

The financial crisis: Reforming the South African risk management environment

JA'NEL ESTERHUYSEN

*Thesis submitted in the School for Economics
of the North-West University (Potchefstroom Campus)
in fulfillment of the requirements for
the Degree Philosophiae Doctor (Economics)*

SUPERVISOR: DR. GARY VAN VUUREN
ASSISTANT-SUPERVISOR: PROF. DR. PAUL STYGER

JOHANNESBURG, NOVEMBER 2010

To my parents,

Essie and Ria Esterhuysen

ABSTRACT

The global financial crisis that commenced in June 2007 has been described as the most serious financial crisis since the Great Depression of the 1930s. It resulted in considerable international distress with almost all major banks experiencing capital shortages and some defaulting outright. Among the principal causes was an explosive increase – by a factor of ten in some cases – in credit defaults precipitated by lax lending standards which prevailed for several years. The crisis caused several major institutions to fail (and be subsequently acquired under duress): many of these were subject to takeovers by their relevant sovereigns, including – amongst others – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group and AIG. The financial crisis is believed to be directly responsible for the bleak forecasts (2009 and beyond) faced by the global economy. The measure of global volatility, the VIX, trebled in the third quarter of 2008, interest rate spreads between government fixed income securities and interbank rates widened to unprecedented levels, global inflation threatened an already fragile, volatile marketplace, corporate and retail loan default rates rose and downgrades of large financial institutions (such as US Monoline bond insurers) and many corporates were experienced by major rating agencies during the first quarter of 2009.

The aim of this thesis was to discuss and critically evaluate how the financial crisis has impacted banking risks and also the effect it had on international banks. This has been accomplished through the modification of existing risk measurement techniques and, in some cases, through the development of new techniques, when older risk models proved to be inadequate. A principal secondary aim of the thesis was the testing of these methodologies – in real-world contexts – to ascertain their reliability and robustness concomitant with the adaptation of these methodologies in the light of the new empirical evidence. Important other secondary objectives were the development of novel approaches where the research results required it and the introduction of practical ways to use the results of the thesis in a post-crisis bank risk management environment. Some of the bank asset portfolios that were investigated in the thesis were generated by simulated data to replicate specific characteristics during the crisis, while the other portfolios comprised entirely of empirical data.

The first objective, of the thesis, was to determine the effect of stressed economic conditions on banks' operational risk loss distributions. The depth and duration of the credit crisis have highlighted a number of problems in modern finance. Banks have been accused of excessive risk taking, rating agencies of severe conflicts of interest, central banks of neglecting the inflation of asset price bubbles and national supervisors of lax regulatory controls. Credit and market losses have been considerable. Operational losses have also surged as surviving corporates merge or acquire less fortunate ones without the requisite controls. As more jobs get made redundant it is believed that employees revert to internal fraud as their sources of income have dried up drastically and stealing from the institution seems to be their last resort. The way in which operational losses have been affected has been presented and a comparison has been made between operational loss characteristics pre and during the crisis. Some of the main findings were that operational losses have shown little change in frequency, but shown a significant increase in severity, meaning that their financial

impact has been more severe during the crisis. It is safe to say that the financial crisis most definitely increased operational risk in banks much more severe losses.

The second objective was to focus on the effect of the stressed economic conditions on the applicability and effectiveness of the credit risk measurement methodologies and the minimum capital requirements, prescribed to banks in Basel II. The robustness of the Basel II accord in protecting banks during volatile economic periods has been challenged in the ongoing financial crisis. Advanced approaches to measuring and managing credit risk in particular have drawn criticism for being too complex and irrelevant. Despite accusations that the accord was largely responsible for the crisis, this study explored which of Basel II's credit risk approaches were more successful in measuring the bank's credit risk and calculating the required minimum capital charge for the bank. It was found that, in general, compliance with Basel II actually protected banks during the crisis with the simpler approaches enjoying greater success than more advanced ones, in protecting banks against credit risk.

The third objective was to appraise the effect of stressed economic conditions on the systemic risk within the South African Banking sector. The financial crisis resulted in increases in credit-, market- and operational risk, but it may also have precipitated a surge in systemic risk. Measuring systemic risk as the price of insurance against distressed losses in the South African banking sector, this study illustrated that the financial crisis has in fact resulted in an increase in systemic risk. Using probabilities of default and asset return correlations as systemic risk indicators, it was established that the financial crisis *has* indeed increased systemic risk in South Africa. The impact was, however, less severe than that experienced in other large international banks.

The fourth and final objective of this study was to focus on liquidity creation in South African banks under stressed economic conditions. The financial crisis placed severe pressure on global bank liquidity. Many banks were unable to create sufficient liquidity and had to receive government support or face default. This study illustrated the impact of the financial crisis on liquidity creation within South African banks using a model previously applied to US banks. Four measures of liquidity creation are discussed and applied to data spanning 2004 – 2009. Although created liquidity decreased steeply from 2007, liquidity levels in 2009 remain about 45% higher than those of 2004. The four large South African banks created about 80% of the total market liquidity, and a possible reason for this is that these banks have very large retail divisions, which have assisted them in creating much more liquidity than the smaller banks which have much smaller retail divisions.

In conclusion, and as illustrated through the findings of this study, the financial crisis did impact the major banking risks on various levels and it is therefore safe to say that the financial crisis has reformed the international risk management environment and will also do so in the years to come.

Key words: *Operational risk; Basel II; systemic risk; bank liquidity creation; credit crisis.*

OPSOMMING

Die wêreldwye finansiële krisis, wat in Junie 2007 begin het, is al beskryf as die mees ernstigste finansiële krisis sedert die Groot Depressie van die 1930's. Dit het gelei tot aansienlike internasionale paniek met byna al die groot banke wat kapitaal tekorte ondervind het. Onder die vernaamste oorsake was 'n plofbare toename – met 'n faktor van tien in sommige gevalle – in krediet verliese gepresipiteer deur laks krediet standaarde wat geheers het vir etlike jare. Die krisis het veroorsaak dat verskeie belangrike finansiële instellings misluk het (en dan onder dwang verkry was): baie van hierdie was onderworpe aan oornames deur hul betrokke regerings, insluitend – onder andere – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac en American International Group, AIG. Die finansiële krisis, word geglo, is direk verantwoordelik gehou vir die somber voorspellings (2009 en daarna) wat die globale ekonomie in die gesig staar. Die maatstaf van globale wisselvalligheid, die VIX verdriedubbel in die derde kwartaal van 2008, verspreiding tussen die regering vaste inkomste sekuriteite en interbank tariewe verbreed tot ongekeende vlakke, globale inflasie bedreig 'n reeds swak, vlugtige mark, korporatiewe en kleinhandel lening wanbetalingskoerse het vermeerder en die laer gradueeringsvlakke van groot finansiële instellings (soos die VSA Monoline verband versekeraars) en baie ander maatskappye is ondervind.

Die doel van hierdie tesis is om krities te evalueer en te bespreek wat die impak van die finansiële krisis was op bank risiko's en ook die uitwerking wat dit op die internasionale banke gehad het. Dit is bereik deur die wysiging van die bestaande risiko meting tegnieke en, in sommige gevalle, deur die ontwikkeling van nuwe tegnieke wanneer ouer risiko modelle onvoldoende bewyse gelever het. Die toets van hierdie metodes – in regte-wêreld-konteks – om hul betroubaarheid en robuustheid vas te stel is 'n prinsipiële sekondêre doel so ook die aanpassing van hierdie metodes in die lig van nuwe empiriese bewyse. Belangrike sekondêre doelwitte is die uitvinding van gewone benaderings (indien navorsingsresultate dit vereis) en die bekendstelling van praktiese maniere hoe om die resultate te gebruik. Sommige portefeuljes wat getoets was gebruik gesimuleerde data, ander bestaan geheel en al uit empiriese data.

Die eerste doel is om die effek van onderdrukte ekonomiese toestande op operasionele risiko verlies verdelings te bepaal. Die diepte en die duur van die finansiële krisis het 'n hele aantal probleme aan die moderne finansier voorgele. Banke is beskuldig dat hul oormatige risiko neem, gradueering agentskappe van ernstige konflik van belange, die sentrale banke vir die verwaarlosing van inflasie op bate pryse en nasionale toesighouers van slap regulatoriese kontroles. Operasionele risiko verliese het ook gestyg soos maatskappye saamgesmelt het en soos kleiner maatskappy gekoop is, sonder die nodige kontroles. Soos meer mense ook hulle werk verloor en hul bronne van inkomste opdroog, word daar geglo dat hul gedwing word om hul hand te speel en om betrokke te raak in interne bedrog en diefstal van hul werkgewers. Die wyse waarop operasionele risiko verliese geraak is word aangebied en 'n vergelyking word gemaak tussen operasionele risiko verlies eienskappe voor en tydens die krisis. Sommige van die belangrikste bevindinge was dat operasionele risiko verliese min verandering in frekwensie getoon het, maar 'n beduidende toename in waarde getoon het, wat beteken dat die finansiële impak daarvan meer ernstige tydens die krisis was. Dit is

veilig om te sê dat die finansiële krisis beslis operasionele risiko geraak het omdat operasionele risiko verliese beslis togeneem het.

Die tweede doel is om te fokus op die effek van onderdrukte ekonomiese toestande op krediet risiko in Basel II. Die robuustheid van die Basel II akkoord om banke te beskerm tydens wisselvallige ekonomiese tye is uitgedaag in die deurlopende finansiële krisis. Gevorderde benaderings tot die meting en bestuur van krediet risiko in die besonder, het kritiek getrek. Ten spyte van beskuldigings dat die akkoord grootliks verantwoordelik was vir die krisis, ondersoek hierdie studie watter van Basel II se krediet risiko benaderings meer suksesvol was in die toekenning van kapitaal om banke teen kredietrisiko te beskerm. Daar is gevind dat, in die algemeen, die gebruik van Basel II eintlik banke tydens die krisis beskerm het met die eenvoudiger benaderings wat groter sukses geniet het as die meer gevorderde benaderings.

Die derde doel is om die effek van onderdrukte ekonomiese omstandighede op sistemiese risiko in die Suid-Afrikaanse banksektor te bepaal. Die finansiële krisis het gelei tot stygings in krediet-, mark-en operasionele risiko, maar dit kan ook 'n oplewing in sistemiese risiko ontketen. Sistemiese risiko word gemeet as die prys van versekering teen nood verliese in die Suid-Afrikaanse banksektor, en hierdie studie gebruik hierdie metode om te bepaal of die finansiële krisis in werklikheid tot 'n toename in sistemiese risiko gelei het. Deur die waarskynlikhede van wanbetaling en bate terugkeer korrelasies te gebruik as sistemiese risiko aanwysers, is daar gevind dat die finansiële krisis inderdaad tot 'n toename in sistemiese risiko in die Suid-Afrika banksektor gelei het. Die impak was egter minder ernstig in klein banke in vergelyking met die ander groot internasionale banke.

Die vierde en laaste doel van hierdie studie is om te fokus op die likiditeitskepping van die Suid-Afrikaanse banke tydens onderdrukte ekonomiese toestande. Die finansiële krisis het ernstige druk op die globale banklikiditeit geplaas. Baie banke was nie in staat om voldoende likiditeit te skep nie en het regering steun of bankkroscap in die gesig gestaar. Hierdie studie toon die impak van die finansiële krisis op likiditeitskepping van Suid-Afrikaanse banke aan en gebruik 'n model wat voorheen gebruik was om die likiditeitskepping van Amerikaanse banke te toets. VIER maatreëls om likiditeitskepping te bepaal word bespreek en toegepas op data wat strek vanaf 2004-2009. Alhoewel likiditeitskepping geweldig verlaag het vanaf 2007, bly likiditeitsvlakke in 2009 met 45% hoër as dié van 2004. Die vier groot Suid-Afrikaanse banke het ongeveer 80% van die totale mark likiditeit geskep vanaf 2004 tot 2009 en n moontlike rede hiervoor is dat die vier groot banke baie van hulle likiditeitskepping te danke het aan hulle groot kleinhandelafdelings, waar die kleiner banke baie kleiner kleinhandelafdelings het wat baie minder likiditeit skep as die van die groot banke.

Laastens, en soos wat in die studie voorgestel is, die finansiële krisis het die meeste bank risiko's op verskillende vlakke geïmpakteer en dit is daarom veilig om te sê dat die finansiële krisis die internasionale risiko omgewing getransformeer het en ook verder sal transformeer in die nabye toekoms.

Sleutelwoorde: Operationale Risiko; Basel II; Sistemiese Risiko; Banklikiditeitskepping; Kredietkrisis

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to everyone who contributed towards this dissertation. The following people/institutions deserve special mention:

- my family for their loving support and continued encouragement,
- my supervisor, Dr Gary van Vuuren, who has been incredibly inspirational in guiding me through my research – without him this study would not have been possible,
- Prof Paul Styger, who always has great ideas and who always provided the most valuable comments,
- all my friends, who always supported me through late nights, Saturdays, and difficult times, especially those times when the thought of given up seriously crossed my mind,
- the editors of each of the respective journals, who approved the publication of my research and the anonymous referees who provided valuable comments which significantly improved the thesis,
- the School of Economics at the North West University for presenting me with an opportunity to further my studies,
- all the interviewees who took time to meet with me and who generously supplied the information that I required and
- The Lord, who gave me the ability and endurance to complete this thesis.

**The Author,
Johannesburg, 2010**

PREFACE

The theoretical and practical work described in this thesis was carried out whilst in the employ of ABSA Capital: South African Head Office, Johannesburg and University of the North West, Potchefstroom under the supervision of Doctor Gary van Vuuren and Professor Paul Styger.

These studies represent the original work of the author and have not been submitted in any form to another University. Where use was made of the work of others, this has been duly acknowledged in the text.

The analysis on the effect of the financial crisis on operational risk has been accepted for publication in the South African Journal of Economic and Management Sciences (Esterhuysen, van Vuuren and Styger, 2010) under the heading "The Effect of Stressed Economic Conditions on Operational Risk Loss Distributions".

Results on which of the Basel II Credit Approaches has been the most effective in allocating capital to banks before and during the financial crisis has been accepted for publication in the South African Journal of Economic and Management Sciences (Esterhuysen, van Vuuren and Styger 2010) under the heading "The Effect of Stressed Economic Conditions on Credit Risk in Basel II".

Other results, involving the measurement of systemic risk in the South African banking sector before and during the financial crisis has been accepted for publication in the South African Journal of Economics (Esterhuysen, van Vuuren and Styger, 2010) entitled "The Effect of Stressed Economic Conditions on Systemic Risk within the South African Banking Sector".

The editors of both the above-mentioned two journals have provided consent that the three articles accepted for publication in their respective journals may be reproduced in this thesis (letters from the editors are attached as Annexures at the end of the study).

Other work to investigate how the South African banks created liquidity before and during the financial crisis has also been accepted for publication in the South African Journal of Economics (Esterhuysen, van Vuuren and Styger, 2010) entitled "Liquidity Creation in South African Banks under Stressed Economic Conditions".

J.T. ESTERHUYSEN

03 May 2011

INDEX

ABSTRACT	i.
OPSOMMING.....	ii.
ACKNOWLEDGEMENTS.....	v.
PREFACE.....	vi.
TABLE OF CONTENTS.....	vii.
CHAPTER 1 – INTRODUCTION	1.
1.1 BACKGROUND.....	1.
1.2 PROBLEM STATEMENT AND OBJECTIVES.....	3.
1.3 THESIS OUTLINE.....	4.
1.4 RESEARCH DESIGN AND PROCEDURE.....	6.
1.5 CONCLUSION.....	8.
CHAPTER 2 (PAPER 1) – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON OPERATIONAL RISK LOSS DISTRIBUTIONS.....	9.
CHAPTER 3 (PAPER 2) – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON CREDIT RISK IN BASEL II.....	29.
CHAPTER 4 (PAPER 3) – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON SYSTEMIC RISK WITHIN THE SOUTH AFRICAN BANKING SECTOR.....	48.
CHAPTER 5 (PAPER 4) – LIQUIDITY CREATION IN SOUTH AFRICAN BANKS UNDER STRESSED ECONOMIC CONDITIONS.....	70.
CHAPTER 6 – CONCLUSIONS AND RECOMMENDATIONS.....	89.
6.1 SUMMARY AND CONCLUSIONS	89.
6.2 RECOMMENDATIONS	93.
6.3 CONTRIBUTION.....	94.
6.4 FINAL STATEMENT.....	95.
BIBLIOGRAPHY	97.
ANNEXURE 1 – CONSENT LETTERS FROM JOURNAL EDITORS	102.

CHAPTER 1 - INTRODUCTION

1.1 BACKGROUND

The global financial crisis which commenced in June 2007 has been described as the most serious financial crisis since the Great Depression of the 1930s (Soros, 2008). It resulted in considerable international distress with almost all major banks experiencing capital shortages and some defaulting outright. Among the principal causes was an explosive increase – by a factor of ten in some cases – in credit defaults (Allen, 2009) precipitated by lax lending standards which prevailed for several years. An early victim, Northern Rock (a medium-sized UK bank), requested security from the Bank of England after its highly leveraged balance sheet led to investor panic and a bank run in mid-September 2007. Although the plea was unsuccessful at first, the UK government eventually relented and the bank (the first of many) was taken into public hands in February 2008 (Allen, 2009). Northern Rock's problems proved to be an early indication of the troubles that would soon befall other banks and financial institutions. Those initially affected were directly involved in mortgage lending and residential home construction (such as Northern Rock and Countrywide Financial), as short term financing through increasingly illiquid credit markets became a virtual impossibility (Allen, 2009). Over 100 mortgage lenders world-wide went bankrupt during 2007 and 2008 and concerns that the large investment bank Bear Stearns would collapse in March 2008 resulted in its 'fire-sale' to JP Morgan Chase. The financial crisis hit its peak through the months of September and October 2008 (Allen, 2009). Global stock markets were slower to react: substantial losses were recorded throughout the early part of 2009 until the nadir was reached in mid-March of that year. The crisis caused several major institutions to fail (and be subsequently acquired under duress): many of these were subject to takeovers by their relevant sovereigns, including – amongst others – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group, AIG.

In many cases it is also believed that the financial crisis only had an impact on credit risk, and the above serves as examples to further substantiate this; however, as will be explained through this study, the financial crisis also had an impact on other banking risks. For example, in January 2009, reports surfaced that the FBI (Federal Bureau of Investigations) were investigating fraud allegations against Sir Alan Stanford, CEO of Stanford Group of Companies in the USA, of more than \$150 million over a three year period. Another high-profile example is the Marc Dreier case, a lawyer from the United States, who stands accused of over \$100million worth of hedge fund fraud over a ten year period (Grant, 2009:1). A third example is the Madoff scandal where Bernard Madoff, the CEO of a large United States Security firm, was arrested for \$50 million worth of securities fraud, wire fraud, mail fraud, money laundering and perjury in December 2008 (Seal, 2009:2). All three cases are examples of the impact of the financial crisis on operational risk.

Since the start of the crisis, criticism of the Basel II accord has increased considerably, especially of its advanced credit risk methodologies. The consensus hold that many of the advanced credit risk methods, prescribed by the accord, were responsible for the crisis as they were too complex to understand and thus did not

assist banks in managing credit risk. Academics and risk practitioners¹ have also argued that systemic risk might have played a bigger role in the financial crisis than was initially believed, particularly in the banking sector as it is highly interconnected (almost all other banks constantly lend to and provide security for each other). Very few banks can be viewed as stand-alone entities within the banking sector (or the economy as a whole) in the current financial milieu. In addition to the above, the crisis has demonstrated that banks are not independent. The failure of one bank in a specific market leads to severe contagion effects as investors quickly come to believe that other banks in the same market may also be experiencing difficulties. This leads to ripple effects or, in common parlance, *systemic* effects on the banking sector. The increase in the perceived systemic risk, particularly after the failure of Lehman Brothers, was mainly driven by heightened risk aversion and reduced liquidity.

An alternative viewpoint² also holds that the financial crisis was further aggravated by banks which could not create the required liquidity to see them through the financial crisis. All financial (or credit) crises are characterised by a large number of credit losses, which precipitate a shortage of bank liquidity as banks must fund incurred losses. These crises are also characterised by market uncertainty – especially in banking sectors – resulting in banks lending less to each other, which then precipitates a liquidity shortage. It is therefore important that banks are able to create liquidity and even more important for banks to create liquidity in distressed periods. Despite the importance of bank liquidity and the creation thereof, there is little evidence of any comprehensive empirical measurement of liquidity creation and measures that incorporate all the on- and off-balance sheet activities of banks are in short supply. Moreover, studies of research and policy issues in banking typically focus only on a few components of liquidity creation.

The financial crisis is believed to be directly responsible for the bleak forecasts (2009 and beyond) faced by the global economy. The measure of global volatility, the VIX, trebled in the third quarter of 2008 (CBOE, 2009),³ interest rate spreads between government fixed income securities and interbank rates widened to unprecedented levels (Reuters, 2009), global inflation threatened an already fragile, volatile marketplace,⁴ corporate and retail loan default rates rose (Allen, 2009) and downgrades of large financial institutions (such as US Monoline bond insurers) and many corporates were announced by the major rating agencies during the first quarter of 2009 (Reuters, 2009).

History is replete with tales of the co-evolution of financial innovation and risk management. As new products emerge and market participants rush for a share of profits, risk measurement techniques must adapt quickly to address fears of potential catastrophic losses. The invention of ever more complex financial products to spread risk and smooth earnings, however, often coincides with spectacular market 'corrections'. These new financial instruments precipitate newer, more complicated risks that ultimately result in the very events they were designed to prevent. Risk management's failure to adapt speedily to the rapidly-changing environ-

¹ See for example Altman (2008), Huang, Zhou and Zhu (2009) and Amin (2008)

² See Borio (2009), Brunermeier (2009) and Adrian and Shin (2008).

³ In January 2009, the VIX fell by half from its December 2008 high of 80, but remained highly volatile for months thereafter (CBOE, 2009).

⁴ The threat of deflation coupled with diminished growth – stagflation – continues to haunt global economies (Stiglitz, 2008: 68).

ment sometimes gives rise to accusations of incompetence or malpractice. This is unfortunate because institutions require better and more adept risk measures to deal with these crises, not distrust and suspicion.

Achieving the goal of improved risk management requires far more research into the nature and manifestation of financial risks. Methods to manage and mitigate these risks can only be developed when the ways in which risks develop and magnify are sufficiently understood. The major concepts of risk management are all well-researched, reported in depth and then firmly established in mainstream 'best practice'. For the sake of simplicity and implementation ease, however, many generalisations abound (Amin, 2008: 199). A few (seemingly) inconsequential details are generalised, glossed over or ignored completely – yet it is precisely here that calamities often reside (Amin, 2008: 199).

1.2 PROBLEM STATEMENT AND OBJECTIVES

Modern financial markets are in constant flux, changing and adapting as novel instruments are invented or augmented. The search for profit opportunities requires increasing knowledge and experience. The accelerated computing speeds, however, make ever increasing demands on practitioners to understand the market as a coherent whole, not in segmented components. Increasing innovation and augmentation is inevitably accompanied by significantly enhanced risks. The events of 2007 through 2009 clearly exposed the vulnerabilities of banks whose business depended too heavily on uninterrupted access to secured financing markets and whose risk management models depended too heavily on risk management methodologies primarily prescribed by regulators and central banks.

This dependence reflected an unrealistic assessment of credit risk, but also operational, liquidity and systemic risk. Previous measures of these risks were too narrowly measured with broad portfolio effects largely ignored or aggregated only in simple ways. Furthermore, the common belief was that the more advanced a bank's Basel II⁵ approach for the management and allocation of credit risk capital, the better the bank is protected against credit risk. This belief has changed since the start of the crisis as many banks, who had already adopted the most advanced Basel II approaches, fell prey to the crisis and either had to close down or receive government rescue funding. It is imperative that future risk management techniques co-evolve with the financial practices it measures and protects, for example by adapting existing risk measures, inventing new risk measurement techniques and merging previously partitioned risk types.

The primary objectives of this thesis are to discuss and critically evaluate stressed economic conditions that resulted from the financial crisis of 2007 to 2009 impacted upon international bank risk measurement and management and how these will reform the international risk environment. This will be accomplished through the modification of existing risk measurement techniques and, in some cases, through the development of new techniques when older risk models proved to be inadequate.

⁵ The Bank for International Settlements has – through their Basel Committee on Banking Supervision – issued a broad range of guidelines which are intended to assist commercial banks in managing their main risk and these guidelines are commonly referred to as Basel II (BCBS, 2006a).

The testing of these methodologies – in real-world contexts – to ascertain their reliability and robustness is a principal secondary objective, as is the adaptation of these methodologies in the light of new empirical evidence. Important secondary objectives are the development of new risk measurement and management approaches) and the introduction of practical ways to use research results. Some portfolios tested employ simulated data, others comprise entirely empirical data.

1.3 THESIS OUTLINE

Since the field of financial risk measurement and management is broad and deep, this thesis focuses on connected aspects of operational, liquidity, systemic and credit risk via several topics.⁶ Together, these projects (which constitute and unify different aspects of risk measurement and management) are components of the main risk types as classified by the BCBS's Basel accords (Amin, 2008).

The unifying theme linking the main concepts of the thesis is illustrated in Figure 1.1 below.

Figure 1.1: Schematic representation of thesis.

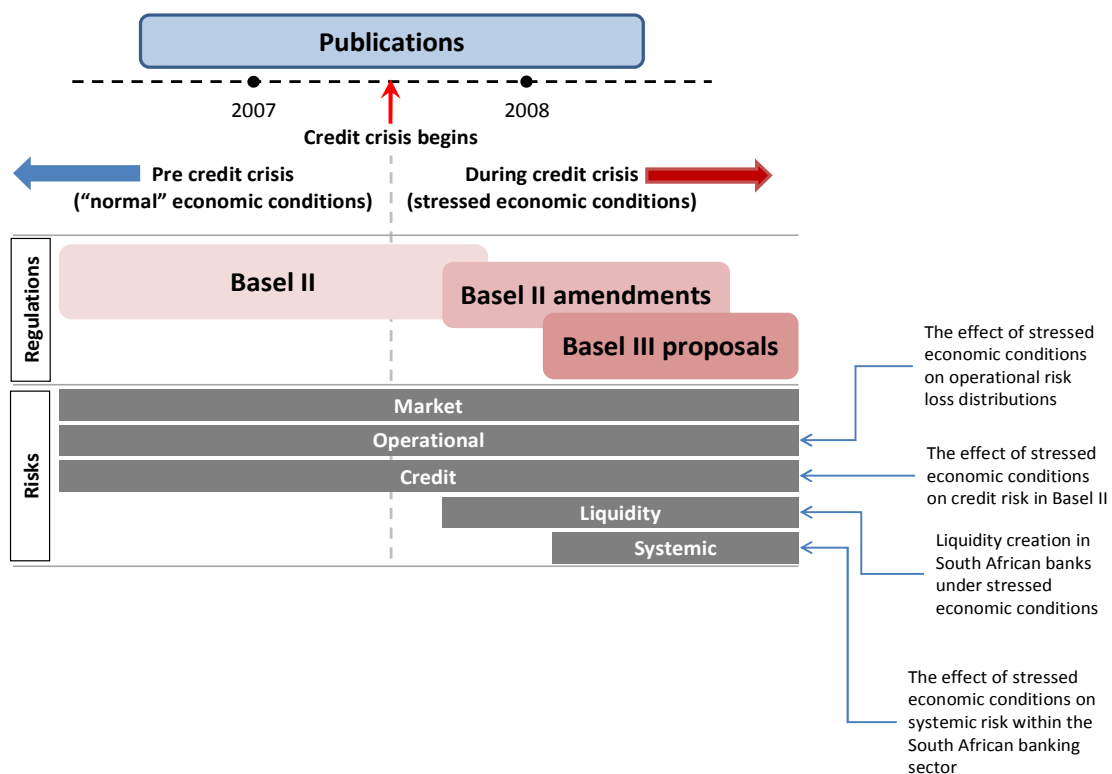


Figure 1 provides an illustration of the way in which the thesis objectives will be accomplished. Firstly, operational risk (regarded as a major bank risk), will be explored to determine the impact of the financial crisis thereon. Prevailing wisdom holds that *credit* risk was the only banking risk impacted by the crisis. Secondly, the Basel II Accord – the basis upon which almost all international banks base their risk management methodologies – credit risk approaches will be examined to determine how successful banks using it were in man-

⁶ Market risk has been deliberately ignored in these studies as the field has been explored in much detail in the recent past and there are various articles and theoretical papers available.

aging their risks. If these risks were mismanaged, and it can be shown that this was due to shortcomings of the Basel II accord, it is likely that the financial crisis will reform the international risk management environment.⁷ Since banks focus mainly upon the management of market, credit and operational risk, this study explores the role of *systemic* risk in the financial crisis. Modern global banking is highly interconnected so if the role of systemic risk upon the financial crisis is particularly severe banks may be forced to exert a much more robust effort in the measurement and management thereof.⁸ Lastly, the lack of liquidity and the poor creation thereof by international banks have been blamed for the increased severity of the financial crisis as banks did not have sufficient liquidity to guard them against severe losses. This study explores the effectiveness of South African banks in creating liquidity to determine if they can be blamed (along with their international counterparts) for poor liquidity creation.

Risk management techniques that appeared robust and accurate in the early part of the new millennium (characterised by low interest rates, steady economic growth and rising asset prices), with deep, unrelenting liquidity and financial crises stunting growth and eroding asset values, seem inadequate and naïve. For risk management to remain relevant in a turbulent financial milieu, constant vigilance is required. The accompanying literature augmentation, on which these studies are based, is vigorous and relentless.

Chapter 2⁹ will focus on the effect of stressed economic conditions on operational risk loss distributions in banks. The depth and duration of the credit crisis have highlighted a number of problems in modern finance. Banks have been accused of excessive risk taking, rating agencies of severe conflicts of interest, central banks of neglecting the inflation of asset price bubbles and national supervisors of lax regulatory controls. Credit and market losses have been considerable. Operational losses have also surged as surviving corporates merge or acquire less fortunate ones without the requisite controls. As more jobs get made redundant it is believed that internal fraud increases as employees' sources of income dries up drastically and stealing from the institution seems to be their last resort. The main objective of this chapter is to establish if there has been a change in the nature of operational risk with regards to the number of operational losses as well as their impact pre and during the crisis. The way in which operational losses have been affected, by the crisis, will be presented and a comparison will be made between operational loss characteristics pre and during the crisis. This study will make use of the latest operational risk measurement techniques and will also develop new techniques where it is found that the existing techniques is insufficient to measure the frequency and severity of operational losses before and during the financial crisis.

Chapter 3¹⁰ will focus on the effect of stressed economic conditions on credit risk in a Basel II regulated bank environment. The robustness of the Basel II accord in protecting banks during volatile economic periods has been challenged in the ongoing financial crisis. Advanced approaches to measuring and managing credit risk in particular have drawn criticism for being too complex and irrelevant. As a result of the accusations

⁷ The timely arrival of Basel III (2010) bears witness to this prediction.

⁸ The timely release of the Basel II systemic risk proposals again stand as proof of this statement.

⁹ At the time of writing (November 2010), Chapter 2 has been accepted for publication in *South African Journal of Economic Management Sciences* (SAJEMS).

¹⁰ At the time of writing (November 2010), Chapter 3 has been accepted for publication in SAJEMS.

that the accord was largely responsible for the crisis, this chapter will explore which of Basel II's credit risk approaches were more successful in allocating adequate capital during the crises. The more advanced approaches are regarded as being superior to the more simpler approaches in allocating credit risk capital to banks; however, since Basel II is still relative new (implementation only started in 2006) there was never enough data to actually test this and the modern financial world has never experience a crisis as severe as the one that started in 2007. This study will therefore be the first to determine how successful Basel II was in allocation credit risk capital during stressed economic conditions and also the first to make a comparison between the more advanced and simpler approaches.

