial industry itself and is relatively simple with the foremost advantage that has become a generally accepted standard for market risk measurement (Wiener, 1997:7). Both the industry and regulators agree that VaR should be applied as the principal risk management tool which contributes to unity in the financial world as it enables market participants to compare the risk between different portfolios and institutions. The two most important characteristics for a successful VaR calculation are relative simplicity of implementation and stability of results (Wiener, 1997:7).

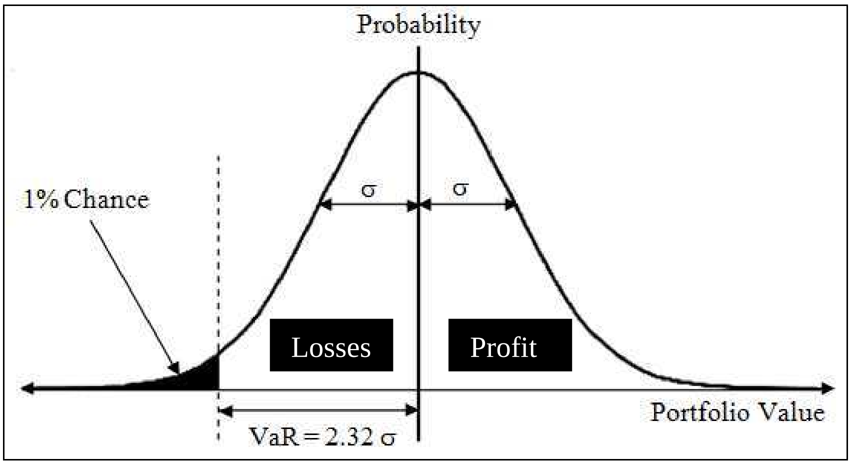
A general assumption in VaR estimates is that relative market movements are normally distributed. For a distribution of losses with mean μ and standard deviation σ, at a confidence interval of 99%, there is a 1% chance that losses is greater than 2.32σ from μ (Marrison, 2002:98). Assuming this normal distribution, 99% VaR may be defined as: $\text{VaR} = \mu - 2.32\sigma$

Where:

- σ = the standard deviation of the portfolio’s returns and
- μ is the mean return.

This is illustrated in Figure 4.1

Figure 4.1: The relationship between VaR and standard deviation.



Source: Bakshi (2004:98)

Banks only consider the movement towards the left of the probability in VaR calculations (i.e. losses). VaR is the value that represents the potential change in a portfolio's future value. This is based on several components the most important of which are:

i. the portfolio volatility – usually measured by the standard deviation,

ii. the time horizon over which the portfolio's change in value is calculated and

iii. the 'degree of confidence' chosen by the risk manager.

The most important motivation for preferring the use of standard deviations is the compelling evidence that the volatility of financial returns is predictable, hence making it possible to forecast future values of the return distribution (JP Morgan/Reuters, 1996:7).

4.4.5 The three VaR measurement methodologies

As long as banks cover all their material risks in their internal model, the BCBS does not prescribe and specific model. The VaR measurement has, however, become crucial, as Basel II provides banks more than one option for calculating VaR (Gatti *et al*, 2007:1). There are three widely accepted methods to estimate VaR (BCBS, 2005a:40) namely the:

i. historical simulation

ii. Monte Carlo simulation and

iii. variance-covariance.

Although the VaR concept is relatively straightforward, its implementation is not simple in practice. The primary reason for its complexity is rooted in the choice of the most suitable, efficient and accurate method (Coronado, 2000:2). Each method has pros and cons which need to be considered carefully. The three methods employ the same underlying idea which is based on assumptions that the behaviour of the financial market in the recent past serves as a good indicator of what will happen in the nearby future. All three methods apply the same classic statistical techniques of percentiles estimation, which underwent a 'renaissance' since being used in the context of the VaR at the end of the 1990s (Coronado, 2000:2).

The most prominent difference between the specified methods lies in the assumption of normality of asset returns. The two simulation methods (Monte Carlo and Historical) can be calculated using non-normal distributions while the variance-covariance method assumes normality (Van de Venter, 2000:190).

4.4.5.1 Historical simulation VaR

The historical simulation method is also called a non-parametric method as it does not assume a parametric distribution of risk factors. The historical simulation method is perhaps the simplest non-parametric method and is used by many large banks (Pritsker, 2006:562).

The historical simulation method uses historical relative differences in market prices to create a distribution of potential future losses and profits for a portfolio and then determines VaR as the percentage that the loss that is exceeded only a certain percentage of the time. Returns are determined by taking the current portfolio value and comparing it to actual price variations experienced in the market (Van de Venter, 2000:191).

As the historic simulation method uses observed market variations for the estimation of expected future market charges, no statistical calculations are required. The simplicity of this method is a major advantage as it is an intuitively logical approach. This has the significant advantage of assisting risk managers to gain wider acceptance for VaR calculations (Van de Venter, 2000:191).

A major disadvantage of this method is, however, that robust historical data are needed to make accurate predictions of the future. Furthermore, the older the data, the less relevant they become for the current market. There is therefore a complicated trade off between more and newer data. More data provide a more inclusive loss picture of the past such as unusual events. However, current risk estimates which are based on old market data might not always convey the most accurate message for today’s market conditions. When different timelines are used in historic simulation VaR calculations, they often result in different results for the same portfolio which demonstrates that results are not stable when using this method (Wiener, 1997:11).

As this study investigates a wide range of bond portfolios with simulated, random underlying elements it was not possible to obtain historical data to the same extent as what random generated bond portfolios could provide. This method was therefore not used.

4.4.5.2 Monte Carlo simulation VaR

The Monte Carlo method is also a non-parametric method and assumes that information about the combined distribution of market changes is available. Monte Carlo simulations generate correlated random variables to model a probability distribution for statistical data analysis (Svendsen, 2004:97). The method generally assumes a normal distribution of underlying risk factors (although this restriction can be relaxed). Distributions can be created by randomly combining a large number of possible scenarios and pricing the portfolio for each scenario whilst preserving historical correlation structures (Marginn *et al*, 2007:600). The broad spectrum of scenarios provides a good approximation for the final value of the portfolio. A 99% confidence interval VaR is the lowest percentile of a return distribution. A small set of simulations will produce a preliminary result which can, if needed, be improved by running additional simulations to enrich the data (Benninga & Wiener, 1998:6).

The first step in calculating VaR by using the Monte Carlo approach is to identify prominent risk factors. A joint distribution of these factors is then constructed, based on historical data implied by observed returns. The simulation is then performed and a large number of scenarios simulated. For each scenario the profit and loss are measured at the end of the simulated period. These profits and losses are then ordered and VaR calculated as a percentile of the returns (Wiener, 1997:14).

The biggest advantage of the Monte Carlo approach is that it is flexible enough to incorporate time variations, volatility, expected returns, fat tails and extreme scenarios in risk factors. For the instruments in an investigated portfolio, the Monte Carlo approach also includes nonlinear price exposures and complex pricing models (Jorion, 2007:266).

The biggest shortcoming of the Monte Carlo VaR method is that the underlying mathematics is highly complex and the method often requires considerable computing time. Furthermore, if the valuations of some of the inputs – which are used repeatedly – are incorrect, the model quickly becomes erroneous. Even though this approach is arguably the most comprehensive market risk measurement approach if implemented and modelled correctly, it is expensive to implement from a system infrastructure as well as an intellectual capital perspective (Jorion, 2007:266).

One of the reasons for not applying this approach in this investigation is that the joint distribution of many market parameters needs to be known in order to derive the most accurate VaR. This concern was raised by Wiener, (1997:15) who argued that when there are more than three of four significant parameters it is difficult to ensure the accuracy of all the data and to build a multi-dimensional distribution.

The risk factors which characterise bond portfolios are usually strongly correlated, particularly if the constituent bonds all originate in the same geographic region (as was the case in this investigation). As this study investigates bonds, this is especially true. Bonds with different maturities, credit ratings etc., from an extremely complex random structure as the different, interconnected variables are difficult to measure and there are no historical data on which to base these simulations (Wiener, 1997:15).

4.4.5.3 Variance-covariance method

The third method for calculating VaR is the variance-covariance approach. As the variance for a variable is an indicator of the spread of values, the covariance indicates the degree to which two variables move together. It is also sometimes referred to as the Analytical Method with the main advantage being the speed of its calculations (Harlow, 2005:87). The variance-covariance method is based on the assumption that portfolio returns are normally distributed. VaR is then expressed as a multiple of the standard deviation of the portfolio's return (Ozcelik & Rees, 2005:4).

The variance-covariance matrix contains information regarding the volatility and correlation of returns relevant to the portfolio. It is a diagonal (symmetric) matrix with all the variances of every asset's return down the diagonal axis whiles the covariances between assets, appear off the diagonal axis. Variances are calculated using standard deviations of market returns while covariances combine standard deviations of market returns with the correlations between market returns (Van de Venter, 2000:190).

Important assumptions used are that risk factors that influence portfolio *daily* market returns are normally distributed around a mean of 0%. These risk factors can include a range of relative changes in interest or exchange rates and share prices. This assumption makes it possible to determine the distribution of portfolio profits and losses as they are also normal. With the distribution of possible profit and losses determined, VaR can be calculated by applying standard mathematical properties of a normal distribution. The VaR then refers to loss that is exceeded only a certain percentage of the time (Van de Venter, 2000:190).

In order to calculate a bond portfolio's VaR, the daily VaR of each bond in the portfolio is required. Furthermore, the correlation is needed for the variance-covariance matrix.

$$VaR = N \times (CI \times \sigma) \times \sqrt{T} \tag{4.1}$$

Where:

- N is the notional amount invested in a security or portfolio
- CI is the confidence interval,
- σ is the instrument or portfolio return volatility (which implicitly takes account of linear correlations between portfolio constituents' returns) and
- $\sqrt{T}$ is the liquidity adjustment or holding period. i.e., the assumed time to unwind a portfolio of size N without materially affecting the underlying constituent prices of the portfolio.

Three of the above parameters are easily and unambiguously measurable, namely N, CI and T; the portfolio volatility is responsible for the bulk of this technique's complexity – a significant amount of which may be reduced by embracing the limiting (but hugely simplifying) assumption that market returns are normally distributed.

The variance/covariance (VCV) method employs matrix multiplication techniques from linear algebra as well as the eponymous VCV matrix, a well-known representation of interrelated data which has the form (for three returns series, 1, 2 and 3):

$$\begin{pmatrix} \sigma_1^2 & \sigma_1 \cdot \sigma_2 \cdot \rho_{12} & \sigma_1 \cdot \sigma_3 \cdot \rho_{13} \\ \sigma_2 \cdot \sigma_1 \cdot \rho_{21} & \sigma_2^2 & \sigma_2 \cdot \sigma_3 \cdot \rho_{23} \\ \sigma_3 \cdot \sigma_1 \cdot \rho_{31} & \sigma_3 \cdot \sigma_2 \cdot \rho_{32} & \sigma_3^2 \end{pmatrix} \tag{4.2}$$

The matrix is symmetrical about its diagonal (diagonal elements are the variances of the returns series) 1, 2 and 3 respectively and off-diagonal terms are covariances between relevant return series (and ρ_{nm} is the correlation between the returns of series n with m series. If the percentage weight in each constituent (1, 2 or 3) is represented by w_1, w_2 and w_3 respectively, then the overall portfolio volatility (Botha, 2005:87) is determined by:

$$\sqrt{\begin{pmatrix} w_1 & w_2 & w_3 \end{pmatrix} \cdot \begin{pmatrix} \sigma_1^2 & \sigma_1\sigma_2\rho_{12} & \sigma_1\sigma_3\rho_{13} \\ \sigma_2\sigma_1\rho_{21} & \sigma_2^2 & \sigma_2\sigma_3\rho_{23} \\ \sigma_3\sigma_2\rho_{31} & \sigma_3\sigma_2\rho_{32} & \sigma_3^2 \end{pmatrix} \cdot \begin{pmatrix} w_1 \\ w_2 \\ w_3 \end{pmatrix}} \tag{4.3}$$

To obtain the VaR for such a portfolio simply involves multiplying the above by the notional amount N, the confidence interval CI and the scale factor $\sqrt{T}$. The above technique obviously applies equally well to a portfolio comprising n positions. Interest rate volatility is only marginally less simple to measure. Because the volatility obtained from the techniques discussed here is interest rate volatility rather than price volatility, the relevant interest rate sensitive instrument's duration must also be calculated. The product of this duration, the interest rate volatility and the measured change in the interest rate gives a price volatility which may then be used in an identical manner to the equity price volatility discussed above (Maitland, 2002:130).

The attraction of this technique lies in its relative simplicity, ease of implementation and enduring robustness while opponents of this approach believe the VCV matrix to be unstable (often, such a matrix is constructed and assumed constant for a period of time: only the portfolio weights change over the period concerned) and that the assumption of normality for the return distribution is highly questionable. Indeed, empirical research has long ago established the existence of a fat tailed, leptokurtic, negatively-skewed return distribution. Despite these criticisms, the technique is widely used (Van Vuuren, 2008).

Other important concepts that are needed to understand and implement methodology introduced in this chapter are discussed in the next section.

4.4.6 Specific (idiosyncratic) risk charge

The VaR approaches discussed do not refer to the *maximum* amount that could be lost (conditional VaR). VaR refers to the measure of market risk which indicates the expected *minimum* loss associated with a particular level of probability. This can be explained by the following example: the expected minimum loss of an investment associated with a probability of 5% is -15% per dollar invested. In other words, there is a 5% chance of losing at least 15% (Collins & Fabozzi, 1999:92). Note that nothing has been mentioned regarding the *maximum* amount that could be lost.

The capital charge for specific risk is intended to protect banks against unfavourable price movements of positions which are the result of factors related to individual issuer and is comparable to credit risk (Bakshi, 2004:430). Specific risk includes the risk that an individual debt or equity security varies by more or less than the general market in day-to-day trading (BCBS, 2005a:3). This also includes periods when the whole market is subject to high volatility. Furthermore, specific risk also covers event risk where the price of an individual debt or equity security varies sharply relative to the general market. This happens in events such as takeover bids or other shock events such events which might include the risk of default.[35]

While the standardised approach applies a 'building-block' approach for specific risk where the general market risk arising from equity and debt positions are measured separately, the focus of IMA is the bank's general market risk exposure. This means that the calculation of specific risk is done largely through the separate credit risk measurement systems (BCBS, 2006b:163).

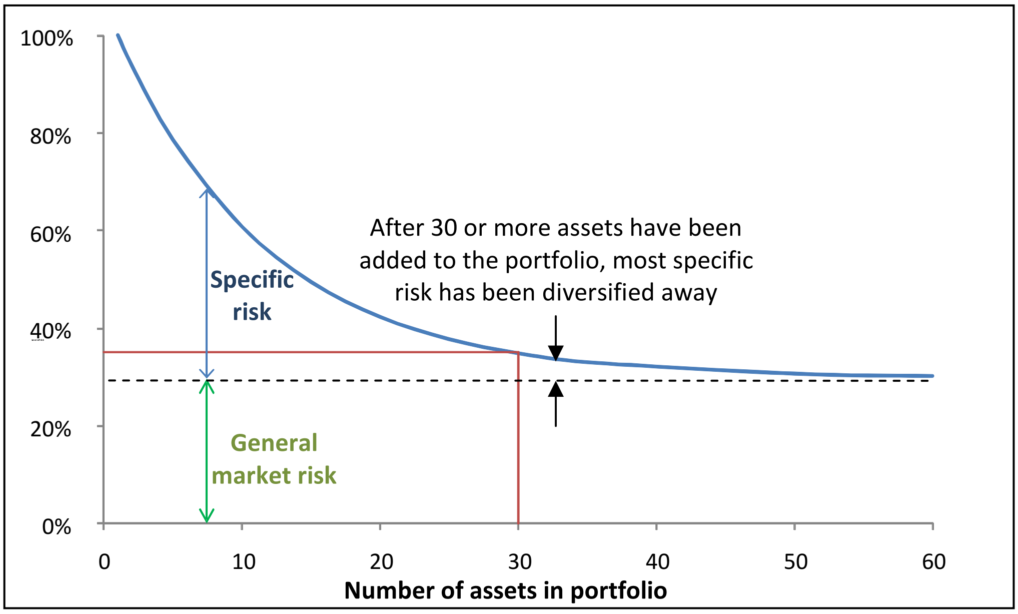
Banks using the IMA are subject to an additional capital charge for specific risk if the VaR measure does not include specific risk factors or if models do not meet all the qualitative and quantitative requirements for general risk models. The BCBS (2005a:46) specifies certain criteria for regulatory recognition of banks' specific risk modelling. In particular, the specific risk models must explain the portfolio's historical price movements and capture concentrations which refer to the magnitude and changes in composition. Internal models must also be robust enough to account for unfavourable environments. Models must capture name-related basis risk as well as event risk and finally be validated through backtesting (discussed later in this chapter).

The degree to which investors are exposed to specific risk can be reduced considerably by diversification within a portfolio. When a portfolio consists of only one specific asset only, the change in value of that portfolio is exactly the same as the price movement of the asset of which it comprises. Therefore, the portfolio is 100% exposed to the specific company's risk of price movement. However, if a portfolio exists of all types of assets in the market the portfolio will diversify away much company-specific risk. Well-diversified portfolios will only be exposed to the unavoidable market risk ('general risk') embedded in the market.[36] It has been shown that a portfolio comprising a broad range of 30 or more assets will follow *average* market movements (Surz & Price, 2000:1). The diversification effect is illustrated in Figure 4.2 below.

[35] In this study, default (with regard to a particular obligor) is considered to have occurred when – as it is in Basel II lexicography (BCBS, 2006a:100) – either or both of the two following events have taken place: (a) the bank considers that the obligor is unlikely to pay its credit obligations to the banking group in full, without recourse by the bank to actions such as realising security and (b) the obligor is past due more than 90 days on any material credit obligation to the banking group.

[36] Individual instruments are always subject to their own specific risk. In a well-diversified portfolio, these largely cancel each other out, but this may *not* imply that the specific risk is cancelled out altogether. In light of this, the BCBS have included (in Basel I) specific risk into the trading book capital charge to compensate for this possibility (BCBS, 1996). The capital charges due to specific risk are almost impossible to calculate without precise knowledge of all the facts pertaining to the instrument (and the circumstances affecting it). For this reason, specific risk was omitted from this analysis.

Figure 4.2: Portfolio diversification and accociated market risk. Vertical axis=exposure to specific risk; horizontal axis=number of assets in the portfolio.



Source: IC-Agency (2009)

The calculation of the market risk charge, as prescribed by Basel II, is now discussed.

4.4.7 Calculating the market risk charge

The 1996 amendment implies that a capital charge applies for the market risk linked to the trading book, but also for currency and commodity risks that arise in the banking book (Jorion, 2007:60). The capital charge for credit risk excludes equity securities and debt in the trading book as well as positions in commodities. Credit risk, however, includes all over-the-counter (OTC) derivatives in both the trading and banking book. Banks using the IMA are required to hold, on a daily basis, capital that is expressed as the higher of (Jorion, 2007:60):

- the previous day's VaR or
- the average of the daily VaR over the last 60 business days multiplied by a factor, k.

The Basel II equation prescribed to determine the internal model's approach market risk charge on any day is:

$$\text{Market risk regulatory capital} = \text{Max}\left(k \times \frac{1}{60} \times \sum_{i=1}^{60} VaR_{t-i},\ VaR_{t-1}\right) + SRC_t \qquad (4.4)$$

Where:

- SRC = the specific risk charge (defined later in this section)
- k = the multiplication factor which is determined by local regulators, based on their quality assessment of the bank's risk management system. This factor ranges from 3 to 4 depending on backtesting

results of banks' internal models. Basel II considered this factor as essential to translate daily VaR estimates into a capital charge where sufficient capital is available to serve as a cushion for potential increasing losses due to unfavourable market conditions over time (Alentorn & Markose, 2008:48). Regulators would not have sufficient comfort unless the VaR measure was multiplied by this factor (BCBS, 1995:15). The reason regulators require this factor is based on the possibility that the qualitative and quantitative criteria might not be sufficient during periods of severe or prolonged market movements. It is, however, important that the multiplication factor should not be seen as a substitute for regular stress testing. Basel II agreed that the multiplication factor should be added as a 'plus' factor which is directly related to the performance of a bank's internal model. It therefore introduces a built-in positive incentive which rewards an accurate and highly predictive model. The multiplication factor has also been designed by the BCBS to compensate for potential weaknesses in the internal modelling process such that:

- Market price movements do not always follow the statistical simplifications used in the modelling assumptions,
- volatilities and correlations observed in the past and used in modelling assumptions could vary considerably in future,
- VaR estimates are usually based on end-of-day positions which ignore the intra-day trading risk, and
- event risk that arises from unanticipated, adverse market conditions cannot be modelled accurately (BCBS, 1995:3).

Even though Equation 4.4 is used by banks for calculating the market risk charge under the IMA, there are additional regulators requirements for banks which is discussed next.

4.4.8 Regulators' criteria for good and bad models

The IMA does not give banks total freedom to design their own risk management systems. The approach is based on the definition of a series of quantitative and qualitative standards with which banks would have to comply. If banks are able to prove to regulators that these standards have been met, they are allowed to use their own market risk measuring models. The regulator, however, allows the necessary flexibility to account for different levels of detail in banks' systems (BCBS, 1995:2).

4.4.8.1 Qualitative criteria

It is important that regulators should be assured that banks that opt for the IMA have conceptually sound market risk management systems in place which are implemented with integrity (BCBS, 2005a:36). Regulators therefore receive a list of qualitative criteria that banks should comply with in order to be permitted to use their own internal models. Seven qualitative criteria are specified by Basel II. These criteria require, *inter alia*, banks to have an independent risk-control unit as well as external audits. Specifications about the design and implementation of the risk management system, as well as fixed reporting lines, are stated as criteria. Banks should also conduct regular backtesting and validation of the internal models in order to demonstrate that sound risk management systems are in place. Basel II refers to backtesting as a formal statistical framework to verify if actual losses are in line with losses projected in a banks modelling process (BCBS, 2006a:192).

Backtesting of VaR models refers to the process whereby the actual portfolio returns or for a given horizon are compared with the estimated VaR numbers (Blanco & Oks, 2004:2). The process of backtesting involves calculating the number of times (expressed as a percentage of the total days tested) that portfolio returns fall outside the forecast VaR value and comparing that number to the confidence level used. For example, If a 95% confidence interval was used over the period being investigated, the VaR model is expected to be accurate only 95% of the time. It is acceptable that 5% of all forecasts are inaccurate, indeed, with a 95% confidence interval, they are *expected*. Forecast inaccuracies in excess of those expected from the confidence interval employed, however, provoke regulatory concern. The BCBS has established a set of 'traffic light zones' (green, yellow and red) which each refer to a region of increasing discomfort with the VaR model under scrutiny as inaccuracies (or exceptions) swell.

There is a direct association between the number of exceptions and the value of the regulatory multiplication factor, k. Up to four exceptions – for example – results in $k = 3.0$, five exceptions gives $k = 3.4$ and ten or more, $k = 4.0$. If the number of exceptions falls into the red zone (which indicates deeper problems with a bank's market risk model) local regulators automatically assign k a value of 4.0 (BCBS, 2006a:318).

The involvement of the board of directors and senior management in risk management activities are regarded as an essential qualitative criterion. Management must be actively involved in the risk control process and banks should be able to provide evidence that risk management techniques are integrated into management decisions and day-to-day bank processes (BCBS, 2005a:36).

4.4.8.2 Specification of market risk factors

A significant element of a bank's market risk model is defining the appropriate set of market risk factors to be included in the bank's risk measurement system (BCBS, 2005a:38). These market risk factors refer to the elements that have an impact on the value of a bank's trading positions and include market rates and prices.

Although regulators allow banks to apply some degree of discretion in specifying these risk factors for internal modelling, the following guiding principles should be satisfied:

- for interest rates banks are required to have a set of risk factors which are relevant to the interest rates in each currency for which the bank holds any interest-rate-sensitive on- or off-balance sheet positions,

- for exchange rates the risk measurement system should incorporate risk factors corresponding to the individual foreign currencies in which the bank's positions are denominated. Since the VaR figure calculated by the risk measurement system is expressed in the bank's domestic currency, any net position denominated in a foreign currency will introduce a foreign exchange risk. Thus, there must be risk factors corresponding to the exchange rate between the domestic currency and each foreign currency in which the bank has a significant exposure,
- for equity prices banks are required to have a set of risk factors which are relevant to the equity markets in which the bank holds any interest-rate-sensitive on- or off-balance sheet positions and
- for commodity prices banks are required to have a set of risk factors which are relevant to the commodity markets in which the bank holds any interest-rate-sensitive on- or off-balance sheet positions.

4.4.8.3 Quantitative criteria

When the above *qualitative* conditions are satisfied and banks have proved sufficient specification of market risk factors, the regulatory capital charge for market risk is based on a set of *quantitative* criteria. Regulators provide banks with the flexibility to design their models however; some minimum principles apply in the modelling process (BCBS, 2005a:40). Local regulators however, have the discretion to apply more conservative standards.

The quantitative criteria for the IMA are:

- VaR should be calculated on a daily basis measured at
- a one-tailed confidence interval of 99% using
- a minimum holding period of 10 working days. Banks are however permitted to use VaR numbers which were calculated for shorter holding periods, provided that they are scaled up to 10 days by applying the 'square root of time' calculation,[37]
- an observation period based on at least a year of historical data must be used,
- data sets must be updated at least once per quarter (more frequently if market prices 'are subject to significant changes'),
- no model is specified, however, the model used must consider all the market risk factors mentioned above,
- banks are allowed to use empirical correlations within broad risk categories such as interest rates, exchange rates, equity prices and commodity prices. Regulators may recognise these empirical correlations only if they are satisfied that a bank has a sound correlation measurement system and

[37] The 'square root of time rule' stems from a statistical property of variance of variable X, namely that $VAR[nX] = n \cdot VAR[X]$ (hence $stdev[nX] = \sqrt{n} \cdot stdev[X]$) and the assumption that variances are constant (J.P.Morgan/Reuters, 1996: 87).

- unique risks associated with options within the board risk categories must also be captured in the bank's internal model.

4.4.9 Credit risk in the trading book: From Basel I to II

There are only minor differences which distinguish Basel I and Basel II's treatment of regulatory rules governing market risk. The significant difference is rooted in the treatment of trading book (derivative) exposures. Market risk exposures under Basel I did not require specific, accurate modelling while Basel II sets out explicit, detailed methods to be evaluated by local regulators (BCBS, 2004:63).

Basel II introduces the treatment of counterparty credit risk in the trading book as follows:

> *Banks are required to calculate the counterparty credit risk charge for OTC derivatives, repo-style and other transactions booked in the trading book, separate from the capital charge for general market risk and specific risk. The risk weights to be used in this calculation must be consistent with those used for calculating the capital requirements in the banking book* (BCBS, 2006a:164).

Basel II specifies that potential future exposures should be modelled by using Monte Carlo simulations. This implies that the way in which derivative exposures could vary due to changes in interest and foreign exchange rates, share prices and volatilities must be simulated by banks. The average (expected value) of these simulated derivative exposures (over time to maturity) is then estimated and revered to as the 'expected exposure'.

The expected positive exposure (EPE) increases throughout the time to maturity. EPE can be defined as the:

> *...weighted average over time of expected exposures where the weights are the proportion that an individual expected exposure represents of the entire time interval (BCBS, 2006a:256).*

The effective EPE is simply the average EPE. This is the exposure used in the market risk calculation according to Basel II but only refers to derivative instruments.

The next sections explore the developments which impacted the regulatory capital charge for market risk since credit crunch began in 2007. Credit risk in the trading book before the credit crunch is examined followed by a brief overview of the credit crunch itself and the impact it had on the BCBS' proposed capital calculation methods capital charge for market risk.

4.4.10 Credit risk in the trading book (pre-credit crunch)

Since VaR was introduced by JP Morgan in the beginning of the 1990s, it has established itself as the most important measure of market risk (Hartz *et al*, 2006:2295). Berkowitz and O'Brien (2002:1110) evaluated the statistical accuracy of the VaR forecasts to determine the accuracy of banks' trading risk models. Their finding that bank's VaR forecasts were conservative under the Basel II regime contributed to the perception that VaR provided a safe and sufficient level of market risk capital. VaR did receive some criticism about issues such as being theoretically deficient and numerically problematic (Hartz, *et al*, 2006:2295). Examples of problematic elements included the extreme value theory, quintile regression methods and Markov switching techniques. In addition to the problems identified for VaR, some research and work done was also done to improve it by exploring, for example, more sophisticated GARCH and EWMA models for calculating volatility (Hartz *et al*, 2006:2295). Despite the shortcomings of VaR it was still recognised by Basel II and remains the most widely used market risk measure in practice. Its accurate calculation is also perceived as a fundamental characteristic for calculating other risk measures such as expected shortfall (Dowd & Blake, 2006:194).

Basel II's confident attitude towards VaR is confirmed in Berkelaar *et al*'s (2002:360) statement that even though restriction exists in the VaR approach mainly due to the gambling strategy of the risk managers, VaR-based risk management has a stabilising effect on the economy as a whole. This made sense as the VaR-based financial models used by banks on which to base capital calculations upon are typically estimates based on data from the several preceding years. If the preceding years were characterised by calm and uneventful VaR movements, models assume similar patterns will occur in the future. This is not, of course, necessarily accurate in the real world (Williams, 2008). The approach was suitable until the onset of the credit crunch (Griffin, 2008).

4.4.11 The onset of the credit crunch

On 9 August 2007, a liquidity crisis (due in part to the enormous exposure of US banks to subprime mortgages) erupted, triggering the onset of the biggest financial crisis since the Great Depression of 1929 (Cane, 2008). The term *credit crunch* soon became part of everyday language as fear paralysed the world's credit markets (although this quickly spread to most trading markets as well).

4.4.11.1 The credit crunch defined

More than a year after the bankruptcy of Lehman Brothers, the unfolding credit crunch (November 2009) has affected almost every segment of the financial system. Credit has been severely curtailed as banks struggle to contain further losses caused by reckless lending practices that characterised the last two decades. Asset prices have tumbled as fearful investors flee to safer havens, abandoning traditional investments and hedge funds with resolute consistency. Governments – in an attempt to stave off stagflation and kick-start failing economies – have reduced interest rates to historic lows, initiated stimulus packages and instigated bank bailouts. The dire economic environment characterised by diminishing industrial production, falling house (and other asset) prices and rising unemployment, has only discouraged spending and investing and promoted capital hoarding. In the ensuing credit crunch, the regulatory economic environment (dominated by Basel II) has proved woefully inadequate. Potential solutions have not yet presented themselves and the credit crunch looks likely to continue for the foreseeable future (Budworth, 2008).

More formally Ghosh & Ghosh (2006:1) defines a credit crunch as:

> *A situation in which interest rates do not equilibrate supply and demand for credit and the aggregate amount is supply constrained, i.e. there is quantity rationing.*

Banks were the hardest hit by this credit crunch as billions in mortgage-related investments had to be written down. Some large investment banks that once ruled the financial world have disappeared or reinvented themselves as normal commercial banks (The New York Times, 2009).

4.4.11.2 Main drivers of the credit crunch

The origin of the credit crunch can be traced back to another important event, namely the technology bubble which arose in the late 1990's. In early 2000, stock markets declined sharply in the US which resulted in a full recession in by 2001 and which lasted until the end of 2002. The Federal Reserve responded with significant interest rate cuts in an attempt to contain the economic damage (The New York Times, 2009). During the years that followed, lenient lending conditions for higher risk borrowers inflated an enormous debt bubble as people borrowed low-cost money which was invested in property. Lenders granted billions of dollars in mortgages to individuals with high risk credit ratings who had low or no income or assets (referred to as sub-prime borrowers). The perception at that time was that if individual would experience difficulties with mortgage repayments, the rising house prices would enable them to remortgage their property. This made logical, business sense given the low interest rate (1%) in the US in the beginning of 2004 (Budworth, 2008).

The dilemma was the low levels of interest rates could not continue forever. In June 2004 interest which triggered a decline in US house prices. This resulted in borrowers defaulting on mortgage payments which sparked a devastating sequence of events. The first shock came in June 2007 as two hedge funds, owned by Bear Stearns, collapsed due to large exposure in the dangerous subprime market. Gradually more banks discovered that securities perceived as safe were indeed affected with what came to be known as toxic mortgages (Bajaj & Creswell, 2007). Even though the Federal Reserve applied extraordinary measures to strengthen Wall Street, losses continued to increase. In March 2008 the Fed prevented the bankruptcy of Bear Stearns by taking over billions in liabilities and facilitating engineering a sale to JP Morgan Chase. In Sept the US Treasury Department announced it was taking the government-sponsored entities Fannie Mae and Freddie Mac to ensure their survival in the falling housing market (The New York Times, 2009). When talks broke down between government and finance officials on 12 September to prevent the bankruptcy of the investment bank Lehman Brothers, the credit crunch became a global financial crisis. Lehman collapsed and Merrill Lynch was sold to the Bank of America to avoid a similar fate (Weber, 2009).

An anonymous member of the 2009 World Economic Forum summarised the events above as follows:

> *The root causes for the economic crisis were too much debt, a culture of short-term rewards for long-term risk-taking* and *fatally flawed mathematical risk models. And plain old greed.* Weber (2009).

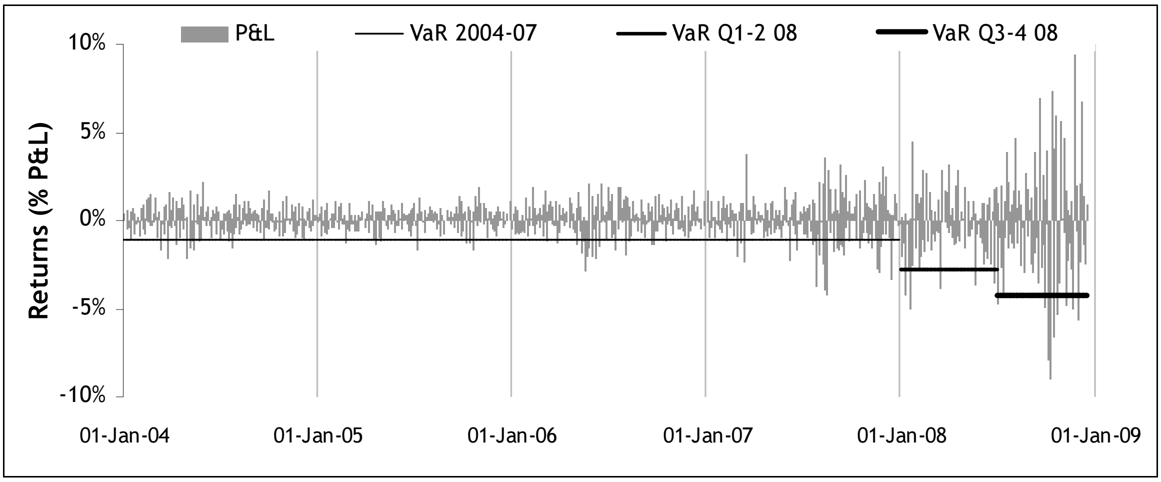
Sharp rate cuts and fiscal stimulus packages were then introduced globally to salvage the financial system from the ravages of the crisis. At the time of writing (November 2009), the credit crunch continues unabated with no indication how long it will continue or how severe the situation might become in future (Weber, 2009).

4.4.11.3 Consequences of the credit crunch

As banks had invested billions of dollars in the sub-prime backed instruments introduced in the previous section, they had to write off enormous amounts of money losses as the value of assets crumbled during the credit crunch. Not only did the losses increase significantly, investors became wary about buying any investment linked to mortgages, regardless of the quality of assets (Budworth, 2008). Volatility of the mortgage backed security increased dramatically as the fluctuation in value was noticeably more significant. VaR, therefore, also increased dramatically. As volatility surged, banks using VaR anticipated much higher losses but only after the credit crunch (Chang *et al*, 2008:3).

Figure 4.3 below represented return data derived from FTSE 100 index returns. The figure illustrates returns measured over the last five years and a hypothetical VaR (of the FTSE 100 'portfolio') at a 95% confidence interval. The figure shows the increase in VaR as a result of the burgeoning credit crunch.

Figure 4.3: Increase in VaR as a result of the credit crunch – FTSE100 index returns



Source: Bloomberg

This observation of VaR is consistent with a report by The Federal Reserve Bank of New York who plotted the average VaR from 2001 to 2008 for Bear Stearns and Lehman Brothers (Adrian & Shin, 2009:21). A significant VaR increase was experienced in from mid 2007 onwards. These increased VaR for these two investment banks provides further evidence that banks' balance sheets were under considerable stress during this time (Adrian & Shin, 2009:21).

4.4.12 How VaR estimates failed during the credit crunch

VaR failed to detect the significance of the credit crunch according to *Merrill Lynch's* (2008) third-quarter filing with the U.S. Securities and Exchange Commission. The BCBS expressed concerned with this in its comments on the increase in trading losses and VaR exceptions (BCBS, 2007b).

Implicit in a 99% confidence interval, VaR forecast is the tacit acknowledgment that 1% of losses will exceed the forecast VaR. Exceptions occurring when losses exceed forecast VaR over and above the expected number of such occurrences (Jorion 2000, 130). Given the complete meltdown of financial markets, and the increase in market volatility across all actively traded asset classes, it could be anticipated that a larger number of banks with significant trading book exposures reported increases in VaR exceptions. These increases in the number of exceptions challenge the assumed robustness of VaR models and also expose flaws in VaR models. It is, therefore, not surprising that numerous banks tried to address the exposed inadequacies of VaR. Citigroup, for example, combines the VaR methodology with additional risk factors that track the specific issuer risk in debt and equity securities. Too many banks, however, simply accepted the normal VaR result as sufficient (Whalen, 2006).

The main concerns about VaR and the recent failure of the method revolve around the following issues:

- VaR is not designed to accurately measure risk during crisis conditions,
- VaR does not give any clarity on events beyond the 99% worst probability of losses,
- VaR measures trading or market risk only and does therefore not provide a complete risk overview, and
- VaR is too dependent on historical volatility and therefore has a *short memory* (Bakhshi, 2007:10).

As VaR is a backward–looking risk measure which is heavily dependent on the averaging of historical data whatever the method used to calculate it, it does not sufficiently capture unexpected market shocks as experienced during the credit crunch. This can be very clearly observed where sudden losses exceed historical trends.

In an environment where risk events are large and abnormally frequent, it can be anticipated that banks might soon have no other choice than to investigate alternative risk measuring methods (Whalen, 2007).

Despite these failures and shortcomings of the VaR estimates, Basel II did not discredit VaR for market risk capital calculations as advised by numerous market participants. Basel II did, however, not fail to act upon the recent developments in the economy as the credit crunch highlighted several of areas that require increased attention (Brouwer, 2008).

4.4.13 Basel II amendments: Incremental Default Risk (IDR)

With the root causes of the credit crunch explained, the need to strengthen various aspects of risk governance model had to come from the regulators (Brouwer, 2008).

The BCBS, however, anticipated the potential risk of credit events in the trading book as the Basel/IOSCO agreement reached in July 2005, contained several improvements to the capital regime for trading book positions (BCBS, 2005a:67). Among others, the revisions included a new requirement for banks that model specific risk to measure and hold capital against default risk that is incremental to any default risk captured in the bank's VaR model. The IDR was incorporated into the trading book capital regime in response to the increasing amount of exposure in banks' trading books to credit-risk related and often illiquid products whose risk is not reflected in VaR (BCBS, 2007b:1).

In October 2007, the BCBS (2007b) released a document for public comments which introduced guidelines for computing capital for IDR. These proposed guidelines were introduced to banks as the market risk charge at the time was not sufficient to cover losses. According to the BCBS (2007b), the increased losses that occurred during market turmoil that started in 2007 did not arise from actual defaults, but rather from *credit migrations combined with widening of credit spreads and the loss of liquidity* (BCBS, 2008a).

An expanded scope for capital charges was therefore needed and the BCBS moved to embed the risk of default (credit risk) in the trading book. IDR was considered to be part of the specific risk component (which up to that point referred to the risk of price movements in an individual company – referred to as price risk (PR) in this study) due to specific events that influence the capital charge calculation. Without more specific guidelines however, IDR was poorly implemented and difficult for regulators to monitor. As a result, the BCBS issued the above mentioned consultative document in which,

> *the decision was taken in light of the recent credit market turmoil where a number of major banking organisations have experienced large losses, most of which were sustained in banks' trading books. Most of those losses were not captured in the 99%/10-day VaR. Since the losses have not arisen from actual defaults but rather from credit migrations combined with widening of credit spreads and the loss of liquidity, applying an incremental risk charge covering default risk only would not appear adequate* (BCBS, 2008a).

In addition, the method proposed for the calculation of trading book credit risk:

> *…for positions covered by the IDR, the incremental capital charge would represent an estimate of the trading book's overall exposure to certain risks over a one-year capital horizon at a 99.9% confidence level, taking into account liquidity horizons of individual positions or sets of positions* (BCBS, 2008a).

By introducing IDR, the BCBS now require that banks (which opted for the IRB approaches) apply the same capital charge standards to credit-related portfolios in the trading book as they do in the banking book. Once the BCBS has finalised the revised requirements, banks must comply by 1 January 2010, while banks is allowed an additional year to incorporate IDR into their capital charge modelling process. The BCBS, however, assured banks that they will not only conduct a two-stage quantitative impact study to test these proposals, but will continue to work together with individual firms as well as industry groups during and after the comment period. This is aimed at refining the proposed changes and to support regulators in implementing these new proposals (BCBS, 2007b).

The evolution of the market risk charge from 1988 to the current charge is presented next by explaining the increase in regulatory requirements over time.

4.4.13.1 Basel I in 1988

No specified capital calculations were required.

4.4.13.2 Amendments in 2004

VaR is formally introduced and the following equation can be seen as the *original market risk charge*:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = \text{Original VaR - based market risk charge} + \underbrace{\text{Specific risk charge}}_{\text{Price risk only}} \quad (4.5)$$

This may be written as:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = \quad k \times \text{VaR}_{99\%}^{10\text{d}} \quad + \quad SR \quad (4.6)$$

Where:

- k = scale factor (introduced in Section 3.4.1) and
- SR = specific risk charge (introduced in Section 4.3.7) which consisted of price risk PR only.

4.4.13.3 Basel II in 2007

Except for the new derivative exposure rules, the market risk charges were left unchanged from Basel I.

4.4.13.4 Proposed October 2008 amendments

A new capital charge was introduced with IDR aimed at addressing the absence of credit risk in the trading book. The proposed charge included the original charge stated in Equation 4.4 (BCBS, 2007c:4):

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = \text{Original VaR - based market risk charge} + \underbrace{\text{Specific risk charge}}_{\text{Default risk + Price risk}} \quad (4.7)$$

This can be written as:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = \quad k \times \text{VaR}_{99\%}^{10\text{d}} \quad + \quad \underbrace{\text{SR}}_{\text{IDR + PR}} \quad (4.8)$$

Where:

$$\text{IDR} = \text{CVaR}_{99.9\%}^{250\text{d}} \quad (4.9)$$

and

$CVaR_{99.9\%}^{250d}$ = the capital charge applied to the credit-risky assets in trading book (calculated to the same degree of severity (i.e. at the 99.9% confidence level over a full one year period) as credit risky assets found in the banking book.

If price risk is sufficiently small (i.e portfolios are sufficiently diversified) then price risk element of the specific risk charge may be ignored. This is important for the analysis conducted and presented later in this chapter. The proposed charge may therefore be written:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = k \times MVaR_{99\%}^{10d} + CVaR_{99.9\%}^{250d} \qquad (4.10)$$

Where:

- MVaR = the original market risk charge prescribed by Basel II and
- CVaR = the new credit risk capital charge for credit-risky assets in the trading book.

Banks are expected to comply with the proposed 2007 guidelines for calculating capital for IDR in the trading book in order to receive specific risk model recognition (BCBS, 2007b). The BCBS requested public comments on the proposed consultative paper before mid February 2008. Some industry participants made use of the invitation for public comments. The International Swaps and Derivatives Association (ISDA) provided the most extensive of these (Benyon, 2007).

4.4.14 Industry response

Market participants expressed deep concern about the BCBS's recent (January 2009) IDR proposals. Market participants stated that the rules would raise regulatory capital to punitive levels, stunt the development of risk models and even kill off entire business lines (Pengelly, 2009: 17).

The invitation by the BCBS to the industry to comment on the proposed IDR charges announced in 2007 was accepted by the ISDA (2008:2) and in an official response they raised their concerns. They elaborated on these concerns by proposing some alternatives. ISDA expressed concern that the proposed IDR charges will have a large impact on the regulation of banks' trading books as the capital charge for market risk is expected to treble on average compared to the current market risk capital charge (ISDA, 2008:2). Their findings were based on an ISDA study into the impact of the proposed IDR performed on seven international banks which contributed information and technical expertise to assist with the study (ISDA, 2007:1).

Banks' failure to align IDR proposals with the existing capital charge for market risk could have a detrimental effect as firms which are active in the current market turmoil could potentially be distracted by the danger of default risk and not focus on the relevant and important elements of market risks (ISDA, 2008:2). This could happen if banks allocate too much effort and resources for managing risks that ISDA do not consider being key drivers of economic losses and therefore this would not encourage prudent risk management of trading book portfolios. ISDA asserts that the proposed IDR charge consisting of a one year capital horizon with a 99.9% confidence interval to be added to the existing market risk charge is unrealistic and almost certainly fails any 'use test' (ISDA, 2008:3).

ISDA (2008:03) put forward an alternative proposal by recommending that the requirement of a 99.9% confidence interval over a full year 'unwind' period for credit risk assets in the trading book is too onerous and should be reduced to a 60-day holding period with the same confidence interval. Not only will this proposal reduce the capital charge to more realistic levels, but also makes mathematical sense as the governing capital charges equations are reduced to identical bases as well as identical scaling factors as summarised below:

The proposed capital charge for market risk (Equation 4.4 – without the maturity factor not needed for retail exposures) is:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = k \times MVaR_{99\%}^{10d} + \text{CVaR}_{99.9\%}^{250d} \tag{4.11}$$

However, ISDA (2007:7) pointed out that:

$$\begin{aligned} VaR_{99.9\%}^{60d} &= \left[\sqrt{6} \times \frac{\text{normsinv}(99.9\%)}{\text{normsinv}(99\%)} \right] \times VaR_{99\%}^{10d} \\ &= [3.25] \times VaR_{99\%}^{10d} \\ &\approx k \times VaR_{99\%}^{10d} \end{aligned} \tag{4.12}$$

Where k is of the same magnitude (and approximately the same size) as the standard scaling factor k used in traditional market risk regulatory capital calculations, i.e. $3 \geq k \geq 4$. This is not a coincidence: ISDA *aimed* to obtain a scaling factor of between 3 and 4 for the credit risk component as well and then reverse-engineered the holding period of 60 days. This allows Equation 4.11 to be conveniently and mathematically elegantly rewritten as:

$$\underbrace{\text{Capital charge}}_{\text{Market risk}} = k \times \left(MVaR_{99\%}^{10d} + CVaR_{99\%}^{10d} \right), \qquad \text{with } 3 \leq k \leq 4 . \tag{4.13}$$

It is important to note that the choice of a 60 day holding period is to introduce less stringent capital charges for the credit component of market risk. That this was achieved through mathematical manipulation (only) of Equation 4.11 means, however, that it is *entirely arbitrary*. There is no empirical reason for the choice of a 60 day holding period. What follows in the remainder of this chapter *is* based on empirical data and does *not* follow the arbitrary approach described by ISDA.

ISDA did, however, express its willingness to participate in future discussions on the IDR charge imposed by the BCBS (ISDA, 2008:1)

4.4.15 The future of IDR

In November 2007 the BCBS announced a comprehensive strategy to address the lessons learned from the credit crunch. Among others, the BCBS's strategy included, a clear statement that strengthening risk capturing in Basel II (in particular for trading book and off-balance sheet exposures) is a point of focus. The BCBS (2008b) stated that they are committed to address the fundamental weaknesses exposed during the credit crunch. This specifically refers to regulation, supervision and risk management of internationally-active banks. The BCBS furthermore stated that their work programme is well advanced and provides practical responses to the financial stability fears raised by policy makers related to the banking sector. Although these comments appear to endorse the ISDA suggestions, the BCBS made it clear in an official statement that:

> *The primary objective of the Committee's strategy is to strengthen capital buffers and help contain leverage in the banking system arising from both on- and off-balance sheet activities. It will also promote stronger risk management and governance practices to limit risk concentrations at banks. Ultimately the goal is to help ensure that the banking sector serves its traditional role as a shock absorber to the financial system, rather than an amplifier of risk between the financial sector and the real economy* (Wellink, 2008).

Even though Wellink (2008) stated that the BCBS did plan to continue public consultation throughout 2009, the degree to which the BCBS would incorporate public opinion in the new regulatory requirements remained a point of uncertainty.

In January 2009, the BCBS (2009b:2) proposed additional requirements for credit exposures in the trading book with the introduction of a stressed VaR requirement. As losses in banks' trading books during the credit crunch have increased to a level which is higher than the minimum capital requirements under the Pillar 1 market risk rules, the BCBS will require banks to calculate a stressed VaR by taking into account a one-year observation period relating to significant losses. This would be in addition to the VaR based on the most recent one-year observation period. This study incorporates these requirements in the empirical capital calculations as the calculated market risk charge is calculated with stressed market element built into the modelling process.

The BCBS (2009b:2) also proposes to:

> *...discontinue the preferential treatment of a 4% capital charge for specific risk of equities that is currently applicable to portfolios that are both liquid and well-diversified. As a result, an 8% capital charge for specific risk of equities would apply in all cases.*

As stated earlier in this chapter excludes SR in modelling; hence the proposal does not impact the analysis of the bond portfolios investigated.

In addition to the BCBS' (2009b:2) proposed changes, it vowed to:

> *...initiate a longer-term, fundamental review of the risk-based capital framework for trading activities.*

4.4.16 Potential consequences of proposed regulatory changes

The impact of the changes to the current regulatory framework, with specific reference to market risk, is explored in the next section. If the changes resulted in a trebling of regulatory capital (as warned by ISDA

(2008:2)), the levels of economic capital would also change dramatically if based on the principals of regulatory capital calculations. The impact of punitive regulatory capital charges on banks could be devastating (ISDA, 2008:3). In the economic downturn this could lead to even less liquidity in the market which might not necessarily be effective and correct. However, before assuming that a bank might consider the proposed capital charge for market risk to be too onerous for their economic capital, the contrarian argument also needs to be explored.

With the surge in VaR levels experienced by banks, the possibility does exist that regulatory capital for market risk might not be sufficient to cover mounting losses in a bank. Regulatory capital for market risk might thus underestimate required market risk capital. From that perspective, this chapter attempts to determine whether economic capital levels would be sufficient by examining recent market developments. The goal of this chapter is, therefore, not to expose the potential flaws in the proposed Basel II amendments, but to determine a fair level of economic capital for the trading book to be held by a bank. This is achieved by investigating empirical data from banks and applying the proposed regulatory requirements to these data. In order to compare the BCBS's standards with the actual experiences in banks, this study used loss data from several large banks (all of whom employed the IRB approach for credit risk).

4.4.17 Conclusion of the literature study

The literature study of this chapter covered a wide variety of concepts, definitions and developments needed to comprehend the methodology presented in this chapter. The next section introduces the background mathematics regarding the methodology as well as an exploration of the required parameters. The next section also applies the mathematics to a specific set of vanilla bond data. The properties of the underlying data are described in detail as well as the modelling procedures and evidence for the assumptions used in the calculations.

4.5 Methodology and parameters

The methodology applied in this chapter is to apply all the relevant market risk concepts including the recent development in IDR to design a model for trading book capital based on the prescriptions of the BCBS. This involves using the BCBS prescription and applying the same level of mathematical rigour for trading book capital calculation as used in the banking book.

ISDA (2008:03) concluded that BCBS' proposed requirement of a 99.9% confidence interval over a full year (250 trading days) holding period for credit risk assets in the trading book is too onerous and asserted an alternative proposal by recommending that it should be reduced to a 60-day holding period with the same confidence interval. With these two proposals in mind, this study attempts to establish e*mpirically* what the *fair* holding period is for the credit exposure in the trading book under the new capital requirements proposed by the BCBS. A fair level of holding period will enable banks to calculate a fair level of economic capital for the trading book by applying the exact same mathematical standard as prescribed by the BCBS. The holding period was specifically selected as the LGD, correlation and equations prescribed by Basel II could not be changed in order to determine a fair level of economic capital. The only element in capital calculation that can be adjusted is the probability of default (PD). While the PD itself cannot be changed, the period over which it is valid *can* be investigated and adjusted (PD is always measured annually unless otherwise stated) (Algorithmics, 2006: A6).

The logic that needs to be followed to achieve the goal of this chapter is therefore to adjust the holding period of the PDs until the capital charges equal the maximum losses experienced by banks immediately after the credit crunch (and ongoing) in the trading book. Once this empirically proven holding period has been determined, banks may use it as their economic capital calculation guide.

This study recognises the fact that banks have no choice but to follow BCBS rules as laid out in Basel II for regulatory capital. However, if they employ the empirical holding period, they could benefit because this is a fairer estimate of economic capital required for the trading book. This study applies the VCV measure of VaR to a portfolio of fixed income instruments and assumes that banks wishing to utilise this technique have been approved for AIRB approach.

4.5.1 Data

In order to compare the BCBS's standards with the actual experiences in banks, this study used loss data from several large banks (all of whom used the AIRB approach for credit risk). Data were sourced directly from the market. Where publicly available data (such as asset return series) were required, these were obtained from third party data sources such as Bloomberg™ or Reuters™. However, some of the data were also not disclosed to market participants, but available to the author. Such privileged data were suitably applied as to disguise the source and where necessary, permission to present analytical results without data source disclosure was sought from data owners.

A fundamental input into this study is the recent finding that (on average) banks' VaR (measured during normal, non-volatile market periods) increased by a factor *of up to three* at the period of highest volatility measured during the credit crunch (Van Vuuren, 2009). The following issues need to be considered:

- Basel I proved inadequate in providing for sufficient capital to cover market risk in the trading book,
- Basel II tried to address this inadequacy by introducing credit risk charges for the trading book (IDR: measured at the same standards as for the banking book),
- the implementation details and monitoring from regulators was, however, insufficient and as credit within the trading book increased (a boom in cheap credit and credit derivatives since the mid 00's) further steps needed to be taken, and
- the BCBS increased the requirements during the credit crunch, but industry participants have not receive these new requirements (which they argue are far too onerous) very well.

To investigate these problems, a simple portfolio comprising only corporate bonds (with no embedded optionality) is considered. VaR (and capital requirements) for this portfolio is measured pre-crisis[38] and this value then compared with the capital charges for the trading book after taking into account (a) increased volatility measured during the most volatile period of the credit crunch and (b) the new IDR capital charges. This latter capital charge will then be compared with worst-case, actual bank loss experience calculated during the credit crisis. If the values compare favourably, it may be said that the Basel II capital charges are – in some sense – 'fair' since the credit crunch is widely considered to be the most severe market event for several decades. If the Basel II capital charges are onerous compared with the actual measured losses then efforts is made to adjust parameters in the Basel II formulas to ascertain how they might be altered to make the charges fairer.

4.5.2 Modelling the market risk charge

The industry and regulators agree that VaR should be applied as the principal risk management tool measure and compare the market risk between different portfolios and institutions, the model built in this study therefore calculates the VaR of the different Monte Carlo simulated bond portfolios.

4.5.2.1 VaR for bonds

Credit-risky investments expose buyers to both market movements (of interest rates) as well as to credit quality transitions (and, ultimately, default of the issuer). Credit risky assets, therefore, are subject to both market and credit risk even though they are held in the trading book (Golub & Tilman, 1997:75). Bonds (specifically plain vanilla, corporate bonds) were used in this study as the idea was to isolate the effects of credit-risky instruments from other types of instruments (such as equities) in the trading book. These portfolio positions are expected to be traded in the market frequently and are not intended to be held (generally) until maturity as they are in the banking book (BCBS, 2005b:3).

In equities the default risk is implicit whereas for debt instruments the default risk is *explicit*. Using simple debt instruments (plain vanilla corporate bonds) illustrates the application of the methodology introduced in this chapter. Complex debt instruments (such as CDSs and CDOs) are complex and this complexity unnecessarily obscures the effective application of the introduced methodology. Banks which hold complex instruments may still apply the methodology introduced in this chapter provided they can accurately determine both the market and credit risk capital charge components. The determination of the market risk charge for complex debt instruments, however, is a complicated task[39] (De Cleen, 2008:22). Sovereign bonds were excluded from this study since they are usually considered risk-free. From a *credit*

[38] This is effectively the "normal market VaR".
[39] For more information on calculation the VaR for these complicated financial instruments (CDSs), refer to the PhD study by Yi (2007) titled: *Value at Risk for a portfolio of Credit Default Swaps*. The study from Yi (2007) illustrates the degree of complexity and advanced mathematical approaches needed to calculate VaR for CDSs.

risk perspective, they are not comparable to corporate bonds which have a higher level of credit risk (Gibson, 2000:39).

Holding period returns[40] for bonds depend on changes in a bond's price over the holding period. The price/yield relationship of a bond is normally nonlinear; however a linear approximation between the current combinations of price (P) and yield (y) can also be (Dowd, 1998:67):

$$P(y+\Delta y) \approx P(y) + \left(\frac{dP}{dy}\right)\Delta y \text{ (To first order)} \tag{4.13}$$

Where:

- $P(y+\Delta y)$ = the total change in the bond price due to a small increase in yield
- dP = change in bond price
- dy = change in yield
- Δy = a small change in yield. However, it is also known that:

$$\left(\frac{\Delta P}{\Delta y}\right) = -D^m P \tag{4.14}$$

Where:

- D^m = the bond's modified duration from the standard definition. The percentage change in bond price in then

$$\left(\frac{\Delta P}{P}\right) \approx -D^m \Delta y = -D^m y\left(\frac{\Delta y}{y}\right) \tag{4.15}$$

and the volatility of bond prices σ_P (and hence, the volatility of returns σ_R) is approximately:

$$\sigma_R = \sigma_P \approx D^m y \sigma_y \tag{4.16}$$

Where:

- D^m = the modified duration
- y = the yield to maturity and
- σ_y = the yield volatility

Assuming relative change in the yield is normally distributed, VaR for bonds is given by (using Equation 4.16):

[40] The return of a bond held over a given period (usually for a shorter period of time, hence not until maturity). The return is measured as the income and other gains (such as appreciation) earned from the bond, divided by the original cost of the bond (Livingston, 1999:59).

$$VaR^{\text{Bond}} = -CI\sigma_R P \approx -CI\left(D^m y \sigma_y\right)P \tag{4.17}$$

Where:

- P = the bond's present price defined as:

$$P = \sum_{t=1}^{m} \frac{C}{u^t} + \frac{F}{(1+r)^T} \tag{4.18}$$

Where:

- F = the face value, payable at maturity
- C = the coupon payment
- u^t = the discount factor
- t = time index
- r = interest rate at which the face value should be discounted
- T = the time to maturity

D^m (in Equation 4.17) = the modified duration. To calculate the modified duration of a bond, the Macaulay duration is used. The Macaulay duration is calculated by adding the results of multiplying the present value of each cash flow by the time it is received. This is then divided by the total price of the asset (Macaulay, 1938). The equation for Macaulay duration is as follows:

$$D_{\text{Macaulay}} = \frac{\sum_{t-1}^{n} \frac{t \times C}{(1+i)^t} + \frac{n \times m}{(1+i)^n}}{P} \tag{4.19}$$

Where:

- n = the number of cash flows until maturity
- t = the time to maturity
- i = the required yield
- m = the maturity (par) value

The modified duration may be used to calculate the effect that an x% change in interest rates will have on the price of a bond. The following equation is used for this purpose:

$$D_{\text{Modified}} = \left[\frac{D_{\text{Macaulay}}}{1 + \frac{YTM}{f}}\right] \tag{4.20}$$

Where:

- f = the number of coupon periods per year

- *YTM* = the bond's yield to maturity

The Monte Carlo technique was used to generate large numbers of simulated portfolios in the trading book. Historical data (including yields to maturity, coupons, credit ratings and maturities) were first collected for 250, actively traded, option free corporate bonds spanning the 5 years from June 2003 to July 2008. Next, the Monte Carlo technique was used to generate thousands of realistic, market-relevant values of duration, yield, credit quality and coupon rate. As in all Monte Carlo simulations, historical averages, volatilities and correlations (see Table 4.1 below) were preserved.

Table 4.1: Correlation matrix derived from 5 years of historical observations of corporate option-free bonds

CORRELATION	Coupon	Maturity	Yield to maturity	Credit rating
Coupon	**1**	-0.13	0.74	-0.35
Maturity		**1**	-0.07	0.11
Yield to maturity			**1**	0.22
Credit rating				**1**

The next step in the process is to determine the VaR for market risk as prescribed in Basel II and as suggested by ISDA.

The individual, simulated bonds were used to construct scenarios for which the market risk charges were then determined. A total of 300 different bond portfolios were used for the analysis, each portfolio consisting of 130 individual bonds. Three classes of bond portfolios were constructed namely *all*, *investment* and *speculative* portfolios. It is important to note that *investment* here refers to a high quality, low risk bond portfolio and not to the bank's investment portfolio as traditionally understood.

The difference in these portfolios is in the quality of the bonds. Each simulated bond was also assigned a credit rating (with an associated PD). Even though this had no effect on the *market* risk charge, it had a significant impact on the *credit* risk charge as the varying PDs determine the credit risk in each portfolio. In Section 4.4.3, which explores the credit component of the capital charge for market risk, the composition of the three portfolio categories is discussed.

4.5.2.2 Portfolio VaR

By applying the variance-covariance method discussed in Section 4.3.6, the portfolio VaR for each of the simulated portfolios was calculated by using the inputs summarised in Table 4.2.

Table 4.2: Inputs used in capital calculations

INPUT	VALUE
Confidence interval	99%
k factor	3.5
Annual yield volatility	15 %
Correlation	0.8
Holding period	10 days

Where:

- The confidence interval is prescribed by the BCBS,
- the *k* factor is the average of 3 and 4 (the range of *k* values specified by Basel II),
- the annual yield volatility = 15 % (Maitland, 2002:133),
- the correlation of 0.8 – this is the median, long-term, bond yield correlation as determined by the IMF (2007:130). This correlation is used in the variance-covariance matrix, and
- the *market risk* holding period is prescribed by BCBS. This component of VaR is a liquidity adjustment, albeit a fairly crude one. The less liquid a portfolio, the longer it will take to dispose of it and the higher is the VaR.

Many properties of the normal distribution may be exploited, including the attribute that variance scales linearly with time or, more precisely, the variance over a given forecast period is linearly related to the forecast period (so the 10-day return variance is double the 5-day return variance for example) or: $10-\text{day variance} = 2\times(5-\text{day variance})$, $10-\text{day variance} = 10\times(1-\text{day variance})$ *etcetera*.

Another expedient characteristic of the normal distribution is that the variance and the standard deviation are related by $V(r_t)=\sigma(r_t)^2$ where V is variance, σ is the standard deviation or volatility, and r_t represents a vector of returns (r) measured at various points in time, (t).

Multiple, and often different, time periods used in market risk can give rise to confusion unless care is exercised. The portfolio standard deviation (volatility) calculated using a set of *daily* returns will produce a *daily* standard deviation (volatility). This is a direct result of the time period between observations – *not* the length of the observation period itself. *Monthly* returns produce a *monthly* standard deviation, etc. Whilst some care must be taken not to use too few data (as this results in spurious results due to statistical inaccuracies) it is important to bear in mind that whether 3 years or 30 years of daily returns were used to estimate the volatility, the calculation yields a *daily* volatility. Scaling this up to an annual volatility, for example, requires multiplying it by $\sqrt{250}$ or the number of trading days in the average year. A 1-day VaR is commonly used in-house, but often a different-period VaR is required, e.g. a 10-day VaR is a mandatory requirement for the regulator.

The next section discusses the credit risk charge.

4.5.3 Modelling the credit risk charge

Banks' trading books can – and do – comprise of bonds (whether gilts (sovereign bonds) or corporate bonds). Since these bonds are in the trading book, and are therefore intended for frequent resale, they exhibit embedded market risk the modelling of which was discussed in the previous section (using VaR). The credit risk component has, however, been ignored historically in the trading book. This is now examined. In this section, the *credit* risk associated with bond portfolios in the trading book is modelled and the associated credit risk capital charges is calculated. In order to determine the underlying credit risk of a bond, the counterparties involved need to be assessed. Credit ratings provided by credit or ratings agencies provide these data and these were used to estimate the associated credit capital charge (Wiener, 1997:3). To determine the underlining credit risk associated with the simulated bond portfolios, the IRB approach is used to calculate the regulatory capital charge for each of the portfolios.

Three types of bond portfolios were simulated. The first portfolio type (*All bonds*) consists of all quality bonds ranging from AAA to CCC. The second portfolio type (*Investment bonds*) comprises bonds with ratings from AAA to A while the third (*Speculative bonds*) comprises bonds from BB to CCC. For every portfolio type, 100 different, random simulations were generated, resulting in 100 portfolios with comparable quality bonds for which the market and credit capital charge could be estimated. Each of the 300 portfolios consisted of 130 randomly simulated bonds. A total of 39 000 bonds were therefore simulated for analysis purposes.

As the bonds in these three portfolio types have different quality ratings, they also have a different associated level of credit risk. As in banks, each credit rating assigned to a bond is associated with a specific PD.

The PDs of each of the bonds are summarised in Tables 4.3 and 4.4.

Table 4.3: PDs assigned to high quality, investment bonds

AAA	AA+	AA	AA-	A+	A	A-
0.03%	0.05%	0.10%	0.12%	0.25%	0.40%	0.50%

Source: BCBS (2006a:279)

Table 4.4: PDs assigned to Lower quality, speculative bonds

BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC
0.75%	1.00%	1.30%	1.50%	2.00%	2.50%	3.00%	4.00%	5.00%	20.00%

Source: BCBS (2006a:279)

PDs were determined by assigning borrowers to risk buckets where each bucket contains customers with the same level of risk. For each level of risk a one year PD is expressed as a percentage. PD buckets (as provided by the BCBS) are standard risk buckets (see Table 4.4) and are used by banks (BCBS, 2006a:279).

The following parameters (introduced in Equation 2.3) are used to calculate the capital charge for credit risk:

$$\text{Credit risk capital required} = EAD \times f(PD, LGD, \rho, M) \times 8\% \qquad (4.21)$$

In this calculation, the EAD is a multiplied by a function which derives its value from of the PD, LGD, asset correlation (ρ) and maturity (M). The capital is then determined by multiplying the total by 8% (specified by Basel II) as indicated in the Equation 2.3 (Lamy, 2006:160). In the attempt to compare the market and credit capital charges for all the simulated bonds and portfolios, the exact values of the parameters used in the VaR calculations for market risk are applied to the equation above (also introduced in Equation 2.3) in order to determine the capital charge for credit risk.

The capital charge for a bond portfolio is the sum of individual capital charges for each underling bond in the portfolio. For the purpose of this study, the 100 different portfolios in each of the three types of bond portfolios are used to compare capital for credit and market risk.

The final capital charge is calculated by multiplying the calculated capital by a scaling factor of 1.06. This scaling factor is based on the concept of incentivising regulatory capital to encourage risk sensitive development of Basel II. The scaling factor could be either more or less than one, hence having a direct impact on the IRB capital requirement derived from revised capital framework. The scaling factor used in this study is based on data from the Quantitative Impact Study 5 (BCBS, 2007a:3).

The next step in calculating regulatory capital (K) for the credit risk associated with a bond is to multiply the EAD with the calculated unexpected loss (UL) as well as the maturity factor associated with the individual bond. To calculate the credit risk capital charge, Equation 4.22, is used:

$$UL = LGD\left(N\left(\frac{N^{-1}(PD)+\sqrt{\rho}\cdot N^{-1}(0.999)}{\sqrt{1-\rho}}\right)-PD\right)\times SF \qquad (4.22)$$

Where:

- LGD = a downturn LGD required by the BCBS. The specific value of 40% was used and is based on the results of the 5th quantitative impact study (BIS, 2007a:30),
- N = a standard normal distribution,
- N^{-1} = the inverse of the standard normal distribution, and
- ρ = the asset correlation and calculated according to the prescriptions of the BCBS (2005b:13). The equation used to calculate the correlation for corporate bonds to be used in Equation 4.23:

$$\rho = 3\% \cdot \frac{(1-\exp(-x\cdot PD))}{(1-\exp(-x))} + 16\% \cdot \left[1-\frac{(1-\exp(-x\cdot PD))}{(1-\exp(-x))}\right] \qquad (4.23)$$

Where:

- x= 50

The asset correlation for corporate bonds consists of two limiting correlations: 12% and 24% that represent extreme high and low PDs (100% and 0% respectively) and are modelled by an *exponential weighting function* which indicates the dependency on the PD. The pace at which the exponential function decreases is determined by a factor, specified by the BCBS, called the x-factor. This x-factor has an assigned value of 50 for corporate exposures (BCBS, 2005b:13).

- SF_{MATURITY}, is the maturity scale factor. A bank's credit portfolio consists of instruments with different maturities. Short-term credit is less risky than in the long-term resulting in increased capital requirements for credit instruments with higher maturity (BCBS, 2005b:9). The maturity factor is calculated as prescribed by Basel II by using Equation 4.24 specified for bonds:

$$SF_{\text{MATURITY}} = (1 - 1.5 \times b(PD))^{-1} \times (1 + (M - 2.5) \times b(PD)) \tag{4.24}$$

Where:

- PD = determined by the risk buckets in Table 4.3 and 4.4 and b(PD) represents the smoothed (regressed) maturity adjustment (smoothed over PDs) and calculated by using Equation 4.25 (BCBS, 2005b:11).

$$b(PD) = (0.11852 - 0.05478 \times \log(PD))^2 \tag{4.25}$$

The methodology introduced in this chapter needed to be tested for accuracy by validating the model. During this model validation process the capital model used (based on the BCBS standards) in this chapter was tested for accuracy by comparing its calculations to what ISDA (2007:1) calculated. Once the model has been validated the methodology will further expanded and discussed.

The BCBS proposes a holding period of 250 days and ISDA 60 days (both with a 99.9% confidence interval), the validated capital model is used to determine an *empirically* established, fair holding period for the credit exposure in the trading book.

4.5.4 Model validation

Three types of bond portfolios were simulated for validating the capital model based on the BCBS' requirements. The results, based on 39 000 bonds were used to validate the model used for capital calculation in this chapter. The following steps were taken to validate the capital model used:

i. calculate the original market risk charge ($MVaR_{\text{ORIGINAL}}$) prescribed by the BCBS for the bond portfolios above,

ii. calculate the proposed credit risk charge (CVaR) of the portfolio (based in the credit rating of underlying bonds),

iii. calculate the new market risk charge ($MVaR_{\text{NEW}}$) due to increased market volatility,

iv. calculate the ratio of the increase in capital required under the proposed capital regulations. This is expressed using:

$$\text{Ratio} = \frac{MVaR_{\text{NEW}} + CVaR}{MVaR_{\text{ORIGINAL}}} \quad (4.26)$$

v. the calculated ratios which represent capital increases is compared to the findings of ISDA (2007:1) which determined that that the total market risk charge ($MVaR_{NEW}$ + CVaR) can treble under the new, proposed capital requirements, and

vi. if the finding of the capital model used in this study is comparable with findings by ISDA (2007:5), which conducted a study in conjunction with seven leading international banks in 2007, it is confirmation that the assumptions and metrics applied are indeed accurate and hence the model would be validated.

These steps are presented next.

4.5.4.1 MVaR results

For the original market risk charge ($MVaR_{ORIGINAL}$) the results found for the different portfolio types are summarised in Table 4.5 below. $MVaR_{ORIGINAL}$ is expected to remain the same for all three types of portfolios as the market risk exposure is not affected by the credit rating.

Table 4.5: MVaR results from the capital model.

	All bonds	***Investment***	***Speculative***
EAD	\$684,009,826	\$684,009,826	\$684,009,826
LGD	40%	40%	40%
Average M	4.1	4.1	4.1
$MVaR_{ORIGNAL}$	\$42,240,774	\$42,240,774	\$42,240,774

Source: Author

Where:

- EAD is the total asset value of the randomly simulated portfolio. The EAD is the same for all portfolio types as the same bonds, with different rating were compared,
- LGD, described in Section 3.3.5, is a downturn LGD and is specified by the BCBS,
- M represents the average maturity of the bonds in the portfolio. The values summarised in Table 4.5 for M are also the average maturity of the 100 different portfolios simulated of the specific portfolio type and

- $MVaR_{ORIGINAL}$ is the calculated market value at risk produced by the model. $MVaR_{ORIGINAL}$ is identical as the risk factors for market risk are the same. Only the PDs differed and therefore credit risk will have different values across the three asset types.

4.5.4.2 CVaR results

The results of the proposed credit risk charge (CVaR) of the portfolio (based in the credit rating of underlying bonds) is summarised in Table 4.6.

Table 4.6: CVaR results from capital model.

BCBS: 1 year	***All bonds***	***Investment***	***Speculative***
Exposure weighted PD	1.00%	0.12%	2.25%
CVaR	$57,307,602	$23,181,520	$70,669,648

Source: Author

4.5.4.2.1 Increase ratio

The results of the calculated increase in capital that would be required under the proposed capital regulations are summaries in Table 4.7.

Table 4.7: Increase in capital that under the proposed capital regulations.

BCBS	***All bonds***	***Investment***	***Speculative***
$MVaR_{ORIGINAL}$	$42,240,774	$42,240,774	$42,240,774
CVaR	$57,307,602	$23,181,520	$70,669,648
Total VaR	$99,548,376	$65,422,293	$112,910,421
Ratio_1y	2.4	1.5	2.7

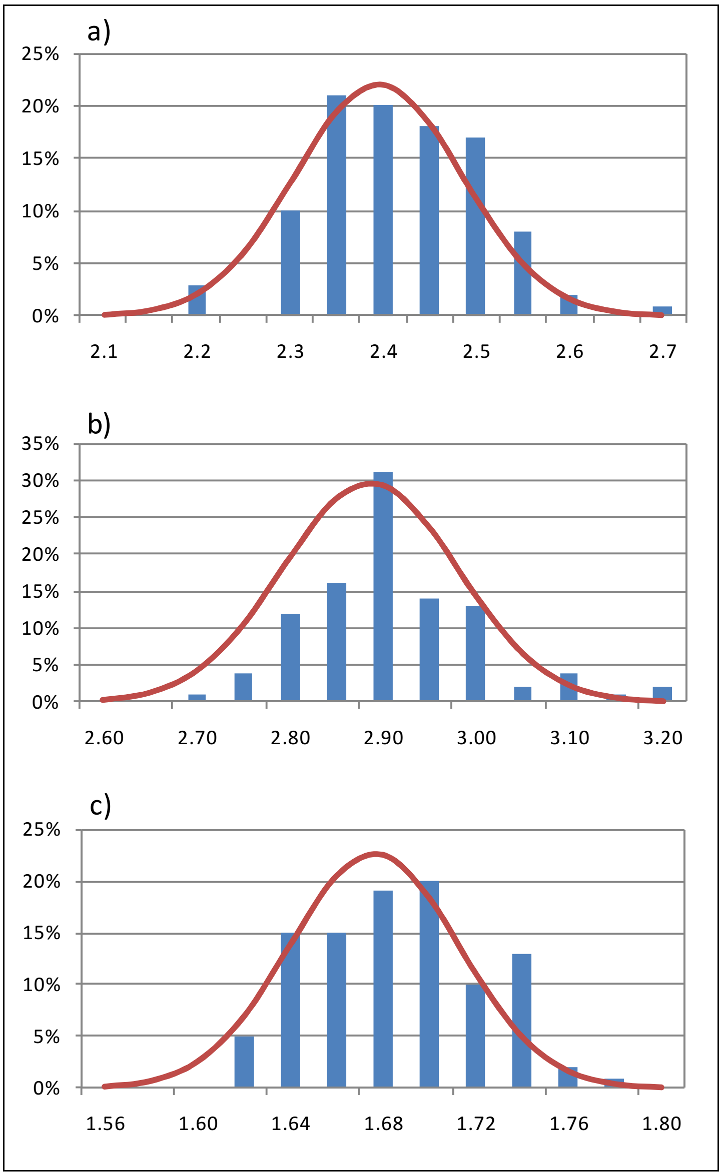
Source: Author

The results indicate that when using the proposed BCBS approach, the result is a capital increase ranging between 1.5 for high quality bonds to 2.7 for lower quality bonds when compared with the current charge. This illustrates the validity of the model as it is in line with ISDA's estimations which asserted that *market risk regulatory capital can be expected to almost treble relative to the current VaR-based regime* (ISDA, 2007:1).