Chapter 4¹¹ will focus on the effect of stressed economic conditions on systemic risk within the South African banking sector. The credit crisis resulted in increases in credit, market and operational risk, but it may also have precipitated a surge in systemic risk. Measuring systemic risk as the price of insurance against distressed losses in the South African banking sector, this chapter will illustrate whether the financial crisis has in fact resulted in an increase in systemic risk. The reason why this done is that most banks do not have formal methodologies in place for measuring or managing systemic risk and therefore did not really know how much systemic risk impacted them through the crisis. Therefore, if systemic risk can be more accurately measured, it will result in banks making a more robust effort in managing it and also in allocating more accurate risk capital to absorb the losses associated with it.

Chapter 5¹² will focus on liquidity creation in South African banks under stressed economic conditions. The financial crisis placed severe pressure on global bank liquidity. Many banks were unable to create sufficient liquidity and had to receive Government support or face default. This chapter will illustrate the impact of the financial crisis on liquidity creation within South African banks using a model previously applied to US banks. Research indicates that there have only been two papers published since 1998 that measures bank liquidity creation and both these focus on international banks, therefore Chapter 5 will be the first study in history to focus on bank liquidity creation in the South African banking sector and also to measure bank liquidity creation during distressed economic conditions in the South African banking sector.

Chapter 6 will summarise and demonstrate from the main research results of the thesis how did the stressed economic conditions that resulted from the financial crisis of 2007 to 2009 impact on international bank risk measurement and management. Suggestions for further research, that is required in this constantly evolving field of bank risk management, will be made.

1.4 RESEARCH DESIGN AND PROCEDURE

The research design of this thesis followed the outline below:

Pose research questions: Broad questions will first be posed about how to address inadequate enterprise risk management in the current (2009-2010) financial environment. Even before the financial crisis, gaps in

¹¹ At time of writing (November 2010), Chapter 4 has been accepted for publication in the *South African Journal of Economics* (SAJE).

¹² At time of writing (November 2010), Chapter 5 has been submitted for publication in the SAJE.

risk management theory and practice were becoming increasingly obvious and more difficult to ignore. With the goal of enterprise risk management uppermost, and the fields of credit, operational, liquidity and systemic risk in need of much further investigation, Chapters 2 to 5 will deal with these issues.

Critical literature review: A critical literature review, in which the existing work by practitioners and researchers in the field was consulted, will be reported on. Before the crisis adjustments were only required to *existing* risk management procedures, i.e. no new techniques were needed to solve particular problems. The existing literature is copious in such cases. Where an entirely new approach to risk practices was required, the literature was less obliging. Nevertheless, popular, well-established mathematical techniques are almost always available for such endeavours and again, abundant literature exists to address these models.

Theory building/adapting/testing: Augmenting existing risk management ideas for practical implementation into bank risk portfolios usually enjoys rich precedent. In these cases, pursuing existing, well-established methodologies allows subtle, but significant, improvements to be made to risk measurement practice. Developing new ideas requires much back-testing, validation and endorsement from other practitioners. Ultimately, the bulk of the results that will be reported in this thesis were from empirical analyses of real return (or other) data.

Action research/data collection: Data that will be used are from reputable sources (e.g. Algo *FIRST* for operational risk data, Standard and Poor's LossStats[®] Database for credit loss data, and Moody's KMV for probability of default data, etc.), and in some cases it will be sourced directly from the market.

Conceptual development: This research is intended to provide accurate, but highly practical, solutions for use by risk analysts and risk managers. As a direct result, the primary source of analytical work will be Microsoft Excel[™] since this is the tool of choice for almost all financial institutions.¹³ While clearly not designed to perform the most advanced statistical or algebraic analysis, Microsoft Excel[™] nevertheless performs adequately. These spreadsheet-based models use visual basic programming language (a flexible, functional and highly valuable desktop tool available to all quantitative analysts and risk managers alike) to develop macros for undertaking onerous and repetitive computing tasks. The use of macros involves much further testing with dummy data, back-testing and model validation. The results will be compared to and calibrated with the more sophisticated software output, available in the banks, to demonstrate the practical applicability of the research models developed for this study.

Reflection/theory extension: Results obtained from these models will be critically assessed, analysed and the findings meaningfully displayed. It is expected that the analysis will sometimes involve further, more detailed investigation, using different – or 'cleaned' – data (e.g. real versus nominal gross domestic product values). If the results indicated inconsistencies or contradictions with theory, further research will be conducted to augment the existing theoretical explanation for the particular phenomena.

¹³ Standard statistical software was used in cases where Excel proved inadequate.

State/disseminate findings: Having analysed the data, obtained meaningful results and displayed these appropriately, the results will be reported in article-style reports for peer review and publication.

Further work: To complement major findings of and ensure the continuation of work not addressed (or that which could not be undertaken due to lack of data or theory) in this thesis, future research will be proposed for risk theorists and practitioners.

1.5 CONCLUSION

The field of risk management is undergoing an upheaval and, possibly, a revolution (Grant, 2009). The severe financial crisis which began in mid-2007 has been blamed on central banks (for not managing interest rates more effectively during boom times), regulators (for lax risk management monitoring procedures), rating agencies (for incorrectly assessing the risks associated with the exotic credit products available in abundance pre-2008), investment and commercial banks (for encouraging profligate risk-taking with little regard for, or complete disregard for, the potential risks involved) (Amin, 2008). Most governments, central banks, institutional investors, practitioners and regulators now realise that the state of risk measurement and management is in jeopardy and urgent issues remain unsolved in the recognition of the conceptual and technological limitations of the models, systems and policies. The results presented in this thesis concur with this view: serious problems were ignored or glossed over in pursuit of higher returns and in an environment of perceived diminished risk. The view expressed in this thesis is that the financial crisis has changed the way banks manage risk and also the perspective that credit risk was the only culprit during the crisis.

This thesis aims to contribute to the debate on the impact of the financial crisis by highlighting the fact that operational risk managers should be much more vigilant during distressed economic conditions, because as companies start to make losses and employees start losing their jobs, they may be forced to play their hand and get involved in criminal activities, for example fraud, in order to survive. Furthermore, usually during an economic downturn there are a relative large number of mergers and acquisitions and these usually happens in record time without the required due diligence, which give rise to operational risk. Since the international banking sector is so closely knitted, this study will also explore the role that systemic risk had in the financial crisis, and will aim to demonstrate that systemic risk played a bigger role in the financial crisis than expected. Finally, this study will be the first to measure bank liquidity creation in the South African banking sector through a severe economic downturn and since the South African banks remained relative strong with adequate liquidity during the financial crisis, this study will determine how effective they really were in creating liquidity.

CHAPTER 2 – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON OPERATIONAL RISK LOSS DISTRIBUTIONS

THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON OPERATIONAL RISK LOSS DISTRIBUTIONS

JA'NEL ESTERHUYSEN^{*} GARY VAN VUUREN[†] & PAUL STYGER[†]

ABSTRACT

The depth and duration of the credit crisis has highlighted a number of problems in modern finance. Banks have been accused of excessive risk taking, rating agencies of severe conflicts of interest, central banks of neglecting the inflation of asset price bubbles and national supervisors of lax regulatory controls. Credit and market losses have been considerable. Operational losses have also surged as surviving corporates merge or acquire less fortunate ones without the requisite controls. Furthermore, as more jobs get made redundant it is believed that people are getting forced to play their hand to get involved in internal fraud as their sources of income has dried up drastically and stealing from the institution seems to be their last resort. The main objective of this paper is to establish if there has been a change in the nature of operational risk with regards to the number of operational losses as well as their impact pre and during the crisis. The way in which operational losses have been affected will be presented and a comparison will be made between operational loss characteristics pre and during the crisis. Some of the main findings of this paper were that operational losses shown little change in frequency, but shown a significant increase in severity, meaning that their financial impact has been more severe during the crisis. Therefore it is quite safe to say that the financial crisis most defiantly had an impact on operational risk as the impact of operational losses became much more severe.

JEL Classification: C46, G21, G32.

Key words: operational risk, loss distribution, frequency distribution, credit crunch.

1. INTRODUCTION

Operational risk, defined as 'the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events (including legal risk)' (BCBS, 2006a), is not a new concept for banks: bank's balance sheets have reflected operational losses for several decades. These losses materially affect the soundness and operational efficiency of all banking activities and all business units. There is, however, not much precedent for measuring operational risk as there is generally a scarcity of data and where there is data; the history only dates back two to three years. However, various academics and authors have done extensive work attempting to measure operational risk². The other two major risk types (as classified by the BCBS), namely market and credit risk, enjoy abundant data and years of standardised, globally-applied methodological approaches. Validation of these models – to assess their suitability and robustness – is also common, employing a catalogue of well-tested approaches including stress- and back-testing. Internal operational risk data, however, is far from abundant for most banks. While there is now a choice of several databases for external loss data, further work is required to determine how banks should adjust these to accommodate the fact that they originated in different size and control environments. In addition, some banks do not always accurately report the correct data in order to disguise control failures that may lead to capital penalties, further affecting the accuracy of operational risk data (Van Grinsven, 2009). In addition, for most risk loss data the collection process is manual, which leaves even greater room for errors and further impacts data quality.

^{*} Absa Capital: Investment Bank Division of Absa Bank, 15 Alice Lane, Sandton, 2196, South Africa. Paper submitted as partial fulfilment of PHD Economics at the North-West University Potchefstroom Campus.

[†] North-West University Potchefstroom Campus, Potchefstroom, 2520, North-West Province, South Africa.

The authors would also like to thank the anonymous referees who gave valuable comments, which improved the paper significantly.

² See for example De Fontnouvelle, DeJesus-Rueff, Jordan & Rosengren (2003), Dutta & Perry (2007) and Lambrigger, Shevchenko & Wuthrich (2007).

Operational risk events have an extremely diverse set of causes, including fraud, improper business practices and product flaws, failures of technology, employment discrimination, transaction and execution errors as well as natural disasters and terrorism – some sources go as far as to say it includes everything except specific causes for credit and mark risk (Cruz, 2002:14). As a result, operational risk data coverage must include *inter alia* a broad spectrum of information regarding sources of internal weaknesses, precise definitions of 'start' and 'end' event dates, clear classification of loss amounts, recovery procedures and duration and much more. Operational loss databases, therefore, need to be significantly more comprehensive than those required for accounting restatements and they need to be much more robust with regards to qualitative data. This study employed data gleaned from a relatively new and extremely detailed operational loss data source – Algo FIRST – that identifies operational loss events and records a host of other loss information.

The onset of the 'credit crunch' in mid 2007³ heralded a sudden, severe and prolonged reduction in the availability of credit affecting all components of the global economy. The origins of the credit crisis are diverse and many, but it is now widely accepted that among the major causes were lax lending conditions, unusually low interest rates (which – maintained at low levels for longer than usual periods – spurred a massive increase of asset prices), low global inflation, elevated oil prices, widespread complacency in financial regulation and naïveté in the assignment of credit ratings of credit derivatives. The credit crisis has tipped the economies of many countries into recession and even those that have fared relatively better than others, are still affected by the lack of credit availability and diminished imports and exports.⁴ The credit crisis represents an interesting opportunity to assess the claim that operational risk (fraud, for example, as evidenced by the devastating Maddof deception (Table 1)), increases in times of recession. Operational loss characteristics were examined and evaluated *prior* to the onset of the credit crisis and these results compared with those obtained *during*⁵ the crisis to establish whether these events have changed in frequency or in severity or in both. The reason for doing this is to establish if the economic crisis have had an impact on operational risk and operational losses as most of the focus has been just on credit risk, and since there have been an increase in high-profile operational losses reported (see section 2) in the last twelve months, there is certainly the belief that operational risk has changed with regards to frequency and severity of operational losses.

Although this paper focus mainly on international results/data, it should be clear that South African results/data were also taken into account; however the international results/data were more easily available and therefore makes up the bulk of the analysis. Furthermore, the inclusion of operational risk in the Basel II framework means that measuring operational risk and making adequate capital provisions for it is directly relevant for financial institutions in South Africa and the rest of the African continent.

The remainder of this paper is arranged as follows: Section 2 provides a brief literature survey of operational loss studies and conclusions reached while Section 3 presents a summary of the distributions employed to investigate the effect of the credit crisis on inter-arrival time, frequency and severity of operational risk

³ It is the subject of some debate as to the originating event which triggered the 'credit crisis'. See Section 4 for a more detailed discussion of and qualifying arguments for the authors' choice of mid 2007.

⁴ Further information about this (ongoing) tumultuous period may be found in Diamond and Rajan (2009).

⁵ Since, at the time of writing (August 2009), and despite some evidence of 'green shoots of recovery', the crisis is arguably far from over. Lending practices remain severely curtailed, stock markets are still well below their pre-crisis highs, most economies remain in the grip of recession and many banks remain supported by their sovereigns.

losses. A description of the data employed in the study is also presented in Section 3 and the subsequent analysis of the data follows in Section 4. Section 5 concludes the article.

2. LITERATURE SURVEY

It is widely known that the level of observed fraud increases during times of recession (Ernst & Young, 2009:3). This is often attributed to fraudsters having less cushioning with which to hide fraudulent activities without incurring even more substantial risks. A recent example of this has been several 'Ponzi' schemes, which involve early investors being paid with money gleaned from subsequent investors. By design, these schemes rely on growth, but more especially on new capital, to perpetuate the fraud. The collapse of Bernard Madoff's fund, which has to date accumulated some US\$50bn of losses, was accelerated by a lack of both liquidity and investable assets. Another possible reason for the increase in fraud during a recession is that business becomes harder and in some cases employees will misrepresent the facts in order to close deals or will window dress financial performance to mask disappointing results – keeping in mind that managers are always under extreme pressure to meet financial targets, even at times of general malaise in the economic cycle (Ernst & Young, 2009:3). Also, when companies are making redundancies or are undergoing management changes in a down cycle, gaps can appear in financial controls making institutions more vulnerable to operational risk (Ernst & Young, 2009:3). A further problem is the inevitable reduction in time and effort spent on operational risk management when profits are halved and bonuses terminated.

In terms of operational risk losses, 2008 was the worst year on record, the severity of losses being driven by credit, market, and liquidity risk. Table 1 lists the top ten operational risk losses ranked by loss amount during 2008. Although many of these events included activities and lapses in diligence that were originally undertaken prior to the credit crisis, the state of global markets amplified their severity.

Table 1: Top ten operational risk losses, ranked by severity in US\$.

ORGANISATION	LOCATION	LOSS (\$US bn)	TRIGGER
Madoff Investment Services	US	50.0	Securities fraud
Wells Fargo	US	8.4	Concealed losses
Societe Generale	France	7.8	Unauthorised trading
Fairfield Greenwich Group	US	7.5	External fraud
Petters Group Worldwide	US	3.0	Records falsified
Siemens AG	Germany	2.8	Bribes and kickbacks
Credit Suisse Group	Switzerland	2.7	Pricing misdeeds
VISA International	US	2.3	Antitrust violations
CITI Group	China	1.9	Unauthorised trading
Ascot Partners	US	1.8	Lack of due diligence

Source: Compiled by the authors

Galbraith (1955) noted – in his original analysis of the 1929 stock market crash which heralded the Great Depression – that inventories of 'undiscovered embezzlement' accumulate during years of booming markets. The disguise of these frauds is sustained and prolonged as periods of strong growth do not encourage searches for the origins of spectacular returns. This situation is reversed when market conditions alter (and

particularly when these conditions alter *abruptly*) resulting in frauds and deceptions which are quickly exposed as suspicions increase and audits become penetrating and meticulous. Some of these incidents take years to unravel and for all the ramifications to be uncovered, significantly increasing the loss severity.

A European survey conducted since the onset of the crisis found 'disappointing tolerance of unethical behaviour among employees across Europe' (Ernst & Young, 2009:2).⁶ The survey found that increasing pressure to stabilise businesses (as well as meet stringent financial targets) has increased the temptation to relax controls. This is a particular problem in banks where – apart from the standard operational problems associated with financial institutions such as fraud and theft – swelling unemployment has created more opportunities during the recessionary environment. Increased staff redundancies result in a shifting of organisational structures which then leads to gaps in financial controls as reporting responsibilities become blurred. In addition, positions are often made redundant without consideration of the employee filling the position: in most cases, however, it is the individual that serves as control and not the position filled by them. These factors all contribute to marked increases in fraudulent activities.

Respondents of the survey by Ernst and Young (2009:2) complained that normal operating policies are frequently overlooked or forgotten completely during periods of redundancies – many respondents believed an increase in fraudulent activities will be experienced 'over the next few years' as a direct result of the credit crisis (Figure 1).

Figure 1: Factors that are believed will cause an increase in fraud over the next few years.

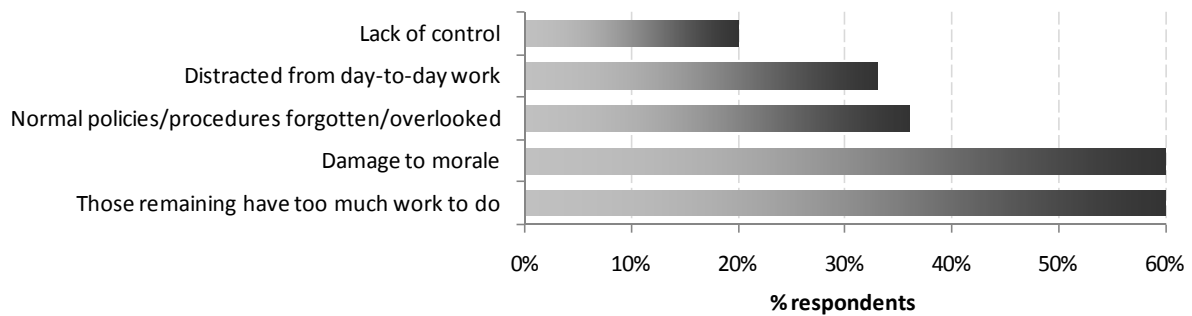


Source: Ernst & Young (2009:2)

The survey confirmed that corporate anti-fraud efforts are severely hampered by redundancies and reorganisations as they often overstretch back and middle offices, resulting in fewer personnel to implement, monitor and maintain procurement decisions or payment authorisations (Figure 2). Authority to execute anti-fraud policies may be delegated to inexperienced managers who may not be able to easily detect anomalies and signs of potential danger and remaining staff are too stretched to accurately perform the control role when large numbers of redundancies were made (Ernst & Young, 2009:3).

⁶ Although this study was conducted in Europe, the risk of increasing fraud is also expected in South Africa as the slowdown continues to cause economic woes.

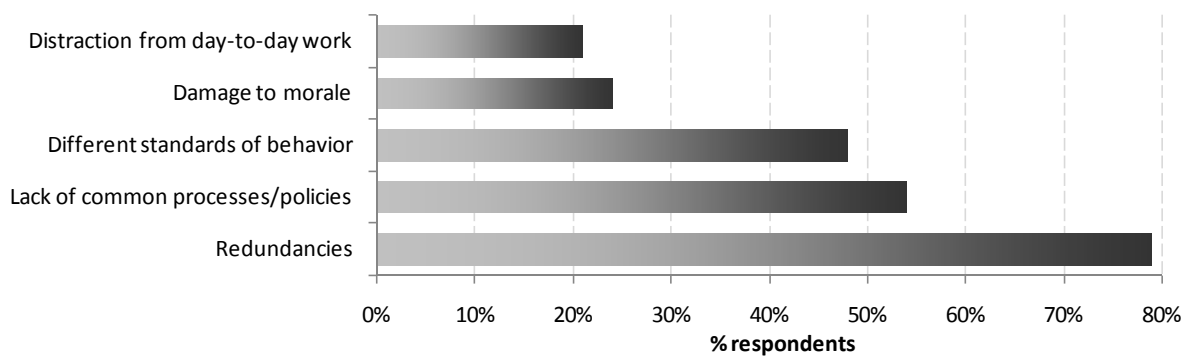
Figure 2: Fraud risks impacted by redundancies.



Source: Ernst & Young (2009:2)

The credit crisis has resulted in the failure of a number of banks (of all sizes). As a result, and in an attempt to curtail the crisis, governments and other banks have both encouraged and engineered a surge in mergers and acquisitions (Douglas, 2007). These activities also have potential negative consequences for operational risk (Figure 3).

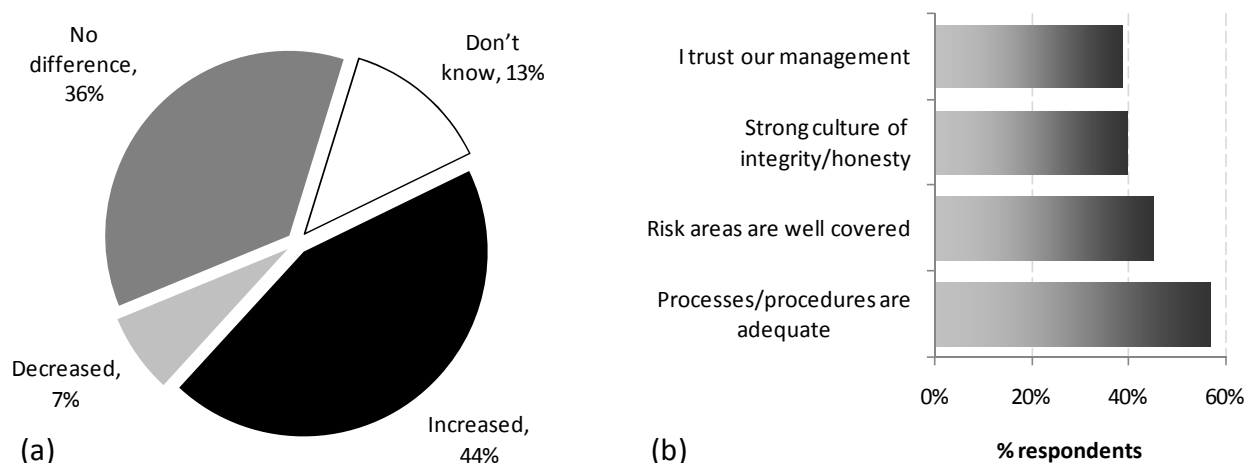
Figure 3: Problems caused by mergers and acquisitions.



Source: Ernst & Young(2009:2)

Only 44% of bank personnel respondents (Ernst & Young: 2009) believed that anti-fraud measures would be increased due to the credit crisis while the same percentage believed either no change would be made or that these would be decreased (Figure 4a). The reasons for the prevailing *laissez faire* attitude to anti-fraud measures is summarised in Figure 4b.

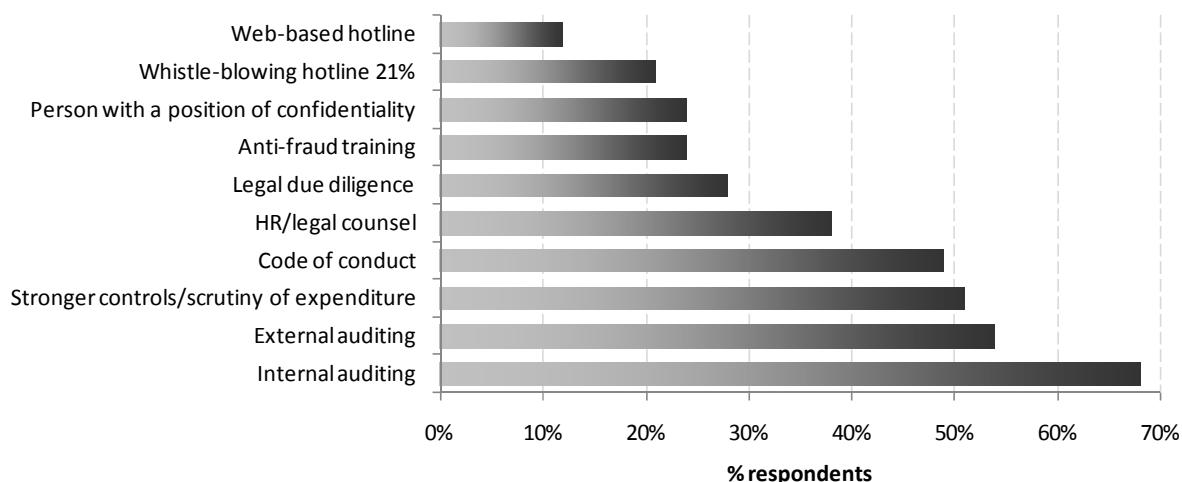
Figure 4: (a) Changes to banks to combat fraud and (b) anti-fraud measures.



Source: Ernst & Young (2009:2)

Responses to the question 'what do you believe will result in a decrease in fraudulent activity over the next few years' are summarised in Figure 5. There is a disproportionate reliance on auditing (whether internal or external) but history has shown that it is frequently in the auditing process that the biggest problems reside.

Figure 5: Factors believed to cause a decrease in fraudulent activity over the next few years.



Source: Ernst & Young (2009:2)

Cagan and Lantsman (2008) asserted that market booms give rise to irrational exuberance,⁷ usually accompanied by lax lending standards and associated large losses when market conditions deteriorate. The implementation of controls is considered counter to growth during boom periods, resulting in financial institution's operating environments and control structures adapting accordingly. Supervision (or rather the lack of supervision) was found to be a key issue for internal fraud, usually the cause of the largest operational risk losses (Cagan and Lantsman, 2008:23). In addition, research suggested that the lack of testing for data accuracy was also a major contributor: many frauds and rogue trading events involved some form of data manipulation. In these cases, most inputs went unchecked by even a second pair of eyes. Furthermore, most

⁷ '...irrational exuberance has unduly escalated asset values, which then become subject to unexpected and prolonged contractions...' (Greenspan, 1996).

‘fraud’ controls are *human* controls: the potential for error resides with the staff member responsible for the control. A strong correlation between high market volatility and the observed frequency of operational risk events was also found (Cagan and Lantsman, 2008). Indeed the former is now believed to be a powerful indicator of the latter and is considered an early warning sign.

By its very nature as a new research area, the empirical literature on operational risk is sparse. The latest empirical studies mostly focus on documenting the size and significance of operational losses. For instance, Cummins, Lewis, and Wei (2006) find a significantly negative equity market reaction to operational loss announcements. Perry and de Fontnouvelle (2005) found a stronger reaction to internal fraud announcements among firms with stronger shareholder rights as proxied by a lower G-index⁸. De Fontnouvelle, de Jesus-Rueff, Jordan and Rosengren (2006) show that capital requirements for operational losses can regularly exceed those for market risks at large U.S. banks. Allen and Bali (2007) examine cyclicalities in operational risk measures, derived from the stock returns of financial institutions, after purging the effect of other sources of risks. However, their approach does not utilize any information from operational losses that actually occurred.

Chernobai, Jorion and Fan Yu1 (2009) found that firms suffering from operational risk events tend to be younger, more complex and financially weaker than those firms that did not. They also had a higher number of anti-takeover provisions, fewer board auditors and fewer CEOs whose option- and bonus-based compensations were larger relative to their salary. These results shed new light on the importance of corporate governance and executive compensation in the understanding of the risk in financial institutions. Important implications for the treatment of correlations among operational risk events emerged from the study (Chernobai *et al*, 2009). The majority of banks treat operational losses as independent events (BCBS, 2006b), either unconditionally or within the same event type or business line. Only a small number of banks have implemented or are considering incorporating more complex dependence structures. Macroeconomic covariates were found to play a lesser role in explaining the arrival distribution of operational risk events, but evidence was found to suggest that many internal factors contribute to operational risk events of all types. The consequence of these conclusions is that the assumption of operational event independence (within the bank) may be seriously unsound and therefore that internal measures of operational risk capital are underestimated. Table 1 supports this conclusion: nine out of the ten incidents illustrated originated within the business and were not caused by external factors.

The credit crisis has exposed weaknesses in several operational processes conducted by banks. The Madoff fraud, for example, demonstrated the danger of unquestioning trust. Years before the discovery of the fraud, the market was unable to replicate or back test Madoff’s winning trading strategies. Despite warning signals such as these, some increasingly vocal, investment continued.

Another factor exposed by the credit crisis was the amplification effect of market volatility on operational risk losses (particularly losses from trading events). The impact of sudden, severe increases in volatility on market activity was overlooked in the benign economic period which preceded the credit crisis. The lack of

⁸ A G-index is an index for quantifying the scientific productivity of physicists and other scientists based on their publication record (Cagan, 2008).

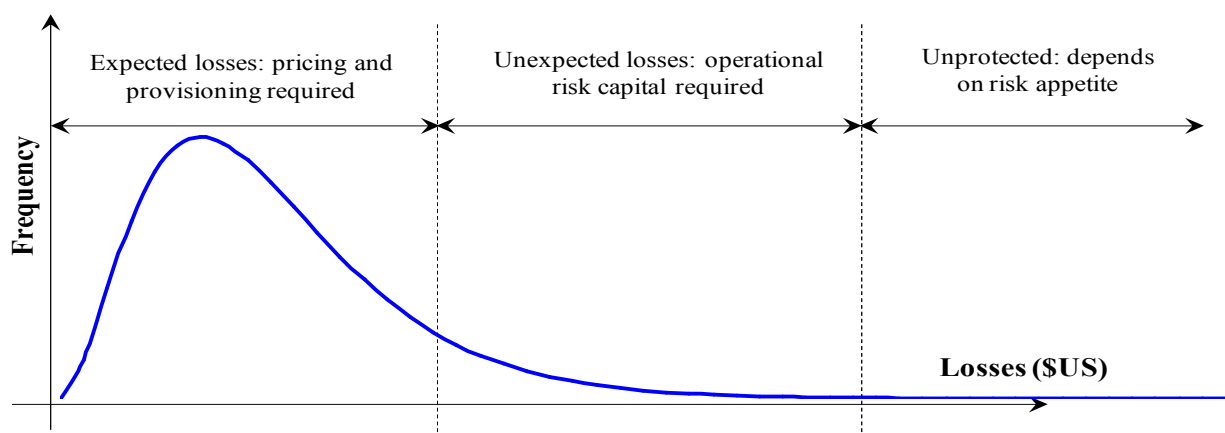
operational risk reviews or stress testing on mortgage-backed securities⁹ or other credit derivatives showed another weakness as did the outsourcing of risk. Many banks believed risk has been transferred, but more virulent risks – in the form of operational and liquidity risk – returned during the crisis.

Frauds perpetrated during ‘boom times’ are inevitably uncovered during market downturns, suggesting that the time to properly manage risk is during the years when controls become more lax and fraud is less feared. Preliminary research done by the authors has shown that it is easier to uncover fraud during downturns (when there is much more focus on managing the ‘bottom line’): it is usually fraud events that impact already smaller ‘bottom lines’ even further. As a result, it is then necessary to test the above-mentioned by means of evaluating operational loss data pre and during the crises to determine if there has been a change in the nature of operational losses and to establish if fraud (assumed as one of the major causes for operational losses) actually did increase during the crisis. The next section will evaluate operational loss data pre and during the crisis by means of modelling frequency and severity distributions for both periods and will provide commentary on each.

3. OPERATIONAL LOSS DISTRIBUTIONS AND DATA

The BCBS classification of the distribution of operational risk loss severity is shown in Figure 6. Expected losses should be covered by pricing and provisioning, and unprotected losses (beyond a certain percentile – 99.9 in the regulatory milieu) can potentially be dealt with using insurance (albeit very expensive). Unexpected losses require regulatory operational risk capital. In fact, Basel II requires that the estimation of the operational risk capital charge, targets unexpected losses and capture tail events (BCBS, 2001:3, BCBS, 2006a:151, and BCBS, 2006b).

Figure 6: Important features of a typical operational risk loss distribution.



Source: Cruz (2002:211)

The choice of July 2007 as the start of the credit crisis was justified in part by the first article which mention the crisis by name (Moneyweek, 2007), but also by the subsequent analysis that indicated that severe signs of weakness were evident (and becoming manifest) by late July 2007 (Daily Kos, 2009).

⁹ One of the major 'toxic assets' still affecting bank balance sheets.