4.5.4.2.2 Data distributions and risk sensitivity

The distributions of ratios ($MVaR_{ORIGINAL}$/Total VaR) are illustrated in Figure 4.4 below:

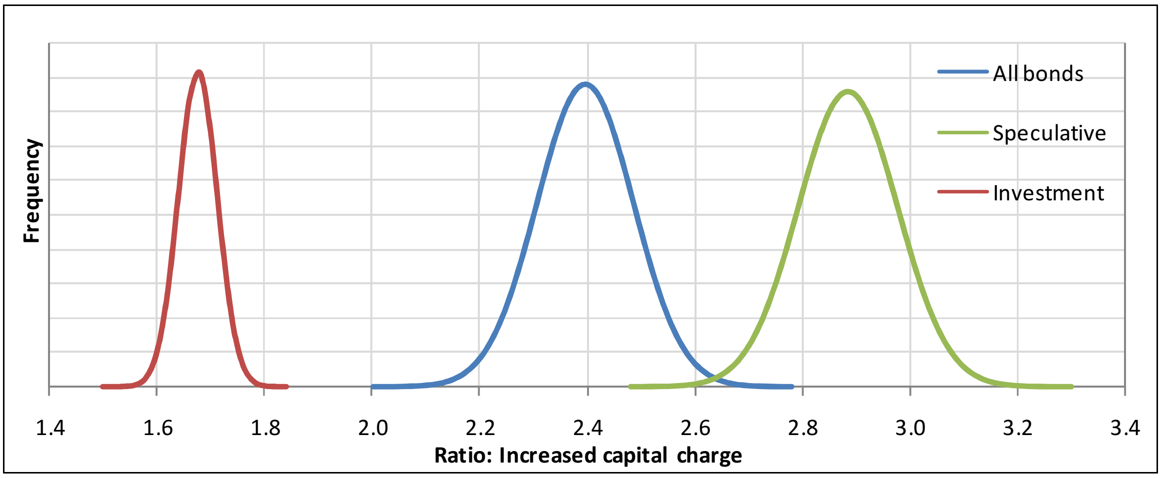
Figure 4.4: Distributions of ratios ($MVaR_{ORIGINAL}$*/total charge) where: a) All bonds, b) Speculative portfolios & c) investment portfolios. The vertical axis represents the frequency*



Source: Author

Figures 4.4 a-c above and Figure 4.5 indicate that the model is indeed credit risk sensitive with low quality bonds (speculative) resulting in a higher capital increase ratio than good quality bonds (investment).

Figure 4.5: Distributions of ratios of all, speculative and investment portfolio bonds on the same ratio scale



Source: Author

The analysis of IDR's impact and the fair unwind period may now be calculated. The results are discussed in the next section.

4.5.5 IDR and the holding period

The simulated bond portfolios used are investigated in this section by altering some assumptions for the model's input in order to account for different market conditions. The simulated bond portfolios will no longer be separated into the three different portfolio types (all bonds, investment and speculative) as this section focuses on portfolios of *all* types of quality bonds. The same metrics as were applied to the above mentioned bond portfolios were applied to the 100 bond portfolios comprising of 130 simulated bonds each.

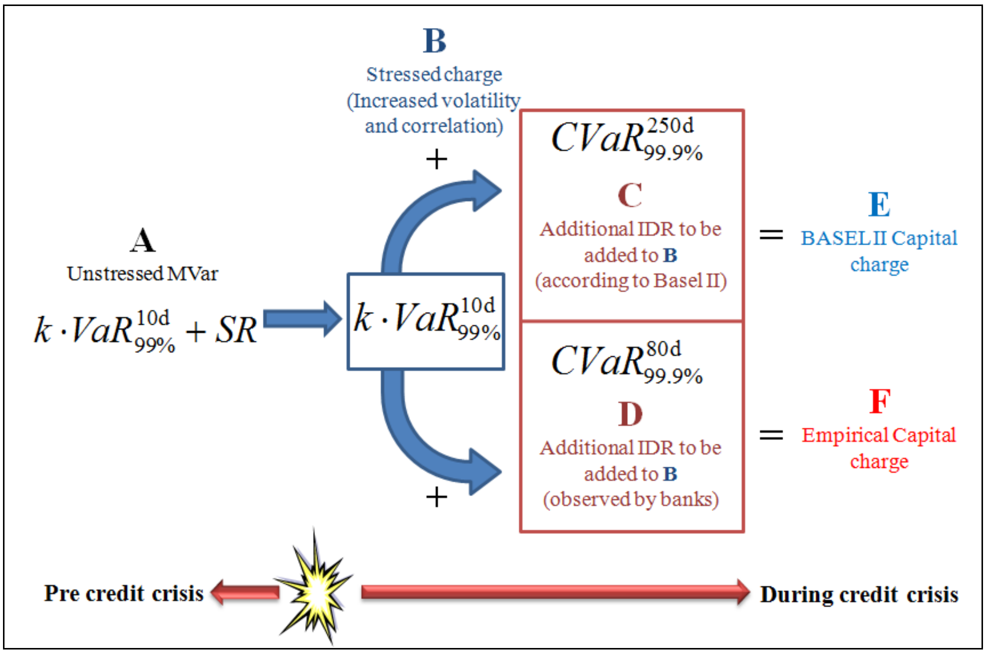
For each of the simulated bonds in the portfolio, the following inputs are known:

- yield volatility,
- yield correlations,
- maturity and
- durations.

The regulatory capital requirement for market risk was calculated by using the inputs mentioned above.

The different steps in calculating the regulatory as well as empirical capital charge is illustrated in Figure 4.6. The process of calculating these different capital charges is discussed in the next section by referring to the different steps in Figure 4.6. Note that the value of "80 days" in block "D" is a result of the analysis performed: details of its derivation are reported later in the chapter and in detail in Chapter 5.

Figure 4.6: Calculating the Basel II and empirical capital charge (before and after the credit crunch for the trading book.



Source: Compiled by the author.

4.5.5.1 **MVaR during unstressed (pre credit crunch) conditions** (**A** in Figure 4.6)

When calculating the current capital charge for market risk, as prescribed by Basel II, the input introduced in Table 4.2 are summarised in Table 4.8 below.

Table 4.8: Inputs for capital charge.

Input	*Value*
Confidence interval	99%
k factor	3.5
Annual yield volatility	15%
Correlation	0.8
Holding period	10 days

The inputs in Table 4.8, which refer to unstressed market conditions (pre credit crunch), are applied to the equation in Step A, Figure 4.6, to determine the unstressed market risk capital charge. The market risk capital calculation model is used to determine a capital charge for market risk which adheres to the current (Basel II) requirements. Based on 13 000 (100 portfolios each comprising 130 bonds) randomly simulated portfolios with bonds of varying credit quality, the calculated capital charge for market risk is:

$$\overbrace{MVaR_{99\%}^{10d}}^{\text{Unstressed}} = \$38.6m \tag{4.27}$$

For the purpose of simplicity, the MVaR above, as well as all the other values calculated in Figure 4.6 was normalised (converted to $100). MVaR in Equation 4.28 is therefore equal to $100m instead of $38.6m as indicated above.

$$\overbrace{MVaR_{99\%}^{10d}}^{\text{Unstressed}} = \$100m \tag{4.28}$$

It is important to highlight that this calculated value is based on an unstressed MVaR and does not include any of the recent changes to market risk capital charges.

4.5.5.2 The new capital charge by adding the CVaR (IDR to MVaR)

The BCBS was not satisfied with the MVaR (**A**) charge alone as credit risk in the trading book increased dramatically in recent times and therefore proposed that the IDR should be added to the capital charge to form a new, credit risk sensitive CVaR (**C** in Figure 4.6) for the trading book. The increased capital charge comprises the new stressed MVaR (due to increased market volatility) plus the new CVaR. The new trading book capital charge was calculated to determine the required capital. These capital requirements were estimated using volatility data extracted from markets still reeling from the effects of the worst economic conditions since the economic meltdown of 1929 (Altman, 2008).

During the 2007-09 credit crunch the interest rate market experienced pressure from two aspects:

- increased yield volatility and yield correlations (for market risk)
- increased defaults manifested through increased PDs (for credit risk)

In the capital calculations a *stressed* economic environment is considered by calculating a stressed market risk capital charge (due to increased volatility and correlations) and a new credit charge (which includes the proposed IDR charges).

4.5.5.3 Capital charge during stressed conditions

For market risk, the yield volatility is stressed to incorporate current market conditions. This is accomplished by increasing the yield volatility of 15% (as found by Maitland, 2002:133) for unstressed market conditions. Yield volatility in the US (measured since 1960) showed an increase during times of adverse economic conditions. This is in line with the view of Borio & McCauley (1996:23) who found than yield volatility can increase from 15% to 30% during adverse economic conditions. The yield volatility was therefore increased to 25% to reflect a stressed economic environment.

During adverse market conditions, one of the most important lessons learned from previous financial crises is that correlation increases (Chang *et al*, 2008:15). As correlation increased from 0.8 to 1.0 during stressed conditions historically (Van Vuuren, 2009), an average correlation of 0.9 was chosen and applied to the stressed MVaR calculation below (Equation 4.34). All the inputs for stressed market conditions are summarised in Table 4.9.

Table 4.9: Inputs for capital charge during stressed conditions

Input	*Value*
Confidence interval	99%
k factor	3.5
Annual yield volatility	25%
Correlation	0.9
Holding period	10 days

The same metrics (only with different inputs) were used to estimate MVaR under stressed conditions (**B** in Figure 4.6). Furthermore, the same selection of 13 000 simulated bonds was used to compare the differences in capital charges. The stressed MVaR resulted in a significantly higher charge for MVaR as given in Equation 4.29.

$$\overbrace{MVaR_{99\%}^{10\,\mathrm{d}}}^{\text{Stressed}} = \$185\text{m} \tag{4.29}$$

The capital model calculated the credit risk capital charge in the trading book in the same way the bank calculates credit risk capital charges for the *banking* book.[41] Using the same portfolio, the credit risk capital charge (using annual PDs) is calculated (**C** in Figure 4.6) and is found to be:

$$CVaR_{99.9\%}^{250\mathrm{d}} = \$148\text{m} \tag{4.30}$$

With the capital charges calculated, the two separate charges (MVaR and CVaR) are added together to result in the total capital charge for the portfolio of bonds as proposed by the BCBS.

Total Capital charge (TC) under stressed conditions is therefore:

$$\begin{aligned} \overbrace{TC}^{\text{Stressed}} &= \overbrace{MVaR_{99\%}^{10\mathrm{d}}}^{\text{Stressed}} + CVaR_{99.9\%}^{250\mathrm{d}} \\ \text{(from Figure 4.6)} \quad E &= B + C \\ &= \$185\text{m} + \$148\text{m} \\ &= \$334\text{m} \end{aligned} \tag{4.31}$$

Comparing this proposed regulatory capital (MVaR + CVaR under stressed conditions) with the preceding regulations (MVaR unstressed) the ratio of capital requirements after the credit crunch to those before the onset of the crisis are:

[41] It has been assumed that the banks in question were approved to employ the AIRB approach for credit risk in the banking book.

$$\text{Ratio}_{\text{Increase}} = \frac{\overbrace{MVaR^{10d}_{99\%}}^{\text{Stressed}} + CVaR^{250d}_{99.9\%}}{\overbrace{MVaR^{10d}_{99\%}}^{\text{Unstressed}}}$$

$$\begin{aligned} \text{(from Figure 4.6)} \quad &= \frac{B+C}{A} \\ &= \frac{\$185\text{m} + \$148\text{m}}{\$100\text{m}} \\ &= 3.34 \end{aligned} \tag{4.32}$$

This implies that the capital charge under the proposed capital calculation requirements is 3.34 times more than the original market risk capital requirements. This ratio was increased at a time when banks are experiencing one of the most severe economic crises in banking history (Altman, 2008). The ratio is therefore higher than it would be during normal (unstressed) market conditions. This is, however, more than banks experienced during the current adverse market conditions as the recent finding (Van Vuuren, 2009) showed that banks reported an increase of, on average, three times the estimated amount (using Basel II standards). The proposed amendments therefore result in a larger capital charge than experienced by banks in arguable the most stressed economic times in history. The most accurate level (based on empirical data) of capital can be calculated as follows:

$$\begin{aligned} TC &= 3 \times \overbrace{MVaR^{10d}_{99\%}}^{\text{Stressed}} \\ \text{(from Figure 4.6)} \quad F &= 3 \times A \\ &= \$300\text{m} \end{aligned} \tag{4.33}$$

Where:

- The MVaR is multiplied by three to reflect the market experience during recent months (stressed conditions).

The proposed Equation 4.32 from the BCBS should therefore be adjusted to find the fair level of the credit risk capital charge ($112m).[42] Some inputs to the capital charge equation cannot, however, be adjusted. MVaR, for example, cannot be changed as the inputs (99% confidence interval and 10 day holding period) are *prescribed* by the BCBS. Furthermore, the yield correlation and volatility already been adjusted to reflect current economic conditions, they cannot, therefore, be altered again. The only input from Equation 4.32 that may be stressed further (or adjusted) is the CVaR component: $CVaR^{250d}_{99.9\%}$. Even though CVaR can be changed, there are still a few inputs in the CVaR (**C** in figure 4.6) calculations that may not be adjusted, such as the EAD, the correlation and the LGD (which is already a downturn measure) .

The PD may also not be changed *per se* as PDs are meant to reflect default probabilities as measure through the economic cycle. However, the period over which the PDs are measured (i.e. holding period for credit risk) could, in principle, be changed. A change in the period therefore changes the PD.

[42] See Equation 4.35 for this derivation.

As the empirical ratio of capital charges pre and post the crisis is approximately three, this increase ratio is applied to Equation 4.32 to proceed with further investigation.

$$MVaR_{99\%}^{10d} = \frac{MVaR_{99\%}^{10d} + CVaR_{99.9\%}^{xd}}{\underbrace{3}_{\text{Empirically - i.e. from market observations}}} \tag{4.34}$$

Where:

- x =the holding period (in days) for the credit risk component and the following inputs are known:
- the unstressed MVaR $\overbrace{MVaR_{99\%}^{10d}}^{\text{Unstressed}}$ (**A** in Figure 4.6)
- the stressed MVaR $\overbrace{MVaR_{99\%}^{10d}}^{\text{Stressed}}$ (**B** in Figure 4.6)
- the difference ratio of three

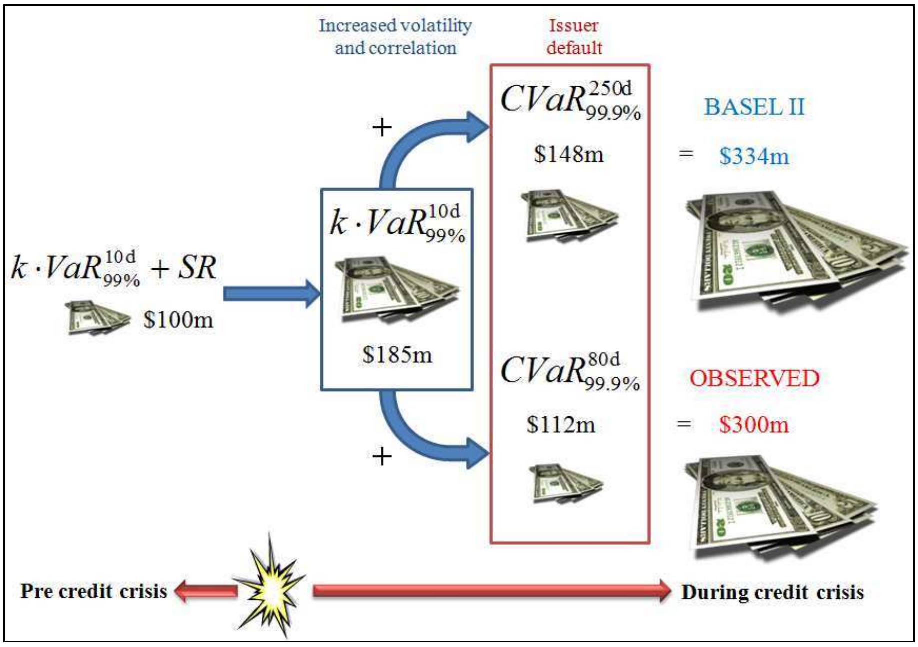
The only unknown in this equation is the holding period for credit risk (x days in Equation 4.32).

When substituting the already calculated numbers in Equation 4.32:

$$\$100\text{m} = \frac{\$185\text{m} + CVaR_{99.9\%}^{xd}}{3}$$
$$(\textit{from Figure } 4.6) \quad A = \frac{B + CVaR_{99.9\%e}^{xd}}{3}$$
$$CVaR_{99.9\%}^{xd} = \$112\text{m}\,(D \textit{ in Figure } 4.6) \tag{4.35}$$

All the values stated above are substituted in Figure 4.7 to illustrate methodology.

Figure 4.7: The Basel II and empirical capital charge (before and after the credit crunch)



Source: Compiled by the Author

Therefore, due to credit risk, the bank therefore lost an amount of \$112m if the empirical difference ratio of three is applied. The \$112m is thus an *empirically* calculated loss.

The only outstanding input is therefore the holding period (x days). The question that needs to be answered is: what value of x will result in a credit risk capital charge (to reflect the credit risk losses) of \$112m? If a bank held this amount (\$112m) for potential losses, it would have had sufficient capital for the losses experienced during the downturn period. The Basel II equation which includes the average maturity, the average PD, the downturn LGD and the sum of all the EADs was used to calculate the CVaR of \$148m. From the simulated bond portfolios the average *annual* portfolio $PD = 0.78\%$ (measured). This annual PD refers to the CvaR of \$148m. However, in order to determine the empirical PD, the average portfolio PD (for the bond portfolios described in this chapter) for a capital charge of \$112m should be determined.

The PD should therefore be adjusted in such a way that, when applying it into the Basel II equations, the CVaR translate to the empirical loss value of \$112m instead of the Basel II prescribed value of \$148m.

The PD can only be adjusted by altering the holding period of 1 year (prescribed by Basel II) to an empirical holding period. This can be done by using a reverse-engineered function. Therefore, to determine the amount of days that translate to a CVaR of \$112m (the *empirically* calculated loss), the following methodology, prescribed by Algorithmics (2006: A6), was used.

For positions in the trading book, the PD can be scale to a horizon shorter than one year. As a PD which is measured over a period less than one-year is difficult to observe, many banks scale the one-year PD downward to reflect a shorter period. Assuming the liquidity horizon for this instrument is (e.g.) one month, the PD may be scaled down using:

Not defaulting in one year = surviving 1 year = surviving 252 days

Thus:

$$ND_{1\text{d}} = \sqrt[252]{ND_{1y}} \text{ and } D_{1\text{d}} = 1 - ND_{1\text{d}} \tag{4.36}$$

Where $D_{1\text{d}}$ is the one day probability of default and $ND_{1\text{d}}$ is the one day probability of survival.

For a period of n days, Equation 4.36 gives

$$ND_{n\,\text{d}} = \sqrt[\frac{252}{n}]{ND_{1y}} \text{ therefore}$$

$$D_{n\,\text{d}} = 1 - \sqrt[\frac{252}{n}]{ND_{1y}} \tag{4.37}$$

The calculated vale for n indicates that the empirical holding period, calculated by using the Basel II proposed modelling and actual loss data is 80 days as opposed to the 250 prescribed by the BCBS and 60 days suggested by ISDA. Therefore, **D** in Figure 4.6 states the equation to be used to calculate a capital charge based on an empirical extracted holding period which is 80 days for the specific dataset used.

4.6 Application of methodology

This section is a step by step application summary which can be used by any bank with sufficient data to extract the empirical holding period.

Step 1: *Know the rules*

Similar to Step 1 in Chapter 3, banks need to determine the exact local and global requirements. Local regulators have the authority to use their own national discretionary rules for some areas within Basel II and banks need to know exactly what these discretionary rules are. Banks also need to stay updated with global requirements as the BCBS may change requirements such as the correlation requirements since the time of this analysis. Banks should therefore always examine the most updated version of Basel II for incremental default risk requirements.

Step 2: *Obtain a portfolio for investigation*

Banks need to identify the credit risky portfolio for which they wish to determine the fair level of economic capital. These portfolios may consist of a mix of CDSs, credit derivatives, bonds (any instruments with a credit risky component, i.e. a possibility of default). Note that equities cannot be included in these portfolios.

Step 3: *Measure VaR*

Banks should next measure the standard market risk VaR of the investigated portfolios. This may be achieved by using any VaR approach.

Step 4: *Stress the parameters*

Stress the parameters (annual yield volatility and correlations) for the VaR calculation. Historical stresses (which may be deemed appropriate to the situations at the time of analysis) should be used.

Step 5: *Measure the credit component of this portfolio*

Measure the credit component of the investigated portfolio using BCBS equations with annual PDs and ratings obtained from relevant sources (either internal or external).

Step 6: *Apply worst case scenario to trading book*

Using historical data (or current) determine worst case scenarios in trading book and apply this to portfolio (similar to the factor of three discussed in Section 4.4.1).

Step 7: *Adjust the PD holding period*

Add values obtained from Steps 4 and 5. If this value does not equal the value obtained in Step 6, adjust the PD holding period according to Algorithmics (2006: A6) equation until the values agree. The value of the holding period at this point is the empirically calculated holding period.

Step 8: *Calculate the fair level of capital*

Use the empirical holding period to determine the empirical PD to be used for calculating capital. The empirical PD can therefore be used in Equation 4.36 (Basel II) to determine a fair level of economic capital, based on empirical numbers derived from the investigated portfolio instead of the BCBS's prescribed PD which does not consider the bank's unique holding period, but rather uses a fixed 250 days.

4.7 Conclusions

This chapter investigated the capital charge for market risk – and more specifically – the trading book. The goal of this chapter was to introduce a calculation methodology which may be employed by banks to determine a fair level of economic capital for market risk assets with a credit risk component (i.e. the trading book). These capital levels should be sufficient to cover losses arising from market and credit risks faced by banks.

In the preceding chapter, asset correlation was investigated as the scientific element to be explored as a component of credit risk models. This chapter investigated IDR which represents the credit risk embedded in bank's trading books. The scientific element investigated in this was the holding period which is one of the few components of contemporary risk models which may be altered subject at the practitioner's whim. By estimating the accurate holding period for a credit risky portfolio, the fair, empirical allocation of economic capital for the trading book may be calculated. Banks can compare this empirically calculated level of capital with regulatory capital which imposes fixed holding periods for banks.

This chapter introduced a calculation methodology, which may be applied by any bank, to determine the empirical holding period for credit instruments in the trading book. The empirical holding period can then be used to calculate a fair level of capital to be held for the trading book, based on the bank's own unique trading book exposures.

The results for the specific dataset applied to the methodology introduced in this chapter is elaborated on and discussed in Chapter 5. Based on the specific data used in this study, a compressive analysis of the credit and market risk charges prescribed by the BCBS is done. The implications of the results from Chapter 3 and 4 will also be discussed and an opinion, based on empirical findings is expressed in Chapter 5.

Chapter 5

Contribution and results of investigated data

> *The assessment of capital adequacy is one of the most critical aspects of bank supervision. Economic capital models can provide valuable additional information that bankers and examiners can use in their overall assessment of a bank's capital adequacy* (FDIC, 2004).

5.1 Introduction

The primary purpose of this study is to introduce calculation methodologies which will allow banks, of any size and complexity, to empirically determine their own unique parameters from their own loss experiences. The two preceding chapters each introduced such calculation methodologies. These empirically determined parameters could be used by banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed in line with the bank's own loss experience. Chapters 3 and 4 provide the calculation methodologies which enable banks to determine fair (i.e. not too punitive as to inhibit efficient functioning of the bank and not too lenient as to allow the bank to malfunction in times of stressed economic conditions) levels of economic capital which should be sufficient to cover losses arising from specifically credit and market risks faced by banks.

If banks, which applied the methodologies introduced in the two preceding chapters, find that the fixed parameters (specified by the BCBS) are too lenient, banks can increase economic capital reserves appropriately and if they are too onerous, banks can judge for themselves whether or not prevailing economic conditions warrant such capital requirement severity. In either case, banks using these methodologies are able to accurately establish their unique, *empirical* capital requirements. Banks do therefore not blindly accept the obscured parameters introduced by Basel II for capital calculations. This chapter will introduce a calculation methodology specifically for credit risk.

In the preceding chapters, Chapter 3 focused on credit risk (under the first pillar of Basel II) and investigated the AIRB which allows banks to choose their own parameters for use in the Basel II specified capital equations. Within the IRB framework, credit risk was investigated by focusing on the estimation of asset correlation. Determining a fair level of economic capital involved an assessment of the empirical asset correlation between loan losses and some measure of economic health. Using this empirical asset correlation in the Basel II specified equations allows the user to determine a fair level of economic capital to be held for credit risk exposures. Asset correlation was deemed important because an incorrect estimation of this value may be detrimental to the management of a bank's capital requirements (Laurent, 2004:23). Chapter 3 focused on retail credit risk which has not received sufficient attention thus far: industry and regulatory resources have always focused more on corporate lending (Ghosh, 2005:3) where more abundant data allows for detailed studies. There are thus unexplored opportunities in retail banking as banks with a well-defined retail credit risk management strategy are able to realise significant growth in the future (Rao, 2005:7). It is critical that asset correlation is thoroughly understood by banks as it is the biggest single driving factor of Basel II (Leighton, 2006). With banks being urged to examine this factor more closely, Chapter 3 introduced a calculation methodology which may be used by banks to extract the empirical asset correlation from their own empirical loan loss data. This application methodology is summarised in this chapter. The results of the application of this methodology to 22 years of quarterly loan loss data for different retail asset types in US banks are presented in this chapter.

Chapter 4 extended the investigation (methodology to determine a fair level of economic capital needed to compensate for losses arising from risks faced by banks) beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book). The investigation into (and modelling of) bank risks through empirical loss data embraces many 'scientific elements' (Currie, 2004:9). In Chapter 3, asset correlation was the scientific element explored as a component of credit risk models. Chapter 4 investigated incremental default risk (IDR) as the scientific element – i.e. the credit risk embedded in the trading book. More specifically, the scientific element explored in Chapter 4 is the length of time required to unwind a financial *credit* position (the holding period) without materially affecting underlying asset prices.

Chapter 4 introduced a calculation methodology, which may be applied by any bank, to determine the empirical holding period for credit-risky assets present in the trading book. The empirical holding period may be used to calculate a fair level of capital to be held for the trading book based on the bank's own unique trading book exposures. Similar to Chapter 3, the application methodology from Chapter 4 is summarised in this chapter. The specific dataset to which the calculation method was applied as well as the resulted derived from them, are also discussed in detail in this chapter.

5.2 Chapter layout

This chapter is presented in two main sections.

Section 1 summarises the calculation methodologies (introduced in Chapter 3 and 4) into a *step-by-step application* that can be used for capital calculation by banks of any size and complexity. These applications will enable banks to *empirically* determine their own parameters from their own, unique loss experiences.

Section 1 presents the calculation methodology (or application) to extract the empirical asset correlation from a set of retail loss data (based on Chapter 3). Banks may use this empirical asset correlation to determine a fair level of economic capital using Basel II credit capital equations. Secondly, Section 1 presents the application that can be used by banks to calculate their own fair holding period of trading book credit exposures (based on Chapter 4). This fair holding period is an important value and could be of strategic interest to banks who wish to establish fair levels of economic capital for market risk.

Section 2 uses the capital calculation methodologies introduced in Section 1 and applies these methodologies to real, empirical data. This is done to illustrate how the methodologies may be used by practitioners to determine fair levels of economic capital (based on their own loss data). In Section 2, the results derived from the application of the suggested methodologies will also be discussed in detail. The results are only reflective of the specific data applied, but this is nevertheless useful for practitioners as it indicate how a bank's own data may be analysed and interpreted.

The application of the methodologies, follow in the next section.

5.3 Application of methodologies

This section summarises the methodologies introduced in Chapter 3 (the extraction of empirical asset correlation from actual loss data and using this to calculate the fair level of economic capital for credit risk) and Chapter 4 (the extraction of the fair holding period of trading book credit exposures, based on banks' own loss data).

5.3.1 Credit risk

The application methodology introduced in Chapter 3, is summarised as a 12 step process. Figure 5.1 below illustrates the steps to be followed by banks in order to firstly extract the empirical asset correlation from actual loss data (specifically for retail asset types) and then to use this to determine the fair level of economic capital.

Figure 5.1: Summarised application methodology from Chapter 3

Step 1: ***Understand the rules:***

Banks need to determine the exact local and global requirements.

Step 2: ***Determine capital charges for each loan type***

Determine the individual capital charge for each loan type using the correlations specified by the BCBS, using the equation 3.5 below:

$$\text{Capital Required} = EAD \cdot LGD \cdot \left(N\left(\frac{N^{-1}(PD) + \sqrt{\rho} \cdot N^{-1}(0.999)}{\sqrt{1-\rho}} \right) - PD \right)$$

Step 3: ***Obtain the data***

Obtain loan loss data for each category of loan type. This study used historical net loss empirical data measured on a quarterly basis.

Step 4: ***Calculate the mean and standard deviation***

The loss data should be used to calculate a mean (μ) and standard deviation (σ) by using elementary statistical methods.

Step 5: ***Calculate Alpha (α) and Beta (β)***

Calculating these two values from loss data is possible by using μ and σ obtained from step 4. μ & σ are the only two inputs required to calculate α and β by using the following two equations (3.8 and 3.9):

$$\alpha = \mu \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right) \quad \beta = (1-\mu) \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right)$$

Step 6: ***Generate the beta distribution***

With α and β calculated in step 5, a beta distribution for the loan loss data can be generated. As stated in Section 3.4.2, the beta distribution is easy to apply and effective for this analysis.

Step 7: ***Calculate the loan loss value at the correct confidence interval***

Using the beta distribution derived in step 6 and the inverse beta function (*BETAINV*), ascertain the value at which 0.1% of the loan losses exceed this value (in other words, at which point 99.9% of loan losses are less than this value) – this is the total loss at 99.9% confidence interval.

Step 8: ***Calculate the Expected Loss (EL)***

The average PD is the amount expected to be lost. Therefore, knowing μ (i.e. average PD) from step 4, it can be used as the EL of the investigated set of data.

Step 9: ***Calculate the Net Unexpected loss (NUL)***

The NUL can simply be calculated by subtracting the EL from the total loss.

Step10: Calculate the empirical correlation (ρ)

Substitute the NUL and equations (3.19):

$$a = z^2 + x^2$$

$$b = 2xy$$

$$c = y^2 - z^2$$

Into the equation (3.20) below in order to calculate ρ which is the empirically extracted asset correlation:

$$\sqrt{\rho} : \frac{-2xy \pm \sqrt{\left(2xy^2\right) - 4\left(z^2 + x^2\right)\left(y^2 - z^2\right)}}{2\left(z^2 + x^2\right)}$$

Step 11: ***Using ρ to calculate the fair level of economic capital***

Use ρ which was extracted in step 10 to determine the fair levels of capital to be held for each retail loan class. This step provides the empirical ρ which can then simply be used in the prescribed in the Basel II equation (3.5) instead of the BCBS's prescribed correlations used in step 2. The values obtained in this step can therefore be seen as the fail levels of economic capital to be held by banks.

$$\text{Capital Required} = EAD \cdot LGD \cdot \left(N\left(\frac{N^{-1}(PD) + \sqrt{\rho} \cdot N^{-1}(0.999)}{\sqrt{1-\rho}} \right) - PD \right)$$

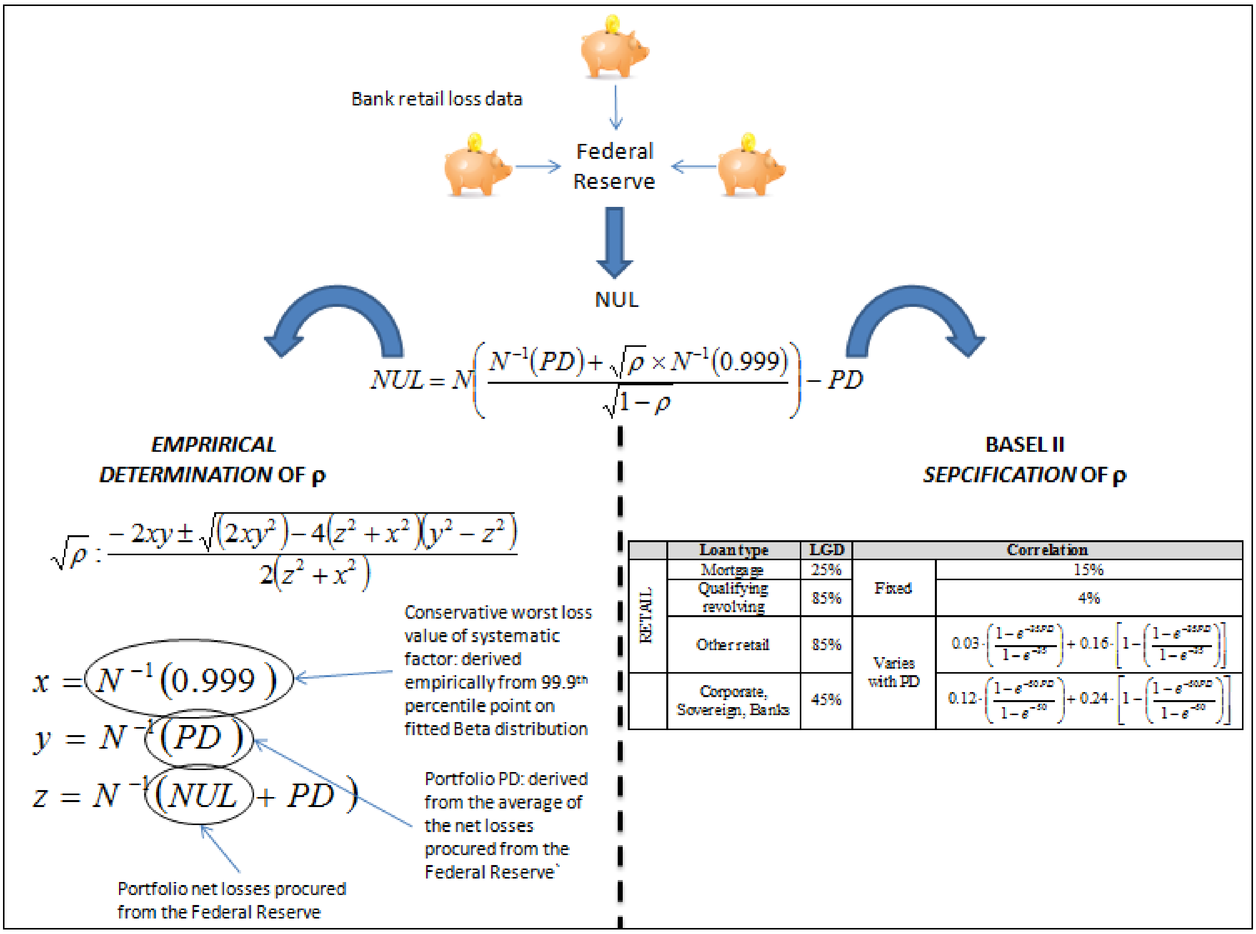
Step 12: ***Using different capital charges.***

The capital charges obtained in step 2 and 11 can finally be compared to determine if the capital charge prescribed by the Basel II framework is to punitive or insufficient for the bank analysed.

Source: Author

Figure 5.2 illustrates some of the key steps discussed above.

Figure 5.2: Illustration of key steps in the methodology introduced in this chapter



Source: Author

This methodology is the main contribution of Chapter 3 as it is a new application that banks may apply not only to extract empirical asset correlations from their loss data, but – more importantly – to calculate the fair level of economic capital for credit risk that should be held by banks to protect them against the credit risk faced in the different retail asset classes.

5.3.2 Market risk

The application methodology introduced in Chapter 4, is summarised as an 8 step process which may be used by banks to calculate their own unique economic capital for a bond portfolio. Figure 5.3 illustrates the steps to be followed by banks in order to calculate their own fair holding period of trading book credit exposures, based on their own data.

Figure 5.3: Summarised application methodology from Chapter 4

Step 1: ***Understand the rules:***

Banks need to determine the exact local and global requirements.

Step 2: ***Obtain portfolio to investigate***

Banks need to identify the credit risky portfolio they want to determine the fair level of economic capital for. These portfolios can consist of a mix of CDSs, credit derivatives, bonds (any instruments with a credit risky component, i.e. a possibility of default). Please note that equities cannot be included in these portfolios.

Step 3: ***Measure VaR***

Banks should next measure the VaR of the investigated portfolios. This can be done by using the variance-covariance of historical approach. This is done to obtain the price history of the investigated instruments. The VaR value obtained from this step should be named “A” (even though this number will not be used during the rest of the methodology).

VaR = A

Step 4: ***Stress the parameters***

Stress the parameters (annual yield volatility and correlations) for the VaR calculation. To do this, historical stresses which can be deemed appropriate to the situations at the time of analysis should be used. The value of VaR obtained during stressed times should be called “B”.

Stressed VaR = B

Step 5: Measure the credit component of this portfolio

Measure the credit component of the investigated portfolio using BCBS equations with annual PDs and ratings obtained from relevant sources (either internal or external) This value should be called "C".

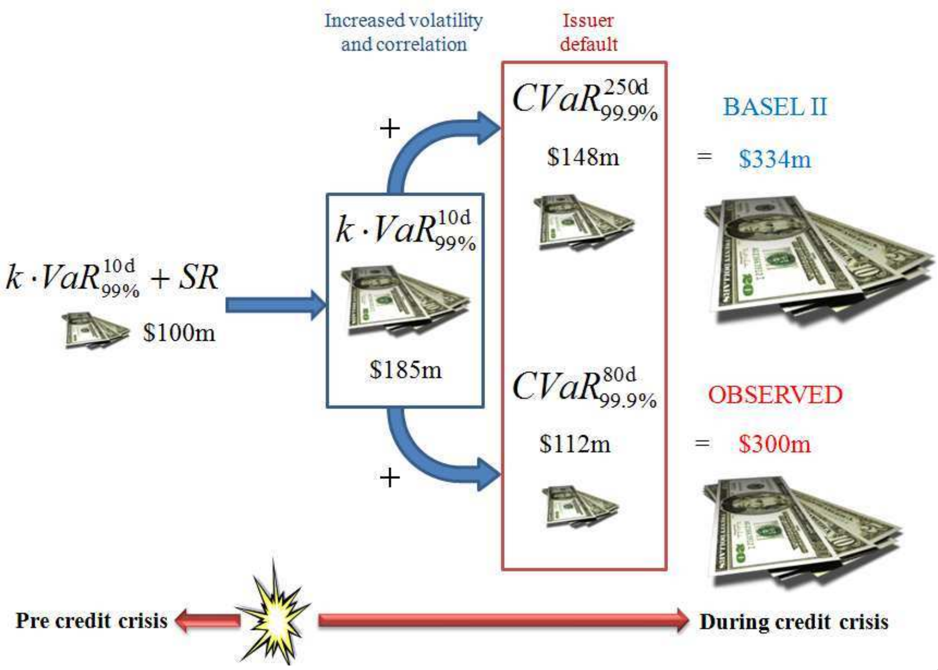
C**redit component of investigated portfolio = C**

Step 6: Apply worst case scenario to trading book

Using historical data (or current) determine worst case scenarios in trading book and apply this to portfolio (similar to the factor of three discussed in Section 4.4.1). This value should be called "D".

Worst case scenario in trading book = D

The figure below illustrates how this methodology can be used in practice.



Step 7: ***Adjust the PD holding period***

Using the values obtained from the above steps; add B + C and call this "E". If the value of E does not equal D, adjust the PD holding period according to Algorithmics (2006: A6) equation until the value of D and E equal each other. The value of the holding period at this point (D=E) is the empirically calculated holding period.

Step 8: ***Calculate the fair level of capital***

Use the empirical holding period to determine the empirical PD to be used for calculating capital. The empirical PD can therefore be used in equation 4.22 (Basel II) to determine a fair level of economic capital, based on empirical numbers derived from the investigated portfolio instead of the BCBS's prescribed PD which does not consider the bank's unique holding period but uses a fixed 250 days.

Source: Author

The methodology explained above is the main contribution of Chapter 4 as it is a new application that banks may apply to calculate the fair level of economic capital that should be held by banks to protect them against the market risk faced.

5.4 Results for data used in this study

This section presents the different results obtained when applying actual data to the proposed methodologies.

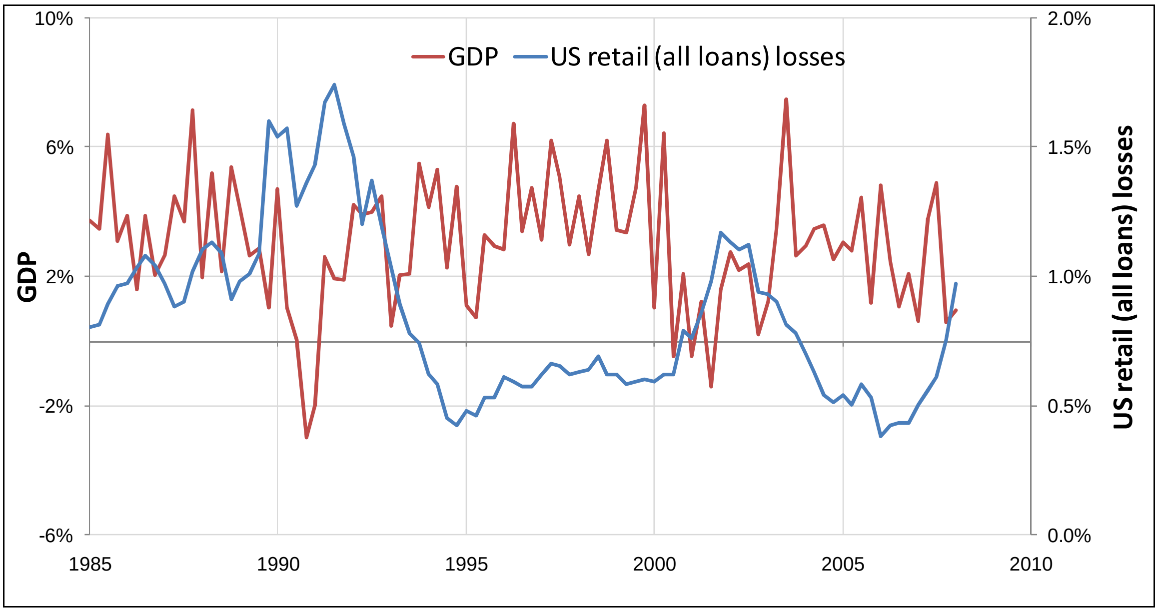
5.4.1 Credit risk results

A wide range of retail portfolios were used to demonstrate the difference between Basel II and empirical asset correlations.

In order to demonstrate the calculation of economic capital derived from empirical asset correlation, historical net loss empirical data measured on a quarterly basis from 1985 to 2008 were obtained from the US Federal Reserve Bank (FED, 2009). From these data the empirical asset correlation was extracted and then compared with the asset correlation prescribed by Basel II. The different asset correlations were then applied to Basel II's prescribed capital calculation equations. Data for eight different asset types were available with at least one asset type in each of the four Basel II categories for retail credit exposures namely: residential mortgages, qualifying revolving, high volatility commercial real estate and other retail exposures. US data were used as they were the only available data for such a long period and for all the individual asset types. Furthermore, the current credit crunch originated in the US credit retail market and these data are therefore the most relevant to explore.

The loss data were investigated to determine if they followed any patterns with economic conditions. In Figure 5.4 the relationship between the economic movement and realised losses are illustrated. A correlation of -0.24 indicates that losses tend to be higher in times of unfavourable economic conditions and vice versa. However, this low correlation indicates that the co-movement of these variables is, at best, weak.

Figure 5.4: The relationship between actual losses and GDP in the US (1985-2008Q1)

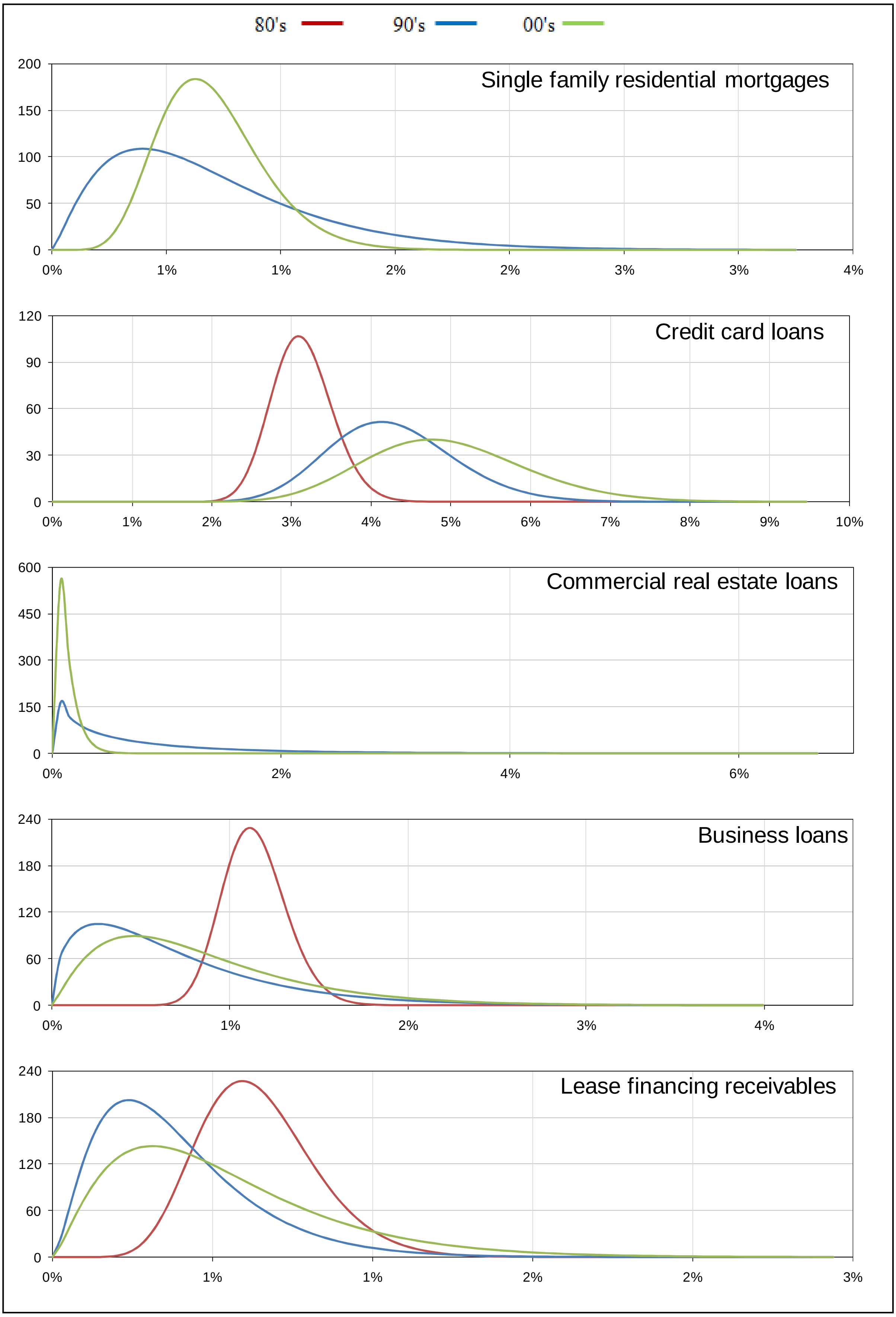


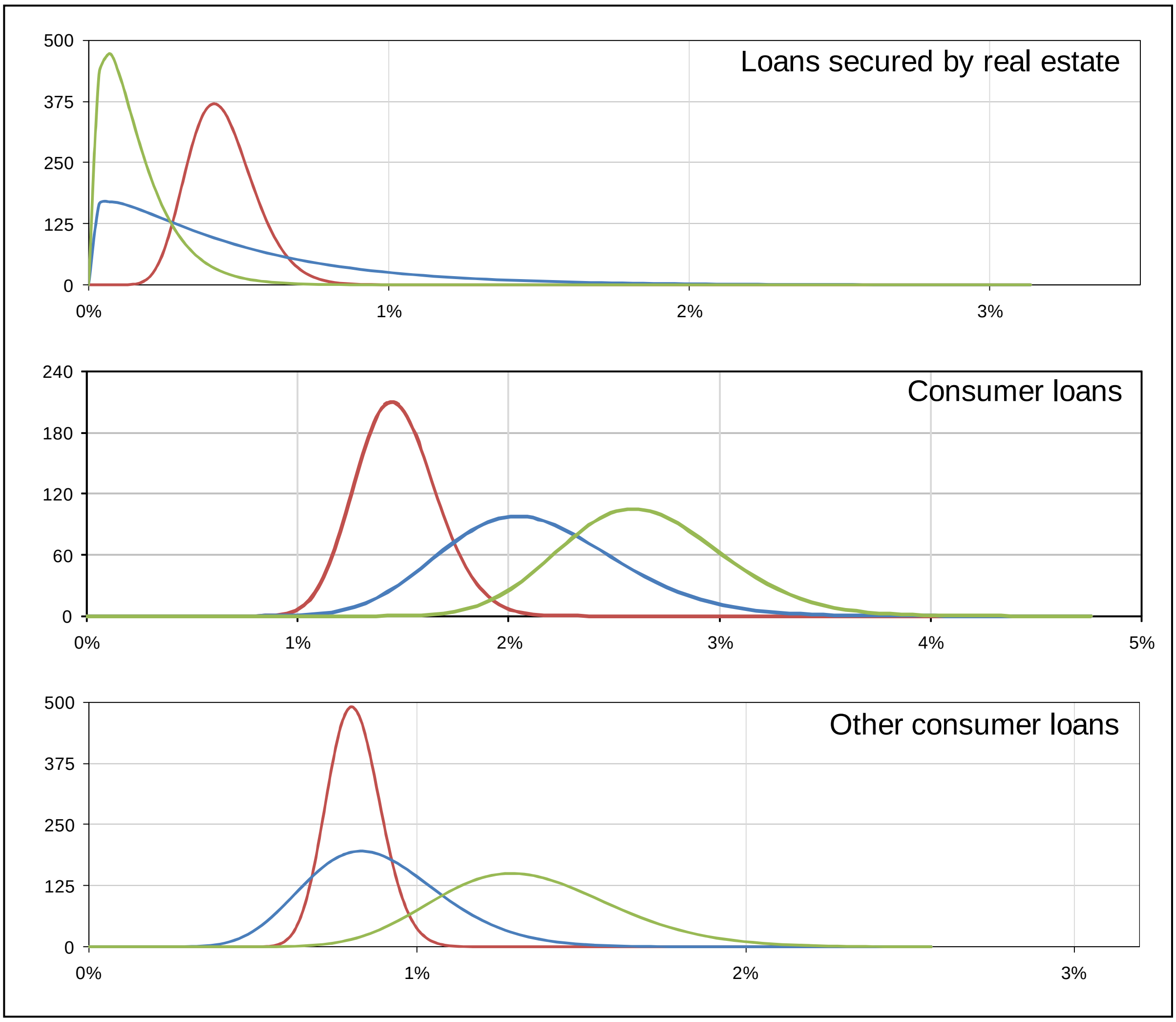
Source: U.S. Bureau Economic Analysis, 2008

As the actual losses recorded (*US retail* (all loans) losses in Figure 5.4) did not follow a consistent pattern to analyse, the losses were decomposed into smaller time brackets to assess the correlation of the different asset types during different cycles of the economy.

The data were divided into three decades: the 80s, 90s and 00s. In the 80s losses were mostly increasing, in the 90s mostly decreasing and in the 00s mostly consistent. The Beta distributions for these periods are illustrated in Figure 5.5 below. Note that 1980s data were not available for all asset classes.

Figure 5.5: Beta distributions over multiple periods (vertical axis = probability density; horizontal axis =loss (%)





Source: Author

The different loan types have been grouped together according to the four asset groups (residential mortgages, qualifying revolving exposures, high volatile commercial real estate (HVCRE) and other retail exposures) defined by Basel II. The results indicate that over time, loss distributions varied considerably. There is no discernible pattern between asset types over the observed time scale.

The different loan types and correlation comparison are presented next.

5.4.1.1 Correlations comparison: Basel II vs. Empirical correlation

A comparison between Basel II's specified correlations and those obtained empirically follows in this section. Tables 5.1 to 5.4 shows the PD as well as the different correlations obtained from Basel II and empirical methods for all the different asset types. The different correlations are also illustrated in Figures 5.6 to 5.13.

5.4.1.1.1 Residential Mortgages

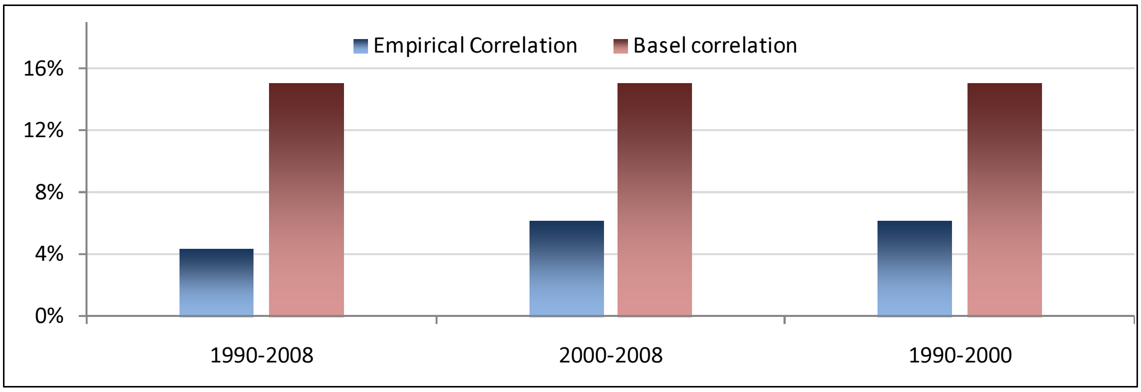
As asset correlation with a fixed value of 15% is reasonably consistent with the available evidence for U.S. residential mortgages. However, the empirical results show that the fixed correlation of 15% specified by Basel II is considerably higher (15%) that what was experienced by banks (on average 4%) since 1990 for single family residential mortgages (Calem & Follain, 2003;20).

Table 5.1: Correlations comparison for Single family residential mortgages

Residential mortgages	*1990-2008*	*2000-2008*	*1990-2000*
Average PD	0.80%	0.88%	0.88%
Empirical Correlation	4.29%	6.09%	1.62%
Basel II correlation	15.00%	15.00%	15.00%

Source: Author

Figure 5.6: Correlation comparison for single family residential mortgages



Source: Author

5.4.1.1.2 Qualifying Revolving exposures

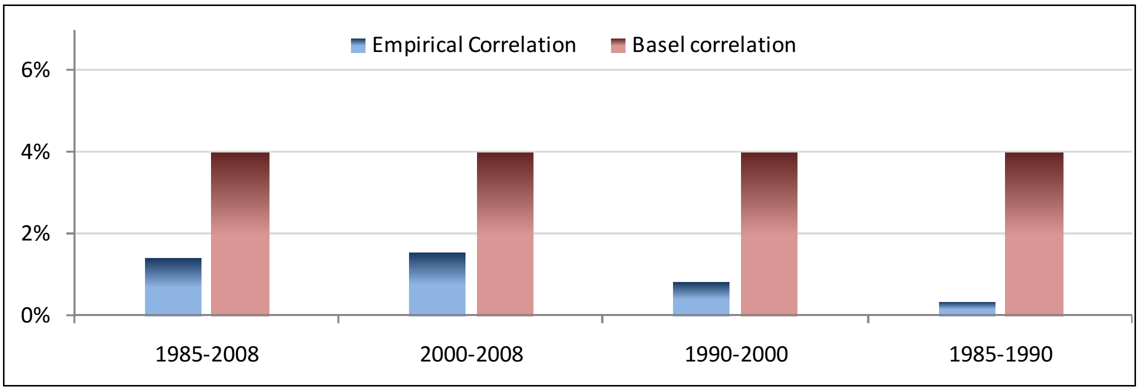
Asset correlations are fixed at 4% for qualifying revolving retail exposures by Basel II. Basel II's values have been found to be particularly conservative for credit card exposures (Gore, 2006:161). The empirical asset correlation results obtained confirm these observations: empirical correlations were *consistently* lower than those specified by Basel II over all investigated periods.

Table 5.2: Correlations comparison for credit card loans

Credit card loans	*1985-2008*	*2000-2008*	*1990-2000*	*1985-1990*
Average PD	5.96%	4.95%	5.96%	4.37%
Empirical Correlation	1.38%	1.52%	0.80%	0.31%
Basel II correlation	4.00%	4.00%	4.00%	4.00%

Source: Author

Figure 5.7: Correlations comparison for credit card loans



Source: Author

5.4.1.1.3 High volatility commercial real estate

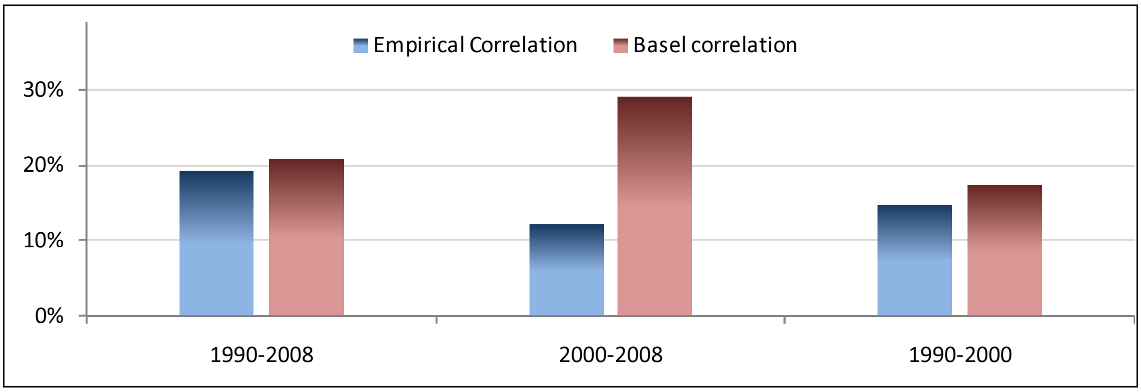
Commercial real estate, classified as High Volatility Commercial Real Estate, has the highest correlation for both Basel II and empirical results. The most important finding for this asset type is that the Basel II correlation is, like in the first two asset types, consistently higher than the empirical values.

Table 5.3: Correlations comparison for Commercial real estate loans

Commercial real estate	*1990-2008*	*2000-2008*	*1990-2000*
Average PD	1.45%	0.11%	2.43%
Empirical Correlation	19.18%	12.05%	14.73%
Basel II correlation	20.72%	29.00%	17.34%

Source: Author

Figure 5.8: Correlations comparison for commercial real estate loans



Source: Author

5.4.1.1.4 Other retail exposures

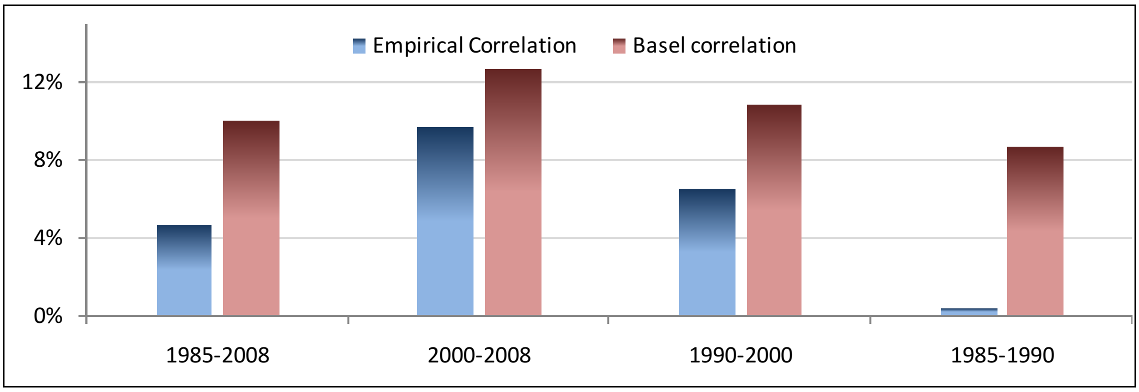
For other retail exposures, empirical asset correlation was lower than what is prescribed by Basel II.

Table 5.4: Correlations comparison for other retail exposures

Business loans	*1985-1990*	*1990-2000*	*2000-2008*	***1985-2008***
Average PD	2.37%	1.43%	0.84%	1.75%
Empirical Correlation	0.40%	6.50%	9.72%	4.64%
Basel II correlation	8.67%	10.87%	12.69%	10.05%
Lease financing receivables				
Average PD	1.03%	0.53%	0.80%	1.34%
Empirical Correlation	1.04%	3.66%	8.11%	3.53%
Basel II correlation	11.13%	12.81%	13.79%	12.07%
Loans secured by real estate				
Average PD	0.93%	0.96%	0.15%	0.72%
Empirical Correlation	0.75%	7.41%	7.80%	6.95%
Basel II correlation	12.39%	12.29%	15.32%	13.09%
Consumer loans				
Average PD	3.07%	4.42%	2.65%	4.52%
Empirical Correlation	0.31%	0.79%	1.22%	1.38%
Basel II correlation	7.44%	5.77%	8.15%	5.67%
Other consumer loans				
Average PD	1.69%	1.83%	1.34%	2.14%
Empirical Correlation	0.16%	0.83%	1.72%	1.43%
Basel II correlation	10.21%	9.85%	11.13%	9.14%

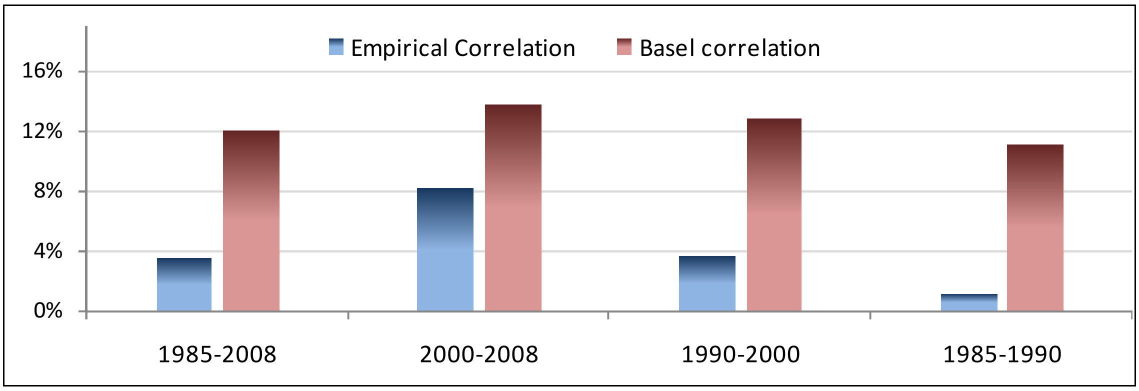
Source: Author

Figure 5.9: Correlations comparison for business loans



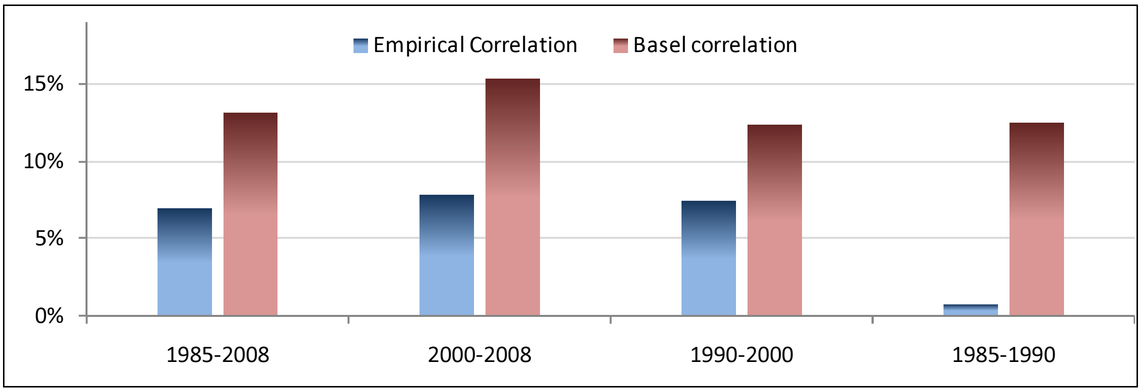
Source: Author

Figure 5.10: Correlations comparison for lease financing receivables



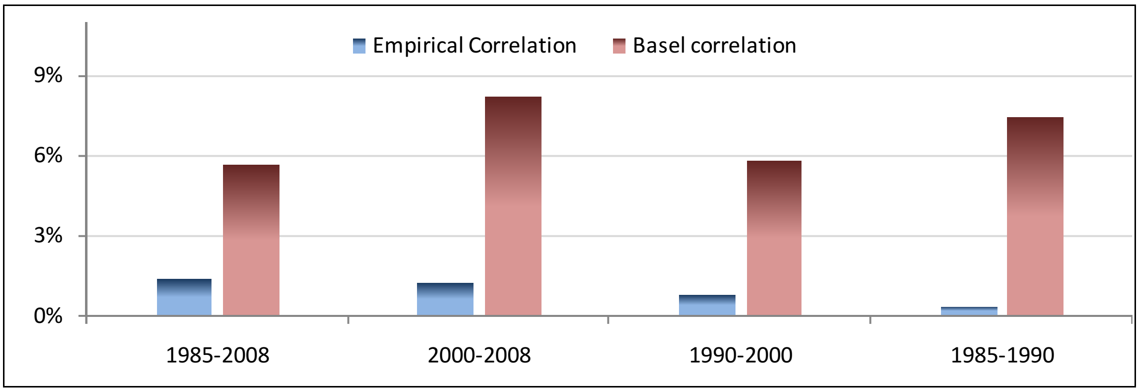
Source: Author

Figure 5.11: Correlations comparison for loans secured by real estate



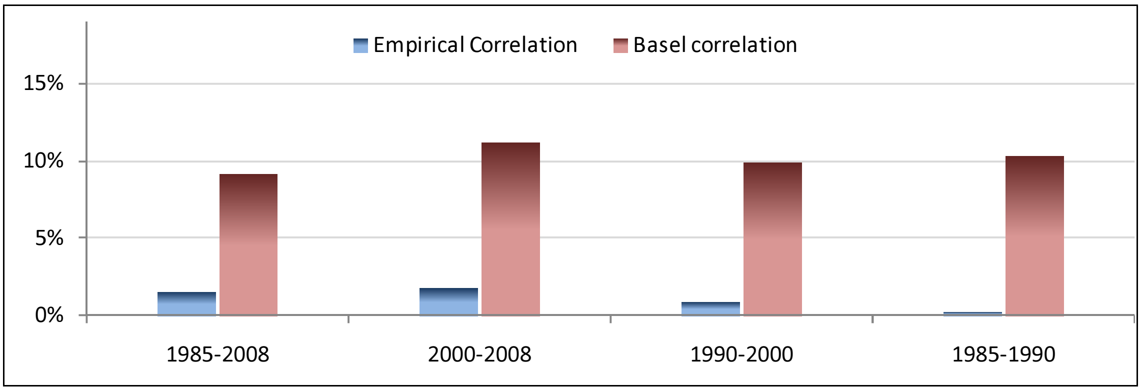
Source: Author

Figure 5.12: Correlations comparison for consumer loans



Source: Author

Figure 5.13: Correlations comparison for other consumer loans



Source: Author

The results indicate that in *all* investigated retail asset classes, over all different time periods, the prescribed retail asset correlations from Basel II are higher than those derived empirically.

As indicated in the ASRF investigation earlier, under the advanced IRB approach, Basel II allows banks to calculate inputs to the provided equation for capital calculation. However, two factors are implicitly given by the Basel II formula, the confidence interval of 99.9% and asset correlation (Altman & Sabato, 2005:22). As the asset correlation was shown to be higher than specified by Basel II, the question arises as to what the BCBS's motivation for this could be. In other words, why does Basel II assume that (on average and among all the investigated asset classes) assets are *more* correlated that they proved to be over the last 23 years? Leighton (2006) asserted that the asset correlation is a critical factor and the biggest single driving factor of Basel II. In addition some academics and risk managers claim that Basel II correlations are overly conservative and usually lead to higher capital charges (Gore, 2006).

When using the prescribed Basel II equation in calculating regulatory capital for credit risk, changing correlation assumptions has a significant large impact on required capital (Wood, 2008:32). The impact of asset correlation on capital was therefore identified as an important point of investigation to determine the impact on the capital banks are required to hold under Basel II considering the large differentiation between empirical and Basel II correlation. The impact of asset correlation on the capital charge is discussed next.

5.4.1.2 Effect of correlation on capital charge

> *Estimation of correlations is a difficult exercise however it is ultimately crucial for economic capital calculation* (Chernih *et al*, 2006:13).

The results obtained in the previous section were used to calculate the unexpected loss (UL) for all investigated retail asset classes but from two different perspectives. Firstly, the Basel II UL is calculated using the fixed Basel II correlation factors. Then the empirical UL is calculated using identical inputs as for the Basel II UL, however, instead of using the Basel II correlations, the calculated empirical correlations were used.

To determine whether the Basel II specified correlations are actually contributing to a fair capital charge the capital charge calculated by using the Basel II and empirical ULs respectively were compared for all asset types. The findings are summarised in Tables 5.5 to 5.8 below.

5.4.1.2.1 Residential Mortgages

Table 5.5: Regulatory Capital comparison for Residential mortgages

Single family residential mortgages	***1985-2008***	*2000-2008*	*2000-2008*
Empirical UL (a)	0.56%	0.80%	0.80%
Basel II UL (b)	2.37%	2.52%	2.52%
LGD	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000
Basel II capital	23,702	25,211	25,211
Empirical capital	5,550	7,994	7,994
Difference in capital	18,152	17,217	17,217
Ratio (a:b)	**4.3**	**3.2**	**3.2**

Source: Author

5.4.1.2.2 Qualifying Revolving exposures

Table 5.6: Regulatory Capital comparison for Qualifying Revolving exposures

Credit card loans	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	3.91%	3.65%	2.82%	1.29%
Basel II UL (b)	10.54%	9.34%	10.54%	8.61%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	105,368	93,442	105,391	86,072
Empirical capital	39,135	36,485	28,210	12,900
Difference in capital	66,233	56,957	77,181	73,172
Ratio (a:b)	**2.7**	**2.6**	**3.7**	**6.7**

Source: Author

5.4.1.2.3 High Volatile Commercial Real Estate

Table 5.7: Regulatory Capital comparison for High Volatile Commercial Real Estate

Commercial real estate loans	***1985-2008***	*2000-2008*	*1990-2000*
Empirical UL (a)	4.97%	0.50%	5.27%
Basel II UL (b)	7.27%	2.01%	8.27%
LGD	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000
Basel II capital	72,726	20,104	82,730
Empirical capital	49,727	4,986	52,726
Difference in capital	22,999	15,117	30,005
Ratio (a:b)	**1.5**	**4.0**	**1.6**

Source: Author

5.4.1.2.4 Other retail exposures

Table 5.8: Regulatory Capital comparison for Other retail exposures

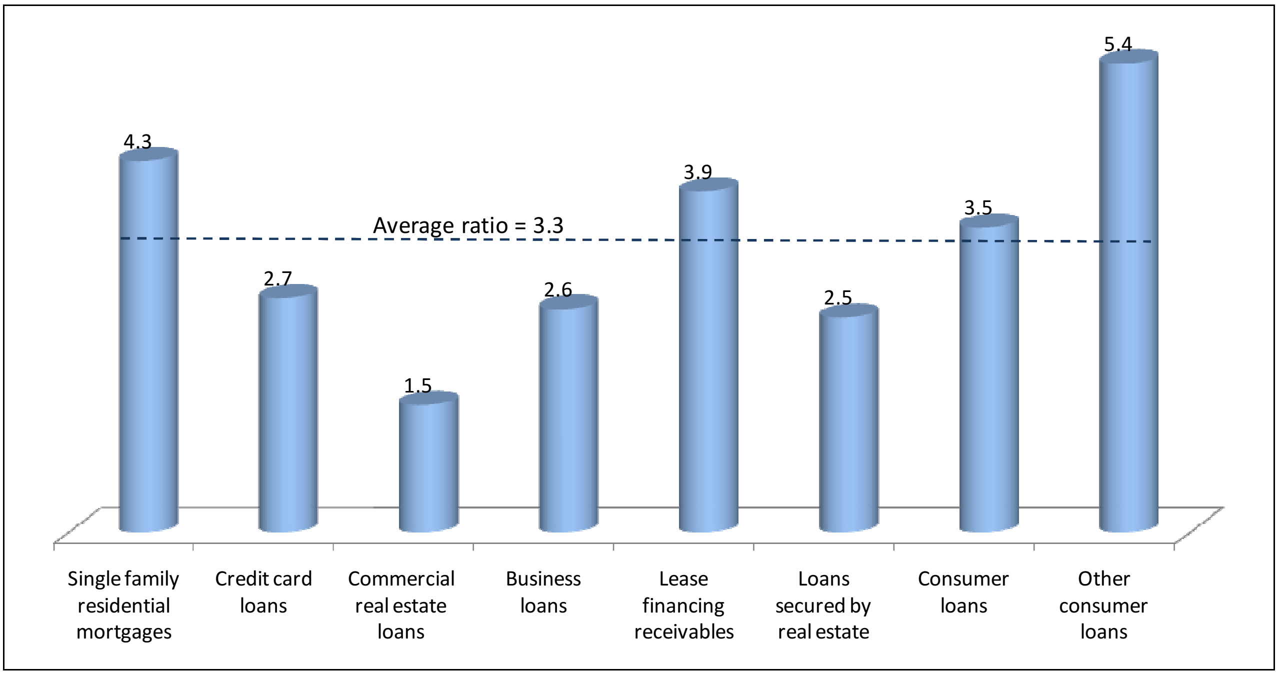
Business loans	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	2.51%	2.79%	2.86%	0.62%
Basel II UL (b)	6.44%	4.88%	6.06%	6.94%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	64,443	48,777	60,582	69,436
Empirical capital	25,075	27,898	28,574	6,233
Difference in capital	39,368	20,880	32,008	63,203
Ratio (a:b)	**2.6**	**1.7**	**2.1**	**11.1**
Lease financing receivables	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	1.36%	1.68%	1.16%	0.71%
Basel II UL (b)	5.34%	3.86%	4.78%	5.92%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	53,353	38,625	47,762	59,184
Empirical capital	13,610	16,829	11,575	7,085
Difference in capital	39,743	21,795	36,187	52,099
Ratio (a:b)	**3.9**	**2.3**	**4.1**	**8.4**
Loans secured by real estate	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	1.84%	0.62%	2.39%	0.42%
Basel II UL (b)	4.54%	1.74%	5.18%	5.10%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	45,423	17,428	51,779	51,040
Empirical capital	18,371	6,183	23,899	4,220

Difference in capital	27,052	11,245	27,880	46,820
Ratio (a:b)	**2.5**	**2.8**	**2.2**	**12.1**
Consumer loans	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	2.16%	1.34%	1.51%	0.66%
Basel II UL (b)	7.58%	7.09%	7.56%	7.26%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	75,781	70,895	75,625	72,570
Empirical capital	21,597	13,389	15,056	6,621
Difference in capital	54,184	57,506	60,569	65,950
Ratio (a:b)	**3.5**	**5.3**	**5.0**	**11.0**
Other consumer loans	***1985-2008***	*2000-2008*	*1990-2000*	*1985-1990*
Empirical UL (a)	1.26%	0.99%	0.79%	0.28%
Basel II UL (b)	6.79%	5.92%	6.53%	6.38%
LGD	100%	100%	100%	100%
EAD	1,000,000	1,000,000	1,000,000	1,000,000
Basel II capital	67,911	59,191	65,279	63,756
Empirical capital	12,593	9,910	7,855	2,766
Difference in capital	55,318	49,281	57,424	60,990
Ratio (a:b)	**5.4**	**6.0**	**8.3**	**23.1**

Source: Author

The results stated above are summarised in Figure 5.14 below.