The data were procured from Algo *FIRST*, a database comprising over 7 500 external loss events (covering the top 200 banks in the world) (May 2009) that addresses exposures related to corporate governance, strategic issues, market practices and business risk. Information on operational losses is gathered by Algorithmics and is gleaned from public sources including regulatory agencies¹⁰ and the media. The database provides information about global operational losses in the financial and non-financial industries since 1920. Detailed descriptions of each event are offered including dates of loss occurrence and settlement, loss amounts, event geographical location, claimant name and event triggers. The data format conforms to the BCBS definition of event types and business lines. It is important to note that, because data are collected from public sources, they may not be representative of the population of operational losses. Since larger losses are more difficult to hide, it is possible that the sample is biased toward higher-magnitude events although it has been argued that it is precisely those events that generate concern as they cause major failures and may require managerial response. Furthermore, the data is also only for large banks (revenue > \$10bn) and excludes the small less complex banks. Operational risk losses across all business lines and from all operational loss types were split into very broad categories:

- **PRE CRISIS**: the benign (from an economic point of view) 4.5 year period from January 2003 to June 2007 characterised by low interest rates, low inflation, relatively new bank regulation on operational risk, explosive growth of credit (and other) derivatives, massive loan securitisations, huge demand for commodities such as oil and metals from India and China, low unemployment and
- **DURING CRISIS**: the turbulent 2 year period from July 2007 to the present (June 2009) – i.e. from the onset of the credit crisis and characterised by almost non-existent interest rates, hugely diminished stock markets, increasing taxes, a severe regulatory environment (for banks, regulators, rating agencies and so on) and rising unemployment.

In the above table it can be seen that the frequency of the operational losses has decrease by about 30% per average 100 days but the average value has increased by more than 10 times, which mean that the number of operational losses went down but that their impact was more significant. Furthermore the maximum loss experienced during the crisis is almost equal to the total of all the operational losses experienced pre crisis. This high-level analysis certainly gives the indication that operational losses became much more severe during the crisis. The next section will examine the results more scientifically. As mentioned in the introduction, South African operational loss data were also taken into account in this study, however international data makes up the bulk as it more easily available.

Loss characteristics are summarised in Table 2 below.

¹⁰ For example, the SEC (US) and the FSA (UK).

Table 2: Operational loss data characteristics and parameters summary pre and during the credit crisis.

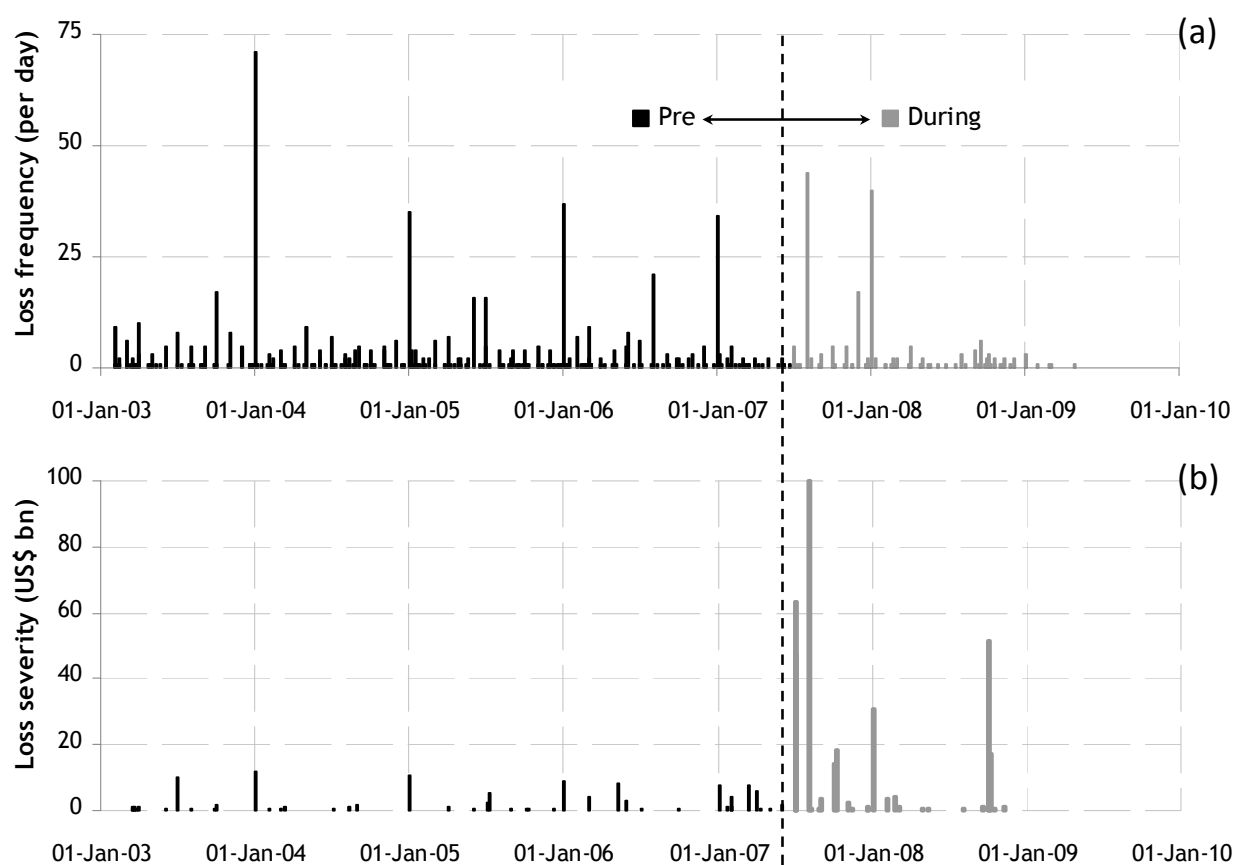
	PRE	DURING
Date range	01/03 – 06/07	07/07 – 07/09
Average frequency/100 days	42	30
Average inter-arrival time	6.5 days	11.0 days
Currency	US\$	
Number of losses	697	205
Average loss	0.17bn	1.80bn
Standard deviation	0.84bn	8.56bn
Coefficient of variation	4.95	4.75
Median loss	3m	60m
Modal loss	200k	72k
Maximum loss	9.3bn	85.0bn

Source: Compiled by the authors

4. ANALYSIS

First, the frequency of operational losses were analysed pre and during the credit crisis. The loss frequency and severity, measured as functions of time, are shown in Figures 7(a) and (b) respectively. The demarcation time is clearly shown.

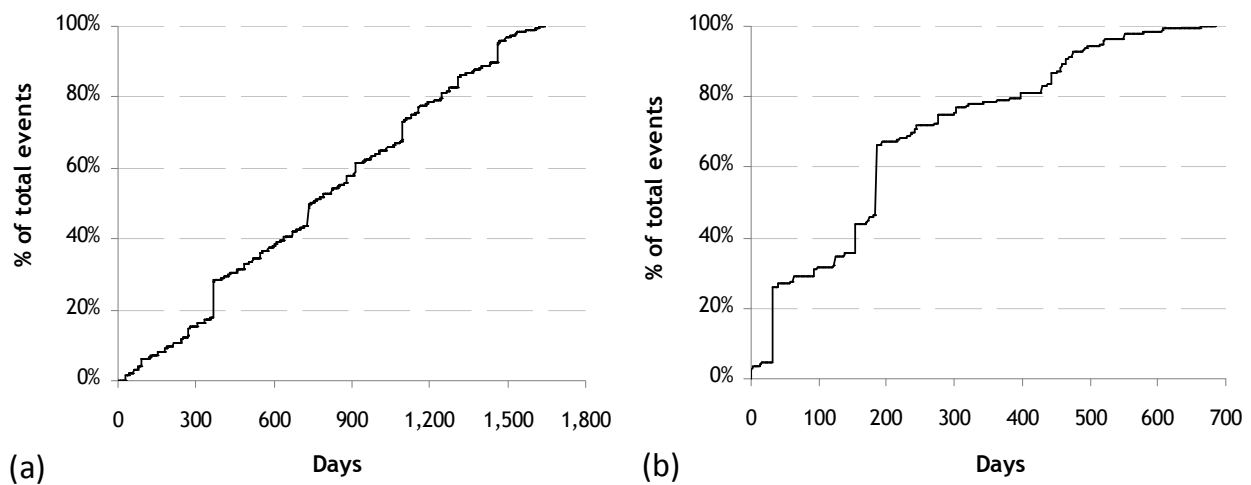
Figure 7a & b: Daily operational loss (a) frequency and (b) severity for the periods under investigation.



Source: Compiled by the authors

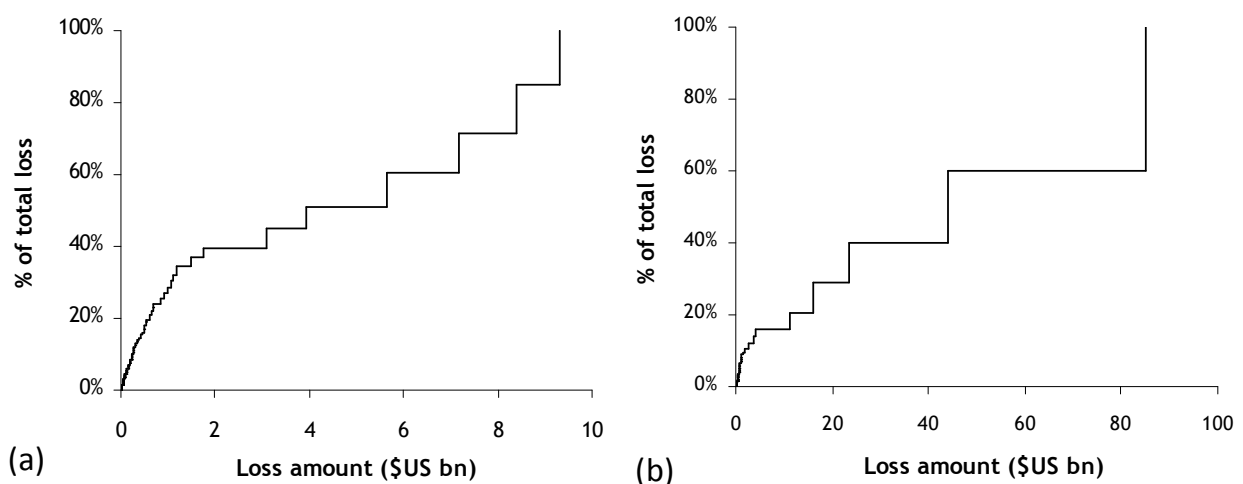
While the overall loss frequency diminishes during the crisis to date, the loss severity increases substantially (see also Table 2: "Average loss"). Note that the frequency 'spikes' at year ends are simply due to increased reporting and the closing out of outstanding cases for financial reporting purposes. Cumulative empirical frequency distributions before and during the crisis are shown in Figures 8(a) and (b) respectively. Before the crisis, a linear relationship holds indicating that losses arrive at a roughly constant rate. During the crisis, however, the relationship is convex. Steep jumps and discontinuities characterise the entire distribution showing the arrival of large losses in short periods of time.

Figure 8a & b: Cumulative empirical distributions of the number of operational risk loss events for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors

Figure 9a & b: Comparison of empirical cumulative losses (as a percentage of total losses) for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



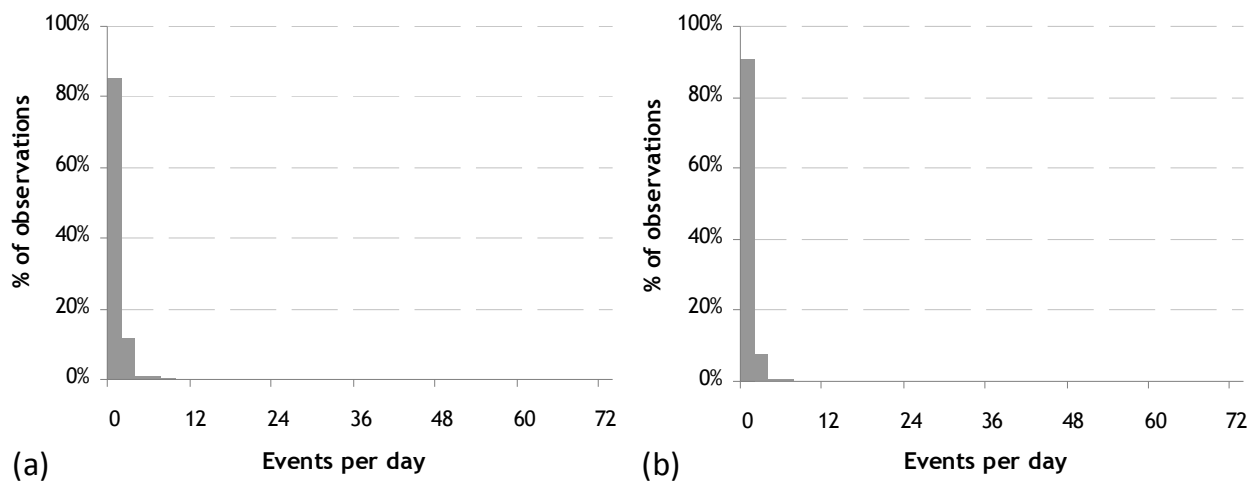
Source: Compiled by the authors

Cumulative empirical severity distributions before and during the crisis are shown in Figures 9(a) and (b) respectively. Before the crisis, the curve rises steeply at first and then becomes roughly linear. This is indicative of losses with severity more or less evenly distributed (i.e. of roughly similar size). During the crisis the

relationship is again highly convex with large jumps – indicative of an uneven severity distribution. A single loan contributes 23% of total losses during the crisis.

Frequency distributions of loss events (measured as events per day) before and during the crisis are shown in Figures 10(a) and (b) respectively. These are broadly similar. The vast majority of recorded operational loss events occur at low frequency with occasional 'bad days'. On one day, 72 losses were recorded pre crisis. During the crisis, to date a maximum of 44 loss events were recorded on a single day.

Figure 10a & b: Loss severity histograms for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors

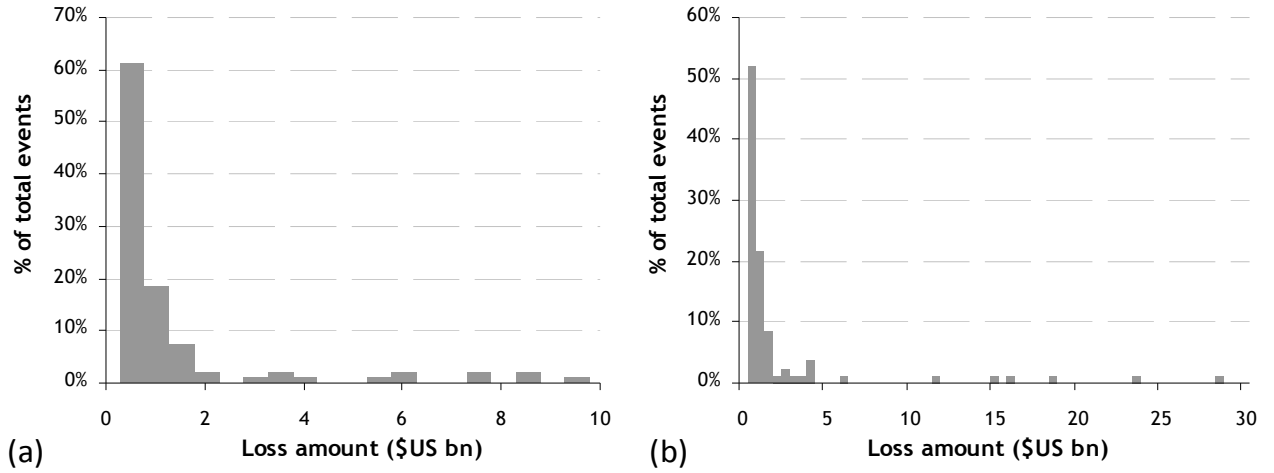
Table 3 records the statistical details of curve fitting and the goodness of fit thereof. Three different fitting techniques have been applied to the data to determine which distribution fits the data the best for both severity and frequency. The reason why this is done is that there are various different types of statistical distributions available, however not all of them can be used as the specific data determine which distribution will be best to use. The “rank” column in Table 3 indicates which type of distribution fits the data the best. For the frequency distribution, the General Pareto Distribution has been used for both pre-and during the crisis data. The Pareto Distribution has been found to be the most accurate in modelling the severity distribution for both pre-and during the crisis data. For the inter arrival time distribution, the Gamma Distribution has been found to be the most useful for the pre-crisis data and the Exponential Distribution has been found to be the best for during the crisis data.

Table 3: Summary statistics and goodness of fit test results for the frequency, severity and inter-arrival time distributions respectively.

		Distribution	Kolmogorov Smirnov		Anderson Darling		Chi-Squared		Parameters		
			Statistic	Rank	Statistic	Rank	Statistic	Rank	k	σ	μ
Frequency	PRE	Gen. Pareto	0.340	1	5.281	3	7.775	1	0.975	0.067	-0.030
		Gen. Extreme Value	0.360	2	5.484	4	9.047	2	0.977	0.064	0.012
	DURING	Gen. Pareto	0.484	1	8.823	4	23.506	2	0.986	0.039	-0.018
		Gen. Extreme Value	0.490	2	9.353	5	21.356	1	0.986	0.037	0.006
Severity	PRE	Pareto	0.082	1	91.617	3	52.168	2	0.329	0.000	
		Frechet	0.086	2	97.631	5	55.336	4	0.442	0.001	
		Log-Logistic	0.098	3	98.086	6	48.003	1	0.412	0.004	
	DURING	Pareto	0.226	1	12.521	2	23.965	3	0.239	0.000	
		Frechet	0.239	2	80.690	4	90.063	2	0.613	0.067	
		Weibull	0.239	3	69.849	1	43.177	5	0.293	0.266	
Inter arrival time	PRE	Gamma	0.130	1	13.007	3	142.990	4	1.068	6.093	
		Gen. Pareto	0.132	2	12.910	1	160.230	9	0.038	6.024	0.245
	DURING	Exponential	0.1993	1	9.2282	2	175.86	4	0.091		
		Weibull	0.2018	2	7.4568	3	176.42	1	1.297	11.953	

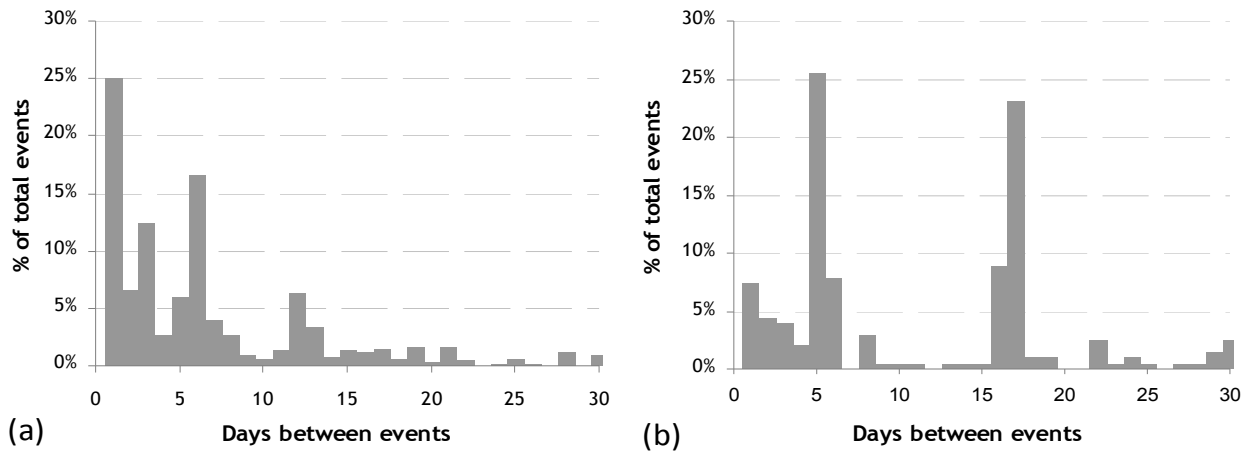
Severity distributions of loss events (again measured as events per day) before and during the crisis are shown in Figures 11(a) and (b) respectively. These show many similarities – a concentration of low severity losses and a few large outliers, or tail events. The inter-arrival time of loss events – measured before and during the crisis – are shown in Figures 12(a) and (b) respectively. Before the crisis, the majority of events occur within one week of each other (although a single, 30-day period between events was also recorded). During the crisis, the distribution becomes bimodal with prominent peaks at 6 and 17 days. Despite the increased loss severity during the crisis, the average time between events (inter-arrival time) almost doubles from 6 days (pre-crisis) to 11 days (during the crisis). This means that although time between events has increased, the severity became much more severe meaning that operational losses during the crisis were not happening as frequent as pre crisis, but that their values were much higher than those happening pre crisis.

Figure 11a & b: Loss severity (truncated at \$US1bn) histograms and distributions for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors

Figure 12a & b: Inter-arrival time distribution of operational risk losses for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors

Low frequency, high severity events are of particular interest to operational risk managers. These events occur in the upper tails of loss distributions. Peak over threshold (POT) models focus on loss events above certain (high) thresholds and then fit distributions to data that occur above these thresholds (Jobst, 2007). For a sufficiently large threshold u , the conditional excess function F_u of such extreme observations may be summarised by the generalised Pareto distribution (GPD). The cumulative distribution function of GPD is:

$$F(x) = 1 - \left(1 + \xi \cdot \frac{x - \mu}{\beta} \right)^{-\frac{1}{\xi}} \text{ if } \xi \neq 0 \text{ and } F(x) = 1 - \exp^{-\frac{x - \mu}{\beta}} \text{ if } \xi = 0 \quad (1)$$

x refers to extreme events above the threshold, μ is the location parameter, which indicates the point where the distribution starts (where $-\infty < \mu < +\infty$ but it is often assumed that $\mu = 0$), β is the scale pa-

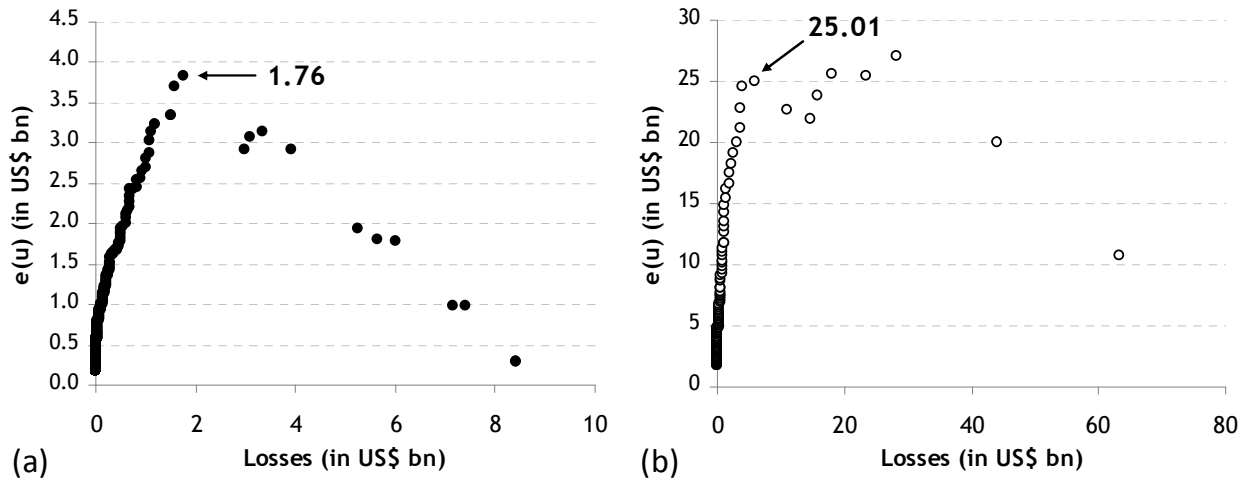
parameter of the distribution (with $\beta > 0$) and ξ is the shape parameter of the distribution, which indicates whether the distribution will have steep or low shape. Of interest to operational risk managers is the choice of a high threshold (indication of which operational losses will form part of the tail – extreme losses), which can be calculated by the mean excess function which is defined as:

$$e(u) = \frac{\beta}{1-\xi} + \left(\frac{\xi}{1-\xi} \right) \cdot u \quad (2)$$

where, e is an indication of the behaviour of the tail of the distribution

A general rule of thumb involves choosing u such that the mean excess plot is linear for $x \geq u$. Figures 13(a) and (b) show the mean excess plots for losses measured pre and during the crisis respectively. Equation 2 explains the fat tail behaviour of the loss distribution, meaning it actually indicated the value of the extreme losses in the distribution – the fatter the tail of the distribution, the more extreme losses. The pre-crisis threshold loss is US\$1.76bn while during the crisis, it is US\$25.01bn – this is a good indication that the extreme losses (those defining the tail of the distribution) became much more extreme during the crisis.

Figure 13a & b: Mean excess plots for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009). Threshold values are indicated.



Source: Compiled by the authors

It is also important to obtain accurate estimates of ξ (shape parameter, which defines the shape of the distribution). While other methods to measure the shape parameter exist (such as the Maximum Likelihood Estimator, which is convenient, but not optimal), the method of choice is invariably the Hill estimator (Hill, 1975) as it was proven over 20 years to be the most reliable and accurate measure of the shape parameter (Cruz, 2002: 221) and (Perry & de Fontnouvelle, 2005 :332). The Hill estimator is given by:

$$\xi^H = \frac{1}{k} \sum_{j=1}^k \ln X_j - \ln X_k, \quad (3)$$

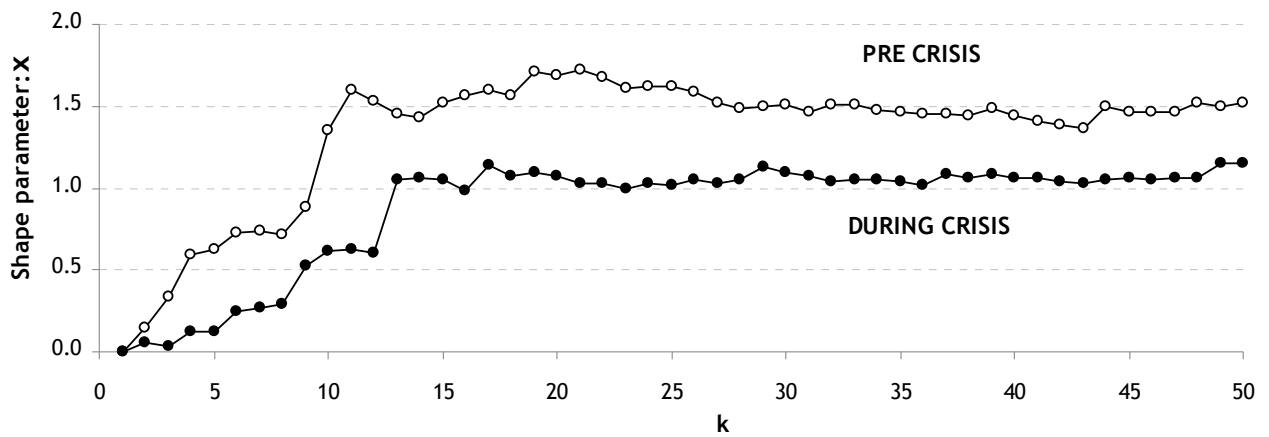
Where:

k is the number of extreme tail values.

X are random variables

Shape parameters pre and during the crisis are shown in Figures 14. The pre crisis shape parameter value of 1.5 indicates an exponential-type distribution of losses, while a during crisis value of 1.0 indicates a longer-tailed distribution (as observed in Figure 14). Knowledge of the parameter values is extremely helpful for the determination of loss values at given percentiles or at extremely high confidence intervals. What this mean is that it is helpful in determining (to a certain confidence) the tail of the distribution, which is a good indication of the value of the extreme events that occurred during a certain time.

Figure 14: Comparison of shape parameters for the period January 2003 to June 2007 and July 2007 to July 2009 measured using the Hill estimator technique.



Source: Compiled by the authors

5. CONCLUSIONS

As discussed in the introduction, the main objective of this paper is to determine if the world economic crisis have had an impact on operational risk regarding the frequency and severity of operational losses. In section 4 (Figure 10), it can be seen that the frequency of operational losses pre and during the crisis relatively remained the same with the vast majority of operational losses occurring at low frequency with occasional “bad days”. The severity distributions of operational losses pre and during the crisis (see Figure 9) were different in that the severities increased during the crisis, giving the loss distribution a “fatter” tail. This mean that during the crisis, the frequency remained relatively constant, but that the severity of losses increased significantly, as can be seen in Table 2, where the average loss increased from \$0.17bn pre crisis to \$1.8bn during the crisis. What this illustrates is that the world economic crisis had an impact on operational risk as the severity of operational losses during the crisis became much more severe. While each financial crisis will exhibit unique characteristics, the same essential features tarnish all significant downturns.

Some of the reasons for this include, but are not limited to, failure of management to identify and isolate key *problem* individuals and key *solution* individuals. The knock-on effect is invariably overworked and dis-

gruntled staff, leading to other problem sources being overlooked or ignored entirely. Also, the current climate (August 2009) of increased corporate failure and subsequent elevated merger and acquisition activity provides opportunities for operational risk to flourish. In such cases, senior management should allow sufficient time for handover. New business heads should ensure that access to skilled resources (such as process understanding, accounting expertise, document review, data analytics and field studies and the ability to report independently i.e. outside of existing hierarchies) are maintained. Senior management should also recognise the significant incentives and opportunities for aggrieved redundant staff to steal invaluable Intellectual Property (IP) on departing and should monitor instances of electronic access to valuable data.

Another possible reason for the increase in operational loss severities is the fact that “deal-making” slowed down drastically in the last twelve months, which mean that some bankers might have forced a deal through that will in normal times never go through. In some cases, some bankers might also have broken the rules (controls) in order to get the deal through and the possibility exists that they might have colluded with, for example credit staff, to let the deal go through.

Some preventative measures proposed by the authors include Audit Committees that should ensure important risks are not ignored. Board members should be informed of the adequacy of audit plans, why focus has been concentrated on certain risk indicators and the way in which approaches to operational risk problems have been validated. Audit teams and committees should be independent, reporting directly to the board in order to minimise the impact on their activities when senior management changes are made. Effort should be made to ensure these functions stay unchanged during merger and acquisitions (or other take-over exercises) to ensure control and risk management stability.

Post-merger, the new organisation is often challenged with the need to be able to gather, analyse, and report on data flowing from multiple, incompatible, disparate and complex systems. At a strategic level, there is a requirement to ensure reporting systems can provide information at a consolidated level that relies on the availability and integrity of data in merged and stand-alone operational systems. For example, remote access possibilities or administrator accounts, which could have been installed by current or ex-employees (i.e., made redundant or disgruntled IT staff) provide potential avenues for information leakage and fraudulent manipulation.

Most organisations struggle to meet these challenges because of (Chernobai *et al*, 2009)

- a lack of understanding of the complexities related to new systems and the requirements of systems integration that can result in security holes that can be compromised,
- incompatible systems across many different divisions or entities,
- the geographical spread of entities,
- systemic data quality issues because of inconsistencies that result from different formats, structures, and storage methods,
- a lack of common reporting tools, and

- a lack of resource availability to focus on pre-emptively detecting and preventing fraud and abuse as a result of the merger.
- the associated costs (during turbulent market periods, all costs are minimised and no increases in ‘unnecessary’ expenses are permitted)

All these factors lead to increased post-merger fraud risk.

After companies have been acquired and integrated, further potential pitfalls remain. Asset write-downs relating to purchased entities have become increasingly common and company management should remain vigilant to risks arising from these, as they can provide a smokescreen where frauds could be potentially hidden.

REFERENCES

- ALLEN, L., and Bali, T. 2007. Cyclicalities in catastrophic and operational risk measurements, *Journal of Banking and Finance*, 31, 1191 – 1235.
- BCBS, 2001. Consultative Document: Operational risk, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbzca07.pdf>, accessed June 3, 2009.
- BCBS, 2006a. International convergence of capital measurement and capital standards, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbse111.htm>, accessed June 22, 2009.
- BCBS, 2006b. Observed range of practice in key elements of advanced measurement approaches (AMA), Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbs131.htm>, accessed August 3, 2009.
- CAGAN, P. 2009. Managing operational risk through the credit crisis, *The Journal of Compliance Risk & Opportunity*, 3, 2, 19 – 26.
- CAGAN, P., and Lantsman, Y. 2008. The cyclicalities of operational risk: the tracking phenomenon. Internet: <http://www.algorithmics.com/EN/publications/whitepapers/registration.cfm?code=wp18>, accessed May 31, 2009.
- CHERNOBAI, A., Jorion, P., and Fan Yul, P. 2009. The determinants of operational risk in U.S. financial institutions, in press.
- CRUZ, M.G. 2002. *Modelling, measuring and hedging operational risk*, John Wiley & Sons Ltd. West Sussex, UK.
- CUMMINS, J. D., Lewis, C. M., and Wei, R. 2006. The market value impact of operational risk events for U.S. banks and insurers, *Journal of Banking and Finance*, 30, 2605 – 2634.
- DAILY Kos, 2009. When did the financial crisis really start? Internet: <http://www.dailykos.com/story/2009/2/12/125228/516/46/696617>, accessed August 1, 2009.