Figure 5.14: Ratio of Basel II vs. empirical (economic) capital



Source: Author

Based on US retail data (1985-2008Q1), the major finding on asset correlation is that Basel II correlation assumptions resulted in a $\approx 3.3\times$ higher level of required regulatory capital than capital required using *empirical* asset correlations. It is possible that the high levels of correlation stem from Basel II's conservative levels of required capital. As Basel II does not make reference to the exact details regarding the BCBS's thinking in the IRB framework, the reason is not explicit. It is not difficult to argue that some retail areas are exposed to an over-conservative correlation requirement (Dev, 2006:67). The required regulatory capital for lower quality retail products – such as credit cards – are problematic and set at levels that are "too conservative" and "not reflective of what empirically happens in banks" (Dev, 2006:68). These conclusions have been confirmed by the empirical findings reported in this chapter: credit cards have a regulatory capital requirement of $\approx 2.7\times$more than typically required in a bank.

This study builds on the results of Dev (2006:66) who argued that an overall assumption about conservative levels of correlation in Basel II is difficult to prove. The empirical findings prove that it is not difficult to draw these conclusions as regulatory capital charges are $\approx 3.3\times$ more that empirically-calculated capital charges. The findings also indicate that for all investigated retail asset classes, the Basel II charge was considerably more than the empirical results.

Inaccurate asset correlations might be misleading for credit risk (Laurent, 2004:1). Vague, inaccurate and conservative correlation assumptions by regulators pose a potential threat for banks as incorrect capital allocation does not contribute to optimisation of their regulatory capital within the financial system. To hold excess capital that cannot be explained empirically or conceptually by regulators complicates modelling for banks as they do not exactly know why correlation, with higher capital effect, is fixed by the BCBS. If banks wish to calculate a fair capital charge under Basel II, this needs to be negotiated with BCBS as was done in the past to determine why this level of conservatism is has been built into the framework. The significant difference between Basel II and empirical capital proved in this study makes this an imperative topic which banks should consider in future negotiations with the BCBS. Dev (2006:67) notes that there is not much likelihood of change in Basel II asset correlation functions in the immediate future. These results raise questions about why the BCBS set correlations at a level which are consistently (and considerably) higher and therefore more conservative that what is observed in the market.

5.4.2 Market risk results

Different elements, requirements, proposals and results for capital charge in the trading book were discussed in Chapter 4. Using the calculation methodology introduced (and the data described) in this study (Chapter 4), the main conclusion of Chapter 4 was that the BCBSs current proposal for trading book capital charges, which include the current market risk charges as well as additional IDR charges, are too conservative.

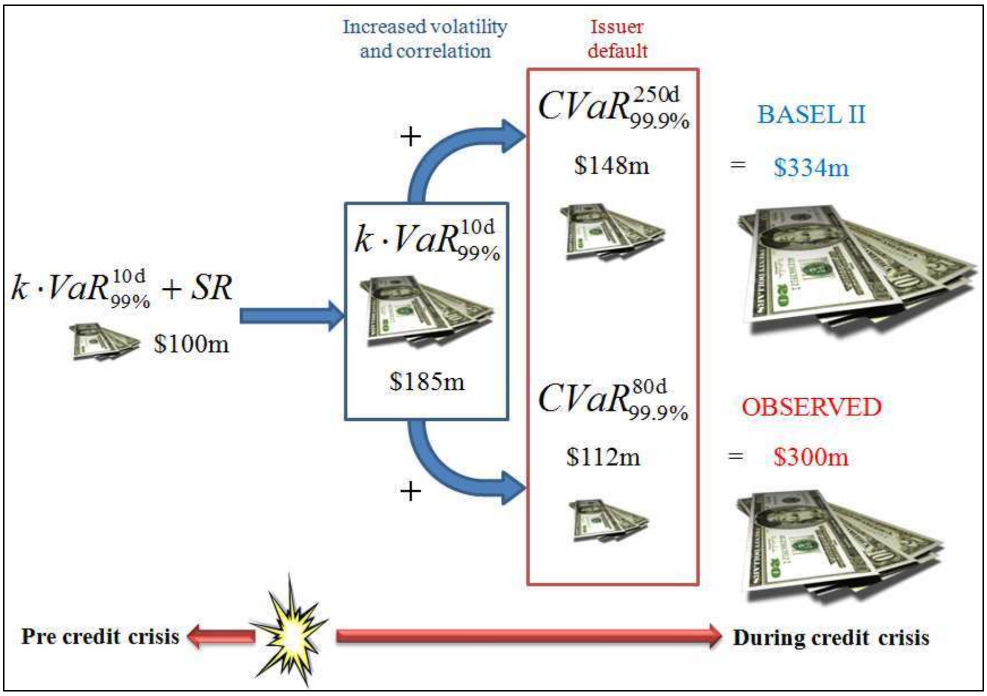
This statement is based on the different holding periods investigated in Chapter 4 (Basel II, ISDA and empirical):

- The Basel II holding period was determined based on the document released for public comments which introduced guidelines for computing capital for IDR in 2007. The proposed guidelines were introduced to banks as the market risk charge at the time was not sufficient to cover losses. According to the BCBS (2007b), the increased losses that occurred during market turmoil that started in 2007 did not arise from actual defaults, but rather from credit migrations combined with widening of credit spreads and the loss of liquidity.

- The ISDA holding period refers to the alternative proposal put forward by ISDA which recommended that the requirement of a 99.9% confidence interval over a full year holding period for credit risk assets in the trading book was too onerous and should be reduced to a 60-day holding period with the same confidence interval.
- The empirical holding period refers to the empirical calculated holding period derived from a randomly generated bond portfolio (explained below). This holding period therefore refers to an empirical holding period which can be calculated by any bank based on actual data.

The results, discussed in the section, are summarised in Figure 5.15 below.

Figure 5.15: Results obtained from investigated data (13000, randomly simulated bonds)



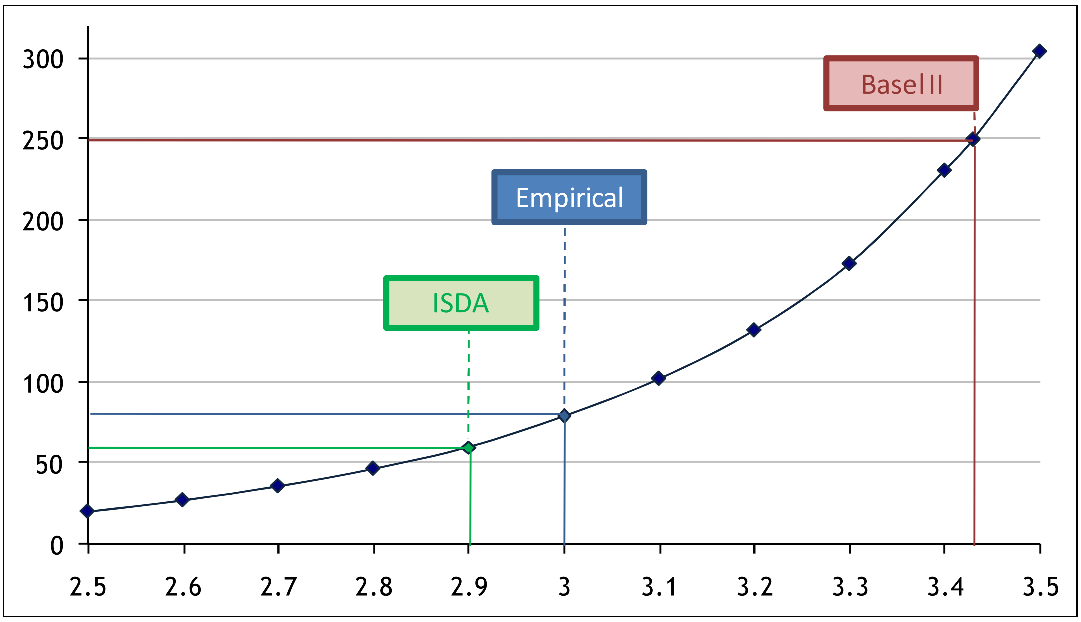
Source: Author

5.4.2.1 Portfolio generation

Monte Carlo simulations were not the best option for VaR calculations in this study as sufficient historical data of the significant market factors were not available. This is explained in more detail in Chapter 4 which investigated different options for VaR calculations. However, for portfolio construction, Monte Carlo simulations are not bound to historical data and users of this method are free to select any distribution believed to accurately describe market price movement. Portfolios may be built by randomly selecting the dimensions of a single asset and then randomly adding simulated assets together (Satchwell &

Scowcroft, 2003:168). In order to analyse market risk charges for banks the Monte Carlo Simulation method to simulate random bond portfolios was used. During this study 13000 bonds were simulated using relevant and possible maturities, yield volatilities, durations and yields. In order to determine the market risk capital charge, the VaR was then calculated according to Basel II. Figure 5.16 below illustrates the different holding periods with their reference scaling factors.

Figure 5.16: Different holding periods with reference scale factors. Vertical axis = unwind period (days); horizontal axis = scale factor (increase in capital pre and during credit crunch).



Source: Author.

Where:

- ISDA: Holding period = **60** days with scaling factor of **2.9**
- Empirical: Holding period = **80** days with scaling factor of **3**
- Basel II: Holding period = **250** days with scaling factor of **3.43**

From Figure 5.16 it is clear that the Basel II proposal to calculate IDR with a holding period of 250 days is very conservative as it results in a *much* larger capital charge than for empirical data (discussed later in this chapter). Empirical results indicate that a holding period of 80 days would have been sufficient to cover the losses banks recently experienced (i.e. in a time of severely stressed market conditions).

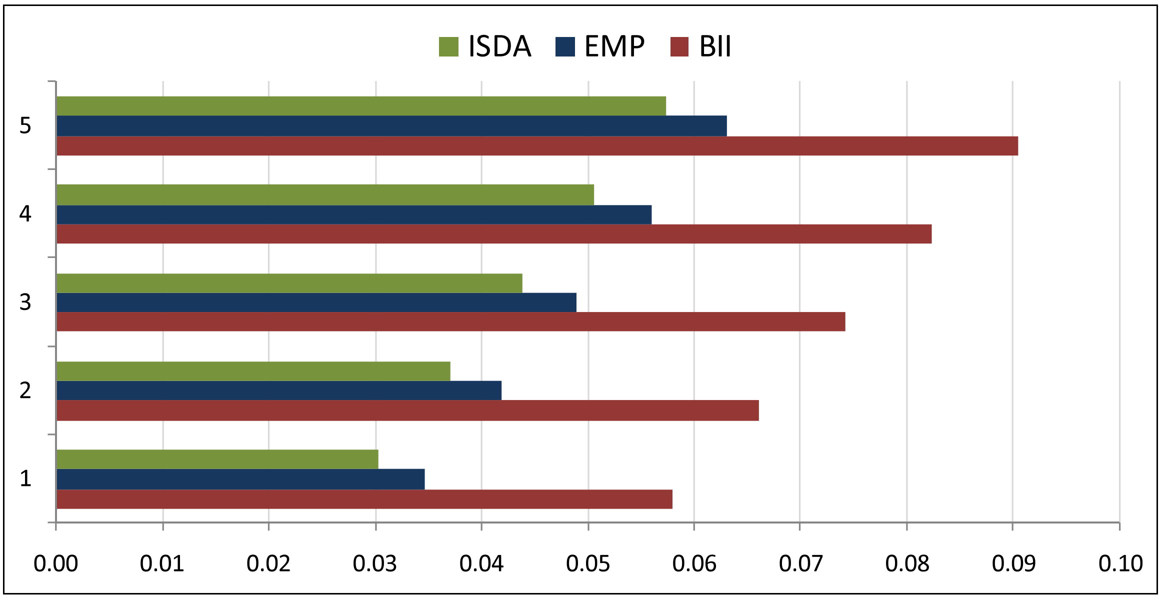
If the results had indicated that 250 days were indeed in line with bank empirical conclusions, the use of a 250d holding period would be justified from a capital perspective. However, if banks are *over*capitalised in *current* (highly stressed) market conditions, they are *significantly* overcapitalised when market conditions return to normal. As the proposed IDR charge does not only apply to unfavourable market conditions, but is required during all phases of the economic cycle, it will become increasingly unrealistic and over-conservative as economic conditions recover from the current extreme state, hence increasing the reputational obligation for banks.

ISDA's proposal of 60 days for the credit risky holding period has been shown to be too lenient. Although the results obtained in this study agree with ISDA's conclusions (that the BCBS is too conservative and will overcharge banks considerably, especially when market conditions start to improve), it was found that ISDA's proposals suggest insufficient capital. If banks held capital corresponding to ISDA's 60-day unwind period suggestion, they would be *under*capitalised in current (stressed) conditions. During normal conditions, ISDA's proposed capital levels might be sufficient, but might fail if adverse market conditions return. From a capital (and empirical) perspective this study concludes that the BCBS regulatory capital requirements are unrealistic high – even in extreme conditions – and ISDA is insufficiently realistic as stressed economic conditions appear to have been ignored.

From a market point of view, further conclusions may be drawn from these findings. The holding period should be compared to that which is currently (2009) being experienced in the market. The real peak of the 2007-09 credit crunch was during mid-September 2008 (Standard & Poors: 2008). The assumption embedded in ISDA's suggestion of a 60-day holding period, is that banks are able to unwind and recover liquidity within three months. According to the ISDA suggestions, therefore, liquidity issues should have been resolved by mid-December 2008, something that did not occur in practice (The New York Times, 2009). This has raised questions about the relevancy of ISDA's proposals when applied to actual market conditions. Again it appears that ISDA neither anticipated nor incorporated potential adverse market conditions into their proposals. The results obtained from this study thus disagree with ISDA's conclusions.

This study agrees with ISDA that the holding period of 250 days by the BCBS is too conservative, however, the empirical unwind period of 80 days (about 4 months) proved to be much more accurate to holding positions and return liquidity than ISDA's 60 days. These conclusions were drawn from including the effect of incremental default risk on regulatory capital for the trading book by calculating and comparing the holding period during adverse market conditions: this is a major empirical advancement. The effect of these different holding periods are illustrated in Figure 5.17 below where the different capital charges to are expressed as an amount that needs to be held for each dollar in the portfolio. It is also expressed for different maturities.

Figure 5.17: Capital requirements for different maturities (average of all credit ratings) – Vertical axis=maturity (years); Horizontal axis=Capital charge required for $1 ($).



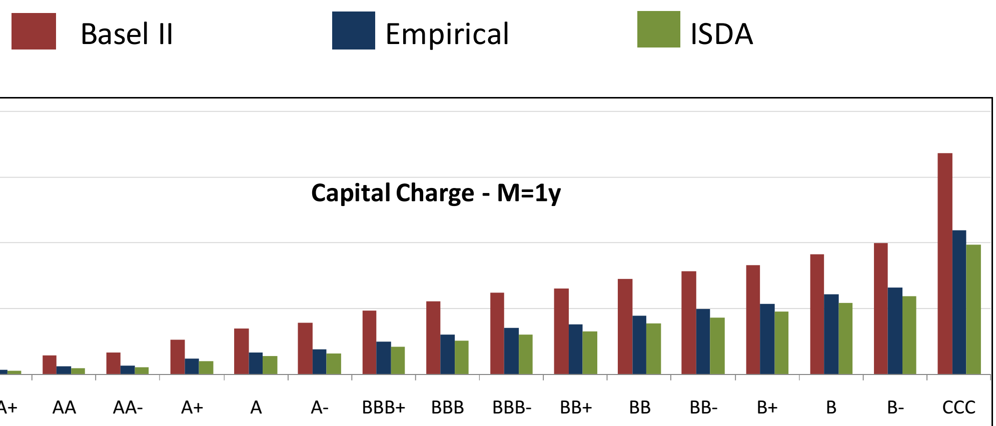
Source: Author.

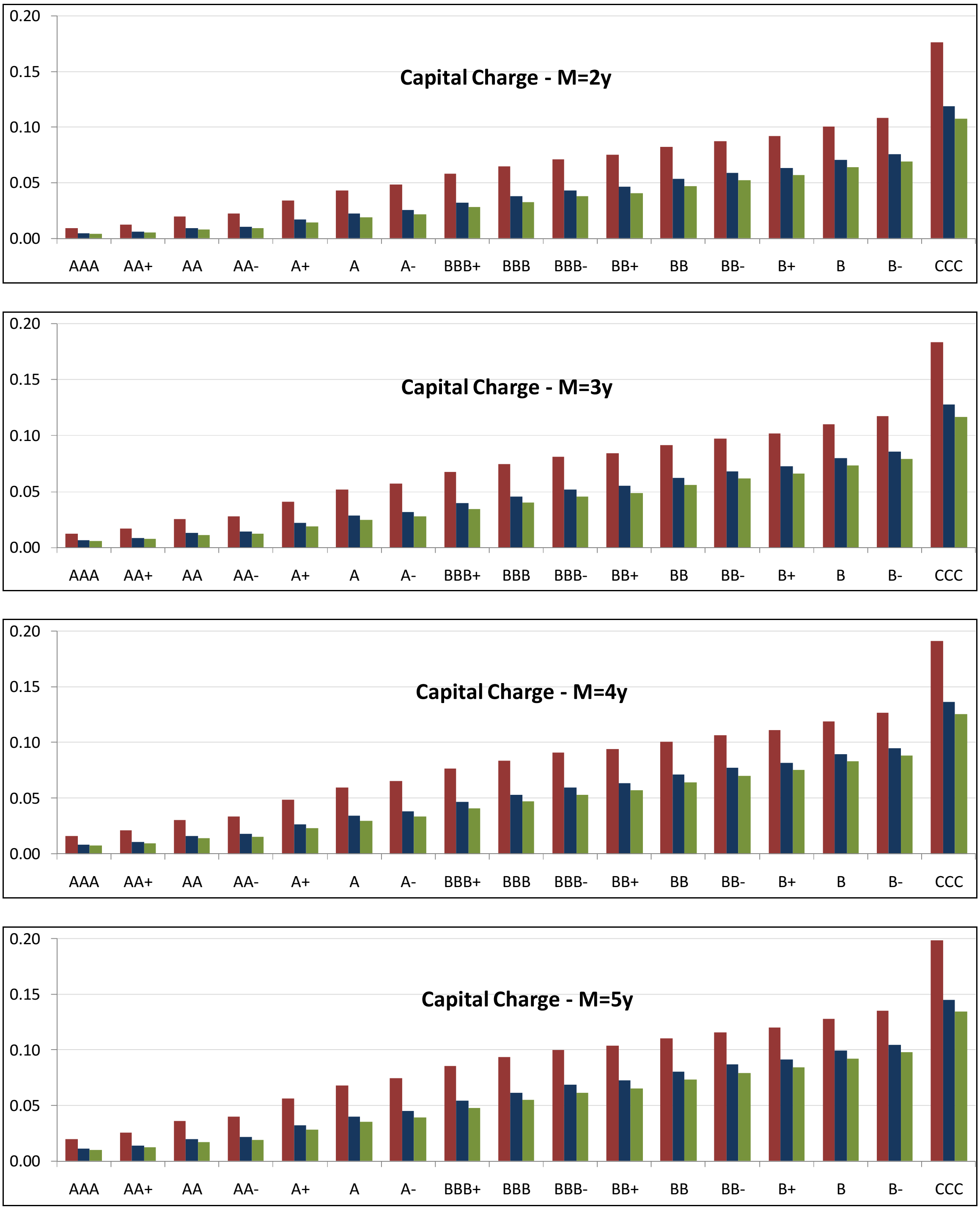
Figure 5.17 indicates that the capital charge estimated using Basel II's 250-day holding period is consistently too conservative when compared with the empirical (80-day) unwind period. The ISDA holding period (60-days), in contrast, is too lenient as compared with the empirical findings. This pattern (Basel II too conservative and ISDA too lenient) was consistent over the different maturities investigated.

Figure 5.17 also illustrates that the empirical capital charges are more in line with industry (ISDA's) view than with Basel II view. Another important finding is that capital charges are consistently higher for longer maturities which prove correctness of methodology as the longer the maturity of a bond the more risky it is.

In Figure 5.18 below the capital requirements for different maturities are illustrated by examining the difference between capital charges for each of the individual credit ratings used in the investigated dataset.

Figure 5.18: Capital requirements for different maturities for all credit ratings – vertical axis = maturity (years); vertical axis=capital charge required for $1 ($); horizontal axis = credit rating.

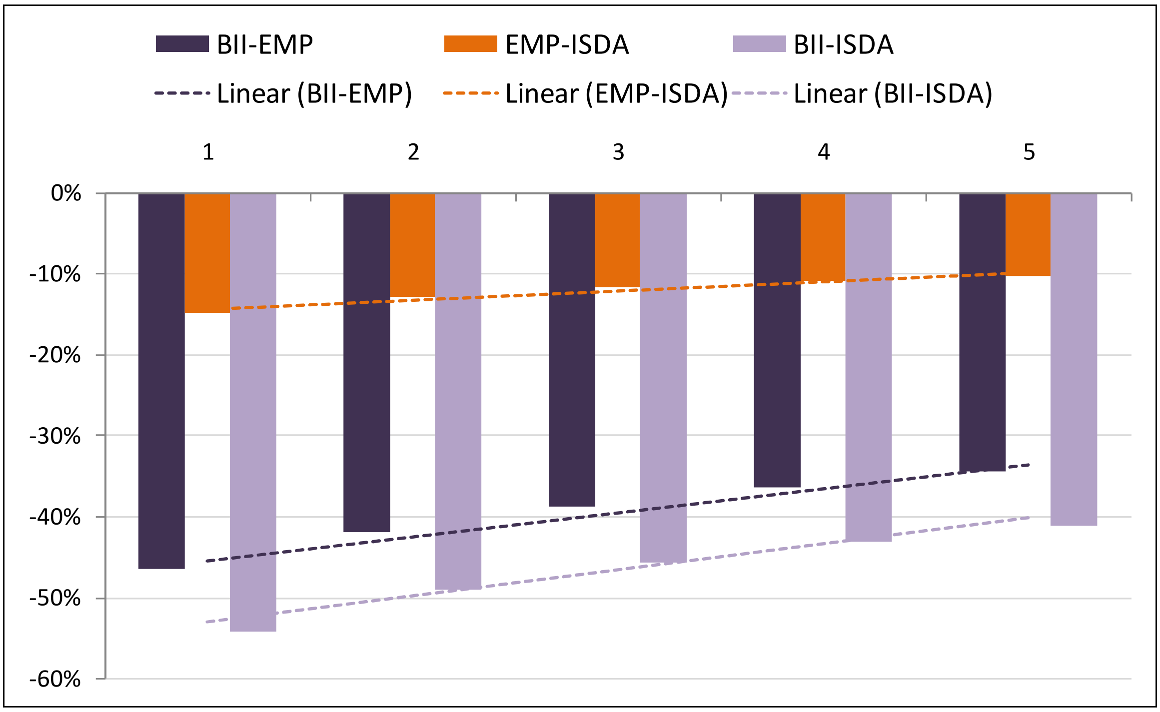




Source: Author.

Based on the above five graphs presented in Figure 5.18, the next figure summarises the difference in capital charge between the three investigated approaches.

Figure 5.19: Difference between capital charges for all credit ratings - vertical axis = difference in capital charge (%); horizontal axis = maturity (years).



Source: Author.

Figure 5.19 above illustrates the difference in capital charge between the three investigated approaches and was calculated by using Equation 5.1 below:

$$BII - EMP = \frac{EMP - BII}{BII} \tag{5.1}$$

This equation illustrates the difference in capital charge between the Basel II (250 days holding period) capital charge and the empirically calculated capital charge (80 days holding period). The same comparison was done for Basel II vs. ISDA and ISDA vs. Empirical. This comparison was, similar to Figure 5.17, calculated over different maturities.

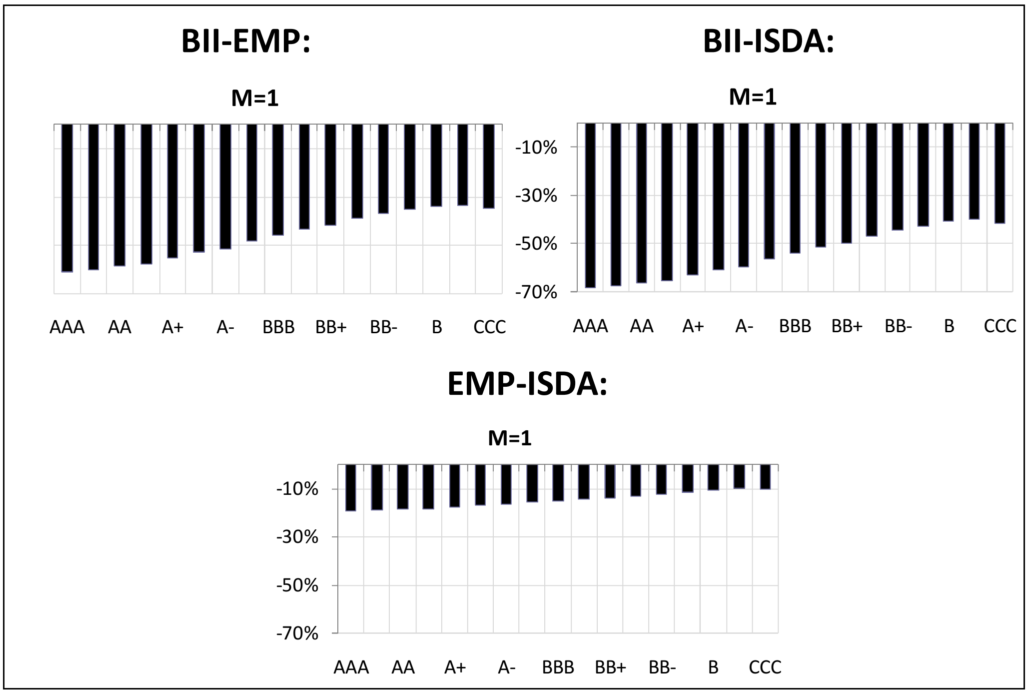
The results derived from these comparisons indicate that there is consistently (over different maturities) a significant difference between the capital charge prescribed by Basel II and empirical capital charges. A similar difference was observed between Basel II and ISDA's prescribed capital calculations. Figure 5.19 also shows that there is a consistently smaller difference between the empirical calculated capital charge and ISDA's capital charge which again supports the fact mentioned earlier that the empirical findings are more in line with industry views than with Basel II's.

The linear trends shown in Figure 5.19 represent an interesting finding. The trend lines shows that the difference in capital charges between the three calculation methods (Basel II's, ISDA's and empirical) becomes smaller over time. This indicates that Basel II's capital charges are the most punitive for assets with a shorter maturity. This might indicate that Basel II does not encourage liquidity in a bond portfolio as assets with a longer maturity might have a more fair capital charge.

Even though these results cannot be viewed as a general characteristic of Basel II's credit-risky capital requirements, it indicates that a bank should have a more fair capital charge for assets with longer maturities. The application introduced can therefore not only be used for the calculation of the empirical holding period and capital charge, but has an added advantage of determining the way in which a bond portfolio can be structured to receive a more fair regulatory capital treatment.

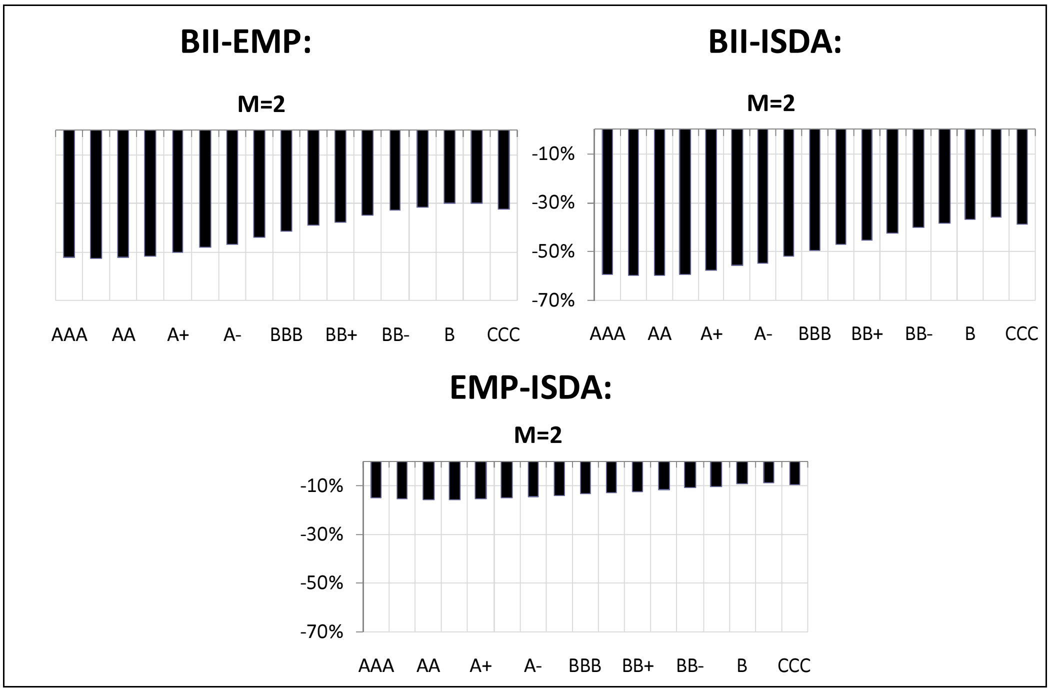
Figures 5.20 to 5.24 below illustrate the difference in capital charge between the three investigated approaches for each of the individual credit ratings used in the investigated dataset. The findings are illustrated for each of the investigated maturities.

Figure 5.20: Difference between capital charges for all ratings (1 year maturity) – All vertical axis = difference in capital charge (%); horizontal axis = credit rating.



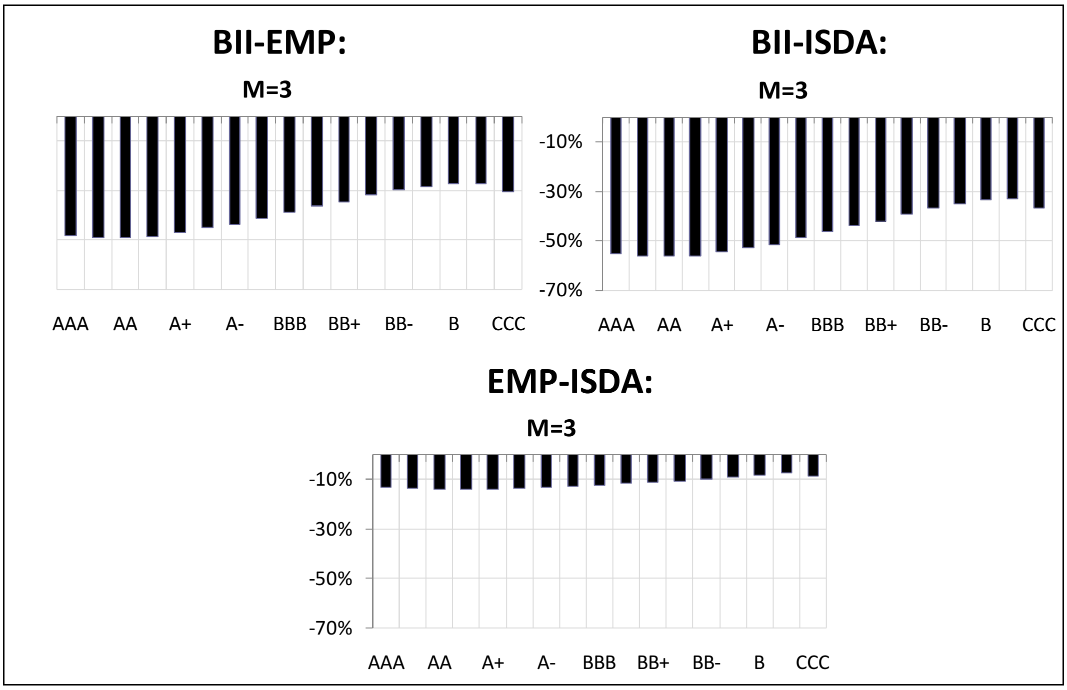
Source: Author.

Figure 5.21: Difference between capital charges for all ratings (2 year maturity) – All vertical axis=difference in capital charge (%); horizontal axis = credit rating.



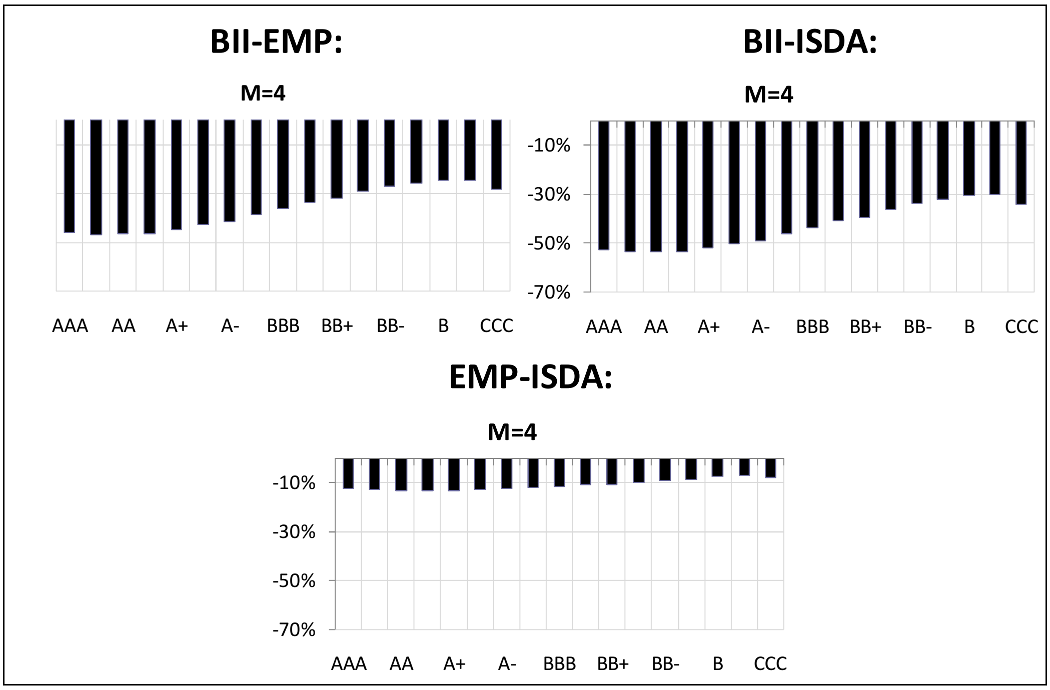
Source: Author.