- DE FONTNOUELLE, P., deJesus-Rueff, D., Jordan, J. and Rosengren, E.** 2003. Using loss data to quantify operational risk, Technical Report, Federal Reserve Bank of Boston.
- DE FONTNOUELLE, P., deJesus-Rueff, D., Jordan, J. and Rosengren, E.** 2006. Capital and risk: New evidence on implications of large operational losses, *Journal of Money, Credit, and Banking*, 38, 1819 – 1846.
- DIAMOND, D. W., and Rajan, R. D.** 2009. The Credit Crisis: Conjectures about Causes and Remedies, *American Economic Review*, American Economic Association, 99, 2, 606 – 60.
- DOUGLAS, S.** 2007. UK mergers and acquisitions at all time record, Investment Markets. Available from <http://www.investmentmarkets.co.uk/20070904-771.html>, accessed 7 June, 2009.
- DUTTA, K. and Perry, J.** 2006. A tale of tails: an empirical analysis of loss distribution models for estimating operational risk capital. Federal Reserve Bank of Boston, Working Paper No 06-13.
- ERNTS & YOUNG**, 2009. Fraud risk on the increase across Europe as recession bites, survey conducted by Ernst and Young's Fraud department. Internet: <http://www.ey.com/RU/en/Newsroom/News-releases/Press-Release>, accessed June 1, 2009
- GALBRAITH, J. K.** 1955. *The Great Crash*, Penguin, New York.
- GREENSPAN, A.** 1996. From a speech made to the American Enterprise Institute on December 5, 1996.
- HILL, B. M.** 1975. A simple general approach to inference about the tail of the distribution, *Annals of Statistics*, 3, 1163 – 1174.
- JOBST, A. A.** 2007. Operational Risk - The sting is still in the tail but the poison depends on the dose, *Journal of Operational Risk*, 2, 2, 435 – 449.
- LAMBRIGGER, D., Shevchenko, P., and Wuthrich, M.** 2007. The quantification of operational risk using internal data, relevant external data and expert opinions, *The Journal of Operational Risk*, 2(3), 3-27.
- MONEYWEEK**, 2007. Is this the start of the credit crisis? Internet: <http://financialmediaandcomms.blogspot.com/2008/09/global-credit-crunch-when-did-it-start.html>, accessed on May 19, 2009.
- PERRY, J., and de Fontnouvelle, P.** 2005. Measuring reputational risk: the market reaction to operational loss announcements, *Working paper*, Federal Reserve Bank of Boston.
- VAN GRINSVEN, J.** 2009. Operational risk losses – Not just reporting. Internet: <http://www.riskfriends.comordpress.com/2009/03/10/ops-risk-not-just-reporting/> accessed on April 20, 2009.

CHAPTER 3 – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON CREDIT RISK IN BASEL 11

THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON CREDIT RISK IN BASEL II

JA'NEL ESTERHUYSEN,^{*} GARY VAN VUUREN[†] and PAUL STYGER[‡]

ABSTRACT

The robustness of the Basel II accord in protecting banks during volatile economic periods has been challenged in the ongoing credit crisis. Advanced approaches to measuring and managing credit risk in particular have drawn criticism for being too complex and irrelevant. Despite accusations that the accord was largely responsible for the crisis, this article explores which of Basel II's credit risk approaches were more successful in allocating capital. It was found that, in general, compliance with Basel II actually protected banks during the crisis with simpler approaches enjoying greater success than more advanced ones in protecting banks against credit risk.

JEL Classification: C46, G21, G32.

Key words: Credit risk, loss and frequency distributions, credit crisis, Basel II.

1. INTRODUCTION

The global financial crisis, which began in June 2007, has been described as the most serious financial crisis since the Great Depression of the 1930s (Soros, 2008). It resulted in considerable international distress with almost all major banks experiencing capital shortages and some defaulting outright. Among the principal causes was an explosive increase – by a factor of ten in some cases – in credit defaults (Allen, 2009) precipitated by lax lending standards which prevailed for several preceding years. An early victim, Northern Rock (a medium-sized UK bank), requested security from the Bank of England after its highly leveraged balance sheet led to investor panic and a bank run in mid-September 2007. Although the plea was unsuccessful at first, the UK government did eventually relent and the bank (the first of many) was taken into public hands in February 2008 (Allen, 2009). Northern Rock's problems proved to be an early indication of the troubles that would soon befall other banks and financial institutions. Those initially affected were directly involved in mortgage lending and residential home construction (such as Northern Rock and Countrywide Financial), as short term financing through increasingly illiquid credit markets became a virtual impossibility (Allen, 2009). Over 100 mortgage lenders world-wide went bankrupt during 2007 and 2008 and concerns that the large investment bank Bear Stearns would collapse in March 2008 resulted in its 'fire-sale' to JP Morgan Chase. The credit crisis hit its peak through the months of September and October 2008 (Allen, 2009). Global stock markets were slower to react: substantial losses were recorded throughout the early part of 2009 until the nadir was reached in mid-March of that year. The crisis caused several major institutions to fail (and be subsequently acquired under duress): many of these were subject to takeovers by their relevant sovereigns, including – amongst others – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group, AIG.

^{*} ABSA Capital: Investment Bank Division of Absa Bank, 15 Alice Lane, Sandton, 2196, South Africa. Paper submitted as partial fulfilment of PhD Economics at the North-West University Potchefstroom Campus.

[†] North-West University Potchefstroom Campus, Potchefstroom, 2520, North-West Province, South Africa.

The authors would also like to thank the anonymous referees who gave valuable comments, which improved the paper significantly.

Catastrophic failures of inadequate capital allocation and management were exposed and culpability for the cause, severity and duration of the crisis placed on regulatory bodies, credit rating agencies, bank CEOs and others. Financial institutions began to question the validity and relevance of the underlying credit risk principles which form the basis of the Basel II Accord (Basel II) issued by the Basel Committee on Banking Supervision (BCBS) in 2005 (BCBS, 2006). These principles were devised to provide banks and other financial institutions (e.g. insurance companies) with methodologies to manage credit risk adequately by providing guidance for assessing credit risk (including equations for determining risk capital for more advanced approaches). Since many institutions' capital levels proved woefully inadequate during the crisis, these principles are now – inevitably – being challenged (Collander *et al*, 2009: 2). However, during December 2009, the BCBS approved for consultation a package of proposals to strengthen global capital and liquidity regulations with the goal of promoting a more resilient banking sector, which form part of its response to address the lessons learned from the crisis and to strengthen the Basel II framework (BCBS, 2009).

Basel II provides two different approaches for the measurement and management of credit risk; the Standardised Approach (the simplest – hereafter referred to as the SA) and the Internal Ratings Based (IRB) approach. The IRB approach is split into two further approaches of increasing complexity: the Foundation (FIRB) and the Advanced (AIRB) approaches – and for the purpose of this study both will be referred to as the 'Advanced Approaches' (AA). The AA employ complex mathematical formulations and it is these that are now under attack (Collander *et al*, 2009: 2). The reason is that the AA allows banks to use their own internal models to assess credit risk and risk sensitive capital adequacy levels. Many such models are mathematically complex and may be incapable of modelling 'exceptional times' (a generic shortcoming of all mathematical models) experienced by the financial world during the credit crisis. It has been posited that financial engineers were aware of the unrealistic restrictions and severe limitations imposed on the models to ensure stability, but embraced them anyway. The fragility (and unreliability) of these models under stressed conditions has surprised many (Cagan, 2009: 12) although the severity, duration and contagion effect of the crisis admittedly did not seem feasible (Subramanian, 2009:3) and was thus not explicitly modelled prior to the eruption of the crisis.

Banks were perceived as being adequately capitalised prior to the credit crisis (Cagan, 2009:12) and by Basel II standards this was certainly true (despite the ensuing market mayhem which revealed inadequate capitalisation). For example, Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac American International Group and JP Morgan were regarded as within the top 30 largest and most capitalised financial institutions in the world (Subramanian, 2009:3). The majority of banks referred to in this article had already been approved for the AIRB approach or were in the process of applying for it under Basel II (see Section 2). The question arises: was Basel II's *simpler* approach to credit risk successful in guarding banks against credit risk catastrophes¹ (through the adequate provision of buffer capital) or was Basel II's *advanced credit risk approach* successful in protecting banks from disasters? This article addresses these questions by comparing bank credit risk losses determined using the Basel II Standardised approach to losses and using the Basel II

¹ These catastrophes can include large credit losses or a liquidity shortage / mismatch that can cause a bank to fail. Central Banks were excluded from the focus of this paper since they do not have to comply with Basel II.

advanced approaches pre and during² the crisis. Whether or not the sophisticated mathematical approaches to the measurement and management of credit risk – used in advanced approaches – were more successful than the simpler approaches, will be discussed.

The remainder of this paper is arranged as follows: Section 2 provides a brief literature study of the Basel II advanced credit risk approaches as well as a brief overview of the major credit risk losses experienced during the crisis. A description of the data employed in the study is presented in Section 3 and the subsequent analysis of these data follows in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

Basel II relies heavily on a number of key elements which now appear weakened in light of the credit and liquidity crisis (Griffin, 2008:2). Firstly, Basel II promotes the use of complex internal quantitative modelling techniques by banks for the calculation of regulatory capital (Griffin, 2008:3) and there are concerns regarding the opacity of these models. Secondly, the new capital adequacy rules depend heavily on the research produced by credit rating agencies. Given the culpability ascribed by many to the rating agencies in the structured credit market turmoil, should Basel II really give these agencies a quasi-regulatory role in relation to capital adequacy and counterparty credit risk assessment? Thirdly, despite improvements over Basel I, the new rules still focus on credit *origination*, as opposed to new credit derivative instruments and structured products. Fourthly, the IMF has recently stated that the pro-cyclical nature of Basel II capital requirements, which require banks to hold additional capital against greater anticipated losses as the economic cycle turns downward, could exacerbate an economic recession by forcing banks to restrict their provision of credit in a downturn scenario (Repullo & Suarez, 2008).³ Lastly, the credit crunch was partly the result of a widespread lack of information, which exacerbated the initial US sub prime problems.

Whilst enhanced disclosure is one of the three pillars that form the basis of Basel II, it is recognised as the weakest in terms of both prescription and enforcement (Griffin, 2008:4). Basel II disclosure is required for external parties like Credit Rating Agencies (CRAs) as well as regulators to assess an individual bank's capital adequacy levels in order to provide the bank with some guidance; however this disclosure was in most cases insufficient which led to the inadequate assessment of capital by external parties and in turn also to inadequate guidance on capital adequacy levels. Banks capital bases could therefore not protect them against the systematic effects of the crisis. These capital levels and the disclosure thereof should be aligned more with the way banks assess credit risk (Griffin, 2008:5)

Although not the focus of this paper, a summary of the different Basel II approaches can be seen in Figure 1, which highlights the major differences between these approaches and provides a good background for the remainder of this paper.

² It is the subject of some debate as to the originating event which triggered the 'credit crisis'. See section 2 for a more detailed discussion of and qualifying arguments for the author's choice of mid 2007. Furthermore, since the time of writing (January 2010) and despite some evidence of 'green shoots of recovery', the crisis is arguable far from over. Lending practices remain severely curtailed, stock markets are still below their pre-crisis highs, most economies remain in the grip of recession and many banks remain supported by their sovereigns.

³ Discussion document presented at the IMF's ninth annual Jacques Polak Research Conference in Washington in November 2008.

Figure 1: Brief overview of Basel II credit risk approaches.

Standardised	Internal ratings based (IRB) Approaches	
• Apply prescribed risk-weights (which differ from Basel I) to exposures residing in asset classes to calculate RWA • Limited recognition of credit mitigation (more than in Basel I) Two options: • Simple Approach: Substitution of risk weighted collateral for risk weighting of counterparty • Comprehensive Approach: Calculate adjusted amount of exposure and value of collateral, using haircuts (standard supervisory or own-estimate haircuts)	Foundation (FIRB) Approach • RWA are calculated using a Basel II Risk-weight formula with the following inputs: Probability of Default (PD), Exposure at Default (EAD), Loss Given Default (LGD) and Effective Maturity (M) • LGD (45% for unsecured), EAD and M is prescribed by SARB • Larger range of credit mitigation recognised	Advanced (AIRB) Approach • RWA are calculated using a Basel II Risk-weight formula or function using PD, EAD, LGD and M as inputs • M is calculated in a similar way to the duration of a bond or the SARB allows the use of contractual maturity • Range of credit mitigation unlimited as long as the LGD parameter estimate can be proved based on sufficient historical data
Credit mitigation (Collateral) recognised under all approaches		

Source: Compiled by the authors from BCBS (2006a).

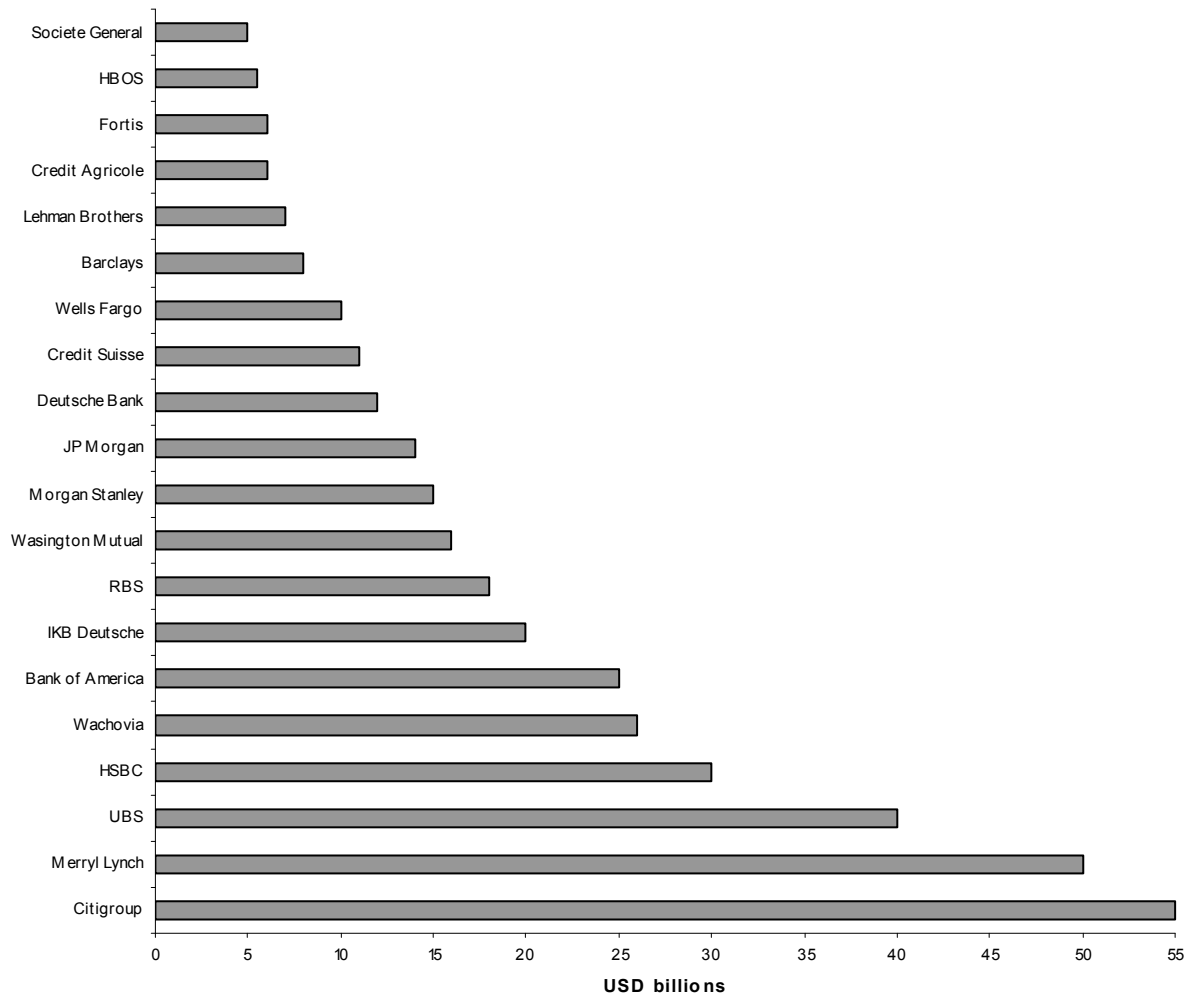
As can be seen in Figure 1, the SA applies only prescribe (by the Regulator) risk weights and use very little credit risk mitigation – the use of models is almost completely absent. The AA on the other hand applies more specific risk measures, for example Probability of Defaults (PDs), Loss Given Default (LGD) and Exposure on Default (EAD) and all these measures are based on comprehensive and complex mathematical models. With the FIRB, LGD and EAD and maturity (M) are prescribed, but with the AIRB, the bank is allowed to use its own models to calculate all the components and in essence have much more freedom with regards to calculating risk capital.

The implementation of Basel II coincides with considerable losses reported by some of the world largest banks (Figure 2), requiring large scale recapitalisations (Benink and Kaufman, 2008: 2). The risk models that underlie Basel II are similar to those employed by many banks (and indeed, the former may have influenced the latter). It is well known that many models are prone to considerable weaknesses through unrealistic assumptions. Recent events have challenged the usefulness of the important elements in Basel II as the need to recapitalise banks has revealed that many banks' internal models for both assessing credit risk and calculating risk capital performed poorly by underestimating the risk exposure (Benink and Kaufman, 2008: 2). This reflects some of the difficulties of accounting for low-probability/high impact events.

Most of Basel II's critics do not oppose the accord in its entirety, they are more critical of the – somewhat arbitrary – 'scientific precision' imposed by the advanced approaches (Diamond, 2009:1). For example, in the European Union (EU) Basel II requires banks and other financial institutions to apply an EU-formulated 'Risk Assessment Model' at the end of each day's trading to demonstrate solvency. If solvency cannot be established, authorities are informed and the bank ceases trading. This does not pose much of a problem in a rising market (Diamond, 2009:2). In a highly volatile or falling market, however, this can prove catastrophic, not least because the model fails to take into account inevitable changes in market sentiment. In addition, the short term impact of new information is factored in regardless of its accuracy or inaccuracy. Most models

also ignore underlying asset worth (Diamond, 2009: 2). In the UK, both Northern Rock and Bradford and Bingley fell foul of Basel II. Both banks were in the process of applying the Basel II advanced approach (Diamond, 2009:2)

Figure 2: *Largest bank write-downs since the beginning of 2008*



Source: Compiled by the authors from CNN Money.com.

Cannata and Quagliariello (2009: 9) were amongst the first to criticise the assessment of credit under the advanced approaches which relies on complex models and also on ratings derived from external credit rating agencies (ECRAs). The assessment of borrowers' creditworthiness provided by ECRAs play a significant role in the models used for assessing credit risk under the advanced approaches and that there are significant doubts on the quality and reliability of their inputs into these models (Cannata and Quagliariello, 2009: 9). The degree of independence of the rating agencies' judgement is also a major concern and this is particular true in the case of securitisations and structured products (Zingales 2008:12). While the 'issuer-pays' model applies to all the products rated by these ECRAs (including corporate bonds), the standard conflict of interest may be more acute for structured finance ratings since ECRAs sometimes discuss the rating implications of

particular structures *during* the structuring process. These conflicts are exacerbated when ECRAAs also sell consulting services to entities that purchase ratings.⁴

Table 1 highlights the major UK banks using the advanced approaches and their sovereign support provided and Table 2 highlights the European countries that had to receive sovereign support and also illustrates the percentage of their banks using the advanced approaches. It is clear that the majority of the banks that received support were those already using the advanced approach.

Table 1: *Top UK banks that received sovereign support (with all using the Basel Advanced Approach).*

	SUPPORT GBP £bn
HBOS	11.5
Lloyds TSB	5.5
Royal bank of Scotland	20.0
Barclays Bank ⁵	6.5
% of total sovereign support	74%

Source: Compiled by the authors from CNN Money.com.

Table 2: *List of European countries and the sovereign support provided.*

	SUPPORT US\$bn	% OF BANKS USING ADVANCED APPROACH
Germany	549	90%
France	440	75%
Spain	137	70%
Austria	21	95%
Belgium	22	86%

Source: Compiled by the authors from CNN Money.com.

Another condemnation focuses on rating methodologies that play a role in the risk assessment of models under the advanced approaches. The assignment of a rating is subject to many challenges, e.g. for complex financial instruments the limitations of statistical models have become even more evident since such products are often illiquid and, in certain market conditions, they do not have a market price (Zingales, 2008: 12). In addition, the shortcomings of models based on external ratings are clear and the need to identify possible solutions is unquestionable, however, it is quite hard to imagine plausible alternatives to the involvement of rating agencies in the assessment of credit quality at this stage. Further criticism is levelled at the lack of adequate and accurate data: historical data on the performance of US sub prime loans, for example, were largely confined to a benign economic environment with rising house prices (Cannata and Quagliariello 2009:9). The lack of sufficient historical data or of scenario analysis that adequately assessed how particular asset pools would respond to potential economic scenarios led to ratings mistakes – in particular, ECRAAs underes-

⁴ Zingales (2008:1) pointed out that it is a mistake to think that the significant power attributed to these new mechanisms to these institutions would have not affected the independence of their judgment, because as power corrupts, absolute power corrupts absolutely. Rating agencies are no exception to this rule.

⁵ Barclays Bank never received sovereign support, but this is the amount that was raised internally to prevent collapse and is therefore included here.

timated the spike in correlations in the defaults that would occur during a broad market downturn (Cannata and Quagliariello 2009:9).

Table 1 shows the four largest banks in the UK which in total received sovereign support of over £30 billion. This support was chiefly to absorb the considerable credit losses that occurred since the start of the economic crisis. Table 2 illustrates the main European countries that provided sovereign support to local banks and also lists the percentage of banks which employed the AIRB approach for credit risk. It is interesting to note that for almost all of the major European and UK banks, 85% of sovereign support was provided to banks using the AIRB approach for assessing credit risk. This indicates significant shortcomings in the AIRB approach for assessing credit risk and for estimating credit risk capital. Benink and Kaufman (2008) argue that this could be due to a key – but incorrect – assumption that banks internal models for measuring risk exposures are superior to any other. The AA implies perverse incentives which induce banks to underestimate their exposure to risk.⁶ Onado (2008) disagrees that the market is more efficient than regulatory authorities in the detection of adequate capital levels and rejects the assumptions that banks, due to their operational expertise, are able to assess risks and their optimal capital requirements.

Furthermore, supervisors may also be partly to blame for the inadequacy of some banks own internal credit assessment and capital calculation models as they are required to assess and examine the robustness of these models before the bank is allowed to use them for regulatory purposes (Benink and Kaufmann, 2008: 3). The reason for this is that is assessment process is clearly a new process for both banks and supervisory authorities, which requires a gradual learning by-doing, but where both parties have not given themselves enough time to really understand the satisfactory ability of these models to measure for example rare but extremely dangerous events. In other words, regulators should have given themselves more time to assess and examine the internal models of a bank before allowing it to use these for regulatory purposes – this indicates to the possible failure of one aspect of the Basel II advanced approaches rather than the entire philosophy of Basel II (Benink and Kaufmann, 2008: 3).

The incentives offered by Basel II (in terms of lower capital requirements) are only justified if the AIRB approach models for calculating capital and assessing credit risk are both sound and prudent (Onado, 2008). In a few countries, validation standards may have not always been sufficiently rigorous and some banks may have underestimated the importance of developing strong risk management and audit functions (Onado, 2008). An anonymous risk manager (*The Economist*, 2008: 12) stated that

At the root of it all, was and still is, a deeply ingrained flaw in the credit decision making process. In contrast to the law, where two sides make an equal-and-opposite argument and is fairly judged, in banks there is always a bias towards one side of the argument. The business line was more focused on getting a transaction approved than on identifying the risk in what it was proposing. Often in meetings our gut reactions as the risk managers were negative, but it was difficult to come up with hard-and-fast arguments for why you should decline a transaction, especially when you were sitting opposite a team that had worked for weeks on the proposal. In the end, with pressure for earnings and a calm market environment, we reluctantly agreed to marginal transactions.

⁶ Basel II creates perverse incentives to underestimate credit risk, because banks are allowed to use their own internal models for assessing risk and determining the amount of regulatory capital, they may be tempted to be overoptimistic about their risk exposure in order to minimize required regulatory capital (Benink and Kaufman, 2008: 2).

Another criticism given to banks' advanced risk assessment methodologies is that they would privilege the use of standardised and quantitative information, neglecting the soft information that is a key driver in the bank-customer relationship (Cannata and Quagliariello 2009:9). This is a problem that should not be underestimated: complex rating methodologies developed by banks for the Basel II AIRB approach focuses too often on quantitative data, disregarding the huge amount of qualitative information on borrowers which cannot easily be incorporated into statistical and mathematical models. A more widespread use of quantitative techniques for measuring and assessing credit risk also tends to make the relationship between banks and firms more transparent.

It is worthwhile to explain the major differences between the Basel II standardised and advanced approaches (Figure 1). Basel II makes use of two approaches with regards to credit risk and includes the Standardised Approach (SA) and the Internal Ratings Based (IRB) approach which is further subdivided into the Foundation IRB (FIRB) and the Advanced IRB (AIRB)⁷ (Styger and Vosloo, 2006: 10). With the SA, banks may not use any internal models. This approach is similar to Basel I in which each exposure is assigned a risk weight based on the specific loan's characteristics (Styger and Vosloo, 2006:10). A corporate borrower's credit quality is reflected by its external rating, as assigned by an external rating agency and if there is no external rating, the loan's risk is generally weighted by 100% (as under Basel I) and a retail exposure (individual) is generally weighted at 75% (Styger and Vosloo, 2006:11). However, lending fully secured by mortgages on residential property, that is (or will be) occupied by the borrower, or that is rented, may be risk weighted at 35% (Styger and Vosloo, 2006:11). This approach is fairly simple and differs substantially from the advanced approaches.

Both the FIRB and AIRB approaches are based on risk components which include Probability of Default (PD), Loss Given Default (LGD) and Exposure at Default (EAD), all of which are based on estimates calculated using mathematical/statistical models which employ the bank's own default history to determine these estimates (Styger and Vosloo, 2006:12). A borrower's (corporate or individual) credit quality is assessed based on the product of the above three estimates, where PD is the possibility (as a percentage) that the borrower will default, EAD is the exposure of the bank at the time of borrower default and LGD which measures the actual loss after all losses have been realised including legal fees (if any) (Styger and Vosloo, 2006:12). Table 3 provides a summary of the difference between the FIRB and AIRB approach.

Table 3: Risk estimates with FIRB and AIRB approach.

	IRB approach	
	FOUNDATION	ADVANCED
PD	Bank calculates	
LGD	Prescribed by the Regulator	Bank calculates
EAD		

Source: Compiled by the authors from BCBS (2006a).

⁷ As both these approaches are considered much more advanced than the SA, they are both considered in this paper as being 'advanced' (AA).

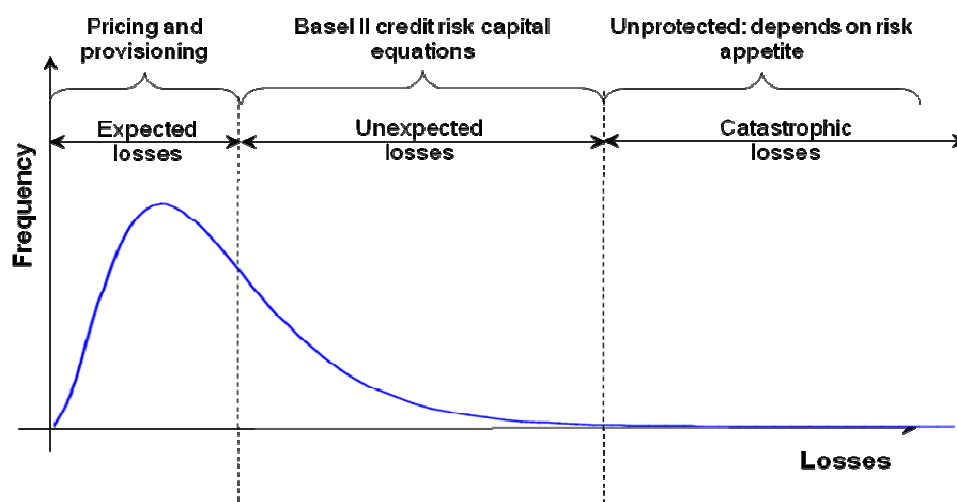
The Basel II AIRB approach relies heavily on calculations from models (in most cases complex and technical), which employ banks' past default history. It is these estimates that are under the spotlight as potential causes of the credit crisis. Banks have been accused of not possessing nor employing adequate loss history on which to base their models, as well as not adequately stress testing these models to assess the possibilities of extreme losses (such as those experienced in the crisis). In some cases financial engineers involved model construction simply did not comprehend the true characteristics of rapidly changing markets.

In order to test the truth or falsehood of the above accusations, the next section evaluates credit losses experienced by global banks using (a) the SA and (b) the AA to assess credit risk pre-and during the crisis. This evaluation will assist in the determination of the more successful approach in the assessment of (and hence mitigation of) credit risk. The analysis proceeds via the construction of severity and frequency distributions for both sets of data (i.e. pre-and during the credit crisis).

3. CREDIT LOSS DISTRIBUTIONS AND DATA

The BCBS classification of the credit risk loss severity distribution is shown in Figure 3. Expected losses should be covered by pricing and provisioning; unexpected losses require regulatory credit risk capital. Basel II requires that the credit risk capital charge targets unexpected losses and captures tail events (BII, 2009:3) at the 99.9th percentile. Banks must either insure (or face the consequences of) losses beyond this percentile.

Figure 3: Important features of a typical credit loss distribution.



Source: BII (2009:2)

The choice of July 2007 as the start of the credit crisis was justified in part by the first article which mentioned the credit crisis by name (Moneyweek, 2007), but also by subsequent analysis that has shown that severe signs of weakness were evident (and becoming manifest) by late July 2007 (Daily Kos, 2009). The credit risk loss data were procured from eight international retail banks through Standard and Poor's LossStats[®] Database of which four apply the SA and the other four the AA for assessing credit risk. There were only minor issues experienced with the data as the database from which it was sourced provided more than enough data points in order to perform an adequate analysis. However, all losses less than ZAR100,000 were excluded, which reduced the data pool quite significantly.

PRE CRISIS: the benign (from an economic point of view) 4.5 year period from January 2003 to June 2007 was characterised by low interest rates, low inflation, relatively new bank regulation regarding operational risk, explosive growth of credit (and other) derivatives, considerable loan securitisations, a huge demand for commodities such as oil and metals from India and China and low unemployment.

DURING CRISIS: the turbulent 2 year period from July 2007 to the present (June 2009) – i.e. from the onset of the credit crisis and characterised by almost non-existent interest rates, hugely diminished stock markets, increasing taxes, a severe regulatory environment (for banks, regulators, rating agencies and so on) and rising unemployment.

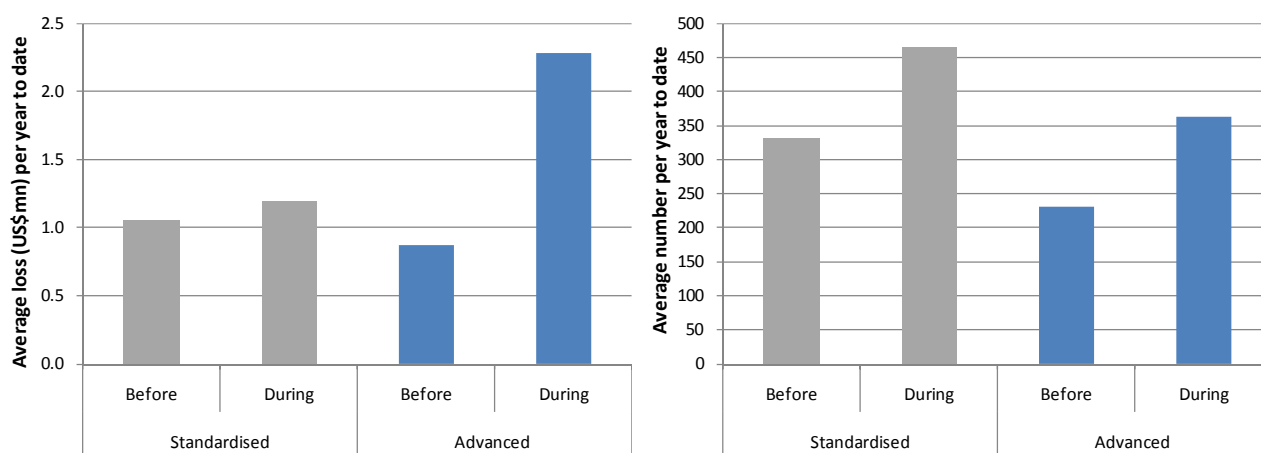
High-level loss characteristics are summarised in Table 4 and a comparison is made between the average number as well as value of losses for the banks using the SA and AA pre- and during the crisis.

Table 4: Credit losses by Basel II approach to credit risk pre- and during the credit crisis

ZAR	Standardised		Advanced	
	Before	During	Before	During
Total value	1.57bn	1.11bn	0.90bn	1.64bn
Total number	1,490	1,629	1,035	723
Average per year	1.05mn	1.19mn	0.87mn	2.28mn
Maximum loss	29mn	37mn	20mn	42mn
Average number per year	331	465	230	362

Source: Compiled by the authors from S & P's LossStats® Database

Figure 4: Comparison of loss averages pre- and during the crisis



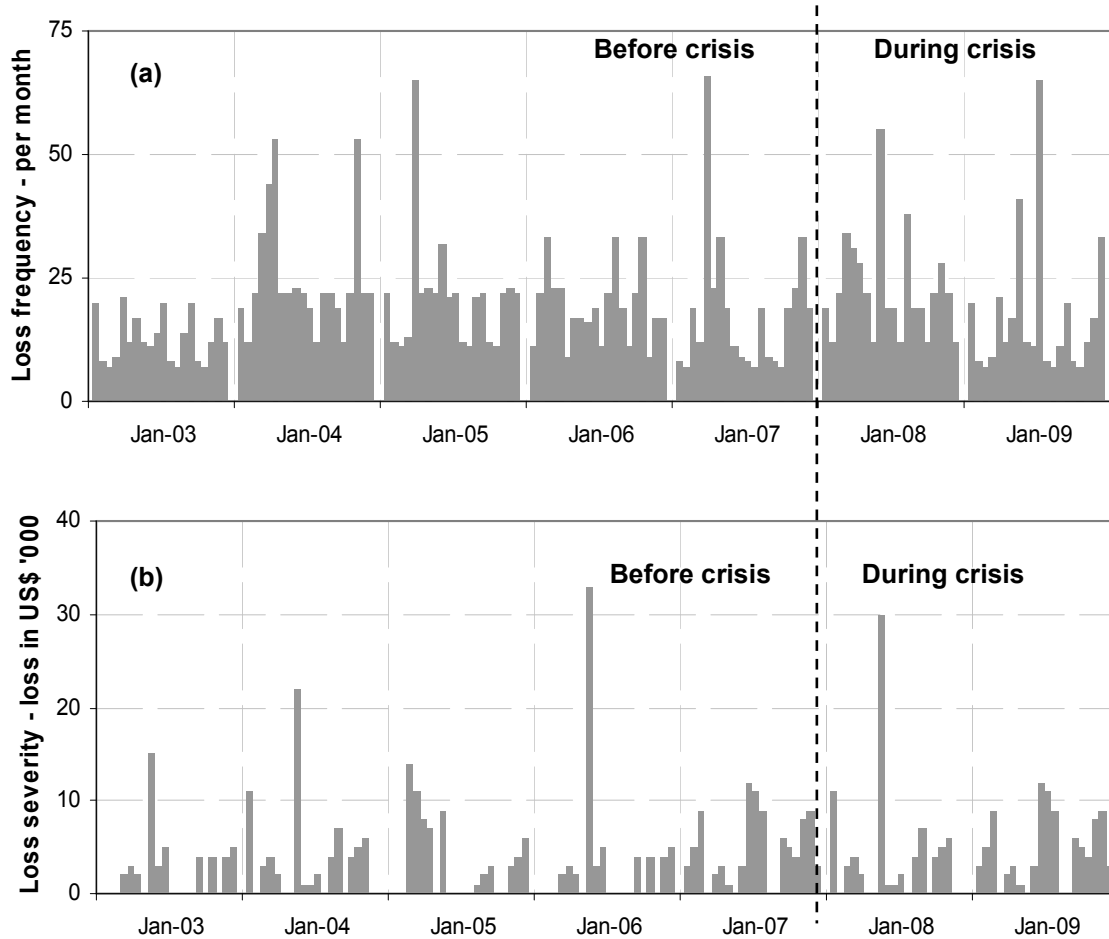
Source: Compiled by the authors from S & P's LossStats® Database

The average severity of credit losses increases for banks using both the SA (+13%) and the AA (+162%) from pre- to during crisis (also see Table 4). The average frequency of losses also increases for both the SA (+40%) and the AA (+57%).

4. ANALYSIS

Figure 5 shows the frequency and severity (as functions of time) of bank credit losses for banks using the SA. The onset of the credit crisis is indicated by a dashed line.

Figure 5: Monthly credit loss (a) frequency and (b) severity for the periods under investigation for banks using the SA.

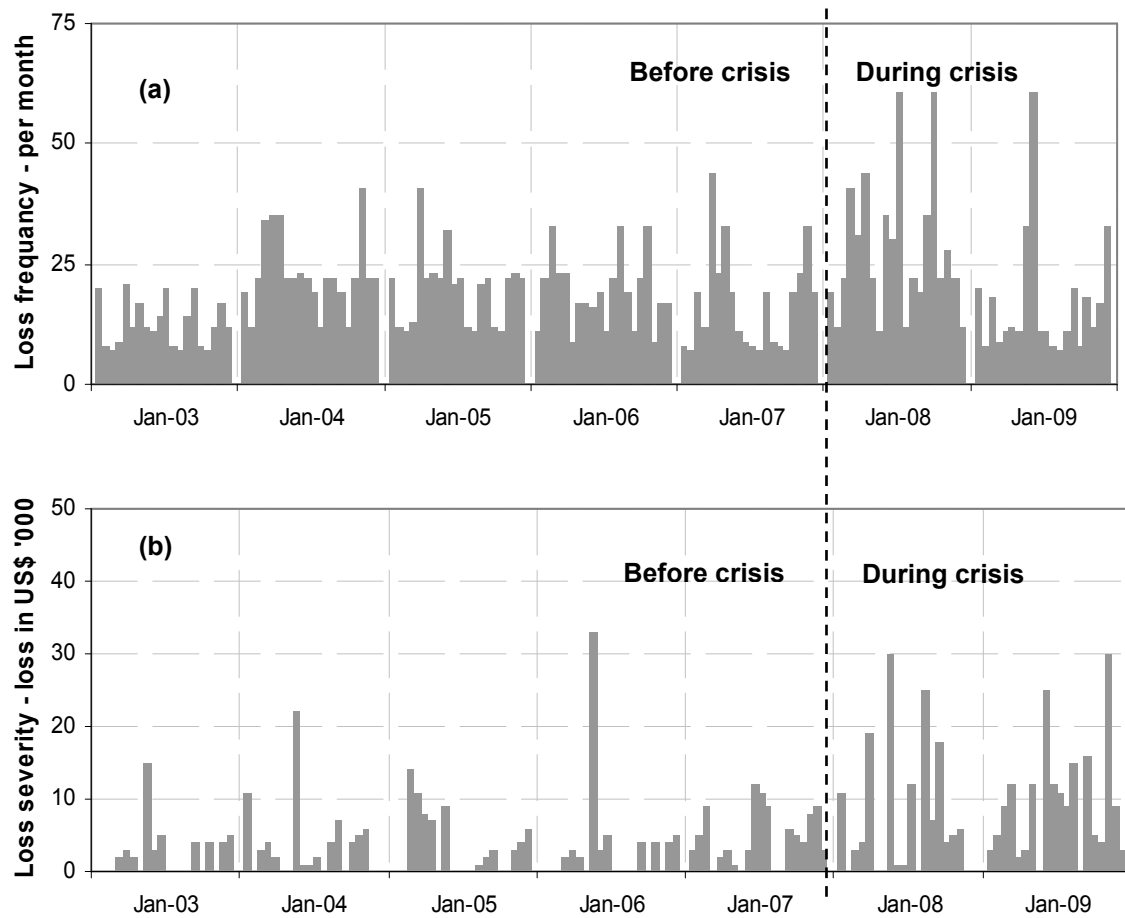


Source: Compiled by the authors from S & P's LossStats[®] Database

The average frequency of credit losses for banks using the SA in Figure 5(a) increases and this can also be seen in Figure 4, where the average number of losses per year also shows an increase from 331 to 465 losses per year (40% increase), however there is very little movement in severity of these losses pre-and during the crisis as illustrated by Figure 4 and Figure 5(b). In summary, Figure 4 illustrates that although the average frequency has increased, the average severity has not increased by the same magnitude.

However, the same cannot be said for the credit losses for banks using the AA as illustrated in Figure 6(a) and (b). Figure 6(a) clearly indicates that there has been a significant increase in the average number of credit losses experienced during the crisis and this is further illustrated in Figure 4 where the average number of losses per year increased from 230 to 362, which is a 58% increase.

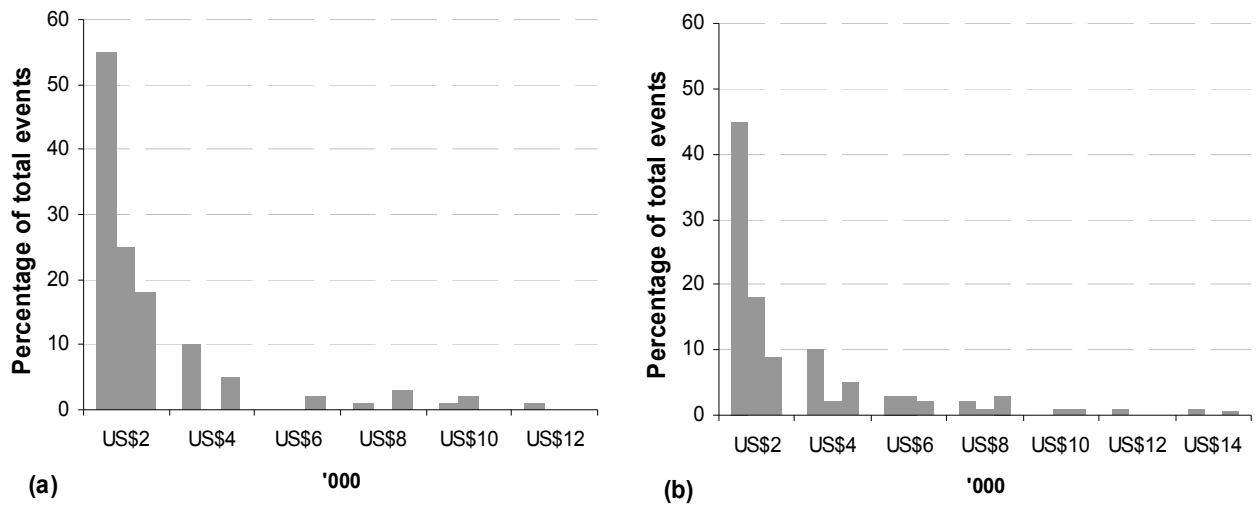
Figure 6a and b: Monthly credit loss (a) frequency and (b) severity for the periods under investigation for banks using the AA



Source: Compiled by the authors from S & P's LossStats[®] Database

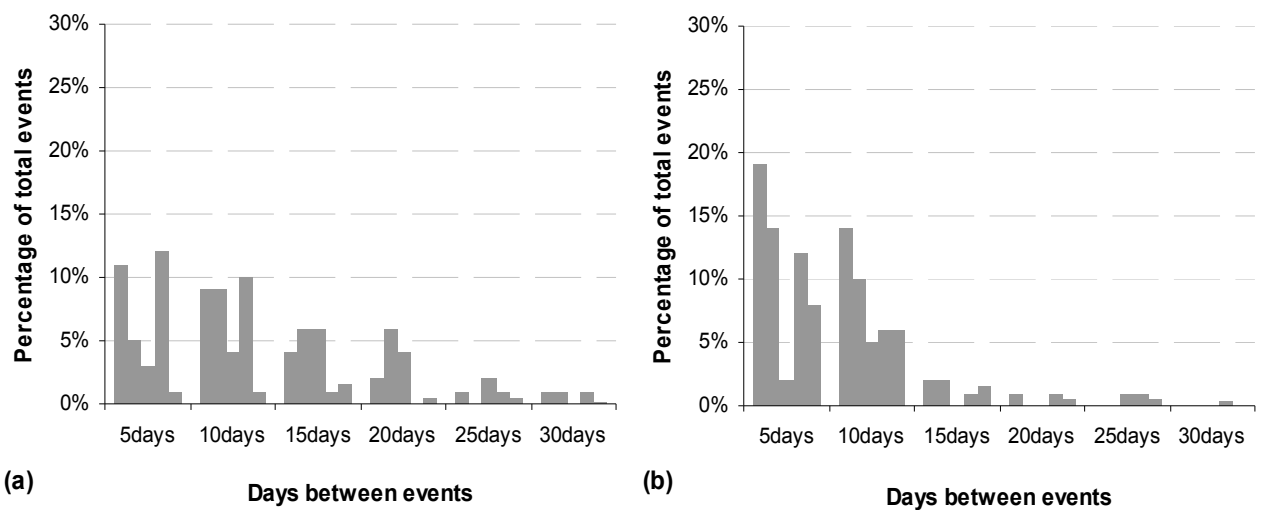
Frequency distributions of loss events for banks using the SA (measured as events per month) before and during the crisis are shown on Figures 7(a) and (b) respectively. These show many similarities – a concentration of low severity losses and a few large outliers, or tail events. The inter-arrival time of loss events for banks using the SA – also measured before and during the crisis – are shown in Figures 8(a) and (b) respectively. Before the crisis the loss events were evenly spread out and with the majority of the events occurring within 10 to 15 days from each other. During the crisis the distribution becomes bimodal with prominent peaks in the 5 and 10 day categories. Both Figures 7(a) and (b) and Figures 8(a) and (b) again illustrates that the frequency of losses for banks using the SA has shown an increase during the crisis.

Figure 7a and b: Loss severity for banks using the SA – histograms and distributions for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors from S & P's LossStats® Database

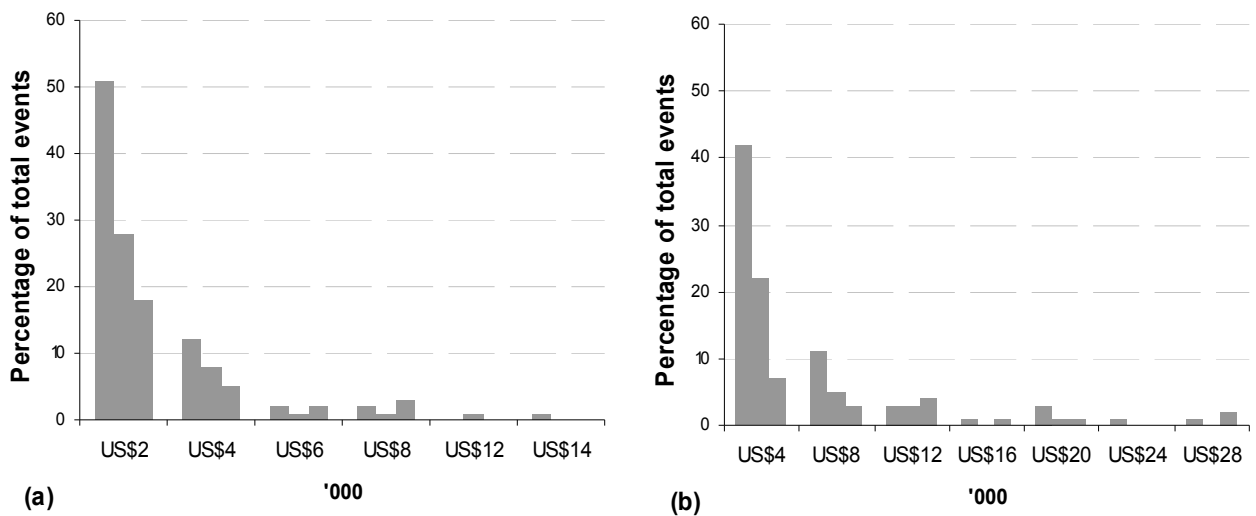
Figure 8: Inter-arrival time distribution of credit losses for banks using the SA for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009.



Source: Compiled by the authors from S & P's LossStats® Database

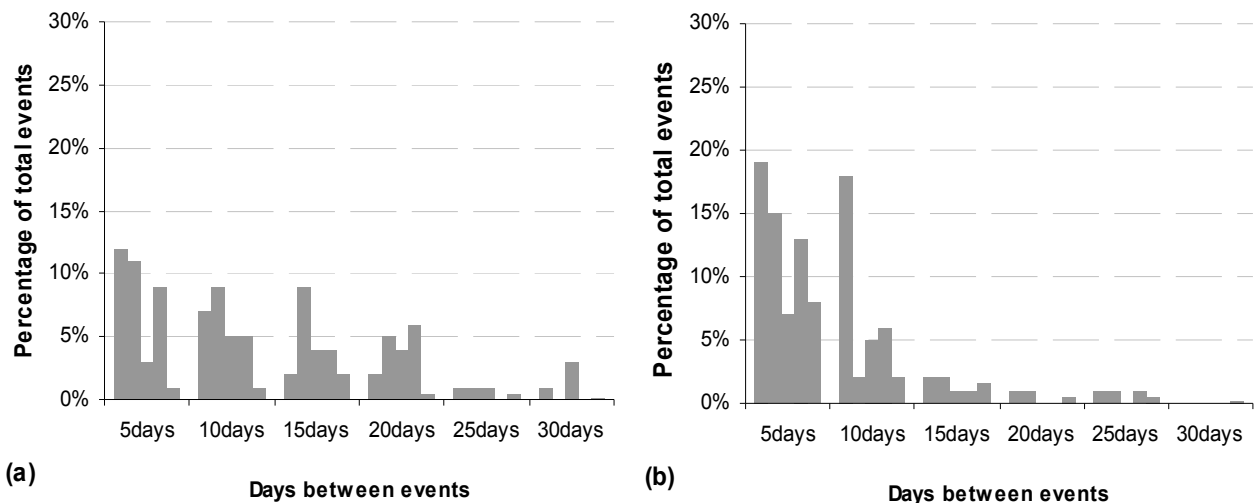
The frequency distribution of loss events for banks using the AA (measured as events per month) before and during the crisis are shown on Figures 9(a) and (b) respectively. Both these show a concentration of low severity losses; however Figure 9(b) shows significant increases in the number of outliers – tail events, which indicates an increase in severity. The inter-arrival time of loss events for banks using the AA – also measured before and during the crisis – are shown in Figures 10(a) and (b) respectively. Before the crisis the loss events were evenly spread out and with the majority of the events occurring within 10 to 20 days from each other. During the crisis the distribution becomes bimodal with prominent peaks in the 5 and 10 day categories. Both Figures 9(a) and (b) and Figures 10(a) and (b) again illustrates that the frequency as well as severity of losses for banks using the AA increased during the crisis.

Figure 9: Loss severity for banks using the AA – histograms and distributions for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009



Source: Compiled by the authors from S & P's LossStats® Database

Figure 10: Inter-arrival time distribution of credit losses for banks using the AA for the period (a) January 2003 to June 2007 and (b) July 2007 to July 2009



Source: Compiled by the authors from S & P's LossStats® Database

In summary, although most banks experienced an increase in the number and the value of credit losses, the Basel II approaches did protect banks during the financial crisis but it can clearly be seen that the SA was much more successful than the AA. The reason why it seems that that the SA was much more successful in protecting banks during the crisis is that although the frequency of losses increased for banks suing the SA, the severity relatively remained the same. However, the same cannot be said for banks using the AA as the frequency also increase but the losses also became much more severe, which is not the case with the SA.

Table 5: Summary statistics and goodness of fit test results of the frequency and severity distributions respectively.

		Distribution	Kolmogorov Smirnov		Anderson Darling		Chi-Squared		Parameters		
			Statistic	Rank	Statistic	Rank	Statistic	Rank	k	μ	σ
SA pre crisis	Frequency	Gen extreme value	0.148	1	0.286	2	N/A		0.5733	0.238	0.328
		Normal	0.169	3	0.348	3	N/A		0.5896	0.255	0.332
	Severity	Pareto	0.448	1	8.888	1	23.224	2	α	β	
		Frechet	0.586	2	9.227	2	55.212	1	0.986	0.039	
SA during crisis	Frequency	General pareto	0.521	1	3.221	1	25.221	2	k	μ	σ
		Gen extreme value	0.647	2	3.917	2	27.354	3	0.946	0.044	0.001
	Severity	Weibull	0.072	1	41.902	1	37.322	1	0.9532	0.232	0.236
		Frechet	0.099	2	48.212	3	40.231	2	α	β	
AMA pre crisis	Frequency	Gen extreme value	0.606	1	1.816	1	11.072	2	0.382	0.532	
		Gen pareto	0.622	2	1.821	2	12.222	3	0.466	0.487	
	Severity	Gamma	0.486	1	2.542	1	13.912	1	k	μ	σ
		Weibull	0.509	2	2.687	2	16.332	2	0.252	0.273	0.361
AMA during crisis	Frequency	Gen pareto	0.102	1	5.395	1	29.325	1	0.261	0.278	3.771
		Gen extreme value	0.111	3	5.8941	2	29.778	2	α	β	
	Severity	Frechet	0.139	1	11.901	1	29.113	1	1.102	0.0544	
		Weibull	0.172	2	13.221	3	29.728	2	1.126	0.0584	

Source: Compiled by the authors.

In Table 5 above, three different 'fitting techniques' were used to determine which distribution fits the data the best and have provided a ranking to each – this means that the distribution with the lowest ranking out of all the three fitting techniques fits the data best. This technique helps to determine which distribution is best to use for modelling a severity and frequency distribution to a specific dataset. This paper has found that the General Extreme Value Distribution has fitted the frequency distribution the best and the Frechet Distribution has fitted the severity distribution the best. (Although the Gamma Distribution and the General Pareto Distribution also fit the data well as indicated in Table 5, the authors have decided to use the above distributions as they have previously done distributions via these and they have shown the required accuracy and reliability. The recommendation is that future research can make use of the other distribution approaches). The above added value to the outcome of this study as it assisted the authors in identifying the best approach to use to transform the data into meaningful results.

5. CONCLUSION

Since the start of the economic crisis in July 2007 numerous banks have written down substantial credit losses and in many cases banks have failed completely. Criticism has been levelled at (among others) Basel II's methodologies for measuring credit risk: it is widely believed that the complex advanced approaches are too complex, introduce perverse incentives to banks, permit 'capital allocation arbitrage' and encourage lax lending standards. This paper investigated the soundness of the Basel II approaches to assessing, measuring and managing credit risk during two very different periods of market stability – pre and during the ongoing credit crisis. Whether the methodologies were adequate in assigning adequate capital fell outside the scope of this paper; instead attention was focussed on the methodologies for assessing credit risk.

The literature research and investigation that were done for this paper have found that most of these methodologies for assessing credit risk under the advanced approaches were based on complex mathematical and statistical principles, however it was not these principles that were challenged but more the applicability of these methodologies to 'adapt' to extreme market conditions. Some of the possible reasons discussed in this paper for the failure of these advanced methodologies include the lack of adequate 'stressed' data, too much reliance on external parties, for example rating agencies and auditing firms, who themselves were reliant on mathematical and statistical data in order to provide guidance to banks,⁸ the financial engineers responsible for model construction were mathematically competent but economically naive, i.e. unable to comprehend the impact and the knock-on effects of extreme market conditions and inadequate time allowed between model construction and testing and model implementation by banks. Furthermore, the ability of these models to adjust in very volatile markets and the signing off by regulators of internal models and methodologies who also did not always understand the model machinations can also be seen as possible reasons for the failure of these advanced methodologies.

To assess whether the methodologies employed under the SA were more successful than those employed under the AA, data were sourced from eight international retail banks (four using the SA and four using the AA approach). The frequency and severity distributions of credit losses from these banks were produced and analysed. For banks using the SA, the average frequency increased from pre to during the crisis; however the average severity remained stable with only a slight increase in the average value. For banks using the AA, the average frequency as well as average severity increased from pre to during the crisis, which means that not only has the average number of events increased, but they became also much more severe.

What the above then implies is that although several market participants were eager to blame Basel II for the financial crisis, it can be said that in most cases that compliance with the Basel II accord actually protected banks in the economic crisis. The SA enjoyed greater success than the AA: the main reason for the failure of the AA being the complex methodologies on which it relies to assess credit risk.

Many banks, while still meeting Basel I minimum requirements, had already reviewed their credit standards in order to make them consistent with the incoming Basel II discipline (and ultimately being Basel II

⁸ This paper is by no means implying that Rating Agencies or Audit Firms were to blame for the failure of the Advanced Approaches, but more that banks and other financial institutions were too reliant on the input from them and did not use enough internal resources to build and test these methodologies.

AA complaint). It is therefore likely that some banks, in an attempt to transform well established credit processes and risk management methodologies, may have misjudged the actual exposures to new risk types (or new manifestations of traditional risks). This does not imply that the new framework should be discarded, but rather it confirms the need for the 'testing' phase of the new rules to be a more rigorous affair. Furthermore, with regards to simplified supervisory tools, such as the 'leverage ratio', which are becoming increasingly popular, the authors do believe that these are likely to raise the same problems posed by Basel I (e.g. the low sensitivity to risk). While it cannot exclude that such tools could be used as a complement to Basel II, especially during stressed times when internal models are not fully reliable, the authors are sceptical that they can serve as a full substitute for a risk sensitive regulation.

The solution may not lie in drafting new rules (under Basel III), but possibly in less of a reliance on complex mathematical and statistical models when assessing credit risk, and more of a focus on experience and client knowledge.

REFERENCES

- ALLEN, L. and Bali, T., 2007. Cyclicalities in catastrophic and operational risk measurements, *Journal of Banking and Finance*, 31, 1191 – 1235.
- BCBS, 2001. Consultative Document: Operational risk, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbzca07.pdf>, accessed June 3, 2009.
- BCBS, 2006a. International convergence of capital measurement and capital standards, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbcs111.htm>, accessed June 22, 2009.
- BCBS, 2006b. Observed range of practice in key elements of advanced measurement approaches (AMA), Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbs131.htm>, accessed August 3, 2009.
- BCBS, 2009. Consultative proposals to strengthen the resilience of the banking sector announced by the Basel Committee, Bank of International Settlements. Internet: <http://www.bis.org/press/p091217.htm>, accessed January 11, 2010.
- BENINK, H. and Kaufman, G., 2008. Turmoil reveals the inadequacy of Basel II, *Financial Times*, 28 February 2008.
- BII, 2009. BIS2 – Best practices for BIS 2 implementation. Internet: http://bis2information.org/content/Credit_Loss_Distribution, accessed October 5, 2009.
- CANNATA, F. and Quagliariello, M., 2009. The role of Basel II in the sub-prime financial crisis: guilty or not guilty? *Garefin Working paper*. University of Bocconi, Milan, Italy.
- CNN MONEY.COM. 2009. List of Bailed out Banks. Internet: <http://money.cnn.com/news/specials/storysupplement/bankbailout/>, date accessed: October 8, 2009.
- COLANDER, D., Follmer, H. and Haas, A., 2009. The financial crisis and the systematic failure of economics. *Kiel working paper*. Kiel Institute for the World Economy. Kiel, Germany.

- DAILY Kos**, 2009. When did the financial crisis really start? Internet: <http://www.dailykos.com/story/2009/2/12/125228/516/46/696617>, accessed August 1, 2009.
- DIAMOND, D. W.** and Rajan, R. D., 2009. The Credit Crisis: Conjectures about Causes and Remedies, *American Economic Review*, American Economic Association, 99, 2, 606 – 60.
- ESTERHUYSEN, J.**, 2007. The management of operational value at risk (OpVaR) in banks. PhD dissertation, North West University, Potchefstroom, South Africa.
- GRIFFIN, C.**, 2008. Basel II capital, adequacy regulations and the credit crisis – cause or cure? Internet: <http://www.charteredaccountants.ie/en/Members/Technical1>, accessed September 4, 2009.
- MONEYWEEK**, 2007. Is this the start of the credit crisis? Internet: <http://financialmediaandcomms.blogspot.com/2008/09/global-credit-crunch-when-did-it-start.html>, accessed on May 19, 2009.
- ONADO, M.**, 2008. Capital is a problem. Internet: <http://www.lavoce.info>, accessed September 19, 2009.
- REPULLO, R.** and Suarez, T. 2008. The procyclical effects of Basel II. IMF Ninth Annual Jacques Polak Research Conference, IMF, Washington DC. Internet: <http://www.imf.org/external/np/siminars>, accessed November 13, 2009.
- SOROS, G.**, 2008. The new paradigm for financial markets: the credit crisis of 2008 and what it means, *PublicAffairs*, USA, 15 May 2008.
- STANDARD & POOR'S**, LossStats[®] Database, Internet: <http://www2.standardandpoors.com/portal/site/sp/en/eu/page.product/riskolutions>, accessed November 13, 2009.
- STYGER, P.** and Vosloo P.G., 2005. The bankers guide to the Basel II framework. *The Banking Association of South Africa*, Johannesburg, SA.
- SUBRAMANIAN, A.**, 2009. The world crisis: reforming the international financial system. *Economic and political weekly*, Mumbai, India. Internet: <http://www.piie.com/publications/papers/subramanian>, accessed September 2, 2009.
- THE ECONOMIST**, 2008. *Confessions of a risk manager*, August 7th 2008 print edition.
- ZINGALES, L.**, 2008. "La sospensione del market-to-market" ("The suspension of market-to-market"), *Il Sole24Ore*, 15 October (translation from the Italian version).

CHAPTER 4 – THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON SYSTEMIC RISK WITHIN THE SOUTH AFRICAN BANKING SECTOR

THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON SYSTEMIC RISK WITHIN THE SOUTH AFRICAN BANKING SECTOR

JA'NEL ESTERHUYSEN,^{*} GARY VAN VUUREN[†] and PAUL STYGER[‡]

ABSTRACT

The credit crisis resulted in increases in credit, market and operational risk, but it may also have precipitated a surge in systemic risk. Measuring systemic risk as the price of insurance against distressed losses in the South African banking sector, this article attempts to determine whether the financial crisis has in fact resulted in an increase in systemic risk. Using probabilities of default and asset return correlations as systemic risk indicators, it is found that the financial crisis *has* indeed increased systemic risk in South Africa. The impact was, however, less severe than that experienced in other large international banks.

JEL Classification: C46, G21, G32.

Key words: Portfolio credit risk, systemic risk, credit crisis an systemic risk indicator.