Figure 5.22: Difference between capital charges for all ratings (3 year maturity) – All vertical axis=difference in capital charge (%); horizontal axis = credit rating



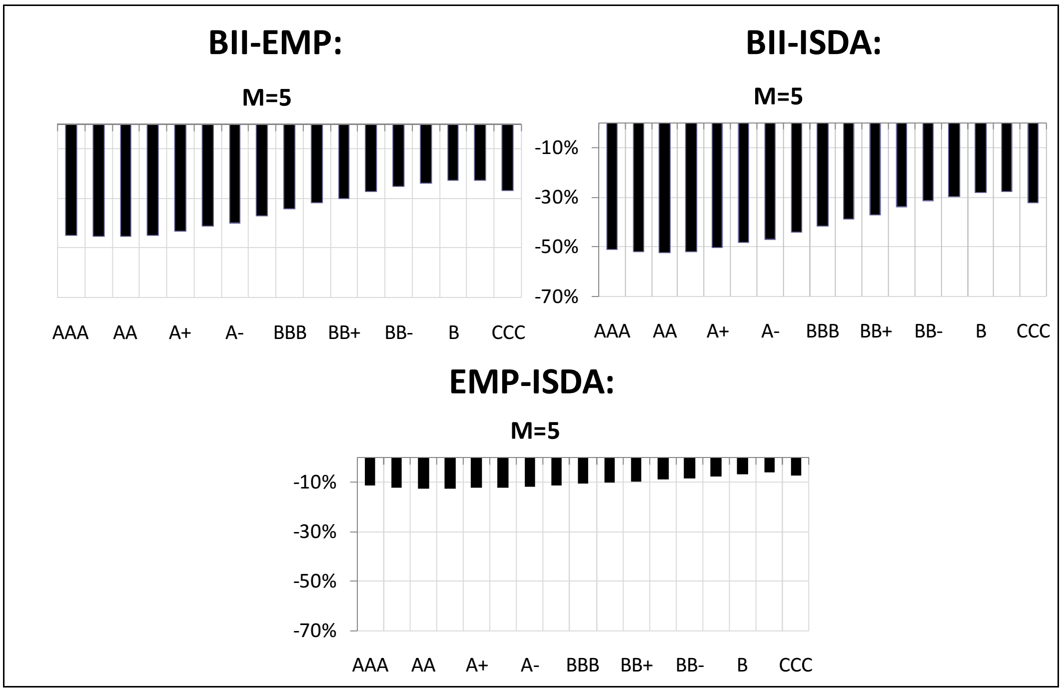
Source: Author.

Figure 5.23: Difference between capital charges for all ratings (4 year maturity) – All vertical axis=Difference in capital charge (%); Horizontal axis=Credit rating.



Source: Author.

Figure 5.24: Difference between capital charges for all ratings (5 year maturity) – All vertical axis=difference in capital charge (%); horizontal axis = credit rating.



Source: Author.

Tables 5.9 to 5.13 below present the underlying data upon which all the results presented in Section 5.4.2 (Figures 5.17 to 5.24) were based.

Table 5.9: Capital charges and difference between approaches for 1 year maturity bonds.

Capital Charge - M=1y						
	Capital charges for $1			Difference between approaches		
	BII	WS	ISDA	BII-WS	WS-ISDA	BII-ISDA
AAA	0.0057	0.0022	0.0018	-60.9%	-19.5%	-68.5%
AA+	0.0085	0.0034	0.0027	-60.0%	-19.1%	-67.7%
AA	0.0141	0.0059	0.0048	-58.4%	-18.6%	-66.1%
AA-	0.0160	0.0067	0.0055	-57.9%	-18.4%	-65.6%
A+	0.0261	0.0117	0.0096	-55.2%	-17.6%	-63.1%
A	0.0347	0.0164	0.0136	-52.8%	-16.9%	-60.8%
A-	0.0393	0.0191	0.0159	-51.5%	-16.6%	-59.5%
BBB+	0.0484	0.0249	0.0210	-48.5%	-15.8%	-56.6%
BBB	0.0552	0.0299	0.0254	-46.0%	-15.1%	-54.1%
BBB-	0.0616	0.0349	0.0299	-43.4%	-14.4%	-51.5%
BB+	0.0651	0.0378	0.0325	-41.9%	-14.0%	-50.0%
BB	0.0722	0.0441	0.0383	-38.9%	-13.0%	-46.9%
BB-	0.0779	0.0492	0.0432	-36.8%	-12.3%	-44.5%
B+	0.0828	0.0536	0.0474	-35.3%	-11.6%	-42.8%
B	0.0915	0.0606	0.0542	-33.8%	-10.5%	-40.8%
B-	0.0994	0.0660	0.0596	-33.6%	-9.8%	-40.1%
CCC	0.1681	0.1097	0.0985	-34.7%	-10.2%	-41.4%
Average	*0.0569*	*0.0339*	*0.0296*	*-46.5%*	*-14.9%*	*-54.1%*

Source: Author.

Table 5.10: Capital charges and difference between approaches for 2 year maturity bonds.

Capital Charge - M=2y						
	Capital charges for $1			Difference between approaches		
	BII	WS	ISDA	BII-WS	WS-ISDA	BII-ISDA
AAA	0.0092	0.0044	0.0037	-52.3%	-14.7%	-59.3%
AA+	0.0127	0.0060	0.0051	-52.6%	-15.2%	-59.8%
AA	0.0196	0.0093	0.0079	-52.3%	-15.4%	-59.7%
AA-	0.0219	0.0105	0.0089	-52.0%	-15.4%	-59.4%
A+	0.0336	0.0167	0.0142	-50.2%	-15.2%	-57.8%
A	0.0431	0.0223	0.0190	-48.2%	-14.8%	-55.9%
A-	0.0481	0.0255	0.0218	-47.0%	-14.5%	-54.7%
BBB+	0.0577	0.0322	0.0277	-44.2%	-13.9%	-51.9%
BBB	0.0648	0.0377	0.0327	-41.8%	-13.4%	-49.6%
BBB-	0.0713	0.0433	0.0377	-39.3%	-12.8%	-47.0%
BB+	0.0748	0.0464	0.0407	-37.9%	-12.4%	-45.6%
BB	0.0818	0.0532	0.0470	-35.0%	-11.6%	-42.5%
BB-	0.0873	0.0586	0.0522	-32.9%	-10.8%	-40.2%
B+	0.0921	0.0631	0.0566	-31.5%	-10.2%	-38.5%
B	0.1006	0.0702	0.0637	-30.2%	-9.3%	-36.7%
B-	0.1084	0.0757	0.0692	-30.2%	-8.5%	-36.1%
CCC	0.1757	0.1186	0.1075	-32.5%	-9.3%	-38.8%
Average	*0.0649*	*0.0408*	*0.0362*	*-41.8%*	*-12.8%*	*-49.0%*

Source: Author

Table 5.11: Capital charges and difference between approaches for 3 year maturity bonds.

Capital Charge - M=3y						
	Capital charges for $1			*Difference between approaches*		
	BII	WS	ISDA	BII-WS	WS-ISDA	BII-ISDA
AAA	0.0126	0.0065	0.0057	-48.4%	-13.1%	-55.1%
AA+	0.0169	0.0086	0.0075	-49.0%	-13.6%	-55.9%
AA	0.0251	0.0128	0.0110	-48.9%	-14.0%	-56.0%
AA-	0.0278	0.0143	0.0123	-48.7%	-14.0%	-55.9%
A+	0.0410	0.0217	0.0187	-47.0%	-13.9%	-54.4%
A	0.0515	0.0283	0.0244	-45.0%	-13.6%	-52.5%
A-	0.0569	0.0319	0.0277	-43.8%	-13.3%	-51.3%
BBB+	0.0671	0.0395	0.0345	-41.1%	-12.8%	-48.6%
BBB	0.0744	0.0456	0.0400	-38.7%	-12.2%	-46.2%
BBB-	0.0809	0.0517	0.0456	-36.2%	-11.7%	-43.6%
BB+	0.0844	0.0551	0.0489	-34.7%	-11.3%	-42.1%
BB	0.0914	0.0623	0.0557	-31.9%	-10.5%	-39.0%
BB-	0.0968	0.0680	0.0613	-29.8%	-9.8%	-36.7%
B+	0.1015	0.0726	0.0659	-28.5%	-9.2%	-35.1%
B	0.1098	0.0799	0.0733	-27.2%	-8.3%	-33.3%
B-	0.1175	0.0854	0.0789	-27.3%	-7.6%	-32.8%
CCC	0.1834	0.1275	0.1165	-30.5%	-8.6%	-36.5%
Average	*0.0729*	*0.0477*	*0.0428*	*-38.6%*	*-11.6%*	*-45.6%*

Source: Author.

Table 5.12: Capital charges and difference between approaches for 4 year maturity bonds

Capital Charge - M=4y						
	Capital charges for $1			*Difference between approaches*		
	BII	WS	ISDA	BII-WS	WS-ISDA	BII-ISDA
AAA	0.0161	0.0087	0.0076	-46.1%	-12.2%	-52.7%
AA+	0.0212	0.0113	0.0098	-46.8%	-12.8%	-53.6%
AA	0.0306	0.0163	0.0142	-46.7%	-13.2%	-53.7%
AA-	0.0337	0.0180	0.0156	-46.5%	-13.2%	-53.5%
A+	0.0485	0.0268	0.0233	-44.8%	-13.1%	-52.0%
A	0.0598	0.0342	0.0299	-42.8%	-12.8%	-50.1%
A-	0.0656	0.0384	0.0336	-41.5%	-12.5%	-48.9%
BBB+	0.0764	0.0468	0.0412	-38.7%	-12.0%	-46.1%
BBB	0.0839	0.0535	0.0474	-36.3%	-11.5%	-43.6%
BBB-	0.0906	0.0600	0.0535	-33.7%	-10.9%	-40.9%
BB+	0.0941	0.0637	0.0570	-32.3%	-10.5%	-39.4%
BB	0.1010	0.0714	0.0644	-29.3%	-9.7%	-36.2%
BB-	0.1063	0.0773	0.0703	-27.3%	-9.1%	-33.8%
B+	0.1108	0.0821	0.0752	-25.9%	-8.5%	-32.2%
B	0.1189	0.0895	0.0828	-24.7%	-7.5%	-30.4%
B-	0.1265	0.0950	0.0885	-24.9%	-6.8%	-30.0%
CCC	0.1911	0.1364	0.1256	-28.6%	-8.0%	-34.3%
Average	*0.0809*	*0.0547*	*0.0494*	*-36.3%*	*-10.8%*	*-43.0%*

Source: Author.

Table 5.13: Capital charges and difference between approaches for 5 year maturity bonds.

Capital Charge - M=5y						
	Capital charges for $1			Difference between approaches		
	BII	WS	ISDA	BII-WS	WS-ISDA	BII-ISDA
AAA	0.0195	0.0108	0.0095	-44.7%	-11.7%	-51.2%
AA+	0.0254	0.0139	0.0122	-45.3%	-12.3%	-52.0%
AA	0.0362	0.0198	0.0173	-45.1%	-12.7%	-52.1%
AA-	0.0396	0.0218	0.0190	-44.9%	-12.7%	-51.9%
A+	0.0559	0.0318	0.0278	-43.1%	-12.5%	-50.3%
A	0.0682	0.0402	0.0353	-41.1%	-12.2%	-48.3%
A-	0.0744	0.0448	0.0394	-39.8%	-12.0%	-47.0%
BBB+	0.0857	0.0541	0.0479	-36.9%	-11.4%	-44.1%
BBB	0.0935	0.0614	0.0547	-34.3%	-10.9%	-41.5%
BBB-	0.1003	0.0684	0.0614	-31.7%	-10.3%	-38.8%
BB+	0.1038	0.0724	0.0652	-30.2%	-9.9%	-37.2%
BB	0.1105	0.0804	0.0731	-27.2%	-9.1%	-33.9%
BB-	0.1157	0.0867	0.0793	-25.1%	-8.5%	-31.4%
B+	0.1202	0.0917	0.0845	-23.7%	-7.9%	-29.7%
B	0.1281	0.0992	0.0923	-22.6%	-6.9%	-27.9%
B-	0.1355	0.1047	0.0982	-22.7%	-6.2%	-27.5%
CCC	0.1988	0.1454	0.1346	-26.9%	-7.4%	-32.3%
Average	*0.0889*	*0.0616*	*0.0560*	*-34.4%*	*-10.3%*	*-41.0%*

Source: Author.

Banks may compare their own results with the data in these tables above as guidance for their own data.

This chapter concludes with a summary of the applications and results of this chapter.

5.5 Conclusion

This chapter was presented in two main sections.

Section 1 was an application section (primary purpose of this study) which summarised the calculation methodologies (introduced in Chapter 3 and 4) into a *step-by-step application* that can be used for capital calculation by banks of any size and complexity. These applications enable banks to *empirically* determine their own parameters from their own, unique loss experiences. Section 1 presented a calculation methodology to extract the empirical asset correlation from a set of retail loss data (based on Chapter 3) as well as a calculation methodology that can be used by banks to calculate their own fair holding period of trading book credit exposures (based on Chapter4).

These two, empirically determined, parameters (asset correlation for credit risk and holding period for trading book credit exposures) can be used by banks to determine a fair level of economic capital

Section 2 used the capital calculation methodologies introduced in Section 1 and applied data to each of the methodologies. This was be done to illustrate how the methodologies, introduced in this study, can be used by practitioners to determine fair levels of economic capital (based on their own loss data). In Section 2, the results of the specific data (applied to the methodologies) were also discussed.

This chapter concludes with a discussion on the presented applications and results.

5.5.1 Presented application

Chapter 3 and 4 of investigated the primary purpose of this study which is to introduce calculation methodologies which will allow banks, of any size and complexity, to empirically determine their own unique parameters from their own loss experiences. This was done in the two preceding chapters and the above mentioned, empirically calculated parameters, will allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed in line with the bank's own loss experience. Banks can therefore, by applying the capital calculation methodologies introduce in this study, determine fair levels of economic capital which is sufficient to cover losses arising from specifically credit and market risks faced by banks.

If a bank finds that the fixed parameters (as specified by the BCBS) are too lenient, the bank can increase economic capital reserves. If, however, a bank finds that the fixed parameters are too onerous, the bank can judge for itself whether or not prevailing economic conditions warrant such capital requirement severity. In either case, the bank using these methodologies is able to accurately establish its unique, empirical capital requirements.

Chapter 3 focused on credit risk and investigated the AIRB by focusing on the estimation of an empirical asset correlation. Using this empirical asset correlation in Basel II specified equations allows the user to determine a fair level of economic capital to be held for credit risk exposures. Chapter 3 specifically focussed on retail credit risk which has not received sufficient attention as industry and regulatory resources have always focused more on corporate lending (Ghosh, 2005:3). The calculation methodology introduced in Chapter 3 was summarised in this chapter as an application to be used by any bank who which to extract their own empirical asset correlation from retail loss data in order to determine an empirical capital charge for these credit risk assets.

Chapter 4 extended the investigation (methodology to determine a fair level of economic) beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book). Chapter 4 investigated incremental default risk (IDR) as the scientific element – i.e. the credit risk embedded in the trading book. More specifically, the length of time required to unwind a financial *credit* position (the holding period) without materially affecting underlying asset prices. This calculation methodology or application to determine the a fair economic capital charge via the empirical holding period for credit instruments in the trading book was summarised in this chapter.

5.5.2 Results

The specific dataset, to which this application was applied, as well as the resulted derived from them, was also discussed in detail in this chapter.

To the credit risk application (introduced in Chapter 3) US retail data (1985-2008Q1) was applied for analysis purposes. The first important finding was that Basel II correlation assumptions resulted in a 3.3 times higher level of required regulatory capital than capital required using empirical asset correlations. This result was then further investigated to determine the impact of the derived asset correlation on capital as Wood (2008:32) stated that, changing asset correlation assumptions has a significant impact the capital charge. The results in this chapter indicated that the regulatory capital charges were, on average, 3.3 times more that empirically-calculated capital charges. Furthermore, the findings also indicated that, for all investigated retail asset classes, the Basel II charges were considerably more than the empirically calculated capital charges. For the specific dataset investigated, this chapter concluded that the Basel II capital charge is too conservative and even punitive. This finding raised the question about why the BCBS set correlation at a level which is consistently higher and more conservative that what is found in the investigated dataset.

For the market risk application (introduced in Chapter 4), 13 000 bonds were randomly simulated to apply to the calculation methodology introduced in Chapter 4 and summarised in this chapter.

The results, which were based on multiple maturities and all different bonds with all types of credit ratings investigated, indicated that capital charges, calculated by using Basel II's 250 holding period were consistently too conservative when compared with the empirical (80 days). For the same data, the ISDA holding period (60days) was too lenient. The results also indicated that the empirical capital charges were more in line with the industry (i.e. ISDA's) view than with Basel II view.

Results also indicated that the difference in capital charges between the three calculation methods (Basel II's, ISDA's and empirical) becomes smaller over time. This indicates that Basel II's capital charges are the most punitive for assets with a shorter maturity which might indicate that Basel II does not encourage liquidity in a bond portfolio as assets with a longer maturity might have a more fair capital charge.

For all the results obtained in this study it is acknowledged that the finding cannot be generalised as it only reflects the specific data investigated. The application methodologies introduced in this study can however be used by any bank to derive their own unique results based on their own data. Those results may be used in economic capital calculations which are and will become more important for banks, regulators and investors in future.

Chapter 6

Conclusions and recommendations

6.1 Introduction

Measuring and managing risk capital in a bank is critical for the maintenance of global financial stability – especially when large losses occur or in times of high market volatility and uncertainty. Ensuring the stability and good governance of the banking milieu is the responsibility of the BIS which recognised the strategic importance of banks and established the BCBS in 1974. The BCBS has engineered and distributed Basel I and Basel II over the last two decades (since1988) and since the introduction of the original Basel I in 1988, risk management has evolved considerably. The Basel II Accord – the final version of which was introduced in July 2006 – is more risk-sensitive than its predecessor as it extends the ambit of risks evaluated and it also sets out significantly more advanced risk modelling techniques intended to improve the measurement and management of bank risk capital (Proctor, 2006).

The current (Basel II) accord sets out, *inter alia,* advanced modelling techniques for use by qualifying banks. The implementation of Basel II helped to correct numerous weaknesses of Basel I, although the economic crisis (which began in 2008) exposed several areas where the accord could be further improved to strengthen the global banking sector (Financial Stability Forum (FSF) and BCBS Working Group, 2009:5). Basel II embraces, in some detail, three significant bank risk components namely market, credit and operational risk. The framework comprises three pillars with which all banks must comply. The first of these pillars requires banks to retain *at least* an amount of capital specified by their adopted (and regulatory-approved) approach. Banks must, in addition, also satisfy local regulators that other risks have been adequately and appropriately addressed and the requisite capital has been reserved for these over and above that required under the first pillar. This second pillar embraces capital required for concentration risk, legal risk, liquidity risk, interest rate risk and others, including capital required for severely adverse market condition. It is the aim of the BCBS that the sum of the banks' capital under pillars one and two will ultimately equate to banks' economic capital requirements.

The most prominent aspect of Basel II is the determination of the *appropriate* amount of regulatory capital, i.e. an amount which is not so lenient that it allows banks to regularly fail and yet not so onerous as to impede the day-to-day operations of a bank. The assessment of bank capital adequacy and the enforcement of sufficient retained capital for this purpose are important functions of banking supervisors or regulators. Regulators that perform these assessments compare banks' available capital (held for protection) with the bank's capital needs (based on its overall risk profile). Bank management must also continuously evaluate internal capital adequacy in relation to risk faced by a bank (Federal Deposit Insurance Corporation (FDIC), 2004).

Banks must comply with regulators' demands: they do not have any choice in implementing the supervisory rules. Several banks, however, face numerous obstacles in order to comply with and effectively implement the Basel II capital requirements (Callaghan, 2006). At the time of writing (November 2009), most banks follow the Basel II Standardised and Basic Approaches for all risk types (Van Roy, 2005:7). To satisfy the requirements required for the advanced approaches as set out in Basel II, banks must have rigorous procedures in place for data collection, model validation and backtesting. Even though this is expensive and complex, banks that qualify are rewarded with a risk management system which provides a competitive advantage as it enables them to raise their ratings and calculate fair regulatory capital charges (Callaghan, 2006). Many banks, however, have neither the resources not the expertise to construct and implement Basel II's Advanced models (see Strand, 2000:1, Yao, 2003:23 and Whalen, 2006:2). All banks, however, also require their own internal (economic capital) models and prior to the introduction of Basel II, these were designed with varying levels of sophistication (Wong, 2008:1). Since Basel II aims to calibrate regulatory capital models with internal economic capital models, many banks simply employ Basel II Advanced *models* for their own (internal) use (Wong, 2008:3). The values of *economic* capital model parameters, however, are chosen completely at the bank's discretion.

Large international banks are increasingly comfortable to use their economic capital frameworks in discussions with stakeholders and to use it for Basel II solutions. Singh and Wilson (2007:19) expect economic frameworks to continue to improve and, in particular over the next few years, to be more widely accepted by the market and regulators in assisting banks to determine their capital management requirements. The determination of economic capital is – and will in future be – increasingly important for all banks, an undertaking that requires intensive modelling and analysis that is not always possible for all banks due to a wide variety of resource issues (Sherris and Van der Hoek, 2006:39).

Despite the retention of capital to protect banks from financial crises, the 'credit crisis' has affected almost every segment of the financial system. Indeed, banks were the hardest hit by the crisis (which was arguably caused by the banks themselves) as billions in mortgage-related investments had to be written down, equity market values losses were considerable and exposure to exotic credit derivatives (such as CDOs and CDSs) which subsequently defaulted, resulted in many bank failures. Some investment banks that once dominated the financial world have either disappeared, been absorbed or have been reinvented as commercial banks (The New York Times, 2009). Although some signs of tentative recovery have been noted recently, at the time of writing (November 2009) the crisis continues unabated.

6.2 Problem statement

The problem statement was explored in this thesis: Under Basel II, many banks are (and in the future most is) regulated by a similar set of rules (with different levels of complexity) in order to ensure that banks reserve sufficient capital for potential adverse events. The BCBS established equations and methodologies that form part of these rules, based on several broadly sound economic assumptions (which are, by design, highly conservative), for calculating the requisite capital. The equations comprise several inputs, most of which may be determined by banks themselves using the most advanced approaches. The remaining parameters, however, have been deliberately *fixed* by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas. However, these fixed parameters may not reflect the individual and unique risk exposures and experience of a particular bank.

The BCBS have presented detailed documentation regarding the choice of model and most of the steps which lead to the capital requirement equations, but the rationale behind the choices of fixed parameters has not been publicly released. This opacity obscures the *fairness* of the capital requirements; *fairness* in the sense of 'do these fixed parameter restrictions make for capital requirements that are *too onerous* or *too lenient*?' Without details of how to estimate (empirically or theoretically) the fixed parameters, banks using the BCBS-specified equations must simply accept that the requirements are, indeed, 'fair' or at least appropriate.

Currently (November 2009), sophisticated banks calculate their economic capital requirements independently of the BCBS while smaller, less sophisticated banks – which often lack the quantitative resources of their more complex peers – rely heavily on Basel II for guidance on the estimation of economic capital (Wong, 2008: 3).

6.3 Research goals and objectives

To address this problem, the following primary and secondary goals were identified:

1. The primary goal is to establish methodologies to empirically estimate some of the opaque, fixed variables present in Basel II’s equations. The methodologies allow banks (of any size and complexity) to determine empirically their own unique parameters (for credit and market risk) from their own unique loss experience. Knowing these empirical values allow banks to ascertain whether or not the BCBS-specified fixed parameters ensure that capital requirements are indeed too lenient or too onerous (i.e. determine a *fair* capital charge). If the former, banks can increase economic capital reserves appropriately and if the latter, banks can judge for themselves whether or not prevailing economic conditions warrant such capital requirement severity. In either case, banks using the suggested methodologies are be able to establish precisely their unique, *empirical* capital requirements without blind acceptance of obscured parameters in Basel II's capital calculations.

2. The secondary goal is to summarise the calculation methodologies introduced in this study into implementable applications which may be employed by any bank. These applications allow banks (of any size and complexity) to determine empirically their own unique market and credit risk parameters from their unique loss experiences.

This study does not seek to discredit Basel II; rather it acknowledges the necessity for banks to ensure that key elements of the Basel II risk management governance structures, policies, processes and systems are robust and integrated within banks' day to day activities. This is especially important in the light of the ongoing (November 2009) credit crisis (Griffin, 2008).

6.4 Contribution

The chapters each explained a contribution which served as building blocks to reach the primary and secondary goals set at the beginning of this study. The individual chapter contributions are discussed next.

- **Chapter 2: Literature survey**

  Chapter 2 presented a literature survey which introduced the three essential role-players of global capital regulation namely: the BIS, BCBS and the Basel II framework. These protagonists were discussed to provide a better understanding of the global regulation of bank capital. The concept of economic capital was also explored in more detail. Historical developments, functioning and status quo of the components were detailed and Basel II's three pillar framework was summarised. Under the first pillar (minimum capital requirements) of Basel II, credit, operational and market risk was introduced briefly. This was followed by a brief introduction of the second pillar (supervisory review) and the third (market discipline).

- **Chapter 3: Fair credit risk capital using empirical asset correlations**

  Chapter 3 focused only on Basel II's first pillar, namely minimum capital requirements for credit risk (chiefly under the Advanced Internal Ratings Based (AIRB) approach). The primary purpose of this chapter is to introduce a calculation methodology which enables banks to determine a fair level of economic capital.

  The first parameter which has deliberately been *fixed* by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas is asset correlation and this was investigated in Chapter 3 with the purpose of determining a fair level of economic capital for credit risk, specifically for retail assets. Asset correlation was specifically identified as a potential problem since an incorrect measurement of this parameter could be detrimental in estimating a bank’s capital requirements (Laurent, 2004:23).

  Chapter 3 comprises three sections: a literature study (which covers the relevant credit risk definitions and focused on the capital calculation framework prescribed by Basel II. As this chapter investigates asset correlations and their impact on credit risk capital charges, a thorough description of this topic was required in order to contextualise the subject and draw accurate conclusions on this topic), a methodology for extracting empirical asset correlations using empirical data (which is employed in the calculation methods of the prescribed Basel II framework (introduced in Section 1) to also calculate the capital charge for credit risk) and a summary of the application which may be employed by banks to extract the empirical asset correlation from a set of retail empirical loss data. Banks may use these derived asset correlations to calculate fair levels of economic capital (using the Basel II framework and equations for credit risk). Section 3 also presented the results obtained from the methodology by applying it to US retail loss data.

The results indicated that the required regulatory capital is roughly three times higher than estimated economic capital, reflecting a high – perhaps even punitive – measure of conservatism imposed by Basel II.

- **Chapter 4: Fair trading book capital using empirical unwind periods**

Chapter 4 extended the investigation beyond credit risk (dominant in the banking book) and into market risk (prevalent in the trading book) and investigated the incremental default risk charge (IDR) which was recently introduced by the BCBS to take account of credit risk embedded in the trading book. This chapter thus investigated another parameter which has been deliberately fixed by the BCBS as a means of introducing and establishing the necessary austerity into capital requirement formulas, namely the credit *holding* (or unwind) *period.*

The holding periods refers to the length of time required to unwind a financial position without materially affecting underlying asset prices. It is one of the few components of contemporary risk models which may be altered subject to the practitioner's whim. Most others are *calculated* and hence manipulation of their values is more difficult. Chapter 4 therefore introduced a calculation methodology, which may be applied by any bank, to determine the empirical holding period for credit risky instruments in the trading book.

Chapter 4 comprises of three sections. Section 1 is a literature which covers all the relevant trading book concepts and developments. Section 2 is a methodology section (as well as an exploration of the required parameters needed) while Section 3 is a summary or application section which may be used by banks to calculate their own fair holding period of trading book credit exposures, based on their own data. This fair holding period is an important value and could be of strategic interest to banks who wish to establish fair levels of economic capital for market risk.

Capital charges, as calculated using Basel II’s 250 holding period were found to be consistently too conservative when compared with the empirical (80 days) data. For the same data, the ISDA holding period (60 days) was too lenient. The results also indicated that the empirical capital charges were more in line with the industry (i.e. ISDA's) view than with Basel II view. The results also indicated that the difference in capital charges between the three calculation methods (Basel II’s, ISDA’s and empirical) becomes smaller over time, showing that Basel II’s capital charges are the most punitive for assets with a shorter maturity.

- **Chapter 5 - Contribution and results of investigated data**

Chapter 5 presented the results obtained in this analysis and comprises two sections: a methodology section (which summarises the capital calculation methodologies from Chapter 3) which may be used by banks to extract the empirical asset correlation from a set of retail loss data. Banks may then use the empirical asset correlation to determine a fair level of economic capital using the Basel II credit capital equations and a summary of the methodology introduced in Chapter 4 which may be used by banks to calculate their own fair holding period of trading book credit exposures, based on their own loss data) and a summary section (which applies these capital calculations (one for credit risk and one for market risk) to specific datasets and presents the results). These two calculation methodologies, introduced for the first time by this study, provide banks with the opportunity to determine, empirically, their own unique parameters based on their actual loss experiences. The contribution of this study is therefore critical for banks as any bank (of any size and complexity) can now, by applying these *easy to use* methodologies, calculate empirical levels of capital which is not based on fixed BCBS parameters, but on their own unique parameters from their own unique loss experience. The results summarised in Chapter 5 indicated – in both cases (for credit and market risk) – that the capital charges calculated by applying fixed BCBS parameters resulted in highly conservative (even punitive) levels of capital when compared with empirically calculated (based on unique loss experience) capital charges.

The contribution of this study is therefore extremely important as banks were not able in the past to compare their regulatory capital (based on fixed BCBS parameters) with their empirical levels of capital (economic capital), based on their own, unique losses. Understanding a bank economic capital is currently (2009) the focus of all banks, including the BIS and local regulators as the credit crunch revealed that pre-credit crunch regulation was ill prepared for the crisis that followed and that it must be addressed in an holistic and comprehensive manner in order to evolve from the crisis (Morrison, 2009:2).

Knowing the accurate levels of economic capital is critical as it is used to better understand the level of bank solvency (Lang, 2009). Economic capital is crucial for banks' strategic decision-making processes as it provides information on issues such as quantitative risk reward trade-offs and where risk mitigating investments are needed. Banks furthermore rely on accurate levels of economic capital to make better pricing decisions (e.g. for credit securities in their trading book). Accurate levels of economic capital also facilitate better understanding of relative returns on risks across banks and supports portfolio optimisation by providing a good understanding of the combinations of return for risk across different business lines. Finally, economic capital is important for investment assessment used when taking decisions about new investments. When a bank considers investment opportunities it must not only look at the return on the investment, but also the risk adjusted return which can be determined by empirical economic capital (Lang, 2009).

This study proved that, for the specific sets of data investigated (by applying the methodologies introduced for the first time in this study); the BCBS' fixed parameters resulted in different levels of capital when compared with empirically calculated capital charges. Even though the regulatory capital cannot be altered, banks can and do use economic capital in decision making.

6.5 Scope

This study is aimed at banks of any size and complexity and introduced calculation methodologies which will allow them to determine empirically their unique parameters for capital calculation from their own loss experience. The study does not aim to discredit Basel II nor its conclusions, but is rather aimed at providing banks with methodologies to determine empirical economic capital, i.e. based on banks' own data. Those results may be used in economic capital calculations which are – and will become – more important for banks, regulators and investors in future.

In Chapter 2 Basel II was discussed along with the three pillar framework of which it comprises. Under the first pillar, credit, operational and market risk are introduced, but this study focuses only on capital calculation methodologies for credit and market risk. Operational risk was not covered.

For credit risk, the capital calculation methodology is specifically aimed at *retail* credit exposures which have not received sufficient attention in recent years as industry and regulatory resources have always focused far more on *corporate* lending (Ghosh, 2005:3).

For market risk, the capital calculation methodology was based on bonds (specifically plain vanilla, corporate bonds). The idea was to isolate the effects of credit-risky instruments from other types of instruments (such as equities) in the trading book. Using simple debt instruments (plain vanilla corporate bonds) the application of the methodology introduced in this study could be effectively demonstrated. Complex debt instruments (such as CDSs and CDOs) are intricate and this unnecessarily obscures the effective application of the introduced methodology. However, banks which do hold complex instruments may still apply this methodology provided they can accurately determine both the market and credit risk capital charge components.

6.6 Recommendations for future study

This study introduced calculation methodologies which enables any bank to calculate fair levels of economic capital for both credit and market risk. This study can therefore be extended to operational risk which is the least known of the three risks under Basel II's Pillar 1.

The Basel equations apply a broad brush approach for banks subject to the framework as single equations govern all sizes and types of banks under the standardised approaches (i.e. the majority of banks worldwide). A potential area of future investigation, therefore, would be to analyse the empirical losses and capital requirements over time to determine if banks were under or overcapitalised in different areas.

Even though flexibility is introduced in the advanced approaches via the bank's choice of input parameters, some of these parameters are fixed and unalterable. This thesis investigated asset correlation for credit risk and the holding period for the trading book (market risk). There are several different parameters which may also be analysed and investigated in future studies.

6.6.1 Areas for future study in credit risk

- Continue the evaluation of empirical retail asset correlations by using more and more data from *deeper into* the credit crisis (i.e. after the crisis is established as being in some sense "complete").
- Ascertain whether the factor of 3 used (increase in capital charge based on empirical asset correlation) is valid after end of the credit crisis
- Extend the investigation beyond retail assets to also cover bank, sovereign, corporates and high volatility corporate real estate assets by investigating specific asset correlations prescribed by the Basel II framework
- Evaluate whether maturity factor – which was excluded from this study as retail does not require maturity factor – is empirically valid for the asset types to which it does apply.

6.6.2 Areas for future study in market risk

- Continue evaluation of whether the holding period for credit risk in the trading book is valid i.e. long after the credit crisis (since IDR has only recently (April 2009) been introduced). There is currently not enough data for such investigations.
- Establish more accurate parameters for simple vanilla bond portfolios (e.g. interest rate volatility, and interest rate correlation).
- Evaluate the effect of IDR on credit derivatives for non-vanilla instruments.

6.7 Final statement

Given the Global financial crisis that shocked markets worldwide (credit crunch from 2007-2009), the role of risk managers and regulators will almost certainly change. This will involve increased prominence and authority of bank regulation and a complete reshuffling of the way in which risks are measured. What will become increasingly critical for banks is to understand the risks they face given the underlying risk environment. This study has made significant progress in this area as it introduce calculation methodologies which allow banks (of any size and complexity) to determine empirically their own unique parameters from their own unique loss experience. As *understanding banks' economic capital* is currently (2009) such a critical focus in the global banking sector (Morrison, 2009:2), the contribution of study is particularly relevant as it provides methodologies to calculate empirical capital charges for credit and market risk.

Firstly, for credit risk, this study has demonstrated how empirical correlations may be calculated from minimal input data (i.e. only gross losses over, at least, a seven year period), how these differ from the BCBS specified correlations and how they change over changing economic conditions. The analysis is relevant for any bank interested in establishing its own internal measure of asset correlation for credit risk for both regulatory and economic capital purposes.

Secondly, for market risk, this study has shown that the austerity of the new trading book rules will lead to significant increases in market risk regulatory capital and developed a measurement method for the *empirical* holding period for credit securities. This period is considerably shorter than that specified by Basel – even after taking the severity of the credit crunch into effect – so this measure will greatly assist banks interested in the accurate pricing of the credit securities in their trading book.