1. INTRODUCTION

The financial crisis that started in 2007 and widely believed to have been triggered by liquidity shortfalls in the US caused the collapse of several large financial institutions and many bank bail outs by global sovereigns. The crisis precipitated a corresponding collapse of international stock markets which, although eroding value in all sectors, the most deeply affected was the financial sector. Many economists believe the credit crisis to be the worst since the Great Depression of the 1930s: the crisis has contributed to the failure of key businesses, a severe decline in consumer wealth, resulted in considerable commitments by governments and led to a significant decrease in economic activity (Altman, 2008). Many large financial institutions have been the subject of takeovers by relevant sovereigns, including – amongst others – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group, AIG. Many reasons have been posted for the crisis, the most common being the bursting of the US housing bubble, which resulted in high default rates on subprime and adjustable mortgages (Altman, 2008:2) and led to severe contagion effects which rapidly eroded market confidence. Furthermore, a series of factors caused the financial system to both expand and become increasingly fragile, a process known as *financialisation*¹ which policymakers did not recognise nor did they acknowledge the increasingly important role played by financial institutions (such as investment banks and hedge funds, also known as the shadow banking system) (Huang *et al*, (2010)). Some researchers believe these institutions had become as important as commercial (depository) banks in providing credit to the US economy, but they were not subject to the same regulations (Altman, 2008:2).

Another interpretation, different from the mainstream explanation, is that the financial crisis is merely a symptom of another, deeper crisis, i.e. a systemic crisis of capitalism itself. According to Amin (2008), the

^{*} Absa Capital: Investment Bank Division of Absa Bank, 15 Alice Lane, Sandton, 2196, South Africa. Paper submitted as partial fulfilment of the requirements for the degree of PhD in Economics at the North-West University, Potchefstroom Campus.

[†] North-West University Potchefstroom Campus, Potchefstroom, 2520, North-West Province, South Africa.

¹ Financialisation is defined as the increasing role of financial motives, financial markets, financial sectors and financial institutions in the operating of domestic and international economies (Epstein, 2005: 3).

constant decrease in GDP growth rates in Western countries since the early 1970s created a growing surplus of capital which did not have sufficient profitable investment outlets in the real economy. The alternative was to place this surplus into the financial market, which became more profitable than productive capital investment, especially with subsequent deregulation. This phenomenon has led to recurrent financial bubbles (such as the internet bubble of the early 2000s) and it is believed to be a deep cause of the financial crisis of 2007-2010 (Amin, 2008: 4).

In addition to the above, Huang *et al*, (2010) argue that systemic risk² might have played a bigger role in the financial crisis than was initially believed, particularly in the banking sector as this sector is highly interconnected with almost all other banks which constantly lend to and provide security for each other. Almost no bank can be viewed as stand-alone within its sector in the current financial milieu. Examples of this are recent bank failures since the beginning of the financial crisis – a problem which began with Northern Rock, a large UK building society, which actively competes with banks for most personal banking services, especially mortgage lending and deposit accounts, requested security from the Bank of England in November 2007. Over 100 mortgage lenders in the US filed for bankruptcy in May 2008 shortly after Northern Rock's request for security: Bear Sterns was sold to JP Morgan in March 2008 as two of the company's main hedge funds lost almost all of their value (US\$6.2 billion) which caused severe liquidity issues for the company and then several global banks requested government intervention and ultimately bailout (Esterhuysen *et al*, 2010). These facts provide evidence that international banks influence each other even if they do not operate in or originate from the same country. The crisis has demonstrated that banks are not independent: the failure of one bank in a specific market has led to severe contagion effects as investors quickly come to believe that other banks in the same market may also be experiencing difficulties which led to ripple effects or, in common parlance, *systemic* effects on the banking sector. The increase in the perceived systemic risk, particularly after the failure of Lehman Brothers, was mainly driven by heightened risk aversion and reduced liquidity (Esterhuysen *et al*, 2010).

There is a renewed drive to measure systemic risk in the banking sector in the light of these connected failures or at least to define a systemic risk indicator for the banking sector. Huang *et al* (2010) argued that a summary indicator of market perceived risk, that reflects expected default risk of individual banks, risk premia and correlated defaults, was needed. The systemic risk measure that Huang *et al* devised was the insurance cost to protect against distressed losses in a banking system. During the last decade there have been few researchers capable of developing an adequate approach to measure systemic risk,³ however it is the view of the authors that the approach developed by Huang *et al*, (2009) is the most adequate as it employs real-time market data.

² Systemic risk is defined as multiple simultaneous defaults of large financial institutions (Huang *et al*, 2010).

³ See for example Lehar (2005) and Siegel (1995).

Contributory factors to the real-time aspect of this systemic risk measurement are that it is based on forward-looking price information of two highly-liquid markets: credit default swap (CDS)⁴ spreads and equity prices of individual banks. Both these parameters are available on a daily basis in real time and, using these, it is possible to derive the risk neutral probabilities of default (PDs) for individual banks and asset return correlations between CDS spreads and equity returns (Huang *et al*, 2009). The aim of this article is to use this approach to measure systemic risk in the South African banking sector before and during the financial crisis and to determine whether the financial crisis had a systemic effect on this sector.

An early problem encountered with the direct application of Huang *et al's* model to the South African banking sector is that only one South African bank reports CDS data. It is thus impossible to use CDS spreads to derive risk neutral PDs. *Physical* PDs – based on expected default frequencies (EDFs)⁵ – will be used instead for the eight South African banks, currently listed on the Johannesburg Stock Exchange (JSE), and also to derive default correlations (indirectly) by estimating the underlying asset return correlation from equity or credit market data for these banks. Data are provided by Moodys KMV. Another difference between the model Huang *et al* (2009) developed and the one employed in this study is that the former employed data from a minimum of 12 banks unlike the eight banks used for the South African study. The systemic risk measurement model is then based on the key parameters: PDs and asset return correlations⁶ of the individual banks. Each of these parameters and their relevance to the systemic risk measurement model are explained in detail in Section 2.

The remainder of this paper is arranged as follows: Section 2 provides a brief literature study of the methodology used to measure systemic risk in the South African banking sector before and after the crisis. A description of the data employed in the study is presented in Section 3 and the subsequent analysis of these data follows in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

The two key parameters for assessing and measuring systemic risk in the banking sector are the bank PDs and asset return correlations of the individual banks in the sector. The way in which these are used to calculate the price of insurance against distress and large losses in the banking sector is discussed in this section. The PD (also known as Expected Default Frequency or EDF) is the likelihood that a loan will not be repaid and will default (Duffie & Singleton, 2003). The credit history of the counterparty/portfolio and nature of the investment are taken into account to calculate the PDs. Default probabilities are estimated from historical data of actual defaults using logistic regression, but may also be estimated from observable credit default swap prices and bonds and options on common stock (Duffie & Singleton, 2003). Basel II

⁴ A credit default swap (CDS) is defined as a specific kind of counterparty agreement, which allows the transfer of third party credit risk from one party to another. One part in the swap is a lender facing credit risk from a third party, and the counterpart in the credit default swap agrees to ensure this risk in exchange of regular periodic payments (essentially an insurance premium) (Duffie, 1999).

⁵ An Expected Default Frequency (EDF) is defined as the probability of default calculated for a one year horizon for a specific counterparty (Dwyer *et al*, 2007).

⁶ These asset return correlations are the correlation of one bank's return on its issued share capital or equity to another bank's return on its share capital or equity in the same banking sector or region.

requires banks to estimate 1-year PDs based on long term averages (Duffie & Singleton, 2003): this may be achieved by generating annual pseudo-obligor pools⁷ in which each obligor is placed according to its rating at the beginning of the year and taking the average of the pools (a minimum of five years is required for Basel II).

Table 1 presents an example of how to derive PDs using pseudo-obligor pools. Using this method, banks may compute transition probabilities or cumulative, multiyear PDs. Duffie and Singleton, (2003) argued that one limitation of this method lies in the size of the pools as most banks do not have sufficiently large credit portfolios to be able to estimate PDs with adequate granularity. For example, 100 obligors in a single rating grade will enable PDs to be calculated as a multiple of 1%, 200 obligors of 0.5%, 1 000 obligors of 0.1%. The smaller the number of obligors, the more volatile the PD estimation.

Table 1: Example of using pools to calculate PDs in the Asian financial sector. Average PDs are obligor-weighted.

Rating	2005			2006			Average PD
	Obligors	Defaults	PD	Obligors	Defaults	PD	
AA	100	0	0.0%	120	1	0.8%	0.44%
A	200	1	0.5%	190	2	1.1%	0.79%
BBB	300	3	1.0%	330	4	1.2%	1.10%
BB	400	5	1.3%	420	6	1.4%	1.35%
B	200	8	4.0%	180	8	4.4%	4.19%
CCC	100	15	15.0%	80	14	17.5%	16.11%

Source: (Duffy & Singleton, 2003).

There are various different types of models whereby the PDs for a specific financial institution can be calculated and these have been rapidly advanced since the introduction of Basel II's 'advanced' credit risk measurement approaches. One of the most common used models for calculating PDs for public firms is the Moody's KMV EDF model, according to which a firm defaults when the market value of its assets (the value of the ongoing business) falls below its liabilities payable (the default point) (Dwyer & Qu, 2007). Furthermore, there are three key values that determine a firm's EDF credit measure (Dwyer & Qu, 2007):

1. the current market value of the firms (market value of assets),
2. the level of the firm's obligations (default point), and
3. the vulnerability of the market value to large changes (asset volatility).

Dwyer and Qu (2007) argued that, because these are objective variables, EDF credit measures have consistently outperformed the rating agencies in distinguishing between defaulting and non-defaulting firms. In addition, they have proven to be a consistent leading indicator of agency rating upgrades and downgrades as the EDF value represents default information embedded in a company's share price combined with its

⁷ These pseudo-obligor pools are pools of PDs of specific counterparties/obligors where the names of the obligors are not known, but where the PDs are actual PDs.

latest financial statements (Duffie, 1999). The three key values described above play key roles in the estimation of firms' EDFs, hence the elaboration that follows.

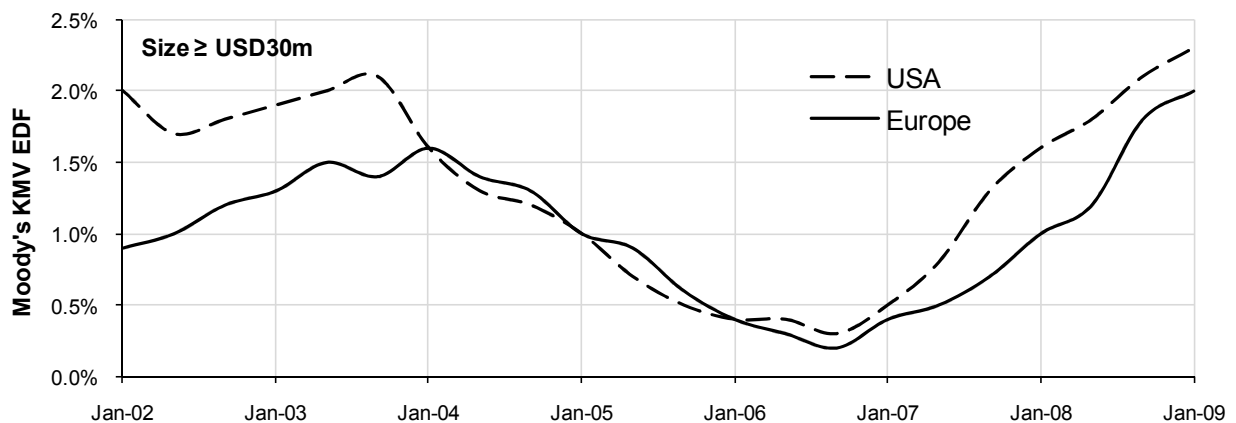
Market value of assets – establishes the market's view of the enterprise value of the firm, as determined by equity value, equity volatility and liability structure (Moody's KMV, 2008). Because the market value of assets is not directly observable, the Moody's KMV EDF model employs a proprietary option model to compute this value, which treats the firm's equity value as a call option on the firm's underlying assets, thereby enabling the model to estimate the market value of a firm's assets knowing only the market characteristics of its equity value and the book value of its liabilities.

Asset volatility – is a measure of the business risk of the firm, usually estimated as the standard deviation of annual percentage changes of the market value of the firm's assets. The higher the asset volatility, the less certain investors are about the market value of the firm and the more likely the firm's will value fall below its default point (Moody's KMV, 2008).

Default point – the default point is firm specific and is a function of the firm's liability structure. This value is calibrated using empirical research by Moody's KMV, which has explored thousands of defaulting firms, observing each firm's default point in relation to the market value of its assets at the time of default (Dwyer & Qu, 2007).

Figure 1 provides an example of Moody's KMV data and is based on actual EDF's for banks with an asset size $\geq$ US\$30m from the US and Europe for the last seven years.

Figure 1: Median Moody's KMV EDF for Europe and the US. Note the declining EDFs (PDs) from 2004 heralding the onset of the credit crisis.



Source: Moody's KMV, 2008.

Some important points from Figure 1:

- the vertical axis shows the EDF credit measure which may be either linear or logarithmic (in Figure 1, these are linear). When the scale is logarithmic, lowest EDFs are at the bottom and highest at the top,

- and if the vertical axis is logarithmic, seemingly small movements for high risk companies can be significant.

It is important to note how bank EDFs increase as the financial crisis gains momentum from 2007 onwards and that the European banks lag their US counterparts in EDFs. One possible reason for this is that the financial crisis began in the US (the first international banks that required a government bail-out were in the US) and flowed over to Europe, then further east – hence the lag in PDs. The South African banks followed a very similar trend, but they lagged behind the European banks. This is illustrated later in this section.

The second factor in the systemic risk measurement model is the asset default correlations of individual banks. These correlations may be indirectly derived by estimating the underlying asset return correlation from equity or market data. These correlations relate to how one financial institution's return on its issued shares (equity) reacts to another financial institution's return on its shares if the second institution has been impacted by a large credit loss or if the institution has defaulted or has failed. In other words, how correlated are the share price movements (or the return on the shares/equity) of institutions in the same sector if one of the institutions, or if the whole sector, has been impacted by an adverse credit risk event. What this is trying to demonstrate is how dependant or correlated the share price movements are for institutions in the same sector, which could be a possible measure of the systemic risk within that sector.

The logic behind this approach is that equity (or debt) may be thought of as representing a call (or put) option on the underlying firm's assets (Huang *et al*, 2009) so the co-movement between equity prices reflects co-movement between underlying asset values. The reason why asset/equity return correlations are used is that they provide a reasonably accurate view on the way in which a bank's share price reacts to large adverse events in the sector and the degree of correlation (correlation of one bank's share price to another or the return thereon within the same sector). This is to explore whether one bank's share price reacts to losses experienced by another bank and provides an indication of the systemic risk within the banking sector.

The systemic risk measurement model uses asset return correlations, derived from equity return correlations (correlation between one banks return on its equity to the others in the same sector), which are publicly available. Using Merton's (1974) framework, the market value of a firm's underlying assets follows a stochastic process is:

$$dV = \mu \cdot V \cdot dt + \sigma \cdot V \cdot dW \quad (1)$$

where:

V = is the firm's asset value,

μ and σ are the drift term and the volatility of the asset value respectively, and

W is a Wiener process.

The firm has only two types of liabilities: debt and equity and for debt (which has a book value of X and is due at time t), Merton (1974) shows that the equity value, E , may be determined using:

$$E = V \cdot N(d_1) - X \cdot N(d_2)e^{-rt}, \quad (2)$$

where:

$$d_1 = \frac{\log\left(\frac{V}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot t}{\sigma \cdot \sqrt{t}}$$

and

$$d_2 = d_1 - \sigma\sqrt{t}.$$

Under the assumption that r , σ and V/X are constant, the equity value is proportional to the asset value ($E \propto V$) since both d_1 and d_2 are constant and $X \propto V$, thus, $d(\log(E)) = d(\log(V))$, where $d(\dots)$ represents the first difference. The equity return correlation, under this condition = the asset return correlation:

$$\text{corr}(d[\log(E_1)], d[\log(E_2)]) = \text{corr}(d[\log(V_1)], d[\log(V_2)]). \quad (3)$$

This article describes how to build a systemic risk measurement model from the one developed by Huang *et al*, (2009) in that

1. it employs physical PDs rather than risk-neutral PDs as a result of the lack of suitable CDS data in the South African banking sector and
2. use will be made of *equity* return data of the South African Banks to derive *asset* default correlations.

Pollet and Wilson (2006) presented the following reasons for using equity return correlations as a proxy for asset return correlations:

- equity is the most liquid type of asset traded in the market. Changes in market conditions and default risk of an entity will be immediately reflected in its share price movements and
- tick-by-tick data are only available in the equity market. The advanced technology regarding high frequency data analysis described in the literature makes it possible to compute reliable realised correlations of one banks return on its equity compared to another in the same sector over short time horizons that were impossible for daily observations.

Using equity return correlations as a proxy for the asset return correlations may also be defended by the fact that, when the firm's leverage is constant, the asset return correlation equals the equity return correla-

tion and when the firm leverage is time-varying, the relationship breaks down and the magnitude of the discrepancy depends on the co-movement between assets returns and leverages and co-movements between changes in the firm's leverage as well. The systemic risk measurement model also uses forecasted asset return correlations to measure portfolio credit risk in that it makes it consistent with the PD measure and therefore the indicator for systemic risk is forward-looking. For the South African banking sector, however, the PD will not be forward looking but rather 'real-time'.⁸ In forecasting the asset return correlation over the next period, for example the next quarter, the model derives the relationship between future realised correlations (*ex post* reserved) and the current period (quarterly and weekly) correlations (Huang *et al*, 2009):

$$p_{t,t+8} = c + k_1 p_{t-8,t} + \sum_{i=1} k_{2i} \cdot p_{t-i,t-i+1} + \eta X_t + \nu_t \quad (4)$$

where:

p = the average asset return correlation of bank i on day t and the subscript $t,t+8$ refers to the time horizon (one week as one unit) to calculate the correlations for eight banks,

X = includes a list of market variables,

k = unit price of correlation risk

ν_t = the number of observation intervals.

c = *ex post* reserved indicator.

η = linear predictor for the independent variables X , which in these case are the market factors

Driessen *et al*, (2006) derived a market based, forward-looking correlation measure (one bank's return on its equity compared to another in the same sector) from the option market. However, option-implied correlations may only be calculated for portfolios in which both the index and the individual entities are actively traded in the option market. The application of this approach is quite limited for the purposes of this exercise of measuring systemic risk.

The next step in the systemic risk measurement model is to build a systemic risk indicator from the physical PDs and the asset default correlations of individual banks as illustrated in Figure 2. Once the two key portfolio credit risk parameters are known, it is possible to use the portfolio credit risk methodology⁹ to determine an appropriate indicator of systemic risk for a pre-defined group of banks. This article will not elaborate on how portfolio credit risk methodology works as it is well-researched and well-documented elsewhere.¹⁰ However, reference to it will be made as it explains how the systemic risk indicator is derived. The indicator of systemic risk is defined as the theoretical insurance premium that protects against distress

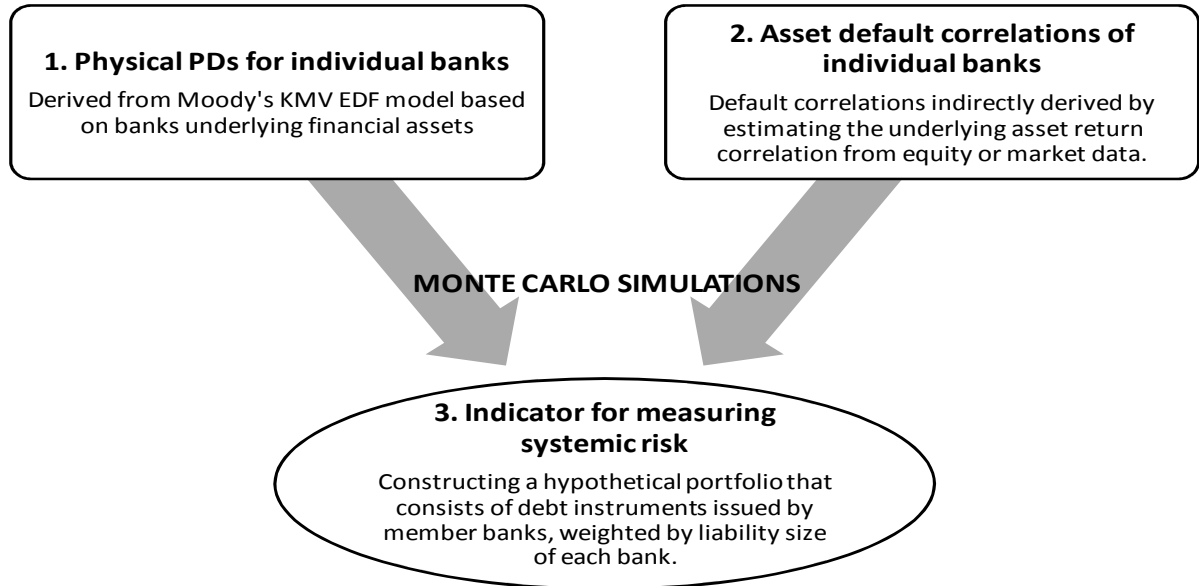
⁸ Only one SA bank provides market CDS spread data and therefore it will not be possible to derive a forward looking PD from these spreads and therefore the model used in this paper will make use of physical PDs, as the majority of PD models calculate PDs for a specific point in time (PIT), which is regarded as more "current" than forward-looking.

⁹ For more detail on the portfolio credit risk methodology see Gibson (2004), Hull and White (2004) and Tarashev and Zhu (2008a).

¹⁰ See Wilson (1998), Frey and McNeil (2003), and Glasserman (2005).

losses of this portfolio in the coming 12 weeks and it is calculated as the risk neutral expectation of portfolio credit losses that equal or exceed a minimum share of the sector's total liabilities (Huang *et al*, 2009). This indicator is chosen over a few alternative measures such as the probabilities of *joint* defaults, credit-value-at-risk (CVaR) and expected shortfalls.¹¹

Figure 2: The systemic risk measurement model.



Source: Compiled by the authors.

To calculate the systemic risk indicator the model developed by Huang *et al* (2009) relies on Monte Carlo simulations to estimate the unconditional probability distribution of credit losses. Under this method, the probability distribution, for example, of defaults in a portfolio of N entities can be derived as follows (Tarashev and Zhu (2008b)) :

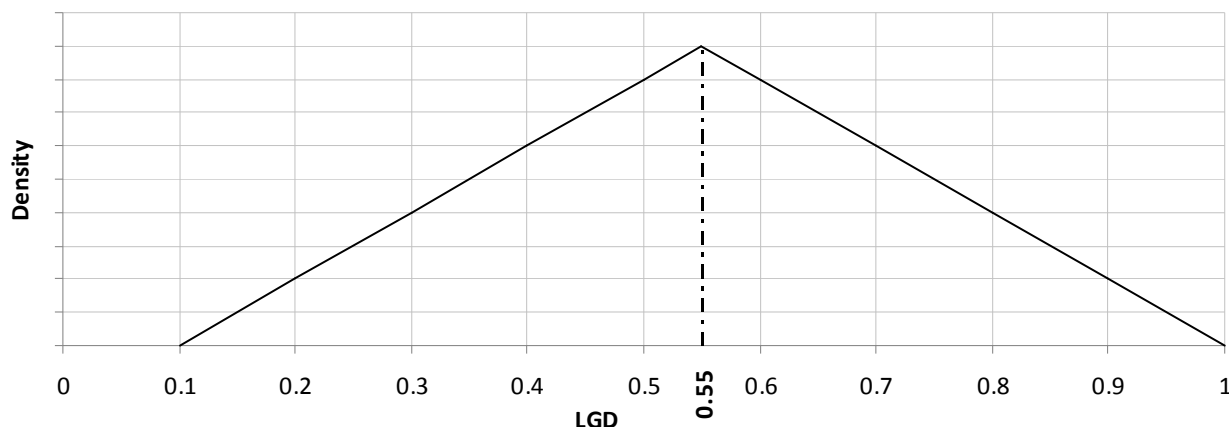
1. Generate N random, independent draws x_0 from the standard normal distribution.
2. Calculate $x = R'x_0$, where R denotes the Cholesky factor¹² of the estimated asset return correlation matrix for the N entities.
3. Denoting the i -th member of the x by x_i ($i=1 \dots N$) and the associated PD by $PD_{i,t}$ entity i is said to default if and only if $x_i < \Phi^{-1}(PD_{i,t})$.
4. Repeat steps 2 and 4 a large number of times to estimate the probability of $n \in \{0, \dots, N\}$ defaults.

¹¹ See for example Avesani *et al*, (2006) and Yamai and Yoshioka (2005).

¹² In linear algebra, the Cholesky decomposition or Cholesky triangle is a decomposition of a symmetric, positive-definite matrix into the product of a lower triangular matrix and its conjugate transpose. It was discovered by André-Louis Cholesky for real matrices and is an example of a square root of a matrix. When it is applicable, the Cholesky decomposition is roughly twice as efficient as the LU decomposition for solving systems of linear equations (Tarashev and Zhu (2008b)).

Furthermore, the paper then assumes that the loss given default (LGD)¹³ follows a stochastic distribution and is independent of the PD process. In particular, it assumes that LGD follows a symmetric triangular distribution with a mean of 0.55 and in range of [0.1,1.0] – the mean of LGD of 0.55 is derived from the Basel II IRB formula, which is also consistent with the data, see Figure 3.

Figure 3: Triangular distribution of the LGD with mean 0.55.



Source: Compiled by the authors.

There are only eight listed banks in South Africa, which results in a much smaller data pool than, e.g., the USA or Europe, which may have an impact on the results.

The first aim of this paper is to apply the systemic risk measurement model developed by Huang *et al*, (2009) to South African data and to determine whether a systemic risk indicator can be developed for the South African banking sector. Since one of the key inputs into the model – CDS spreads – is largely absent in the South African market, physical PDs will be used instead. The second aim is to determine whether the global financial crisis exerted an impact on the systemic risk of the South African banking sector. The systemic risk indicator will therefore be measured pre- and during periods of the financial crisis. The next section explains the data selection.

3. DATA

The proposed methodology, outlined in Section 2, is general and may be applied to any portfolio comprising entities with publicly tradable equities and where physical PDs are known. At present (June 2010), there are eight banks in the financial sector listed on the JSE. These are listed in Table 2.

The choice of July 2007 as the start of the credit crisis was justified in part by the first article which mentions the credit crisis by name (Moneyweek, 2007), but also by subsequent analysis that has shown that severe signs of weakness were evident (and becoming manifest) by late July 2007 (Daily Kos, 2009). The credit risk data were procured from the eight South African banks that are currently listed on the JSE.

¹³ The actual total loss that is experienced by a bank when a debtor defaults on a loan from that bank. The loss given default is not always equal to the total amount of the loan; for example, if the debtor pledged collateral against the loan, the bank could receive these assets, and their total loss would not be greater than the amount of the loan minus the value of the assets (Duffie, 1999).

- **PRE CRISIS**: the benign (from an economic point of view) four to five year period from January 2003 to June 2007 was characterised by low interest rates, low inflation, relatively new bank regulation regarding operational risk, explosive growth of credit (and other) derivatives, considerable loan securitisations, a huge demand for commodities such as oil and metals from India and China and low unemployment.
- **DURING CRISIS**: the turbulent two year period from July 2007 to December 2009 – i.e. from the onset of the credit crisis and characterised by almost non-existent interest rates, hugely diminished share markets, increasing taxes, a severe regulatory environment (for banks, regulators, rating agencies and so on) and rising unemployment.

Table 2: South African banks listed on the JSE (sorted by market capital).

Bank	Market Cap: ZAR bn
Standard Bank	156
ABSA	96
First Rand Bank	81
Nedbank	61
Investec Bank	28
African Bank Ltd	25
Sasfin Bank	25
Capitec Bank	3.2

Source: Compiled by the authors.

The EDFs (or PDs) for the eight banks in Table 2 were sourced from Moody's KMV over the six year period from January 2004 – January 2010 and a comparison of annual averages, highs and lows are shown in Table 3 below. Although the names of the banks used in this study are mentioned in Table 2, the rest of the analysis will not display bank names since approval to make these results public was not obtained.

Table 3: PD and Rating statistics for eight South African banks over the period January 2004 – January 2010 sorted by average PD ratings.

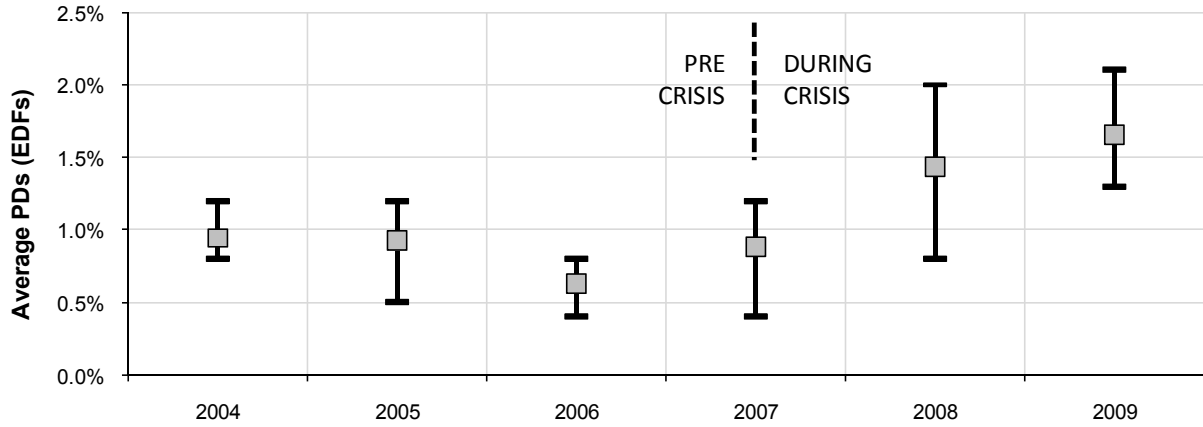
Bank	PD Ratings			Rating Agency equivalent (Fitch)		
	High (%)	Average (%)	Low (%)	Low Rating	Average Rating	High Rating
1	0.25	0.18	0.11	BBB	BBB+	A
2	0.31	0.21	0.17	BBB-	BBB	BBB+
3	0.28	0.21	0.17	BBB-	BBB	BBB+
4	0.28	0.22	0.16	BBB-	BBB	BBB+
5	0.3	0.24	0.19	BBB-	BBB	BBB+
6	0.39	0.28	0.22	BBB-	BBB	BBB+
7	0.41	0.31	0.30	BBB-	BBB	BBB+
8	0.38	0.34	0.28	BBB-	BBB	BBB+

Source: Compiled by the authors.

4. ANALYSIS

The first step in calculating the systemic risk indicator for a banking sector is to determine the PDs (EDFs) of individual banks: a summary of the annual averages appears in Figure 3 for the six years from January 2004 to January 2010. These increased as the severity of the impact of the financial crisis increased.

Figure 4: Observed average PDs (and highs and lows) for eight South African banks over the last 6 years.



Source: Compiled by the authors.

The actual data used in Figure 4 comprise 1 152 data points: these are weekly PDs for the eight banks recorded over six years. The next step in the systemic risk measurement model is to forecast asset return correlations. The one week and one quarter realised correlations (i.e. the correlation of one bank's return on its assets to the other seven banks' return on their assets – where the return on assets is expressed as return on share equity) are illustrated in Figure 5. Table 4 illustrates the determinants of future (forecasted/simulated) asset return correlations measured by equity return correlation observed in the next quarter. The data used comprise all transaction data for the shares of the eight banks traded on the JSE. The last price observation in the previous 30 minute interval was used as the price of the 30 minute mark and the 30 minute geometric returns were then computed by taking the difference between two adjacent logarithmic prices. For example, the last price in the previous 30 minute mark was R55, thus the 30 minute price is R55. The last price in the next 30 minute interval is R57, which means the geometric return for that 30 minutes will be the logarithmic difference between the R55 and the R57 prices. The asset/equity return correlations used in the model are the correlations between one bank's geometric return on its equity in 30 minutes to the other seven banks return on their equity within the same 30 minutes.

It is important to understand how to estimate the realised correlation between the return on the assets of one bank compared to another (in this case the correlation of the eight banks' within this data pool return on assets/equity). Consider the following: the vector of the logarithmic prices of the eight shares, $p(t)_{8 \times 1}$ is assumed to be a 8-dimension semi-martingale (SM) by the no-arbitrage condition $t \geq 0$ that denotes con-

tinuous time, with the no-arbitrage condition requiring that there be no market risk involved over a continuous time period. Then the log price, $p(t)$, may be written as:

$$p(t) = a(t) + m(t) \quad (5)$$

where:

$a(t)$ = is the drift with finite variation and

$m(t)$ = is the diffusion.

Assume that there are M equally spaced observations for each h time period. In this study it is assumed that h can be one day, one week or one quarter. Corresponding to the 30 minute-sampling interval, M takes the values of 12, 60, or 8640. Then i th period and j th return is a 12×1 vector, computed as:

$$r_{ij} = p\left[(i-1)h + \frac{hj}{M}\right] - p\left[(i-1)h + \frac{h(j-1)}{M}\right] \quad (6)$$

where:

$j = 1, 2, \dots, M$.

The realised correlation coefficient, $\hat{\rho}_{(kl),j}$, for the i^{th} period between share k and l is:

$$\hat{\rho}_{(kl),j} = \frac{\sum_{j=1}^M r_{(k),j,i} r_{(l),j,i}}{\sqrt{\sum_{j=1}^M r_{(k),j,i}^2 \sum_{j=1}^M r_{(l),j,i}^2}} \quad (7)$$

Barndorff-Neilson and Sheppard (2004) proposed the asymptotic theory underlying the above realised correlation measure, in particular they show that $\hat{\rho}_{(kl),j}$ is consistent for the unobserved population correlation coefficient $\rho_{(kl),j}$ as the sampling frequency goes to infinity.

$$\hat{\rho}_{(kl),j} \xrightarrow{M \rightarrow \infty} \rho_{(kl),j} \quad (8)$$

If the price process is a continuous stochastic volatility semi-martingale, that is – there are no jumps in the price process, Barndorff-Neilson and Sheppard (2004) showed that $\rho_{(kl),j}$ is asymptotically, conditionally, normally distributed. With the above well-defined asymptotics underlying the p measure, this study computes the realised correlation coefficient measure according to Equation 7.

Three regressions were run to illustrate that estimating realised correlations from high frequency data is helpful for the forecasting exercise (see Table 4). In the first regression, the illustrative variables only include realised correlations estimated over one quarter and one week time horizons. The one week correlations incorporate very recent changes in the correlations and are therefore helpful to predict future correla-

tions. This is also further supported by the regression results with $\bar{R}^2 = 0.61$. In the second regression, the one-week realised correlations are excluded and instead include a list of current-period market factors including the South African Reserve Bank (SARB) funding rate, the JSE return and the implied volatility of the current quarter. This approach can be regarded as one of the best efforts to explain future correlations without resorting to realised correlations measures. It is important that the correlation is constant as a high lagged correlation leads to a high future correlation, and that low market returns lead to high co movement (high systemic risk) – however, the results of this regression are similar to that of the first regression with a $\bar{R}^2 = 0.63$ – again, an indication of a good fit. The ** in Table 4 represents significance at a 95% confidence level.

Table 4: Forecasting asset return correlations.

	Regression 1	Regression 2	Regression 3
$p_{t-8,t}$	0.45**	0.41**	0.33**
$p_{t-8,t}$	0.22**	0.14**	0.18**
SARBFR _t		0.075	0.069
JSE ret _t		-0.09**	-0.11**
VIX _t		0.0048	0.0045
Constant	0.59**	0.51**	0.49**
Adjusted $\bar{R}^2$	0.61	0.63	0.59
Observations	210	210	210

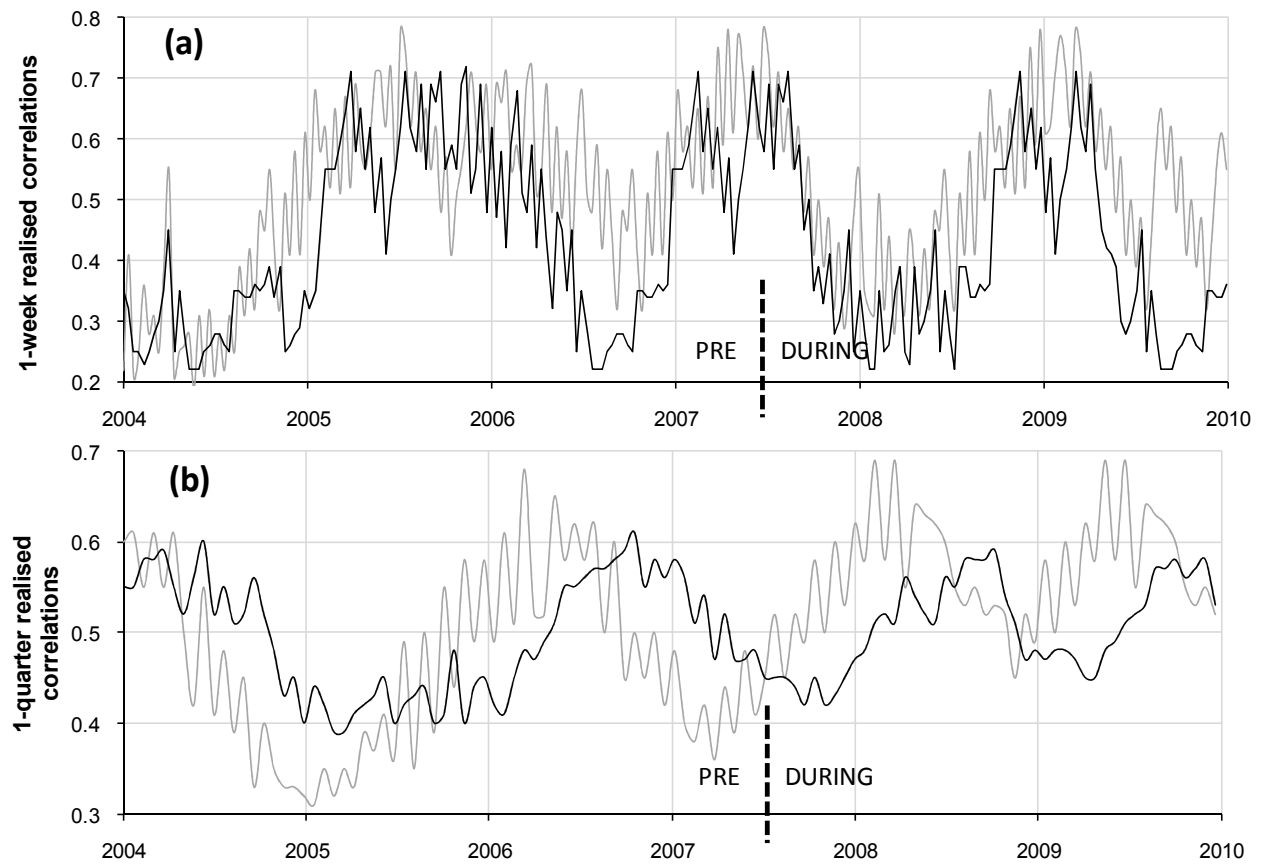
Source: Compiled by the authors.

The third regression included all the explanatory variables, used in the first two regressions, and resulted in a $\bar{R}^2 = 0.59$ while maintaining the sign and significance of the lagged correlations and market returns. What the results show is that the movements in the short term realised correlations incorporate important and additional information on the future movements.¹⁴ The lines in Figure 5 plot the in-sample predictions of future asset return correlations and illustrate the trend of correlation movements (these are not perfect and have a mean squared error of 0.0045).

Figure 5 plots the time series of weighted average 1-week realised correlations and the weighted average 1-quarter correlations. The dark black lines refer to the observed data. The grey line refers to in-sample reductions based on: (1) a VAR analysis that consists of credit risk factors (average PDs and 1-week realised correlations) and financial market variables (SARB fund rates, terms spreads, JSE one-month returns and implied volatility); (2) regressions of the individual PDs; and (3) a regression of future (one quarter) correlations on the current period 1-quarter correlations, weekly correlations and other market factors (Table 4, Regression 3).

¹⁴ Refer to Morris *et al* (2009) for further evidence of the long memory of stock returns in the South African market

Figure 5: (a) 1-week and (b) 1-quarter realised correlations



Source: Compiled by the authors.

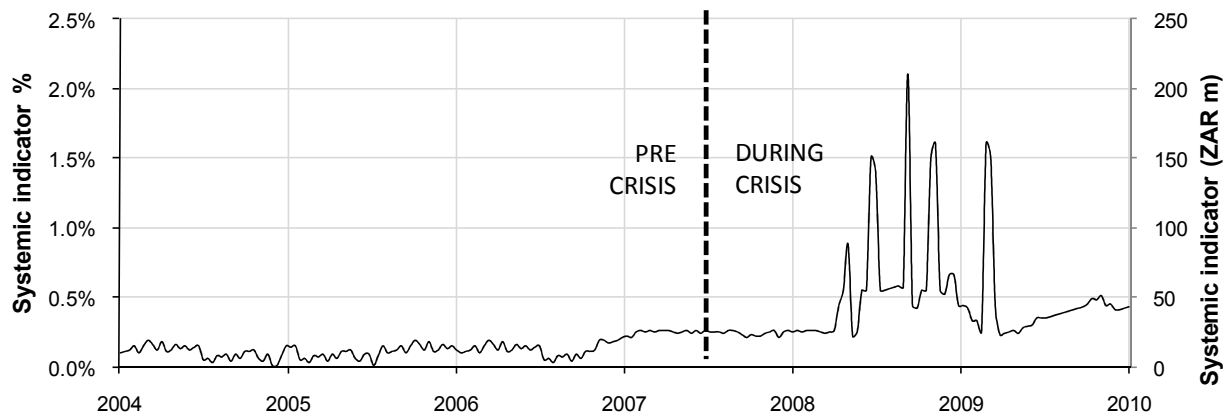
Note that autocorrelation in these data was found to be negligible (according to the Durbin Watson statistic) and no heteroscedasticity was found using the White statistic and F -statistic.

If the PDs of the individual banks are known and asset return correlations have been forecasted, it is possible to derive the indicator for systemic risk, or the price of insurance against distress losses. 'Distress' here refers to a situation in which at least 20% of total liabilities of the financial system have defaulted (any threshold may be chosen as it only impacts the level of systemic risk indicators and not their trend). This may be done using Monte Carlo simulations (see steps in Section 2) by performing two steps. The first is to simulate the joint default scenarios based on the information of individual PDs and the asset return correlation and the second step, conditional on defaults in the first step, the realisation of LGD and overall credit losses for the whole portfolio is simulated.

This methodology fits the purpose of modelling an indicator for systemic risk because the PDs of the entities are homogeneous as the South African banking sector is small. If one bank defaults, the likelihood that it will lead to the default of another is high. The underlying instruments (equity) are unequally weighted (meaning that the size of the bank does play a role) and the LGDs are fixed and independent from PDs, which means each bank could have the same asset base or capital to absorb a large loss. This approach assumes that if one bank defaults, there is a chance that another (one or all) will follow (as the banking sys-

tem is relatively small and there is potential systemic risk): this is measured by how quickly the other bank's return on its equity/assets decrease in line with the return on equity/assets of the bank that is defaulting. In other words, how correlated is the decrease in the return on equity/assets of the other seven banks in the pool to the return on equity/assets of the one bank that is defaulting in that sector? The LGD (fixed and independent from the PD) assumes each bank applies almost the same credit risk principles and has a similar risk appetite.

Figure 6: Price of insurance against distressed losses in a) percent (left axis) and b) ZAR (right axis).



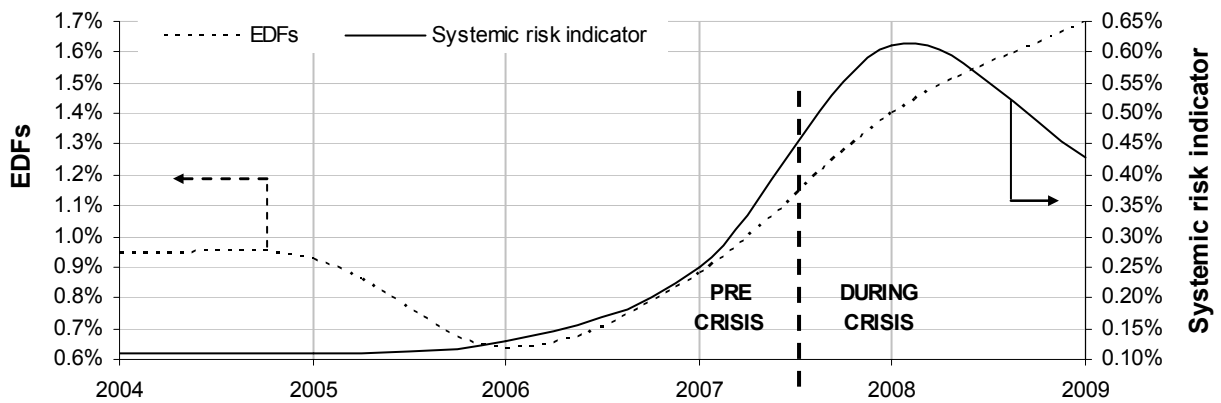
Source: Compiled by the authors.

Figure 6 plots the price of insurance against portfolio credit losses for the eight South African banks listed on the JSE that equal or exceed 20% of total liabilities of the banking system, with the left axis indicating % of overall exposures (i.e. total liabilities) and the right axis showing the results in ZAR terms. The indicator was low in 2004 (average about 20bp basis points (bp)) until the middle of 2007 when it became highly volatile (peaking at just over 200bp) with an average of almost 90bp from mid-2007 to end 2009. The indicator stabilised somewhat in the mid-2009 and approached levels similar to that of early 2007. In ZAR terms, the highest theoretical insurance premium was approximately ZAR200bn in August 2008 (believed to be the height of the financial crisis) and the average was ZAR105bn during this time.

These values are low compared with the eight bank's market capitalisation in Table 2 and it might be that the market's expectation was that no bank would fail. However, it was at this time that ABSA Bank announced a write off of ZAR1.1bn on single share futures, FNB announced a 29% increase in impairment figures and Standard Bank announced a 31% increase in bad debts. In total, the South African banking sector wrote off about ZAR10.9bn during 2008 and about R9.4bn during 2009, which is also very low compared to the figures above. However, none of these banks had experienced real difficulties compared to their US and European counterparts who had to accept government loans. It is clear that the South African banking sector was not expecting defaults hence the relatively low (but volatile) systemic risk indicator. It is also possible that – if the South African Government had to bail-out the banks – the costs would have been similar to the total value of the systemic risk indicator during the financial crisis.

It is also interesting to note how the indicator for systemic risk moves in a similar way to the PDs of the individual banks (Figure 4), but is also affected by the movement in correlations though to a lesser extent. For example, the peak of the indicator coincides with the peak in both PDs and correlations. For example, in Figure 7, the dashed-dotted line indicates the average PD (EDF as % – also see Figure 4) and the solid line shows the average systemic indicator percentage (also see Figure 6) and it is obvious how these two factors track each other and both shows a peak in 2008, although the average systemic indicator percentage decrease more in the middle of 2009, where the average PD shows a small increase.

Figure 7: Average PDs compared to the average systemic indicator percentage.



Source: Compiled by the authors.

The impact of the PDs and the correlations on the indicator of systemic risk is more rigorously examined in Table 5, where the regression shows that the indicator of systemic risk (the price of insurance against distress losses) increases in both the PDs and the coefficients are highly significant. For example a 1σ increase in average PDs (0.43%) increases the indicator by 16bp and a 1σ in average correlations (5.21%) increases the indicator by 6bp. This suggests that changes in the PDs have a dominant effect on the indicator and that the correlation effect plays a secondary role. Asterisks in Table 5 represent significance of coefficients at a 95% confidence level.

Table 5: Systemic risk indicators.

	SYSTEMIC RISK INDICATORS			
	Insurance price	$n = 1$	$n = 2$	$n \geq 1$
PD_t	0.1222*	1.0245*	0.2555*	1.1445*
p_t	0.0124*	0.0214*	0.0142*	0.1278*
Adjusted $\bar{R}^2$	0.88	0.89	0.88	0.87
Observations	230	230	230	230

Source: Compiled by the authors.

The impact of the PDs and correlations on the indicators are examined in Table 5. It shows that the indicator for systemic risk increases in both PD and correlations and that the coefficients are highly significant.

What this means is that there is a strong correlation (relationship) between the return on equity/assets of one bank and the return on equity/assets of the other banks and their respective PDs indicating the high systemic risk present.¹⁵ Quantitatively, a one-standard-deviation increase in the average PDs (0.0053) increases the indicator by 11bp and a one-standard-deviation increase in the average correlation (0.0681) increases the indicator by 2bp. This suggests that changes in the PDs have a dominant effect on the indicator; the correlation impact exists, but plays a secondary role. By contrast, the (risk-neutral) nth-to-default probability measure, an indicator used in other studies (such as Avesani *et al* (2006)), does not have this property. In fact, an nth-to-default measure typically increases in the PDs but decrease in correlations. Therefore, using the nth-to-default probability measures will produce at best an unsatisfactory, sometimes misleading, indicator on the systemic risk of the banking system.

5. CONCLUSION

The main objective of this paper was to apply the systemic risk measurement model of Huang *et al* (2009) to the South African banking sector to determine whether changes have been experienced to systemic risk indicators pre- and during the crisis. Huang *et al's* (2009) model used CDS spreads to derive risk-neutral PDs and make use of asset return correlations to derive the systemic risk indicator (i.e. the price of insurance against distressed losses). This presents a problem in the South African banking sector as there is only one bank which reports CDS data, insufficient to estimate the model and effectively determine relevant parameters. Determining whether it is possible to use physical (i.e. *not* risk neutral) PDs (available from Moody's KMV to derive the systemic risk indicator for the South African banking sector) is another key objective of this article.

The data are based on eight South African banks, currently listed on the JSE, as both their PDs and asset return correlations, which are derived from equity return correlations, are publicly available. It has been found that it *is* possible to use physical PDs rather than CDS spreads as the one component in the systemic risk measurement model, with the only difference being that the use of the physical PDs make the systemic risk indicator slightly more volatile as CDS spreads are used to derive risk-neutral PDs, which should result in a less volatile systemic risk indicator. Also, if physical PDs are used, they play a much more dominant role in the systemic risk indicator model than when risk neutral PDs are used that are derived from CDS spreads – a possible reason for this could be that the physical PDs are more sensitive to market movements than the risk neutral PDs.

Furthermore, it has been determined that there has been a significant change in the price of insurance against distress losses pre- and during the crisis as the price of insurance from 2004 to middle 2007 averaged at about ZAR30m or 20bp and the total for that period equal ZAR598m. For the period starting in the middle of 2007 (also when it is believed the financial crisis started) to the end of 2009, the price of insur-

¹⁵ This is in line with the model developed by Huang *et al* (2009), but it should be kept in mind that their model uses PDs derived from CDS spreads, which are risk-neutral, where this study uses the actual physical PDs.

ance against distress losses averaged at about ZAR105 million with the highest being ZAR200m and a total of ZAR2.7bn.

A marked increase in systemic risk has been observed during the financial crisis within the South African banking sector: the systemic risk indicator (the price of insurance against distressed losses) has increased by more than 200%. Possible reasons for this include, for example, that as the news regarding the European and US banks' difficulties (more prominently the failure of Lehman Brothers and Northern Rock) reached the market, South African banks became concerned and enforced stricter lending criteria against each other. It is also commonly known that most banks' largest counterparty, from an exposure point of view, is usually another bank. What followed was that the liquidity in the South African bank sector *theoretically* dried up as all the banks still had sufficient capital, but none was prepared to lend this capital to others.

Although the South African banking sector is relatively small compared to the US or European banking sectors, it is evident that there is considerable systemic risk between the eight listed banks in SA and this systemic risk may also be measured. Since the start of the financial crisis in 2007, South African banks have reported large losses, but it was the events concerning large European and USA banks that led to significant contagion, a key driver for the increase in systemic risk in South Africa.

The systemic risk indicator is relatively small compared to the total market capital of the eight banks in the data pool and a possible reason for this might be that the market was not expecting a large loss (more than 10% of a bank's lending book) or that any one of these eight banks would fail and default like some of their larger international peers. Many theorists believe that the smaller the market, the larger the systemic risk because if one bank fails it will have a much bigger impact than in a market where there are many players.¹⁶ The systemic risk indicator in the South African banking sector is, however, relatively small given the fact that the sector has only eight listed banks with four of these contributing almost 80% of the market share, contradicting what was previously thought about systemic risk.

REFERENCES

ALTMAN, A.C. 2008. Altman foreign affairs – The Great Crash of 2008. Internet: <http://www.foreignaffairs.org>, accessed March 1, 2010.

AMIN, S. 2008. Financial Collapse, Systemic crisis. Internet: <http://www.globalresearch.com>, accessed March 2, 2010.

AVESANI, R., Pascual, A. and Li, J. 2006. A new risk indicator and stress testing tool: A multifactor Nth-to-default CDS Basket, IMF Working paper, Internet: <http://www.papers.ssrn.com/>, accessed March 10, 2010.

BARNDORFF-NEILSON, O., and Shepard, N. 2004. "Econometric analysis of realised co variation: High frequency based covariance, regression, and correlation in financial economics, *Econometrica*, vol. 72, 885-925.

BCBS, 2009. Consultative proposals to strengthen the resilience of the banking sector announced by the Basel Committee, Bank of International Settlements. Internet: <http://www.bis.org/press/p091217.htm>, accessed January 11, 2010.

¹⁶ See for example Lehar (2005), Siegal, (1995) and Huang et al, (2009).

- DAILY Kos**, 2009. When did the financial crisis really start? Internet: <http://www.dailykos.com/story/2009/2/12/125228/516/46/696617>, accessed March 1, 2010.
- DRIESSEN, J.**, Maenhout, P. and Vilkov, G. 2006. Option-implied correlation and the price of correlation risk, Internet: <http://icf.som.yale.edu/pdf/seminars04-05/Maenhout>, accessed March 9, 2010.
- DUFFIE, D.** 1999. Credit default swap valuation, *Financial Analyst Journal*, 73-87.
- DUFFIE, D.** and Singleton, K. 2003. The Standard & Poor's guide to measuring and managing credit risk. Internet: <http://www.openlibrary.org>, accessed March 3, 2010.
- DWYER, P.**, Douglas, T, and Qu, S. 2007. EDFTM 8.0 model enhancements, Moody's KMV Documents.
- EPSTEIN, G.** 2005. Introduction: Financialisation and the World Economy, Cheltenham and Northampton: Edward Elgar.
- ESTERHUYSEN, J.**, van Vuuren, G. and Styger, P. 2010. The effect of stressed economic conditions on credit risk in Basel II. *South African Journal of Economic and Management Sciences*, South Africa, forthcoming.
- FREY, R** and McNeil, A. 2003. Dependant defaults in models of portfolio credit risk, *Journal of Risk*, 19, 19-41.
- GIBSON, M.** 2004. Understanding the risk of synthetic CDOs. Internet: <http://www.curacao-law.com/wp-content/uploads/2008>, accessed March 10, 2010.
- GLASSERMAN, P.** 2005. Importance Sampling of Portfolio Credit Risk, *Management Science*, Vol. 51, No 11, 1643-1656.
- HUANG, X.**, Zhou, H., and Zhu, H. 2009. A framework for assessing the systemic risk of major financial institutions. BIS Working papers, No 281. Internet: <http://www.BIS.org>, accessed March 1, 2010.
- HUANG, X.**, Zhou, H., and Zhu, H. 2010. Assessing the systemic risk of a heterogeneous portfolio of banks during the recent financial crisis. *BIS Working papers*. #296. Internet: <http://www.BIS.org>, accessed March 2, 2010.
- HULL, J.** and White, A. 2004. Valuation of a CDO and an n-th to default CDS without Monte Carlo Simulation, *Journal of Derivatives*, 12, 8-23.
- KLEINERT, H.** 2004. Path integrals in quantum mechanics, statistics, polymer physics and financial markets, World Scientific, Singapore, Paperback ISBN 981-238-107-4.
- LEHAR, A.** 2005. Measuring systemic risk: A risk management approach, *Journal of Banking and Finance*, 60, 2213-2253.
- MERTON, R.** 1974. On the pricing of corporate debt: the risk structure of interest rates, *Journal of Finance*, 29, 449-470.
- MONEYWEEK**, 2007. Is this the start of the credit crisis? Internet: <http://financialmediaandcomms.blogspot.com/2008/09/global-credit-crunch-when-did-it-start.html>, accessed on March 12, 2010.
- MOODY'S KMV.** 2008. EDF Overview. Internet: <http://www.moodyskmv.com/newsevents/files/EDF>, accessed March 4, 2010.
- MORRIS, Q.**, Van Vuuren, & Styger, P. 2009. Further evidence of long memory in the South African Stock Market, *South African Journal of Economics*, 77, 81-101.
- POLLET, J.** and Wilson, M. 2006. Average correlation and stock market returns, *Journal of Finance*, 56, 3, 815-849. Internet: <http://people.physics.anu.edu.au>, accessed, March 8, 2010.
- SIEGEL, F.A.** 1995. Measuring systemic risk using implicit beta. Internet: <http://portal.acm.org/citation>, accessed March 2, 2010.
- TARASHEV, N.** and Zhu, H. 2008b. Specification and calibration errors in measures for portfolio credit risk: The case of the ASRF model, *International Journal of Central Banking*, 4, 129-174.

WILSON, T. 1998. Portfolio credit risk, *International Journal of Central Banking*, 4, 129-174.

YAMAI, Y. and Yoshida, T. 2005. Value at risk versus expected shortfall: A practical perspective, *Journal of Banking and Finance*, 29, 997-1015. Internet: <http://www.econpapers.repec.org>, accessed, March 10, 2010.

CHAPTER 5 – LIQUIDITY CREATION IN SOUTH AFRICAN BANKS UNDER STRESSED ECONOMIC CONDITIONS

LIQUIDITY CREATION IN SOUTH AFRICAN BANKS UNDER STRESSED ECONOMIC CONDITIONS

JA'NEL ESTERHUYSEN,* GARY VAN VUUREN† and PAUL STYGER†

ABSTRACT

The financial crisis placed severe pressure on global bank liquidity. Many banks were unable to create sufficient liquidity and had to receive Government support or face default. This paper attempts to determine the impact of the financial crisis on liquidity creation within South African banks using a model previously applied to US banks. Four measures of liquidity creation are discussed and applied to data spanning 2004 – 2009. Although created liquidity decreases steeply from 2007, liquidity levels in 2009 remain about 45% higher than those of 2004. The four large South African banks created about 80% of the total market liquidity.

JEL Classification: C46, G21, G32.

Key words: Bank liquidity creation, financial crisis and bank regulation.

1. INTRODUCTION

Modern financial intermediation theory asserts that banks play an important role in the economy by creating liquidity through the funding of illiquid loans with liquid demand deposits (e.g. Diamond, 1984, Ramakrishnam and Thakor 1984). More generally, banks create liquidity on the balance sheet by transforming less liquid assets into more liquid liabilities. Kashyap, Rajan and Stein (2002) suggest that banks may also create significant liquidity on the balance sheet through loan commitments and similar claims to liquid funds. The Basel Committee for Banking Supervisions (BCBS) recently argued that liquidity, or the ability to fund increases in asset values and meet obligations as they come due, is crucial to the ongoing viability of any bank or banking organisation (BCBS, 2000:7). Sound liquidity management can reduce the probability of serious funding problems; indeed, the importance of liquidity transcends individual banks, since a liquidity shortfall at a single institution can have system-wide repercussions (BCBS, 2000:7).

Since the summer of 2007, world financial markets have been battered by severe credit and liquidity crises (commonly referred to as the 'credit crisis'). The combination of events that precipitated these crises was slow to accumulate and – despite several warnings signals – difficult to forecast. Many market practitioners and academics¹ attribute the financial crisis of 2007 through 2009 to credit risk as it is generally believed that banks lent too aggressively to borrowers who could not afford such loans. An alternative viewpoint² holds that the crisis was further aggravated by banks which could not create the required liquidity to see them through the financial crisis. It is almost certain that all financial (or credit) crises are characterised by a large number of credit losses, which precipitate a shortage of bank liquidity as banks must fund losses incurred. These crises are also characterised by market uncertainty, especially in banking sectors resulting

* Absa Capital: Investment Bank Division of Absa Bank, 15 Alice Lane, Sandton, 2196, South Africa. Paper submitted as partial fulfilment of the requirements for the degree of PhD in Economics at the North-West University, Potchefstroom Campus.

† North-West University Potchefstroom Campus, Potchefstroom, 2520, North-West Province, South Africa.

¹ See Amin (2008), Huang, Zhou and Zhu (2010) and Diamond and Rajan (2009).

² See Borio (2009), Brunermeier (2009) and Adrian and Shin (2008).

in banks lending less to each other, which then results in a shortage of liquidity. It is therefore important that banks are able to create liquidity and even more important for banks to create liquidity in distressed periods.

The importance of bank liquidity creation may be explored through an examination of recent bank failures caused by a shortage of liquidity. Northern Rock (a medium-sized UK bank), for example, requested security from the Bank of England after its highly leveraged balance sheet led to investor panic and a bank run in mid-September 2007 (Allen, 2009). Over 100 mortgage lenders world-wide then went bankrupt during 2007 and 2008 and concerns that the large investment bank Bear Sterns would collapse in March 2008 resulted in its "fire-sale" to JP Morgan Chase. Other large financial institutions that were impacted by the financial crisis include Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group, AIG. The main cause for these institutions' catastrophic problems was a lack of liquidity and the inability to create liquidity through normal market activities.

Despite the importance of bank liquidity and the creation thereof, there is little evidence of any comprehensive empirical measurement of liquidity creation. Liquidity measures that incorporate all the on- and off-balance sheet activities of banks are in short supply. Moreover, studies of research and policy issues in banking typically focus only on a few components of liquidity creation. Berger and Bouwman (2006) developed an approach to measure bank liquidity and tested the measure on almost all United States (US) banks over the period spanning 1993 – 2003 (a total of 84,080 bank-year observations). In this approach, a three-step procedure to develop a liquidity creation measure was used. In Step 1, all bank assets, equity, and off-balance sheet activities are classified as liquid, semi-liquid, and illiquid. Step 2 assigns weights to activities classified in Step 1, and Step 3, constructs liquidity creation measures by combining the activities classified in Step 1, and weighted in Step 2, in different ways. Results indicate that the US banking industry creates approximately \$2.50 per \$1.00 of capital, and although liquidity creation using this measure declined slightly after 2000, overall bank liquidity creation grew by approximately two thirds in real terms between 1993 and 2003 (Berger and Bouwman, 2006).

A shortfall of the Berger and Bouwman model is that it only measures bank liquidity creation up to the end of 2003 when most banks were perceived to be well-capitalised and most banks were perceived to be holding sufficient liquidity³ – the model provides no measure for how effective banks were in creating liquidity before the start, and during, the current financial crisis. Bank failures and bailouts of the last three years provide sufficient evidence to illustrate that banks were not effective in creating sufficient liquidity. The main objective of this paper is to provide a measure of bank liquidity creation before and during the financial crisis by adapting and calibrating the model developed by Berger and Brown (2006) and by applying it to South African bank data.

³ See for example Adrian and Shin (2008), Cifuentes, Ferrucci and Shin (2005) and van Vuuren and Chan-Aston (2010).

South African banks were perceived to have had sufficient liquidity during the financial crisis as none had to receive a sovereign bailout. As far as the authors are aware, no other studies have conducted an investigation of this sort on the South African banking sector. The Berger/Bouwman-model compares the liquidity creation between small and large banks over its sample period and this study does the same. However, as discussed later, the South African banking sector has much fewer banks than the US, which could also influence the results.

The remainder of this paper is arranged as follows: Section 2 provides a brief literature study of the methodology and model used by Berger and Bouwman (2006) and also discusses the model construction. A description of the data employed in the study is presented in Section 3 and the subsequent analysis and interpretation of these data follows in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

The existing literature indicates that there have only been two papers that measure bank liquidity creation: one by Berger and Bouwman (2006) in which a three-step approach is employed, and a second by Deep and Schaefer (2004), in which a measure of liquidity transformation is constructed and applied to data gathered from 200 of the largest US banks over the period 1997 to 2001. The liquidity transformation gap, or "LT gap", is defined as liquid liabilities minus liquid assets divided by total assets (Deep and Schaefer, 2004). All loans with a maturity of one year or less are considered to be liquid in this model and loan commitments and other off-balance sheet activities are explicitly excluded due to their contingent nature. The LT gap was found to be about 20% of total assets on average for the sample of large US banks and the conclusion reached was that these banks do not appear to create much liquidity. Further tests were conducted to explain this result, e.g. an examination of the roles of insured deposits, credit risk, and loan commitments.