Appendix I

The best fit to the distribution of these loss data was the Beta distribution. In this appendix, the top 10 (10 best fits) fitting results are provided. Beta was – on average – ranked the best overall fit using the Kolmogorov-Smirnov, Anderson-Darling and Chi-Squared tests.

i. Single family residential mortgages

Residential mortgages - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	73	Min	0.3
Range	8.57	0.05	0.39
Mean	1.1648	0.1	0.39
Variance	2.6893	25% (Q1)	0.49
Std. Deviation	1.6399	50% (Median)	0.69
Coef. of Variation	1.4079	75% (Q3)	0.99
Std. Error	0.19194	0.9	1.954
Skewness	3.574	0.95	6.304
Excess Kurtosis	12.472	Max	8.87

Residential mortgages - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07585	2	0.44877	1	3.9584	1
2	Burr	0.08964	8	0.5632	5	5.5449	8
3	Burr (4P)	0.07743	3	17.446	44	4.1029	2
4	Cauchy	0.17887	19	3.6269	16	6.9721	11
5	Chi-Squared	0.4403	48	15.152	42	77.235	41
6	Dagum	0.22074	25	6.4115	20	12.628	16
7	Dagum (4P)	0.47004	50	0.5149	2	4.7495	7
8	Error	0.37087	42	14.373	39	42.666	28
9	Error Function	0.57258	52	26.975	49	114.89	46
10	Exponential	0.25714	28	7.8925	25	53.931	35

Single family residential mortgages - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=0.16403 a_2=1.3287
		a=0.3 b=9.757
2	Burr	k=0.16473 a=9.0899 b=0.41809
3	Burr (4P)	k=0.5409 a=2.3941
		b=0.27032 g=0.26893
4	Cauchy	s=0.18833 m=0.63877
5	Chi-Squared	n=1
6	Dagum	k=131.37 a=2.5136 b=0.07002
7	Dagum (4P)	k=2.9211 a=1.5082
		b=0.17757 g=0.24986
		k=1.0 s=1.6399 m=1.1648
9	Error Function	h=0.43119
10	Exponential	l=0.85852

ii. Credit card loans

Credit cards - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	2.78
Range	8.18	0.05	4.16
Mean	6.0704	0.1	4.328
Variance	2.3701	25% (Q1)	4.645
Std. Deviation	1.5395	50% (Median)	6.12
Coef. of Variation	0.25361	75% (Q3)	7.195
Std. Error	0.15631	0.9	8.12
Skewness	0.5519	0.95	8.672
Excess Kurtosis	0.26492	Max	10.96

Credit cards - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06666	1	0.73394	5	2.2283	1
2	Burr	0.09476	24	0.91763	21	7.0343	6
3	Burr (4P)	0.08301	7	0.7328	4	8.7255	13
4	Cauchy	0.13148	44	2.2601	41	10.229	27
5	Chi-Squared	0.31404	53	12.097	51	72.108	50
6	Chi-Squared (2P)	0.27325	50	10.721	50	27.386	46
7	Dagum	0.09471	23	1.0607	27	8.4069	10
8	Dagum (4P)	0.08916	20	0.82989	20	8.602	12
9	Erlang	0.12086	40	1.5836	37	16.451	43
10	Erlang (3P)	0.09279	21	0.81055	17	10.728	33

Credit cards - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=6.5315 a_2=33.985 a=1.7492 b=28.555
2	Burr	k=1.7299 a=5.8114 b=6.7378
3	Burr (4P)	k=6.5391 a=2.8183 b=7.752 g=2.3858
4	Cauchy	s=1.0081 m=5.9613
5	Chi-Squared	n=6
6	Chi-Squared (2P)	n=3 g=2.7184
7	Dagum	k=1.1127 a=6.5118 b=5.7495
8	Dagum (4P)	k=0.31654 a=6.5329 b=4.7439 g=2.5753
9	Erlang	m=15 b=0.39044
10	Erlang (3P)	m=10 b=0.48819 g=1.2291

iii. Commercial real estate loans

Commercial real estate - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	73	Min	0
Range	8.41	0.05	0.058
Mean	1.6163	0.1	0.082
Variance	5.4829	25% (Q1)	0.16
Std. Deviation	2.3416	50% (Median)	0.46
Coef. of Variation	1.4487	75% (Q3)	1.97
Std. Error	0.27406	0.9	5.8
Skewness	1.6267	0.95	7.367
Excess Kurtosis	1.4424	Max	8.41

Commercial real estate - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07986	1	2.6953	2	4.8467	3
2	Burr	0.08856	10	2.7638	6	5.6973	9
3	Burr	0.08856	9	2.7638	5	5.6972	8
4	Cauchy	0.25681	35	14.527	42	11.037	17
5	Chi-Squared	0.16757	24	6.7226	30	16.87	23
6	Chi-Squared	0.16757	23	6.7226	31	16.87	22
7	Dagum	0.08411	5	2.7329	3	6.0132	11
8	Dagum	0.08411	6	2.7329	4	6.0132	12
9	Error	0.34649	44	10.59	38	46.197	38
10	Error Function	0.5	49	20.06	45	18.125	27

Commercial real estate - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=0.28827 a_2=0.81
		a=-7.8816E-15 b=8.41
2	Burr	k=0.31705 a=2.0274 b=0.14284
3	Burr	k=0.31704 a=2.0274 b=0.14283
		s=0.27385 m=0.27172
5	Chi-Squared	n=1
6	Chi-Squared	n=1
7	Dagum	k=13.24 a=0.78802 b=0.01065
8	Dagum	k=13.24 a=0.78802 b=0.01065
9	Error	k=1.2715 s=2.3416 m=1.6163
		h=0.30198
10	Exponential	l=0.6187

iv. Business loans

Business loans - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	0.23
Range	4.42	0.05	0.418
Mean	1.7885	0.1	0.516
Variance	1.1894	25% (Q1)	0.69
Std. Deviation	1.0906	50% (Median)	1.77
Coef. of Variation	0.6098	75% (Q3)	2.67
Std. Error	0.11073	0.9	3.26
Skewness	0.44231	0.95	3.72
Excess Kurtosis	-0.70449	Max	4.65

Business loans - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.07637	3	0.94906	1	8.9241	3
2	Burr	0.10804	11	1.6812	8	18.522	15
3	Burr (4P)	0.11454	16	1.7577	10	22.105	26
4	Cauchy	0.16959	45	3.5103	35	22.538	28
5	Chi-Squared	0.45083	57	40.302	57	80.785	51
6	Chi-Squared (2P)	0.3245	55	25.425	56	58.212	50
7	Dagum	0.10292	8	1.3568	4	7.7197	2
8	Dagum (4P)	0.08716	6	4.7899	43	N/A	0
9	Erlang	0.25973	52	12.107	52	50.154	48
10	Erlang (3P)	0.17243	46	6.0541	47	32.273	41

Business loans - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=0.99801 a_2=1.9721
		a=0.23 b=4.8464
2	Burr	k=2047.9 a=1.7021 b=177.19
3	Burr (4P)	k=1527.3 a=1.3914
		b=334.64 g=0.211
4	Cauchy	s=0.81926 m=1.6418
5	Chi-Squared	n=1
6	Chi-Squared (2P)	n=1 g=0.23
7	Dagum	k=0.14322 a=8.1713 b=3.2594
8	Dagum (4P)	k=0.10726 a=8.4928
		b=3.1872 g=0.23
9	Erlang	m=2 b=0.66504
10	Erlang (3P)	m=2 b=0.98726 g=0.20381

v. Lease financing receivables

Lease financing receivables - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	0.07
Range	2.09	0.05	0.137
Mean	0.69928	0.1	0.216
Variance	0.15686	25% (Q1)	0.385
Std. Deviation	0.39605	50% (Median)	0.68
Coef. of Variation	0.56638	75% (Q3)	0.99
Std. Error	0.04021	0.9	1.166
Skewness	0.71584	0.95	1.452
Excess Kurtosis	0.65767	Max	2.16

Lease financing receivables - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06212	3	0.46397	1	6.3747	2
2	Burr	0.07233	13	0.5481	7	8.0139	8
3	Burr (4P)	0.06788	8	0.5709	10	9.0734	18
4	Cauchy	0.14495	42	3.2105	40	16.833	42
5	Dagum	0.10234	31	0.71944	16	7.5458	6
6	Dagum (4P)	0.07133	12	0.53953	6	8.6416	14
7	Erlang	0.10364	32	1.2063	31	11.557	32
8	Erlang (3P)	0.12002	37	1.7517	36	8.988	15
9	Error	0.13455	39	1.5967	33	11.675	34
10	Error Function	0.65712	56	138.75	56	398.9	53

Lease financing receivables - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=1.7917 a_2=5.9455
		a=0.04394 b=2.8667
2	Burr	k=300.13 a=1.8513 b=17.147
3	Burr (4P)	k=351.43 a=1.7006
		b=23.216 g=0.03989
4	Cauchy	s=0.26818 m=0.61762
5	Dagum	k=0.20558 a=6.7318 b=1.1375
6	Dagum (4P)	k=0.14409 a=7.3519
		b=1.1532 g=0.06916
7	Erlang	m=3 b=0.22432
		m=3 b=0.2298 g=-0.04096
9	Error	k=1.5474 s=0.39605 m=0.69928
10	Error Function	h=1.7854

vi. Loans secured by real estate

Loans secured by real estate - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	0.1
Range	8.47	0.05	0.3
Mean	1.929	0.1	0.34
Variance	3.6223	25% (Q1)	0.49
Std. Deviation	1.9032	50% (Median)	1.13
Coef. of Variation	0.98665	75% (Q3)	2.51
Std. Error	0.19324	0.9	5.15
Skewness	1.4288	0.95	6.224
Excess Kurtosis	1.4784	Max	8.57

Loans secured by real estate - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.0875	2	0.91885	1	4.6471	1
2	Burr	0.10486	13	1.6062	19	10.738	18
3	Burr (4P)	0.09169	4	1.4927	18	18.667	34
4	Cauchy	0.26137	49	10.909	47	30.393	41
5	Chi-Squared	0.38519	55	26.042	53	47.899	45
6	Chi-Squared (2P)	0.31435	51	23.737	51	N/A	0
7	Dagum	0.11007	18	1.4036	10	8.8862	9
8	Dagum (4P)	0.10406	11	1.3457	8	9.2036	12
9	Erlang	0.11672	25	1.6448	23	13.741	26
10	Error	0.2115	40	6.732	41	26.122	40

Loans secured by real estate - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=0.50814 a_2=1.8451
		a=0.1 b=10.284
2	Burr	k=1.9104 a=1.3604 b=2.3136
3	Burr (4P)	k=16.994 a=0.96366
		b=31.093 g=0.1
4	Cauchy	s=0.70481 m=0.8648
5	Chi-Squared	n=1
6	Chi-Squared (2P)	n=1 g=0.1
7	Dagum	k=4.5042 a=1.2307 b=0.24444
8	Dagum (4P)	k=1.5431 a=1.3175
		b=0.66202 g=0.07146
9	Erlang	m=1 b=1.8778
10	Error	k=1.2622 s=1.9032 m=1.929

vii. Consumer loans

Consumer loans - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	1.07
Range	4.29	0.05	1.368
Mean	2.3299	0.1	1.47
Variance	0.55849	25% (Q1)	1.7
Std. Deviation	0.74732	50% (Median)	2.28
Coef. of Variation	0.32075	75% (Q3)	2.685
Std. Error	0.07588	0.9	3.156
Skewness	1.197	0.95	3.635
Excess Kurtosis	2.6645	Max	5.36

Consumer loans - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.06286	1	0.4082	1	4.5918	3
2	Burr	0.094	33	0.64117	25	9.6267	30
3	Burr (4P)	0.07549	8	0.49452	2	9.1553	27
4	Cauchy	0.11917	40	1.8655	41	11.088	35
5	Chi-Squared	0.46767	57	28.05	56	127.78	54
6	Chi-Squared (2P)	0.41741	55	30.901	57	N/A	0
7	Dagum	0.0912	29	0.75293	28	6.2474	7
8	Dagum (4P)	0.07999	20	0.52275	6	8.3941	20
9	Erlang	0.14436	46	3.0455	43	9.3545	29
10	Erlang (3P)	0.0935	32	0.74615	27	11.303	36

Consumer loans - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=3.8069 a_2=3.1948E+6
		a=0.88405 b=1.2140E+6
2	Burr	k=1.1644 a=5.4264 b=2.3179
3	Burr (4P)	k=3.8576 a=2.2853
		b=2.5332 g=0.97151
4	Cauchy	s=0.43241 m=2.2605
5	Chi-Squared	n=2
6	Chi-Squared (2P)	n=1 g=1.07
7	Dagum	k=1.311 a=5.214 b=2.0581
8	Dagum (4P)	k=0.318 a=5.084
		b=1.8224 g=1.0357
9	Erlang	m=9 b=0.23971
10	Erlang (3P)	m=4 b=0.37595 g=0.87766

viii. Other consumer loans

Other consumer loans - **Descriptive Statistics**			
Statistic	*Value*	*Percentile*	*Value*
Sample Size	97	Min	0.67
Range	3.42	0.05	0.75
Mean	1.5248	0.1	0.906
Variance	0.37605	25% (Q1)	1.155
Std. Deviation	0.61323	50% (Median)	1.4
Coef. of Variation	0.40216	75% (Q3)	1.725
Std. Error	0.06226	0.9	2.116
Skewness	1.8206	0.95	2.905
Excess Kurtosis	4.5797	Max	4.09

Other consumer loans - **Goodness of Fit - Summary**							
#	*Distribution*	*Kolmogorov*		*Anderson*		*Chi-Squared*	
		Statistic	*Rank*	*Statistic*	*Rank*	*Statistic*	*Rank*
1	Beta	0.04547	1	0.24218	1	2.092	2
2	Burr	0.08	20	0.8705	21	7.6604	25
3	Burr (4P)	0.04848	4	0.31606	4	4.3588	10
4	Cauchy	0.11029	31	1.9341	30	8.8333	27
5	Chi-Squared	0.58695	56	50.451	56	282	53
6	Dagum	0.0483	3	0.28525	2	4.4402	12
7	Dagum (4P)	0.05983	7	0.39395	6	4.5578	14
8	Erlang	0.11506	33	1.8689	29	7.4101	23
9	Erlang (3P)	0.16363	40	3.8379	40	12.291	34
10	Error	0.1744	43	3.1035	37	12.032	32

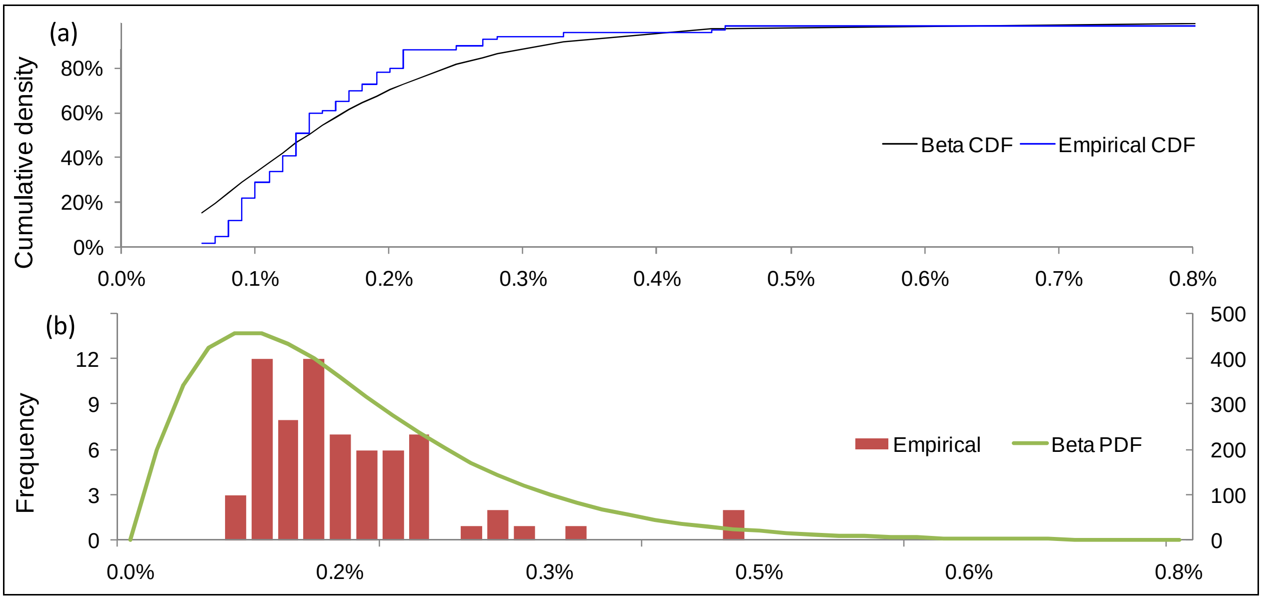
Other consumer loans - **Fitting Results**		
#	*Distribution*	*Parameters*
1	Beta	a_1=2.4593 a_2=5.9691E+6
		a=0.59996 b=2.2560E+6
2	Burr	k=0.67501 a=6.0485 b=1.2683
3	Burr (4P)	k=1.1839 a=3.2347
		b=1.0232 g=0.44431
4	Cauchy	s=0.2488 m=1.3591
5	Chi-Squared	n=1
6	Dagum	k=1.5675 a=4.5032 b=1.2277
7	Dagum (4P)	k=0.50616 a=3.5854
8	Erlang	b=1.0545 g=0.61727
		m=6 b=0.24661
9	Erlang (3P)	m=3 b=0.35801 g=0.58672
10	Error	k=1.0 s=0.61323 m=1.5248

Appendix II

The results for cumulative probability distribution function for the various retail asset classes are shown in the (a) graphs of Figure A1.[43] For a discrete random variable, the probability density function (PDF) at a certain value is the probability that the random variable will have that value. For a continuous random variable, the probability density function is represented by a curve in such a way that the area under the curve between two numbers is the probability that the random variable is between those numbers. The cumulative density function (CDF) evaluated at a number x, describes the probability that a variable takes on a value less than or equal to x (Brown, 2005): these are shown in the (b) graphs of Figure A1.

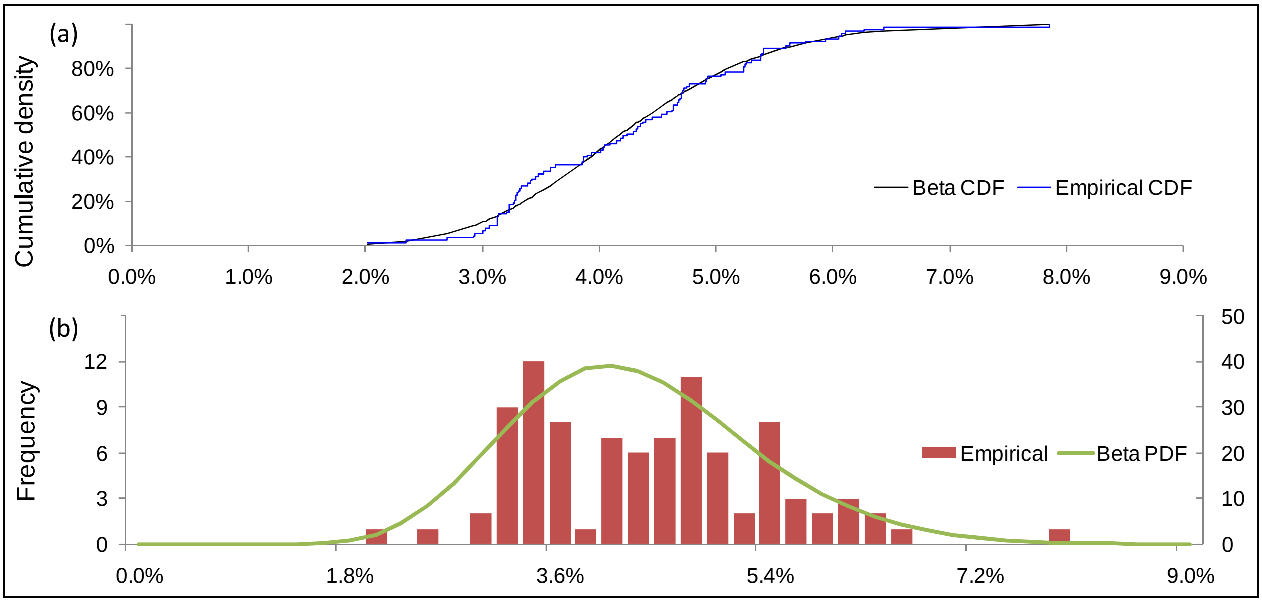
Figure A1*: (a) The Cumulative & (b) Probability density function of fitted Beta distribution - Vertical axis= (a) Cumulative density & (b) Frequency; Horizontal axis= Percentage loss*

Single family residential mortgages

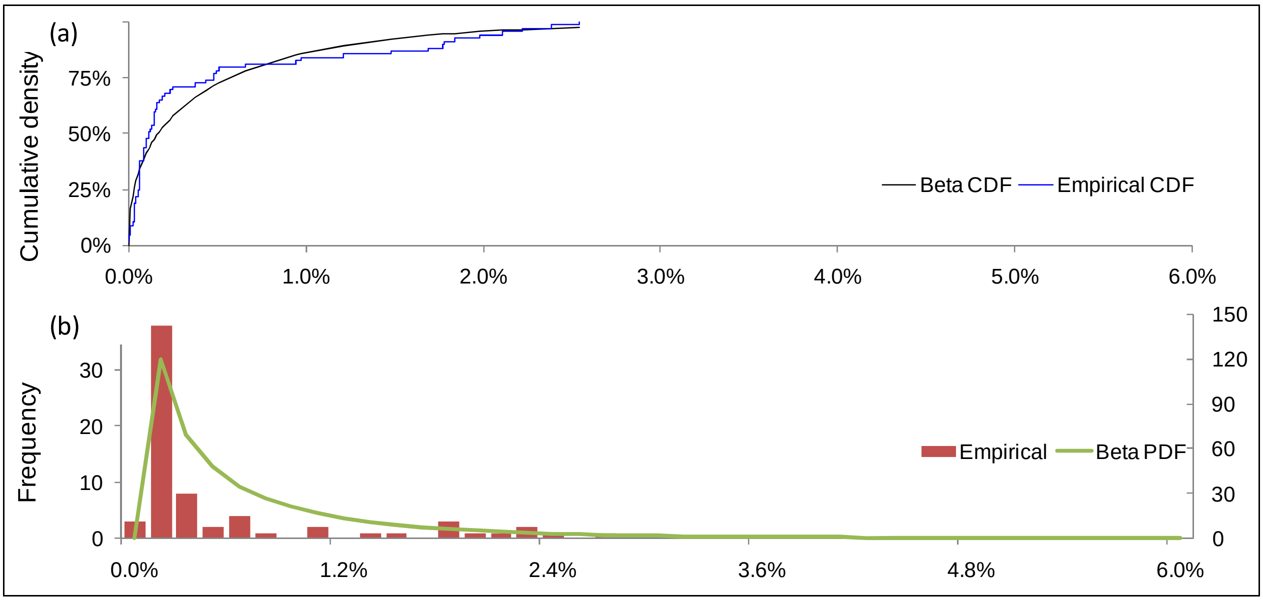


[43] The Beta distribution depends on two parameters, α and β (established directly from the empirical loss data, μ and σ). As these two parameters change, the distribution also changes. It is therefore possible for the loss distribution to be approximately normally distributed while still actually being an underlying Beta distribution. Therefore, a Beta distribution (as illustrated in Appendix II) can sometimes look like a normal (as does the binomial, Poisson, Weibull etc under certain conditions) without it actually being a normal distribution.

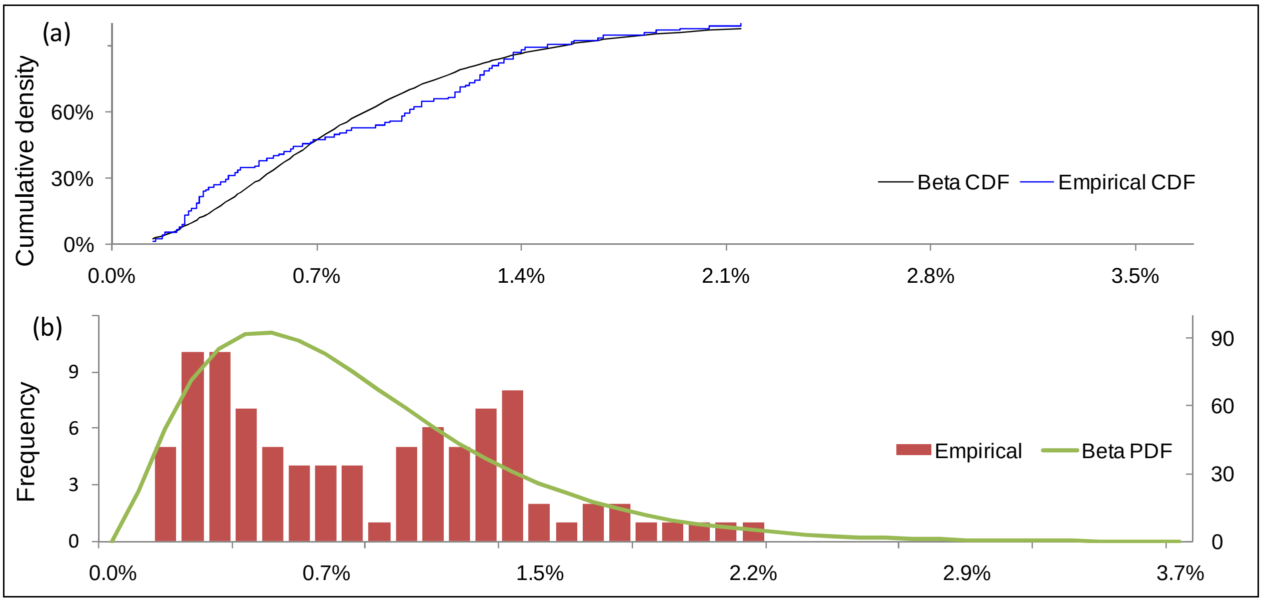
Credit card loans



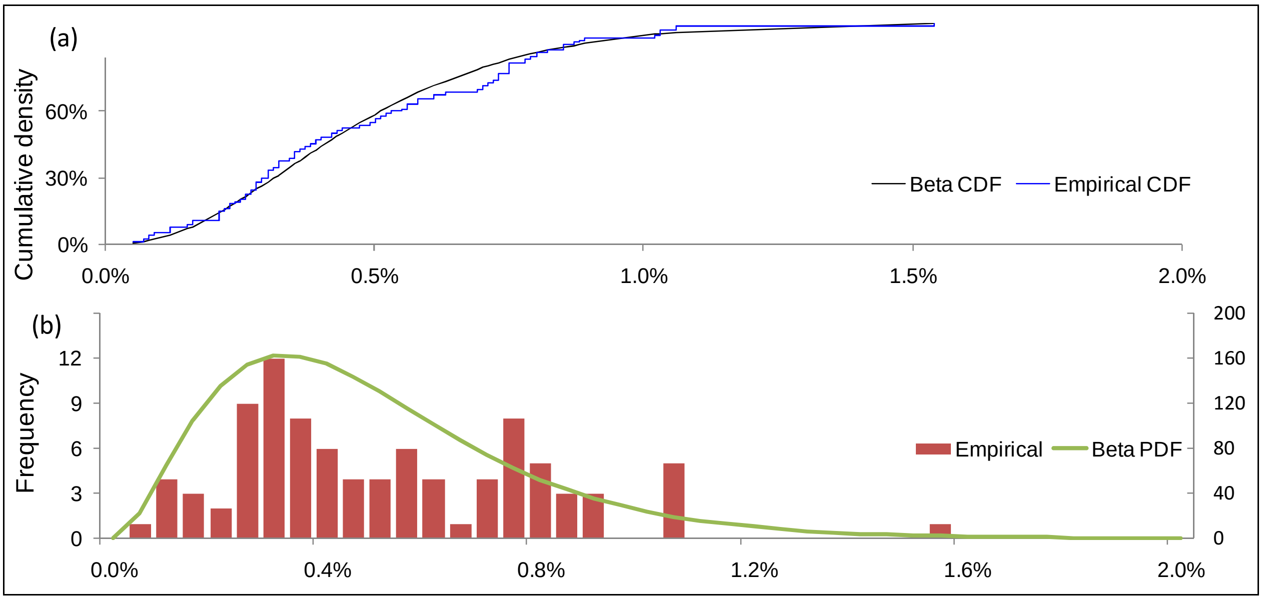
Commercial real estate loans



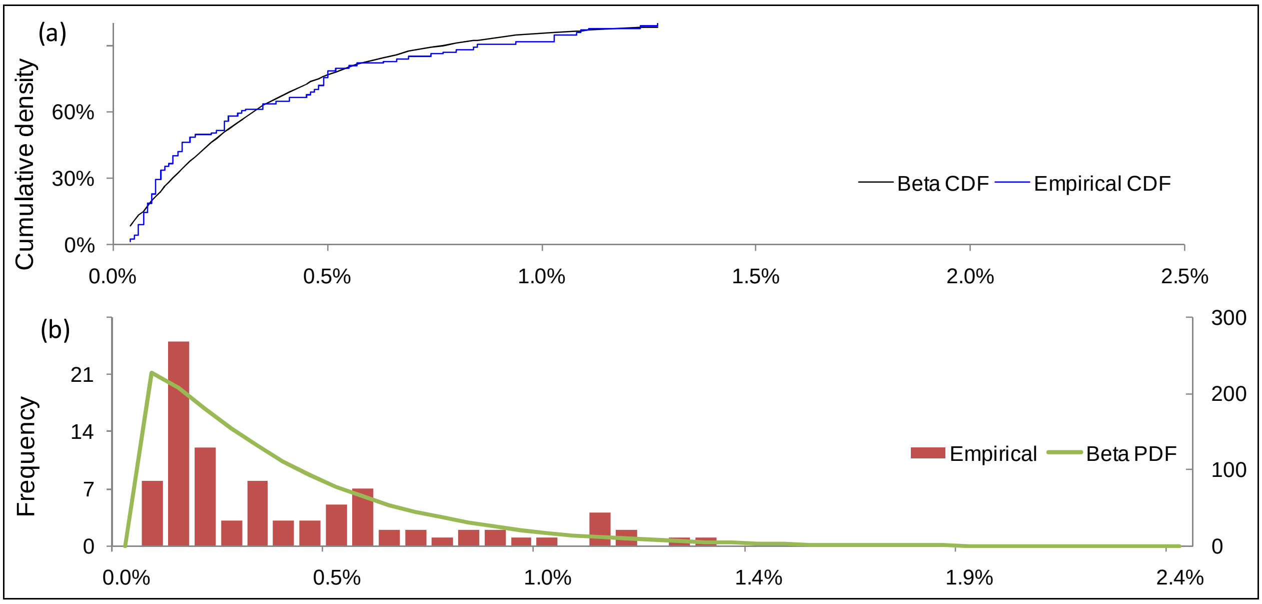
Business loans



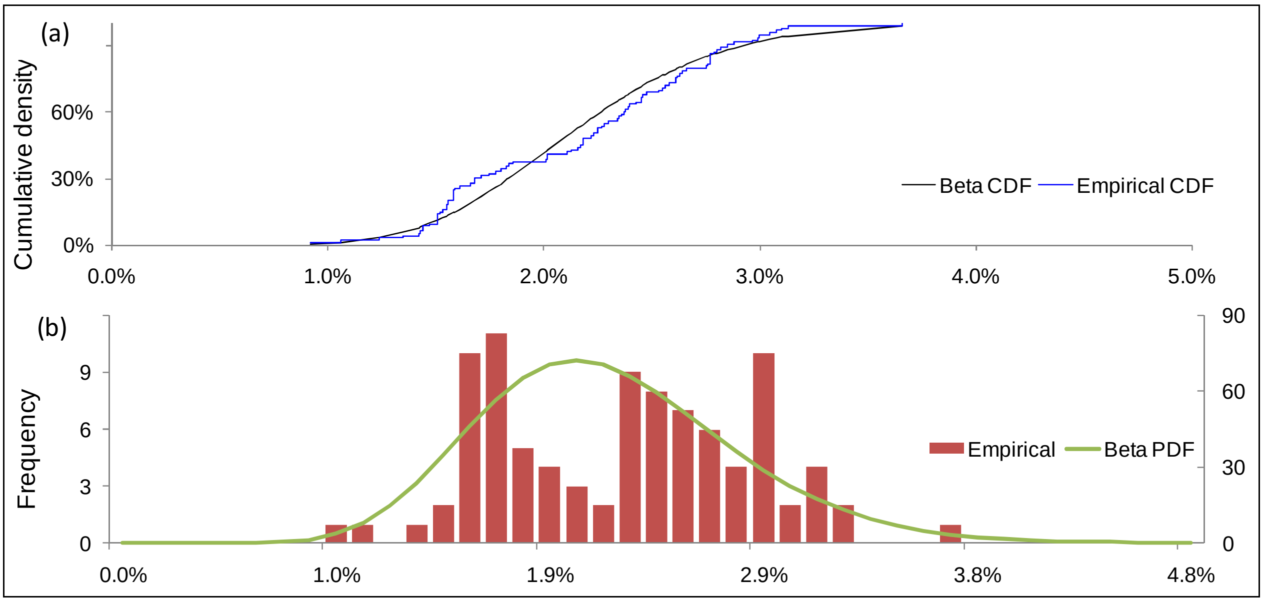
Lease financing receivables



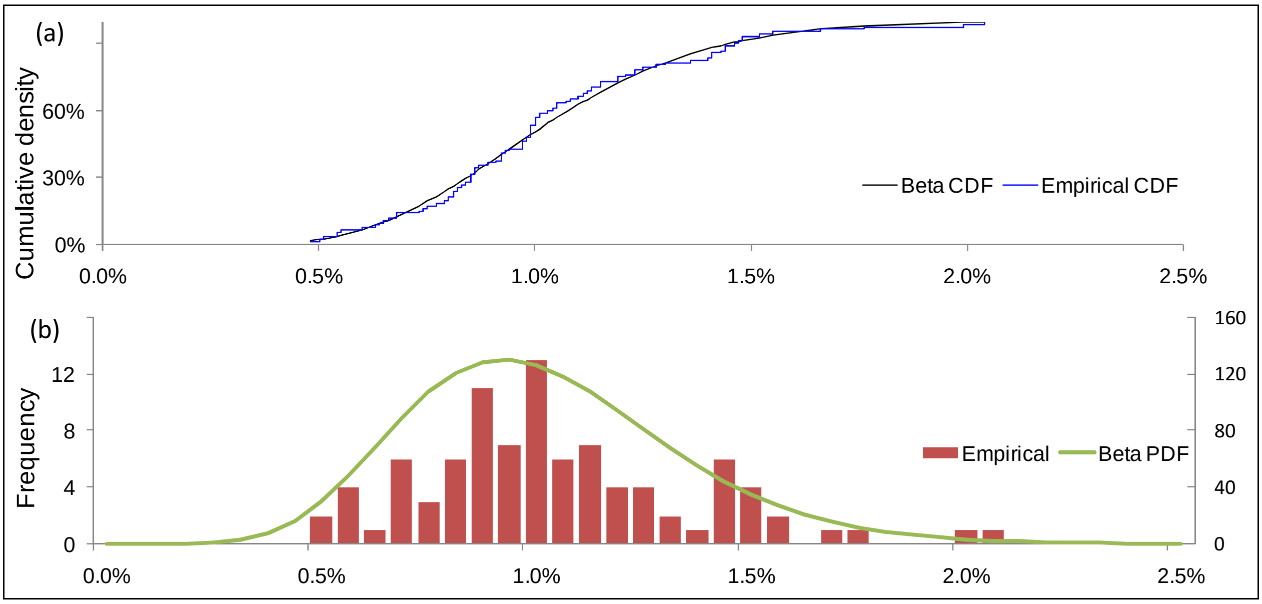
Loans secured by real estate



Consumer loans



Other consumer loans



Source: Author

References

AAS, K. 2005. The Basel II IRB approach for credit portfolios: A survey. Norsk Regnesentral, Oslo, Norway, no.SAMBA/33/05.

ADRIAN, T. & SHIN, H.S. 2009**.** Liquidity and Leverage, Federal Reserve Bank of New York, Staff Report no. 328.

AGUAIS, S. 2008. Designing and Implementing a Basel II Complaint PIT-TTC Ratings Framework. MPRA Paper No. 6939. 27 January. pp. 1-33.

ALENTORN, A. & MARKOSE, S. 2008. Generalized Extreme Value Distribution and Extreme Economic Value at Risk (EE-VaR). Computational methods in financial engineering. Published by Springer Berlin Heidelberg, pp. 47-71.

ALGORITHMICS QUANTITATIVE RESEARCH GROUP INCORPORATED. 2006. Losing Default Correlations, Step by Step. Press release in October [Available on the Internet:] http://www.bis.org/publ/bcbs14041/ca/algorithmics.pdf [Date of access: 5 December 2008].

ALTMAN, E.I. & SABATO, G. 2005. Effects of the New Basel Capital Accord on Bank Capital Requirements for SMEs. Journal of Financial Services Research. Vol 28, no.1/2/3. pp. 15–42 Springer Science and Business Media Incorporated, Manufactured in The Netherlands.

ALTMAN, E.I. & SAUNDERS, A. 2001. An analysis and critique of the BIS proposal on capital adequacy and ratings. Journal of Banking & Finance, New York University, New York, USA, 2001, no. 25, pp. 25-47.

ALTMAN, R. 2008. Modern history's greatest regulatory failure. Financial Times. [Available on the Internet:] http://www.ft.com/cms/s/0/1dc86ec4-84ce-11dd-b148-0000779fd18c.html [Date of access: 30 November 2008].

APARICIO, J. & KESKINER, E. 2004. A review of operational risk quantitative methodologies within the BASEL-II framework. Accenture Technology Labs, Sophia Antipolis, France, May.

APPLABS. 2007. BASEL II: Impact on IT Systems & Testing for Compliance. Applabs White Paper on Basel II, May, no. 1v04.

AUSTRIAN FINANCIAL MARKET AUTHORITY (AFMA). 2007. Market Risk under Pillar I. [Available on the Internet:] http://www.fma.gv.at/cms/basel2/EN/einzel.html?channel=CH0274 [Date of access: 1 June 2007].

BAJAJ, V. & CRESWELL, J. 2007. Bear Stearns Staves Off Collapse of 2 Hedge Funds, New York Times. Press release on 21 June 2007. [Available on the Internet:] http://www.nytimes.com/2007/06/21/business/21bonds.html?_r=2&ref=business [Date of Access: 4 December 2008].

BAKHSHI, B.S. 2007. Risk Information: Disclosure and Use. Speech at Risk Management Investor Day, Credit Suisse, London. 22 May.

BAKSHI, S. 2004. Basel norms: Challenges in India. The Charted Accountant - New Delhi. Vol. 53, Part 4, pp. 426-432.

BALTHAZAR, L. 2004. PD estimates for Basel II. RISK Magazine, Vol. 17, no. 4, pp. 84-85.

BALZAROTTI, V., FALKENHEIM, M. & POWELL, A. 2002. On the use of Portfolio Risk models and capital requirements in Emerging Markets: The Case of Argentina. World Bank Economic Review, Vol. 16, no. 2, pp. 197-212.

BANK OF FRANCE. 2006. Methods for calculating capital adequacy ratios. Paris, France, January.

BORIO, E.V. & MCCAULEY, N. 1996. The economics of recent bond volatility. Bank of International Settlements Economic papers. No. 45, July.

BASEL COMMITTEE ON BANKING SUPERVISION. 1995. An internal model-based approach to market risk capital requirements. [Available on the Internet:] http://www.bis.org/publ/bcbs17.pdf [Date of access: 29 August 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 1996. Amendment to the capital accord to incorporate market risks. Press release in January 1996 [Available on the Internet:] http://www.bis.org/publ/bcbs24.pdf [Date of access: 12 July 2007].

BASEL COMMITTEE ON BANKING SUPERVISION. 1999. Principles for the Management of Credit Risk. Press release in July. Consultative document. [Available on the Internet:] http://www.bis.org/publ/bcbs54.pdf?noframes=1 [Date of access: 3 October 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2000. Principles for the Management of Credit Risk. Press release in September. [Available on the Internet:] http://www.bis.org/publ/bcbs75.pdf?noframes=1 [Date of access: 3 October 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2001a. The Standardised Approach to Credit Risk. Supporting Document to the New Basel Capital Accord, Basel, Switzerland, May.

BASEL COMMITTEE ON BANKING SUPERVISION. 2001b. Pillar 2 (Supervisory Review Process). Supporting Document to the New Basel Capital Accord, Basel, Switzerland, May.

BASEL COMMITTEE ON BANKING SUPERVISION. 2001c. Pillar 3 (Market Discipline). Supporting Document to the New Basel Capital Accord, Basel, Switzerland, January.

BASEL COMMITTEE ON BANKING SUPERVISION. 2001d. Working Paper on the Regulatory Treatment of Operational Risk. Basel, Switzerland, September.

BASEL COMMITTEE ON BANKING SUPERVISION. 2002. QIS 3 FAQ: I. IRB-inputs: PD, LGD and EAD. Available on the Internet: http://www.bis.org/publ/bcbs119.pdf [Date of access: 14 November 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2004. International Convergence of Capital Measurement and Capital Standards - A Revised Framework. Basel, Switzerland, June.

BASEL COMMITTEE ON BANKING SUPERVISION. 2005a. Amendment to the capital accord to incorporate market risks (2005 Update) [Available on the Internet:] http://www.bis.org/publ/bcbs119.pdf [Date of access: 12 September 2007].

BASEL COMMITTEE ON BANKING SUPERVISION. 2005b. An Explanatory Note on the Basel II IRB Risk Weight Functions. [Available on the Internet:] http://www.bis.org/bcbs/irbriskweight.htm [Date of access: 2 March 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2006a. International Convergence of Capital Measurement and Capital Standards: A Revised Framework (Comprehensive Version). Basel, Switzerland, June.

BASEL COMMITTEE ON BANKING SUPERVISION. 2006b. Part 2: The First Pillar – Minimum Capital Requirements. [Available on the Internet:] http://www.bis.org/publ/bcbs128b.pdf [Date of access: 14 September 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2007a. Fifth Quantitative Impact Studies (QIS 5): Overview of documents. [Available on the Internet:] http://www.bis.org/bcbs/qis/index.htm [Date of access: 9 April 2007].

BASEL COMMITTEE ON BANKING SUPERVISION. 2007b. Guidelines for Computing Capital for Incremental Default Risk in the Trading Book - consultative document [Available on the Internet:] http://www.bis.org/publ/bcbs134.htm [Date of access: 12 September 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2007c. Guidelines for Computing Capital for Incremental Default Risk in the Trading Book - consultative document [Available on the Internet:] http://www.bis.org/publ/bcbs134.pdf?noframes=1 [Date of access: 12 September 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2008a. Computing Capital for Incremental Risk in the Trading Book" and "Revisions to the Basel II market risk framework" - consultative documents. [Available on the Internet:] http://www.bis.org/press/p080722.htm [Date of access: 12 August 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2008b. Comprehensive strategy to address the lessons of the banking crisis announced by the Basel Committee. Press release on 20 November. [Available on the Internet:] http://www.bis.org/press/p081120.htm [Date of access: 25 November 2008].

BASEL COMMITTEE ON BANKING SUPERVISION. 2009a. Range of practices and issues in economic capital frameworks. [Available on the Internet:] http://www.bis.org/publ/bcbs152.pdf Date of access: 25 April 2009].

BASEL COMMITTEE ON BANKING SUPERVISION. 2009b. Revisions to the Basel II market risk framework, Consultative document. Press release in January. [Available on the Internet:] http://www.bis.org/publ/bcbs148.pdf?noframes=1 [Date of access: 30 March 2009].

BEATON, N. 2002. Major Canadian Banks Become Basel II Compliant. Available on the Internet:] http://www.banktech.com/news/showArticle.jhtml?articleID=204803666 [Date of access: 13 February 2010].

BENNINGA, S. & WIENER, Z. 1998. Value-at-Risk (VaR). Mathematica in Education and Research. Vol. 7, no. 4. pp. 1-8.

BENTULAN, T. 2001. The story behind urban bank's closure: Strategic downgrade. Businessworld, August, no. 5.

BENYON, D. 2007. Market risk regulatory capital expected to rise. Oprisk & Compliance. [Available on the Internet:] http://www.opriskandcompliance.com/public/showPage.html?page=477008 [Date of access: 22 November 2008].

BERKELAAR, A., CUMPERAYOT, P & KOUWENBERG, R. 2002. The effect of VaR-based risk management on asset prices and the volatility smile. European Financial Management. Vol 8, no. 2, pp 139-64. Blackwell Publishers Ltd. June.

BERKOWITZ, J. & O'BRIEN, J. 2002. The Journal of Finance. Vol. 57, no. 3, pp. 1093-1111. Blackwell Publishing for the American Finance Association. June.

BERLIN, M. & MESTER, L.J. 2004. Retail credit risk management and measurement: An introduction to the special issue. Journal of Banking & Finance. Vol. 28, pp. 721–725.

BIERI, D.S. 2004. The Basel Process and Financial Stability. Bank for International Settlements, November.

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2001. History of the Basel Committee and its membership, Basel, Switzerland, March.

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2006. 76th Annual Report (1 April 2005–31 March 2006). Basel, Switzerland, June.

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2007. History of the Basel Committee and its membership, Basel, Switzerland, January.

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2009a. About the Bank for International Settlement. [Available on the Internet:] http://www.bis.org/about/index.htm [Date of access: 2 March 2009].

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2009b. BIS Homepage. [Available on the Internet:] http://www.bis.org/ [Date of access: 2 March 2009].

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2009c. The BIS in profile. [Available on the Internet:] http://www.bis.org/about/profile.pdf [Date of access: 13 April 2009].

BANK FOR INTERNATIONAL SETTLEMENTS (BIS). 2009d. Organigram 2009 [Available on the Internet:] http://www.bis.org/about/organigram.pdf [Date of access: 29 April 2008].

BLANCO, C. & OKS, M. 2004. Backtesting VaR Models: Quantitative and Qualitative Tests. Risk Desk. Vol. 4, Nr. 1.

BLOOMBERG. 2009. [Available on the Internet:] http://www.bloomberg.com/?b=0&Intro=intro3 [Date of access: 9 December 2009].

BOTHA, M. 2005. Risk management in hedge funds. Masters dissertation, North West University.

BORIO & MCCAULEY. 1996. The economic of recent bond yield volatility [Available on the Internet:] http://www.bis.org/publ/econ45.pdf?noframes=1 [Date of access: 2 May 2008].

BROUWER, H. 2008. The Regulators perspective on the crisis'. Speech at Nederlandsche Bank: FBA / NCCC Finance Seminar, Amsterdam. 26 March.

BROWN, R.J. 2005. Connecting the CDF and the PDF. [Available on the Internet:] http://demonstrations.wolfram.com/ConnectingTheCDFAndThePDF/ [Date of access: 12 May 2008].

BUDWORTH, D. 2008 - August 14, 2008 - The credit crunch explained. [Available on the Internet:] http://www.timesonline.co.uk/tol/money/reader_guides/article4530072.ece [Date of access: 4 December 2008].

CALEM, P.S., FOLLAIN, J.R. 2003. The Asset-Correlation Parameter in Basel II for Mortgages on Single-Family Residences. Background for Public Comment by the Board of Governors of the Federal Reserve System. 15 October. pp. 1-27.

CALLAGHAN, H. 2006. The 'Basel II effect' on IT infrastructure at banks. [Available on the Internet:] ttp://www.infowatch.biz/threats?chapter=148831547&id=191398218 [Date of access: 12 December 2008].

CANE, J. 2008. The Great Panic. Press release in August 2008. [Available on the Internet:] http://www.portfolio.com/news-markets/top-5/2008/08/08/Birth-of-the-Credit-Crunch [Date of access: 4 December 2008].

CANNATA, F. & QUAGLIARIELLO, M. 2009. The Role of Basel II in the Subprime Financial Crisis: Guilty or Not Guilty? Centre for Applied Research in Finance. Research Paper , No. 3/ 09, 14 January.

CASSART, D.,CASTRO, C., LANGENDRIES, R. & ALDERWEIRELD, T. 2007. Confidence Sets for Asset Correlation. Press release in February. [Available on the Internet:] http://www.econ.kuleuven.be/ew/academic/econmetr/abstracts/abstract0607/Iragorri.pdf [Date of access: 3 October 2008].

CERAM. 2007. Global banking regulations: The role of the BIS Basel Capital Accord: from Cook to McDonough, November.

CHANG, K.J., LIN, C. & ZHU, T. 2008. Risk Measurement and Management: An in-depth look at how Wall Street professionals deal with market risk. Press release on 10 December. [Available on the Internet:] http://www.stat.berkeley.edu/~aldous/157/Old_Projects/chang_lin_zhu.pdf [Date of Access: 10 January 2009].

CHAUDHARY, D., SINGH, P. & PRABHAT, P. 2005. Basel II: The Duckworth-Lewis of banking. [Available on the Internet:] http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm [Date of access: 27 April 2007].

CHEN, X. 2005. Dependence and the Copula Approach, (Thesis – Masters of Art), Burnaby, Canada: Simon Fraser University.

CHERNIH, A., VANDUFFEL,S., & HENRARD, L. 2006. Asset Correlations: A Literature Review and Analysis of the Impact of Dependent Loss Given Defaults. Press release on 6 November. [Available on the Internet:] http://www.econ.kuleuven.be/insurance/pdfs/CVH-AssetCorrelations_v12.pdf [Date of access: 3 October 2008].

COLLINS, B.M. & FABOZZI, F.J. 1999. Derivatives and Equity Portfolio Management. John Wiley and Sons. 1999.

COMMITTEE OF EUROPEAN BANKING SUPERVISORS (CEBS). 2005. Application of the Supervisory Review Process under Pillar 2. Consultation Paper, London, United Kingdom, June.

CORNFORD, A. 2006. Basel II: Convergence on a Definitive Framework. pp.1-9. [Available on the Internet:] http://www.fmcenter.org/atf/cf/%7BDFBB2772-F5C5-4DFE-B310-D82A61944339%7D/Basel_II_tech_1006.PDF [Date of access: 12 March 2008] **176**

CORONADO, M. 2000. Comparing different methods for estimating Value at Risk for actual nonlinear portfolios: Empirical evidence. 1st International Research Conference in Financial Risk Management, Global Association of Risk Professionals (GARP), London, June.

COX, D. 2007. Frontiers of Risk Management: Key Issues and Solutions. Euromoney Institutional Investor PLC, London, 2nd Ed.

CURRIE, C.V. 2004. The Potential Effect of the New Basel Operational Risk Capital Requirements. School of Finance and Economics Working Paper No. 137. University of Technology, Sydney, School of Finance and Economics. September.

DANSKE BANK. 2007. Pillar III. Augustus. [Available on the Internet:] http://www.danskebank.com [Date of access: 27 April 2007].

DAS, S.R. 2006. Basel II Technical Issues: A Comment. Working Paper: Santa Clara University. pp. 1-26. 27 August. pp. 1-26.

DAVIES, J. 2005. Is There Only 1 Unexpected Loss?. Operational Risk 2005: A Special Edition of T*he RMA Journal*. pp.1-3. [Available on the Internet:] http://www.riskbusiness.com/InterestingReading/ [Date of access: 2 June 2008].

DE CLEEN, B. 2008. Credit Portfolio Management: A practioners' view. Essex, March 19 [Available on the Internet:] www.essex.ac.uk/ccfea/NewsEvents/.../Bruno%20de%20Cleen.pps [Date of access: 9 June 2008].

DE SWAAN, T. 1997. The Supervision of Financial Conglomerates A Cooperative Effort. Speech given to the Institute of International Finance, 29April.

DEV, A. 2006. The correlation debate. Risk Magazine. Vol. 10, no. 10. October.

DEVINE, M. 2005. The Second Pillar – Supervisory Review. City & Financial Publishing, 1st ed, Surrey, United Kingdom, pp. 181-198.

DOWD, K. 1998. Beyond Value at Risk: The New Science of Risk Management. Published by Wiley, John & Sons, pp. 286.

DOWD, K. & BLAKE, D. 2006. After VaR: the theory, estimation and insurance applications of quantile-based risk measures. J. Risk Insurance. Vol. 73, no.2, pp. 193–229.

DUCHEMIN, S., LAURENT, M. & SCHMIT, M. 2003. Asset return correlation: The case of automotive lease portfolios. Working Paper by Solvay Business School, Université Libre de Bruxelles. [Available on the Internet:] http://www.solvay.edu/EN/Research/Bernheim/documents/wp03007.pdf [Date of access: 19 June 2008].

DULLMANN, K. & SCHEULE, H. 2003. Determinants of the Asset Correlations of German Corporations and Implications for Regulatory Capital . Press release in October. [Available on the Internet:] http://www.cofar.uni-mainz.de/dgf2003/paper/paper53.pdf [Date of access: 3 October 2008].

DVORAK, B. 2005. Uses and Misuses of Required Economic Capital. [Available on the Internet:] http://www.isda.org/c_and_a/ppt/Uses-and-Misuses-of-Required-Economic-Capital11-15-05.ppt [Date of access: 11 December 2008].

THE ECONOMIST. 2003. Blockage in Basel: New rules for international banks' capital have hit an obstacle. Vol. 369, 4 October, pp. 85.

EGAN, B. 2003. Monitoring risk in the financial system. Speech given at Australian Prudential Regulation Authority, Sydney, Australia, 2 September.

EICHENGREEN, B. 2004. The Dollar and the New Bretton Woods System. Lecture delivered at the University of California, Berkeley, United States, December.

ELIZALDE, A. & REPULLO, R. 2004. – Economic and Regulatory Capital: What is the difference?. Center for Monetary and Financial Studies (CEMFI), Working Paper No. 0422, Madrid. December.

ESTERHUIZEN, J. 2003. The Management of Operational Risk in South African Banks. (Thesis - M.Comm), Potchefstroom, South Africa: North West University.

EUROPEAN COMMISSION: INTERNAL MARKET DG (ECIM). 2003. Review of capital requirements for banks and investment firms. The treatment of Expected and Unexpected losses. Brussels, Belgium, December.

FEATHERSTONE, A.M., ROESSLER, L.M. & BARRY, P.J. 2004. Determining the Probability of Default and Risk-Rating Class for Loans in the Seventh Farm Credit District Portfolio. Review of Agricultural Economic, Vol. 28, no. 1, pp. 4–23.

FEDERAL DEPOSIT INSURANCE CORPORATION (FDIC). 2004. Economic Capital and the Assessment of Capital Adequacy. [Available on the Internet:] http://www.fdic.gov/regulations/examinations/supervisory/insights/siwin04/economic_capital.html [Date of access: 30 March 2009].

FEDERAL RESERVE BOARD (FED). 2006a. Basel II Capital Accord: Notice of Proposed Rule-making. Preamble II, 5 September.[Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.federalreserve.gov/ [Date of access: 8 May 2007].

FEDERAL RESERVE BOARD (FED). 2006b. Basel II Capital Accord: Notice of Proposed Rule-making. Preamble II, 30 March. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.federalreserve.gov/ [Date of access: 8 May 2007].

FELSENFELD, C. & BILALI, G. 2004. The role of the Bank for International Settlements in shaping the World Financial System. Research Paper 44, School of Law, Fordham University, New York, United States, January.

FERGUSON, R.W. 2003. Basel II: Before the Committee on Banking, Housing and Urban Affairs. Testimony of Vice Chairman, 18 June. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.federalreserve.gov/ [Date of access: 3 June 2007].

FINANCIAL PLANET. 2009. Risk Neutrality (and Risk Aversion Preview). [Available on the Internet:] http://www.financialplanet.info/category/finance/ [Date of access: 1 December 2008].

FINANCIAL SERVICE AUTHORITY OF LONDON. 2007. Our Pillar 2 assessment framework. Paper: Pillar 2 review, London, United Kingdom, May.

FINANCIAL STABILITY FORUM (FSF) & BASEL COMMITTEE OF BANKING SUPERVISION (BCBS) WORKING GROUP. 2009. Joint FSF-BCBS Working Group on Bank Capital Issues: Reducing procyclicality arising from the bank capital framework. Press release in March 2009. [Available on the Internet:] http://www.fsforum.org/publications/r_0904f.pdf?noframes=1 [Date of access: 30 March 2009].

FONTNOUVELLE, P., GARRITY, V., CHU, S. & ROSENGREN, E. 2005. The Potential Impact of Explicit Basel II Operational Risk Capital Charges on the Competitive Environment of Processing Banks in the United States. Federal Reserve Bank of Boston, Boston, United States, 12 January.

FOUNDATION FOR AMERICAN COMMUNICATIONS. 2002. A Journalist's Guide to Economic Terms. [Available on the Internet:] http://www.facsnet.org/index.php?option=com_content&view=article&id=190:journalists-guide-to-economic-terms-04-02&catid=75:archives [Date of access: 13 February 2010].

FRATIANNI, M. & PATTISON, J. 1999. An Assessment of the Bank for International Settlements. Paper prepared for the International Financial Advisory Commission, 26 December.

GALLATI, R.R. 2003. Risk Management and Capital Adequacy. Published by McGraw-Hill Professional. pp. 550.

GATTI, S., RIGAMONTI, A., SAITA, F. & SENATI, M. 2007. Measuring Value-at-Risk in Project Finance Transactions. European Financial Management. Vol. 13, no. 1, pp. 135-158. January.

GHOSH, A. 2005. Retail Credit Risk & Basel II – Children of a Lesser GOD. Whitepaper, Wipro Technologies, Worldwide HQ, Bangalore, India.

GHOSH, S. & GHOSH, A.R. 2006. East Asia in the Aftermath: Was There a Crunch? World Bank International Monetary Fund (IMF), Policy Development and Review Department , IMF Working Paper No. 99/38. March.

GIBBONS, T.P. 2007. Comment: Notice of Proposed Rulemaking. The Bank of New York, New York, United States, 23 March.

GIBSON, R.C. 2000. Asset Allocation: Balancing Financial Risk. Published by McGraw-Hill Professional, 3rd Ed. pp. 317.

GOLUB, B. & L. TILMAN. 1997. Measuring Yield Curve Risk Using Principal Components Analysis, Value at Risk, and Key Rate Durations. Journal of Portfolio Management, Vol. 23. Pp. 72–84.

GORDY, M.B. 2003. A risk-factor model foundation for ratings-based bank capital rules. Journal of Financial Intermediation, Vol. 12, pp. 199–232.

GORE, G. 2006. Correlation Confusion. Risk Magazine, Vol. 19, no. 7. July/August.

GRIFFIN,C. 2008. Basel Capital Adequacy Regulations & the Credit Crisis cause of cure?. Institute of Chartered Accountants in Ireland (ICAI). Press release on 8 July [Available on the Internet:] http://www.icai.ie/en/Members/Technical1/Financial-Services/Accountancy-Ireland-Articles/BASEL-II-CAPITAL-ADEQUACY-REGULATIONS - THE-CREDIT-CRISIS-CAUSE-OR-CURE/ [Date of access: 3 October 2008].

GÜTTLER, A. AND LIEDTKE, H.G. 2007. Calibration of Internal Rating Systems: The Case of Dependent Default Events. [Available on the Internet:] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=855084 [Date of access: 5 December 2008].

HARLOW, L. 2005. The Essence of Multivariate Thinking: Basic Themes and Methods. Published by Routledge.

HARTZ, C., MITTNIK, S. & PAOLELLA, M. 2006. Accurate value-at-risk forecasting based on the normal. GARCH model. Computational Statistics & Data Analysis. pp. 2295 – 2312.

HASHAGEN, J. 2003. Basel II - A Closer Look: Managing Operational Risk. KPMG Financial Services. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.us.kpmg.com/microsite/ [Date of access: 5 June 2007].

HEID, F. 2007. The Cyclical Effects of the Basel II Capital Requirements. Journal of Banking & Finance, 30 March.

HEINRICH, G. 2006. Operational risk, payments, payment systems and implementation of Basel II in Latin America: Recent developments. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm . http://www.sadcbankers.org/ [Date of access: 3 June 2007].

HELBEKKMO, H. 2006. Retail Banks and Economic Capital: Special Issues and Opportunities: Part 1. The RMA Journal, pp. 62-68 New York, The Risk Management Association. Gale Group, Farmington Hills, Michigan. October.

HO, T.S.Y, SANG, S.B. LEE & YI, S. 2004. The Oxford Guide to Financial Modelling: Applications for Capital Markets, Corporate Finance, Risk Management, and Financial Institutions. Oxford University Press US.

HOLLOWAY, J. & GROBLER, J. 2005. The First Pillar – Market Risk. City & Financial Publishing, 1st ed, Surrey, United Kingdom, pp. 149-180.

IBM (INTERNATIONAL BUSINESS MACHINES). 2005. French bank turns to IBM for Basel II technology and expertise. IBM Case Study. [Available on the Internet:] http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm ftp://ftp.software.ibm.com/software/studies/ [Date of access: 9 June 2007].

IC-AGENCY. 2009. Equity Portfolios: Diversification. [Available on the Internet:] http://www.financial-guide.ch/ica/investing/equity_portfolios/diversification/wdba3.html [Date of access: 19 October 2009].

ILAKO, C. & STOILOV, V. 2005. The First Pillar –Minimum Capital Requirements. City & Financial Publishing, 1st Ed, Surrey, United Kingdom, pp. 33-46.

ING. 2009. Glossary. [Available on the Internet:] http://www.ingwholesalebanking.com/smartsite.shtml?id=180 [Date of access: 19 March 2009].

INTERNATIONAL MONETARY FUND 2004. Compilation Guide on Financial Soundness Indicators. Washington DC, Appendix VII, Glossary . [Available on the Internet:] http://www.imf.org/external/np/sta/fsi/eng/2004/guide/appendx.pdf [Date of access: 12 June 2008].

INTERNATIONAL MONETARY FUND. 2007. World Economic Outlook: Spillovers and Cycles in the Global Economy. Published by International Monetary Fund. April. pp.1-302

INTERNATIONAL SWAPS AND DERIVATIVES ASSOCIATION, INC (ISDA). 2007. IDR impact study. Final version. 13 July. pp.1-12.

INTERNATIONAL SWAPS AND DERIVATIVES ASSOCIATION, INC (ISDA). 2008. Industry response to BCBS Consultative document "Guidelines for Computing Capital for Incremental Default Risk in the Trading Book." 15 February.

ISLE OF MAN FINANCIAL SUPERVISION COMMISSION. 2006. Basel II: Implementation - Update. September. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.gov.im/fsc/ [Date of access: 22 May 2007].

ITO, T., FOLKERTS-LANDAU, D., CASSARD, M., INTERNATIONAL MONETARY FUND, CHEN, Z. JANSEN,.A., KODRES, L., LIPWORTH, G., MONTGOMERY, J., SAVASTANO, M., SCHINASI, G., SIMMONS, B., SMITH, T., SPENCER, M. & SRIRAM, S. 1996. International Capital Markets: Developments, Prospects, and Key Policy Issues. Published by the International Monetary Fund. pp. 158.

JACKSON, P. 2001. Bank capital standards: the new Basel Accord. Bank of England Quarterly Bulletin, London, United Kingdom, Spring.

JACOBSOHN, O. 2004. Impact of Basel II on the South African Banking System. (Dissertation - M.Comm), Johannesburg, South Africa: Rand Afrikaans University.

JANSON, N. 2003. The new Basel regulation: the unresolved issues. Consultation Paper, Rouen School of Management, Mont-Saint-Aignan, France.

JORION, P. 2000. Value at Risk. McGraw Hill Higher Education. 1 September.

JORION, P. 2007. Value at Risk – The new benchmark for managing financial risk. The McGraw-Hill Companies, Inc., 3rd ed, Singapore, pp. 602.

J.P.MORGAN/REUTERS. 1996. RiskMetrics™ - Technical Document. Fourth Edition, New York, 17 December.

KAUFMAN, G.G. 2003. Basel II: The roar that moused. Loyola University Chicago, Chicago, United States, 6 October.

KHINDANOVA, I.N. & RACHEV, S.T. 1999. Value at Risk: Recent advances. Working Paper: University of California, Santa Barbara and University of Karlsruhe, Germany. pp. 1-52.

LAMY, M. 2006. The Treatment of Credit Risk in the Basel Accord and Financial Stability. International Journal of Business, Vol. 11, no. 2. pp. 159-170.

LANDO, D. & NIELSEN, M.S. 2008. Correlation in Corporate Defaults: Contagion or Conditional Independence? Working Paper Series. [Available on the Internet:] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1108649 [Date of access: 12 May 2008]

LAURENT, M. 2004. Asset return correlation for Basel II: Implications for Credit Risk Management. pp. 1-34. 15 April.

LEIGHTON, G. 2006. Correlation Confusion. Risk Magazine, Vol. 19, no. 7. July/August.

LIVINGSTON, M. 1999. Title Bonds and Bond Derivatives. Published by John Wiley Professio, 2nd Ed. pp. 262.

MAGINN, J.L., TUTTLE, D.L., PINTO, J.E. & MCLEAVEY, D.W. 2007. Managing Investment Portfolios: A Dynamic Process. Published by John Wiley and Sons, 3rd Ed. pp. 932.

LANG, J. 2009. Economic Capital – a common currency of risk. [Available on the Internet:] http://ozrisk.net/2009/04/20/economic-capital-a-common-currency-of-risk/ [Date of access: 9 May 2009]

LLOYD, W. 2001. Measuring Monoline Exposures. Barclays Capital, Asset-Backed Securities Research Paper, London, United Kingdom, May.

LONDON STOCK EXCHANGE. 2009. Glossary of Terms [Available on the Internet:] http://www.londonstockexchange.com/en-gb/Global/F/glossary/ [Date of access: 29 April 2008]

LOPEZ, J. A. 2004. The empirical relationship between average asset correlation, firm probability of default, and asset size. Journal of Financial Intermediation, Vol. 13, no. 2. pp. 265–283.

LOPEZ, J.A. 2005. Empirical Analysis of the Average Asset Correlation for Real Estate Investment Trusts. Working Paper, Federal Reserve Bank of San Francisco, San Francisco, United States, October, no. 2005-22.

LUCAS, D. 2004. Default Correlation: From Definition to Proposed Solutions. CDO Research paper, London . 11 August.

MACAULAY, F. R. 1938. Some theoretical problems suggested by the movements of interest rates, bond yields and stock prices in the US since 1856. Columbia University Press. New York.

MAITLAND, A.J. 2002. Interpolating the South African Yield Curve using Principal Components Analysis: A Descriptive Approach. South African Actuarial Journal, Vol. 2, pp. 129-145.

MARRISON, C. 2002. The fundamentals of risk measurement. Published by McGraw-Hill Professional. pp. 415.

MARS, M. 2008. Interviews and Basel *eLearnig*, January, Amsterdam.

MEDOVA, E.A. 2002. Operational Risk Capital Allocation and Integration of Risks. Centre for Financial Research, The Judge Institute of Management, University of Cambridge, Cambridge, United Kingdom. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.cfr.jims.cam.ac.uk [Date of access: 5 June 2007].

MERTON R.C. 1973. On the pricing of Corporate Debt: The Risk Structure of Interest Rates. Presented at the American Finance Association Meetings, New York, December.

MIU, P. & OZDEMIR, B. 2006. Basel requirement of downturn LGD: Modelling and estimating PD & LGD correlations, Journal of Credit Risk, Vol. 2, No. 2, pp.43-68.

MOODY'S KMV. 2009. Stand-Alone Credit Risk Measures. Available on the Internet:] http://www.moodyskmv.com/products/standAlone_creditRisk.html [Date of access: 5 June 2007].

MORRISON, J.A. 2009. Credit Economic Capital - Financial Predictive Analytics. White Paper, UL Union Legend. January.

NAVARRETE, E. 2006. Practical Calculation of Expected and Unexpected Losses in Operational Risk by Simulation Methods. [Available on the Internet:] http://www.palisade.com/downloads/pdf/CalculationofExpectedandUnexpectedLossesinOperationalRisk.pdf [Date of access: 21 November 2008].

NAZARETH, A.L. 2007. Remarks from the U.S. Securities and Exchange Commission. Speech given before the Securities Industry and Financial Markets Association (SIFMA) Risk Management Conference, New York, 27 June.

NOUY,D. 2003. The Changing role of Non-Financial risk: UNEP Finance Initiatives. Speech given by the Secretary General of the Basel Committee, Paris, France, 8 January.

OESTERREICHISCHE NATIONALBANK. 2007. Monetary Policy and Economics - Financial Market and Stability - Basel II - Fundamentals. [Available on the Internet:] http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.oenb.at/en/finanzm_stab/basel_II/ [Date of access: 5 June 2007].

OZCELIK, Y. & REES, J. 2005. A New Approach for Information Security Risk Assessment: Value at Risk. [Available on the Internet:] http://ssrn.com/abstract=1104264 [Date of access: 21 November 2008].

PENGELLY, M. 2009. The bank capital burden. Risk magazine, 01 July, pp. 17-20.

PHILOSOPHOV, L.V. 2004. Assessing credit loss distributions for individual borrowers and credit portfolios: Bayesian Multi-period model vs. Basel II model. Paper by Moscow Committee of Bankruptcy Affairs, Moscow, Russia, 9 August.

PRITSKER, M. 2006. The hidden dangers of historical simulation. Journal of Banking & Finance, Vol. 30, pp.561–582.

PROCTOR, C. 2006. Basel II: Credit Risk Mitigation. Bird&Bird, 18 October. [Available on the Internet:]http://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm http://www.twobirds.com/english/publications/ [Date of access: 11 June 2007].

RAO, T.S.R.T. 2005. Retail Credit Risk Tack – The Reach vs. Risk Debate. [Available on the Internet:] http://www.sas.com/images/email/aiglobal/022005/icfai_sas.pdf [Date of access: 30 November 2008].

RESERVE BANK OF AUSTRALIA. 2001. Glossary. [Available on the Internet:] http://www.rba.gov.au/Glossary/text_only.asphttp://www.thehindubusinessline.com/iw/2005/02/06/stories/2005020600621300.htm [Date of access: 11 June 2007].

SAAYMAN, A. 2002: Securitization as a liquidity source for small banks in South Africa. (Thesis – D.Comm), Potchefstroom, South Africa, P.U. for CHE.

SABATO, G. AND SCHMID, M.M. 2008. Estimating Conservative Loss Given Default. Working Paper Series. [Available on the Internet:] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1136762 [Date of access: 18 March 2008].

SAIDENBERG, M. & SCHUERMANN, T. 2003. The New Basel Capital Accord and Questions for Research. Wharton Financial Institutions Centre, New York, United States.

SANTOS, J.A.C. 2001. Bank capital regulation in contemporary banking theory: A review of the literature, Financial Markets, Institutions & Instruments, Bank for International Settlements, Basel, Switzerland, Vol. 10(2), pp. 41-84.

SAS. 2002. Comply and Exceed: Credit Risk Management for Basel II and Beyond. SAS White Paper, Heidelberg, Germany, pp. 1-19.

SATCHELL, S. & SCOWCROFT, A. 2003. Advances in Portfolio Construction and Implementation. Published by Butterworth-Heinemann, pp. 365.

SCHELLER, 2004. The European Central Bank – History, Role and Functions. Official Publication of the European Central Bank, Frankfurt am Main, Germany, July. [Available on the Internet:] http://www.ecb.int [Date of access: 9 June 2007].

SCHUERMANN, H.K. 2004. What Do We Know About Loss Given Default? Wharton Financial Institutions Centre, Wharton School, The University of Pennsylvania, Pennsylvania, United States, February, no. 04-01.

SHERRIS, M. & VAN DER HOEK, J. 2006. Capital Allocation in Insurance: Economic Capital and the allocation of the default option value. North American Actuarial Journal. Vol. 10, no. 2.

SIMMONS, B.A. 1993. Why Innovate? Founding the Bank for International Settlements. World Politics, April, Vol. 45, no. 3, pp. 361-405.

SINGH, R. & WILSON, T. 2007. Insights from the joint IFRI/CRO Forum survey on Economic Capital practice and applications. International Financial Risk Institute, Geneva, Switzerland.

SMITH, R. & KAVERIPATNAM, S. 2005. The First Pillar – Credit Risk: Internal Ratings Based Approach. City & Financial Publishing, 1st ed, Surrey, United Kingdom, pp. 67-84.

SMITHSON, C. 2008. Economic capital ideas. Press release in June 2008. [Available on the Internet:] http://www.risk.net/public/showPage.html?page=799002 [Date of access: 23 September 2008].

STANDARD & POOR'S (S&P). 2008. Annual Decline in US Home Prices Accelerates. [Available on the Internet:] http://www.researchrecap.com/index.php/2008/11/25/annual-decline-in-us-home-prices-accelerates/ [Date of access: 30 November 2008].

STRAND, R. 2000. Bank for International Settlements Committee on Banking Supervision: Revision of the Risk-Based Capital Standard. [Available on the Internet:] http://www.aba.com/Industry+Issues/GR_RC_BIS_RBC_Sum.htm [Date of access: 17 September 2009

STYGER, P. 1998. Basel, tydsduur en waarde op risiko. Potchefstroom, South Africa, PU vir CHO, Ingehoude Rede, no.150.

SURZ, J. & PRICE, M. 2000. The Truth about diversification by the numbers. The Journal of Investing, Winter pp. 1-3.

SVENDSEN, A. 2004. Enzyme Functionality: Design, Engineering, and Screening. Published by CRC Press. pp. 667.

TASCHE, D. 2008. The Vasicek Distribution. Lloyds TSB Bank. Press release in August. [Available on the Internet:] http://www-m4.ma.tum.de/pers/tasche/Seminar_Vasicek_08_2008.pdf [Date of access: 3 October 2008].

TEMENOS. 2007. T-Risk Overview. Geneva, Switzerland. [Available on the Internet:] www.temenos.com [Date of access: 9 June 2007].

THE NEW YORK TIMES. 2009. Credit Crisis - The Essentials [Available on the Internet:] http://topics.nytimes.com/topics/reference/timestopics/subjects/c/credit_crisis/ [Date of access: 4 December 2008].

THORAVAL, P. 2006. The Basel II framework: the role and implementation of Pillar 2. Financial Stability Review, Bank of France, December, no. 9.

U.S. BUREAU ECONOMIC ANALYSIS. 2008. GDP Quarterly data with annualized growth rates [Available on the Internet:] http://www.econstats.com/gdp/gdp__q1.htm [Date of access: 22 August 2008].

US FEDERAL RESERVE BANK (FED) 2009. Statistics & Historical Data. [Available on the Internet:] http://www.federalreserve.gov/datadownload/Choose.aspx?rel=CHGDEL [Date of access: 4 March 2009].

VAN DE VENTER, T.W.G. 2000. Backtesting historical simulation value-at-risk for a selected portfolio of South African bonds. Research Journal of the School of Accounting Sciences. Vol. 8. pp. 183-197.

VAN ROY, P. 2005. Credit Ratings and the Standardised Approach Credit risk in Basel II. Working Paper Series, The European Central Bank, Frankfurt am Main, Germany, August, no. 517.

VAN VUUREN, 2007. Interviews first meeting in London, May 15.

VAN VUUREN, 2008. Private communication., October 22.

VAN VUUREN, G.W. 2009. Fitch Ratings proprietary data obtained from leading UK banks. Private communication.

VARGHESE, K.C. 2005. Risk Management and Basel II Compliance. Speech by Chairman & Managing Director at the Conference of Business Heads of Banks, Union Bank of India, Hyderabad, India, 5 October.

VASICEK, O.A. 2002. The Distribution of Loan Portfolio Value. Risk Magazine. December. pp. 1-10. [Available on the Internet:] http://www.moodyskmv.com/ [Date of access: 26 June 2008].

WALSH, P. 2003. Operational Risk and the New Basel Accord. Hyperion Solutions Corporation, Sunnyvale, United Sates, October.

WEBER, T. 2009. How bad is the crisis going to get?, BBC News website. [Available on the Internet:] http://news.bbc.co.uk/1/hi/business/davos/7859179.stm [Date of access: 22 February 2009].

WELLINK, N. 2008. Comprehensive strategy to address the lessons of the banking crisis announced by the Basel Committee. Press release on 20 November. [Available on the Internet:] http://www.bis.org/press/p081120.htm [Date of access: 25 November 2008].

WHALEN, C. 2006. Viewpoint: Data-Quality Issue Lost in Basel Debate. American Banker, 10 November, [Available on the Internet:] http://www.institutionalriskanalytics.com/research/AB_111006.pdf [Date of access: 17 September 2009].

WHALEN, C. 2007. Bank Risk: Will Basel II Finally Discredit VAR? Seeking Alpha. [Available on the Internet:] http://seekingalpha.com/article/35557-bank-risk-will-basel-ii-finally-discredit-var [Date of access: 25 May 2008].

WIENER. Z. 1997. Introduction to VaR. Risk Conference: Management and Regulation in Banking, Jerusalem, 18 May.

WILLIAMS, C. 2008. How risk managers missed the credit crunch. Press release on 7 October 2008. [Available on the Internet:] http://www.financeweek.co.uk/risk/how-risk-managers-missed-credit-crunch [Date of access: 4 December 2008].

WOLFRAM RESEARCH, 2009. Beta Distribution. [Available on the Internet:] http://mathworld.wolfram.com/BetaDistribution.html [Date of access: 12 March 2009].

WONG, A.S.K. 2006. Basel II and the Risk Management of Basket Options with time-varying correlations. International Journal of Central Banking, December, Vol. 2, no. 4. pp. 1-31.

WONG, M. 2008. Bank capital budgeting after Basel II. [Available on the Internet:] http://www.corporateportfoliomanagement.org/article-17-Bank-Capital-Budgeting-After-Basel-II [Date of access: 17 September 2009]

WOOD, D. 2008. Breaking down. Risk Magazine, pp: 30-32. September.

YAO, W. 2003. Presentation to GARP: Overview of Basel II. [Available on the Internet:] http://web.sakarya.edu.tr/~adurmus/basel_II/Overview_of_Basel_II.pdf [Date of access: 17 September 2009].

YI. Y. 2007. Value at Risk for a portfolio of Credit Default Swaps. [Available on the Internet:] http://www.few.vu.nl/nl/Images/stageverslag-yangyi_tcm38-90728.pdf [Date of access: 27 March 2009].

YOSHIKUNI, S. 2002. The Basel Process and Regional Harmonisation in Asia. Paper: Pacific Economics - Technical Report, The Australian National University, Canberra, Australia, April, no. 326.

ZAHER, F. 2007. Does The Basel Accord Strengthen Banks? European Central Bank, Germany, Frankfurt am Main, 29 January.

ZHANG, J., ZHU, F. & LEE, J. 2008. Asset correlation, realized default correlation, and portfolio credit risk – Modelling methodology, Moody's KMV Company. Press release in March. [Available on the Internet:] http://www.moodyskmv.com/research/files/wp/Asset_Correlation_and_Portfolio_Risk.pdf [Date of access: 30 March 2009].