Berger and Bouwman (2006) averred that the LT gap is a step forward, but argued that it is not sufficiently comprehensive by highlighting a few differences between their approach and the LT gap developed by Deep and Schaefer (2004). Firstly, the Berger/Bouwman-model includes almost all commercial banks and compares findings for large and small banks rather than including only the largest institutions.⁴ The Berger/Bouwman-model also classifies loans by *category*, rather than *maturity* and finally, the Berger/Bouwman-model employs measures which include off-balance sheet activities, consistent with the arguments of Kashyap *et al.*, (2002) and others.

Before the Berger/Bouwman-model is described, it is important to understand the relationship between capital and liquidity creation as these concepts are closely connected and in most cases regarded as identical. Some theoretical literature (e.g. Diamond and Rajan (2001) and Gorton and Winton (2000)) produces opposing predictions regarding the link between capital and liquidity creation. One hypothesis – the "financial fragility-crowding out" hypothesis – predicts that higher capital reduces liquidity creation. Diamond

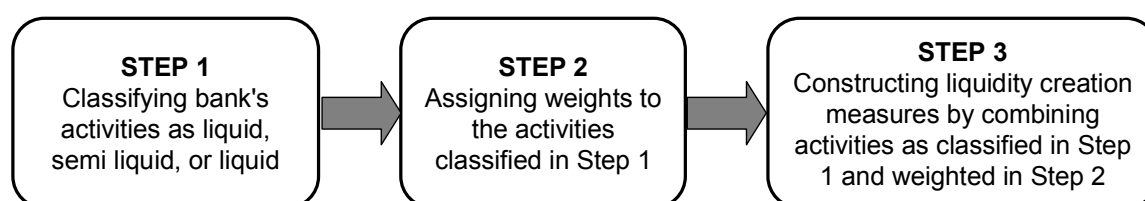
⁴ As discussed in the introduction, this study only focuses on the eight listed SA banks, but these eight banks are made up of a comprehensive combination of small and large banks.

and Rajan (2001) model a relationship bank that raises funds from investors to provide financing to an entrepreneur, in which the entrepreneur may withhold effort, which reduces the amount of bank financing attainable. More importantly, the bank may also withhold effort, which limits the bank's ability to raise funding. A deposit contract mitigates the bank's hold-up problem because depositors can run on the bank if the bank threatens to withhold effort and therefore maximises the liquidity creation. Providers of capital cannot run on the bank, which limits their willingness to provide funds, and hence reduces the liquidity creation – thus, the higher a bank's capital ratio, the less liquidity it will create.⁵ Gorton and Winton (2000) show a higher capital ratio may reduce liquidity creation through the crowding out of deposits and argue that deposits are more effective liquidity hedges for investors than investments in equity capital. Thus, the higher capital ratios shift investors' funds from relative liquid deposits to relative illiquid bank capital, reducing the overall liquidity for investors.⁶

Other hypotheses – the "risk absorption" hypotheses – argue that higher capital enhances banks' ability to create liquidity based on two strands of literature. The first⁷ argues that liquidity creation exposes a bank to risk as the more liquidity it creates, the greater the likelihood and severity of losses associated with having to dispose of illiquid assets to meet the liquidity demands of the customers. The second⁸ argues that bank capital absorbs risk and expands banks' risk-bearing capacity. Combining these two strands yields the prediction that higher capital ratios may allow banks to create more liquidity.

The measure of liquidity creation of the South African banking sector pre-and during the financial crisis is based on the model developed by Berger and Bouwman (2006), which is itself based on three steps (see Figure 1). In Step 1, all assets are classified as liquid, semi-liquid or illiquid based on ease, cost and time for banks to dispose of their obligations to obtain liquid funds to meet customers' needs. In Step 1, all liabilities plus equity are also classified as liquid, semi-liquid, or illiquid based on ease, cost and time for customers' to obtain funds from the bank. Off-balance sheet guarantees and derivatives are classified consistently with treatments of functionality similar to on-balance sheet items.

Figure 1: The Berger/Bouwman-model as a measure of bank liquidity creation.



Source: Compiled by the authors

⁵ Diamond and Rajan's (2001) model builds on Calomiris and Khan's (1991) argument that the ability of uninsured depositors to run on the bank in the event of expected wealth expropriation by bank managers is an important disciplining mechanism.

⁶ Gorton and Winton's (2000) analysis suggests that even if equity holders did not reduce funding to the bank, there would be less liquidity creation with a higher capital ratio.

⁷ See Diamond and Dybvig (1983), Diamond (1984), Allen and Santomero (1998) and Allen and Gale (2004).

⁸ See Bhattacharya and Thakor (1993), Repullo (2004) and Von Thadden (2004)

Information regarding both product category and maturity is used to classify all bank activities. For example, business loans are generally more liquid than residential mortgages and consumer loans as the latter can often be more easily securitised and sold to meet liquidity demands as shorter maturity items are more liquid than longer maturity items because they self-liquidate without effort or cost (Berger and Bouwman, 2006). The Berger/Bouwman-model therefore either classifies loans entirely by category ("cat") or entirely by maturity ("mat") (Berger and Bouwman, 2006):

Assets

Classifying loans

- *Category ("cat")* – for the "cat" measure of liquidity creation, all business loans and leases are classified as illiquid assets because these items typically cannot be sold quickly without incurring major losses. Residential mortgages and consumer loans are generally relatively easy to securitize, and loans to depositories and governments are likely to be comparatively easy to sell or otherwise disposed and these are classified as semi-liquid.
- *Maturity ("mat")* – shorter maturity items are more liquid than longer maturity items because they self-liquidate sooner, so all short term loans of up to one year are classified as semi-liquid and all long term loans longer than one year are classified as illiquid for the mat measures.

Classifying assets other than loans – Premises and investments in unconsolidated subsidiaries are classified as illiquid assets, because these items can not be sold quickly without incurring major loss and cash, securities, and other marketable assets that the bank can use to meet liquidity needs quickly without incurring a major loss as liquid assets.

Liabilities

Classifying liabilities – Funds that can be quickly withdrawn by customers – such as transaction deposits – are classified as liquid liabilities, with other deposits that can be withdrawn with slightly more difficulty or penalty as semi-liquid. Liabilities that can not easily be withdrawn, such as subordinated debt, are classified as illiquid.

Classifying equity – Equity is classified as illiquid since investors can not demand liquid funds from the bank and the maturity is very long. Although the equity of some of the banks is publicly traded and may be sold relatively easily, the investors are able to retrieve liquid funds through the capital market, and not from the bank.

Off balance sheet activities

Classifying guarantees – Loan commitments and commercial letters of credit are classified as illiquid as these items are functionally similar to on-balance sheet business loans in that they are obligations that are illiquid from the point of view of the bank – except in unusual circumstances, the bank

must provide the funds to the customer upon demand. Net standby letters of credit, net credit derivatives and net securities are classified as semi-liquid guarantees since they can potentially be sold. Net participants acquired from other institutions are classified as liquid guarantees, since they are functionally similar to on-balance sheet securities.

Classifying derivatives – All derivatives including interest rate, foreign exchange and equity and commodity derivatives are classified as liquid since they can be bought and sold easily and are functionally similar to liquid securities. The model discussed here only focuses on the fair values of these derivatives as it measures how much liquidity the bank is providing or absorbing from the public.

Step 2 of the model is to assign weights to all the bank activities as classified in Step 1. These weights are based on the liquidity creation theory and according to this theory; banks create liquidity on the balance sheet when they transform illiquid assets into liquid liabilities (Diamond and Rajan, 2001). An intuition for this is that banks create liquidity because they hold illiquid items in place of the non-bank public and give the public liquid items and therefore the model applies positive weights to both illiquid assets and liquid liabilities. Thus, when liquid liabilities (such as transaction deposits) are used to finance illiquid assets (such as business loans) liquidity is created. Following a similar logic, the model applies negative weights to liquid assets, illiquid liabilities, and equity, so that when illiquid liabilities or equity are used to finance a dollar of liquid assets – such as treasury securities – liquidity is destroyed.

Table 1: Step 2 – Assigning weights to bank activities.

ASSETS					
Illiquid assets (weight = ½)		Semi-liquid assets (weight = 0)		Liquid assets (weight = -½)	
Cat		Cat			
Commercial real estate loans	Mat	Residential real estate loans	Mat	Cash	
Commercial and industrial loans	All loans and leases with a Remaining maturity >1 year	Consumer loans	All loans and leases with a Remaining maturity >1 year	All securities	
Other loans and lease financing		Loans to depository institutions		Trading assets	
		Loans to governments			
LIABILITIES					
Liquid liabilities (weight = ½)		Semi-liquid liabilities (weight = 0)		Liquid liabilities and equity (weight = -½)	
Transaction deposits		Savings deposits (domestic)		Bank's liability on bankers acceptance	
Overnight federal funds purchased		Time deposits (domestic)		Subordinated debt	
Trading liabilities		Foreign deposits		Other liabilities	
OFF-BALANCE SHEET GUARANTEES					
Illiquid guarantees (weight = ½)		Semi-liquid guarantees (weight = 0)		Liquid guarantees (weight = -½)	
Unused commitments		Net standby letters of credit			
Commercial and similar letters of credit		Net standby derivatives		Net participations required	
All other off-balance sheet liabilities		Net securities lent			
OFF-BALANCE SHEET DERIVATIVES (GROSS OF FAIR VALUES)					
				Liquid derivatives (weight = -½)	
				Interest rate derivatives	
				Foreign exchange derivatives	
				Equity and commodity derivatives	

Source: (Berger and Bouwman, 2006:33)

It needs to be noted that the Berger/Bouwman-model uses US Dollar (\$) as currency; however, this paper will make reference to South African Rand (R). Table 1 provides an illustration of the weights prescribed in the model. The magnitudes of the weights are based on simple Rand-for-Rand-up constraints, so that R1 of liquidity is created when banks transform R1 of illiquid assets into liquid liabilities, similarly, R1 of liquidity is destroyed when banks transform R1 of liquid assets into R1 of illiquid liabilities. Based on these constraints, a weight of $\frac{1}{2}$ is assigned to both illiquid assets and liquid liabilities and a weight of $-\frac{1}{2}$ to both liquid assets and illiquid liabilities. Thus, when a Rand of liquid liabilities (such as transaction deposits) is used to finance a Rand of illiquid assets (such as business loans) liquidity creation is (Berger and Bouwman, 2006: 13):

$$(\frac{1}{2}) * R1 + (\frac{1}{2}) * R1 = R1 \quad (1)$$

In this case, maximum liquidity is created. Intuitively, the weight of $\frac{1}{2}$ applies to both illiquid assets and liquid liabilities, since the amount of liquidity created is only "half" determined by the source or use of the funds alone as both are needed to create liquidity. Similarly, when a Rand of illiquid liabilities or equity is used to finance a Rand of liquid assets (such as treasury securities) liquidity creation equals (Berger and Bouwman, 2006: 13):

$$(-\frac{1}{2}) * R1 + (-\frac{1}{2}) * R1 = -R1 \quad (2)$$

In the above case, maximum liquidity is destroyed. Furthermore, the intermediate weight of 0 is applied to semi-liquid assets and semi-liquid liabilities, based on the assumption that semi-liquid activities fall halfway between liquid and illiquid activities. Thus, the use of time deposits to fund residential mortgages would yield approximately zero net liquidity creation, since the ease, cost and time with which the time depositors may access their funds early and demand liquidity, roughly equals the ease, cost and time with which a bank can securitize and sell the mortgage to provide the funds. Weights are applied to off-balance sheet guarantees and derivatives using the same principles consistent with the functional similarities to on-balance sheet items as discussed in Step 1.

For example, illiquid off-balance sheet guarantees (such as loan commitments) are functionally similar to on-balance sheet liquid loans (such as business loans) in that they are obligations of the bank to provide funds that cannot easily be sold or participated. Therefore the same weight of $\frac{1}{2}$ is applied to illiquid guarantees as well as to illiquid assets, a weight of 0 is applied to semi-liquid guarantees as well as to similar semi-liquid on-balance sheet assets and a weight of $-\frac{1}{2}$ is applied to liquid guarantees and functionally similar on-balance sheet liquid assets.

Step 3 of the model is to construct liquidity creation measures by combining the activities as classified in Step 1 and as weighted in Step 2 (Berger and Bouwman, 2006:33). The measures are similar in that they all classify activities other than loans using information on the product category and the maturity as discussed in Step 1, but they are different in that the model classifies loans by category or maturity ("cat" versus

"mat") and alternatively include or exclude off-balance sheet activities ("fat" versus "nonfat") – therefore the model has four measures (also illustrated in Table 2):

- "cat fat",
- "cat nonfat",
- "mat fat", and
- "mat nonfat".

Table 2: Step 3 – Combining bank activities as classified in Step 1 and as weighted in Step 2.

LIQUIDITY CREATION MEASURES as weighted in Step 2		BANK ACTIVITIES AS CLASSIFIED IN STEP 1		
Cat fat		+½ * liquid assets (cat)	+0 * semi-liquid assets (cat)	-½ * liquid assets
		+½ * liquid liabilities	+0 * semi-liquid liabilities	-½ * illiquid liabilities
		+½ * liquid guarantees	+0 * semi-liquid guarantees	-½ * equity
				-½ * liquid guarantees
				-½ * liquid derivatives
Cat nonfat		+½ * illiquid assets (cat)	+0 * semi-liquid assets (cat)	-½ * liquid assets
		+½ * illiquid liabilities	+0 * semi-liquid liabilities	-½ * illiquid liabilities
				-½ * equity
Mat fat		+½ * illiquid assets (mat)	+0 * semi-liquid assets (mat)	-½ * liquid assets
		+½ * liquid liabilities	+0 * semi-liquid liabilities	-½ * illiquid liabilities
		+½ * illiquid guarantees	+0 * semi-liquid guarantees	-½ * equity
				-½ * liquid guarantees
				-½ * liquid derivatives
Mat nonfat		+½ * illiquid assets (mat)	+0 * semi-liquid assets (mat)	-½ * liquid assets
		+½ * liquid liabilities	+0 * semi-liquid liabilities	-½ * illiquid liabilities
				-½ * equity

Source: (Berger and Bouwman, 2006:33)

In Table 2, bank activities are arranged into those that add to liquidity creation on the left, those that subtract from liquidity creation on the right, and those with an approximately neutral effect in the centre. For all measures, the model multiplies the weights of ½, -½ or 0 respectively times the dollar amounts of the corresponding bank activities to arrive at the dollar value of liquidity creation at a particular bank. The model further sums across all banks to obtain the total dollar value of liquidity created by the entire industry. It is important to note that the liquidity creation measures of the model discussed here are approximations, however it is interesting to also note that Deep and Schaefer's (2004) LT gap measure is conceptually close to the model's "mat nonfat" measure and may be viewed as a special case of it. Furthermore, if all assets and liabilities are classified as either liquid or illiquid (none as semi-liquid) using maturities, excluded off-balance sheet activities, and specified assets (A) rather than gross total assets (GTA), the "mat nonfat" formula reduces to the Deep and Schaefer's (2004) formula. The next section explains the data selection.

3. DATA

The sample data includes annual data (as of December 31) from 2004 to 2009 on all South African commercial banks that are listed on the Johannesburg Stock Exchange (JSE) and are highlighted in Table 3. In

order to ensure completeness and in order to procure more data, monthly DI 900 data was also used from the individual banks for only a few selective months. The data exclude all international banks that do not have their primary listing on the JSE. A distinction is made between small banks and large banks (see Table 3) and the data exclude banks if 1) they are not listed, 2) they have no commercial real estate or commercial and industrial loans outstanding, 3) they have zero deposits, and 4).

Table 2: South African banks listed on the JSE (sorted by market capital).

Bank	Market Cap: ZAR bn	
Standard Bank	156	} Large banks
ABSA	96	
First Rand Bank	81	
Nedbank	61	
Investec Bank	28	} Small banks
African Bank Ltd	25	
Sasfin Bank	25	
Capitec Bank	3.2	

Source: Compiled by the authors.

The data sample contains 15,672 bank-year observations, which include 2,789 for large banks and 12,883 bank-year observations for small banks. The choice of July 2007 as the start of the financial crisis was justified in part by the first article which mention the financial crisis by name (Moneyweek, 2007), but also by subsequent analysis that has shown that severe signs of weakness were evident (and becoming manifest) by late July 2007 (Daily Kos, 2009). The data used are publicly-available data from the eight South African banks listed on the JSE and these are distinguished (between large and small) based on market capital.

- **PRE CRISIS**: the benign (from an economic point of view) three and a half year period from January 2004 to June 2007 was characterised by low interest rates, low inflation, relatively new bank regulation regarding operational risk, explosive growth of credit (and other) derivatives, considerable loan securitisations, a huge demand for commodities such as oil and metals from India and China and low unemployment.
- **DURING CRISIS**: the turbulent two year period from July 2007 to December 2009 – i.e. from the onset of the financial crisis and characterised by almost non-existent interest rates, hugely diminished share markets, increasing taxes, a severe regulatory environment (for banks, regulators, rating agencies and so on) and rising unemployment.

The next section provides an overview of the analysis and explains why the "cat fat" liquidity measure is the preferred measure.

4. ANALYSIS

Berger and Bouwman (2006) have indicated that they have found the "cat fat" measure as their preferred measure of liquidity creation with the main argument being that the "cat" measures are preferred to the corresponding "mat" measures primarily because what matters to liquidity creation on the asset side is the ease, cost, and time for banks to dispose of their obligations to obtain further funds. The ability to securitize loans is closer to this concept than the time until-self liquidation. For example, a 30-year residential mortgage may be securitised relatively quickly even though it is a long term loan. The argument then exist that the "fat" measures are preferred to the corresponding "nonfat" measures based on the argument that off-balance sheet activities provide liquidity in functionally similar ways to on-balance sheet items – hence, "cat fat" measures are preferred. In order to illustrate how the South African banks have created liquidity before and through the financial crisis, the analysis will begin with the "cat fat" measures.

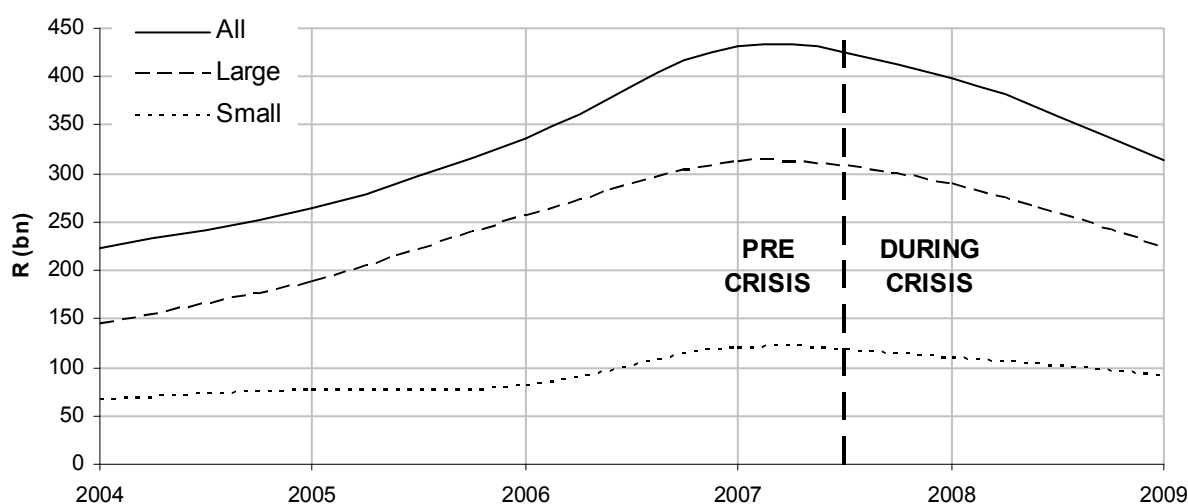
Table 3, shows liquidity creation for the South African banking sector measures through the "cat fat" measures in South African Rand (R) and as a fraction of gross total assets (GTA) in 2004 and 2009, and liquidity creation from the entire 2004 to 2009 period is illustrated in Figure 2.

Table 3: Measuring liquidity creation by means of the "cat fat" measure for 2004 and 2009

	2004 LIQUIDITY CREATION			2009 LIQUIDITY CREATION		
	N	(R 'billion)	Fraction of GTA)	N	(R 'billion)	Fraction of GTA)
All banks	3214	222	15%	2510	314	18%
Large	551	145	21%	312	223	22%
Small	2663	66	11%	2198	91	13%

Source: Compiled by the authors.

Figure 2: Measuring liquidity creation by means of the "cat fat measure for the full period from 2004 to 2009.



Source: Compiled by the authors.

The "cat fat" measure, which classifies loans by category and includes off-balance sheet activities, indicated that banks created liquidity of R314bn in 2009, equal to 18% of industry GTA and represents about R2.50 of liquidity per R1.00 of equity capital (not shown). The trend of liquidity creation in Figure 2 is illustrative of the timing of the financial crisis as both large and small banks were able to increase liquidity creation from 2004 to 2007, but found it more difficult from 2007 onwards as the financial crisis started to have an impact.

The liquidity created in 2009 shows a large decrease from that what was created in 2007; however, it is still about 50% more than that what was created in 2004. As shown in Table 3, liquidity creation as a fraction of GTA increased by only 3% from 15% to 18%, so liquidity creation grew at a slightly faster rate than GTA. At large banks, liquidity creation increased by almost 42% in real terms, although it declined from the middle of 2007. In 2004, large banks created about 65% of the industry's liquidity, but that has increased to 71% in 2009, which is an indication that the larger banks were more successful in creating liquidity during the financial crisis.

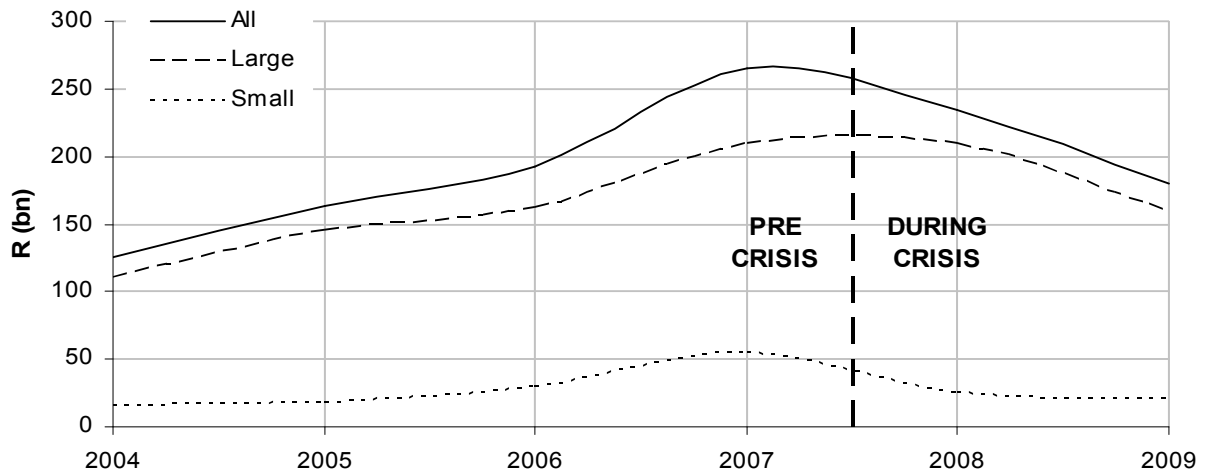
Other liquidity creation measures indicate that much less measured liquidity creation for the "cat nonfat" measure, which is the same as "cat fat" except for the exclusion of the off-balance sheet activities. In Table 4 and as illustrated in Figure 3, the 2004 measured "cat nonfat" liquidity creation is less than 55% of "cat fat" and only 10% of GTA, and actually falls to only 7% of GTA by 2009.

Table 4: *Measuring liquidity creation by means of the "cat nonfat" measure for 2004 and 2005.*

	2004 LIQUIDITY CREATION			2009 LIQUIDITY CREATION		
	N	(R 'billion)	Fraction of GTA)	N	(R 'billion)	Fraction of GTA)
All banks	3214	125	10%	2510	180	7%
Large	551	110	8%	312	159	7%
Small	2663	15	3%	2198	21	2%

Source: Compiled by the authors.

Figure 3: Measuring liquidity creation by means of the "cat nonfat" measure for the full period from 2004 to 2009.



Source: Compiled by the authors.

Figure 3 shows that the decline in liquidity creation for the "cat nonfat" measure was concentrated in the last two years of the sample period when liquidity creation by large banks fell considerably, which is similar to the "cat fat" measure. Measured liquidity creation increased from 2004 to 2007 primarily because the increase in illiquid assets outweighed the increase in liquid assets, but the growth was less pronounced than for the "cat fat" measure because the significant rise in illiquid off-balance sheet guarantees is not included in the "cat nonfat" measure.

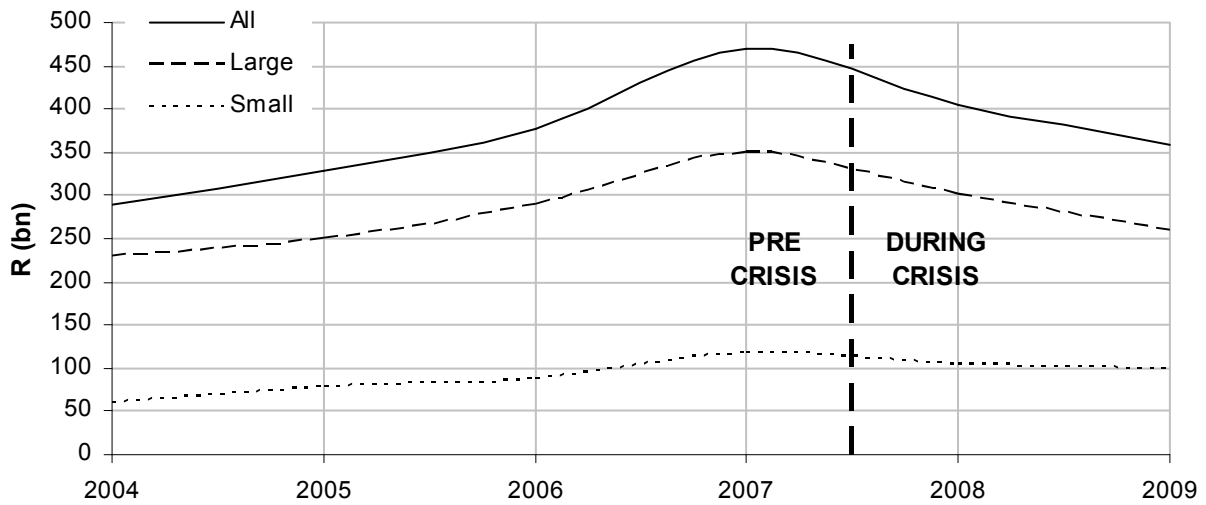
Analysing the "mat fat" measure it shows that liquidity creation is the highest in all years using this measure and is different from the "cat fat" measure as it uses loan maturities in place of categories to classify loans. Treating all loans with a maturity of at least one year as illiquid assets increases the measured liquidity creation from 22% of GTA in 2004 to 25% in 2009, primarily because most residential mortgages are classified as illiquid (weight = $\frac{1}{2}$) rather than semi-liquid (weight = 0). The "mat fat" pattern of liquidity creation over time is similar to the "cat fat" measure, except that the measured liquidity creation is more in the "mat fat" measure (see Figure 4) in the last two years (2008 – 2009). The reason for this is that when loans are classified by maturity, illiquid assets (primarily residential mortgages) grew in those years, and their growth more than offset the growth in illiquid assets.

Table 5: Measuring liquidity creation by means of the "mat fat" measure for 2004 and 2005.

	2004 LIQUIDITY CREATION			2009 LIQUIDITY CREATION		
	N	(R 'billion)	Fraction of GTA)	N	(R 'billion)	Fraction of GTA)
All banks	3214	288	22%	2510	358	25%
Large	551	230	18%	312	259	22%
Small	2663	60	11%	2198	99	11%

Source: Compiled by the authors.

Figure 4: Measuring liquidity creation by means of the "mat fat" measure for the full period from 2004 to 2009.



Source: Compiled by the authors.

The "mat nonfat" measure, which uses loan maturities and excludes off-balance sheet activities, yield a much smaller measured liquidity creation compared to all three other measures of liquidity creation and its growth rate is below the growth rate of GTA as illustrated in Table 6 (liquidity creation drops from 15% of GTA in 2004 to 0.12% of GTA in 2009).

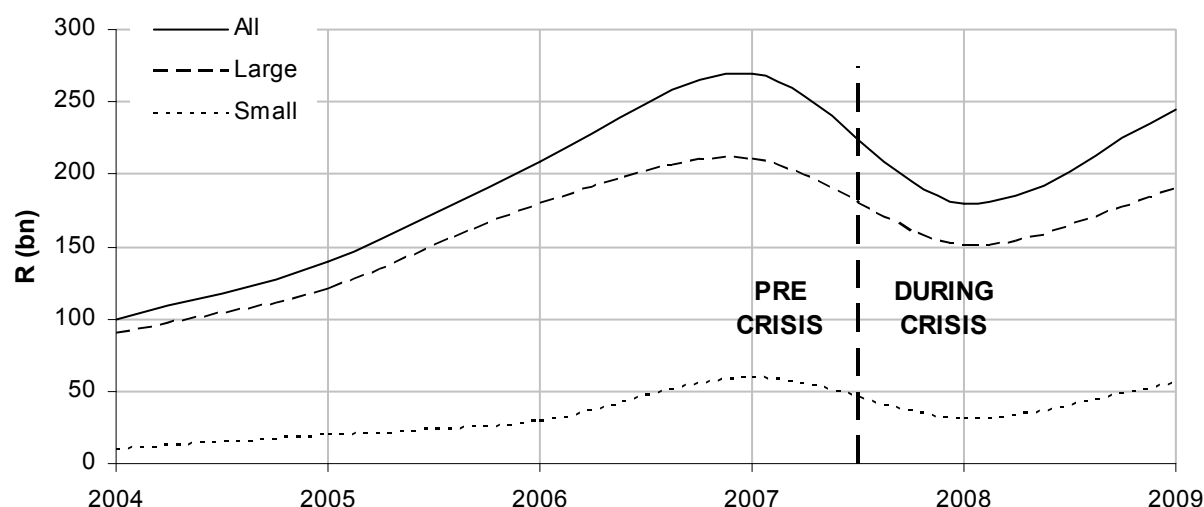
Table 6: Measuring liquidity creation by means of the "mat nonfat" measure for 2004 and 2005.

	2004 LIQUIDITY CREATION			2009 LIQUIDITY CREATION		
	N	(R 'billion)	Fraction of GTA)	N	(R 'billion)	Fraction of GTA)
All banks	3214	130	15%	2510	340	12%
Large	551	120	13%	312	259	22%
Small	2663	10	4%	2198	99	11%

Source: Compiled by the authors.

The "mat nonfat" liquidity creation pattern resembles the "cat nonfat" pattern (see Figure 5); however the "mat nonfat" measure is the only measure of liquidity creation that shows an increase in liquidity creation in 2009 during the hype of the financial crisis. This may be because illiquid assets outweigh the increase in liquid assets.

Figure 5: Measuring liquidity creation by means of the "mat nonfat" measure for the full period from 2004 to 2009.



Source: Compiled by the authors

Table 7: Components of 2009 liquidity creation

		UNWEIGHTED RAND VALUE (R 'BILLION) (I)	WEIGHT (II)	WEIGHTED RAND VALUE (R 'BILLION) (III) = (I)*(II)	GTA (R 'BIL- LION) (IV)	WEIGHTED RAND VALUE (FRACTION OF GTA) (V)=(III) / (IV)
Illiquid assets (cat)	All banks	310	0.5	155	930	0.17
	Large	280	0.5	140	840	0.16
	Small	30	0.5	15	90	0.19
Illiquid assets (mat)	All banks	380	0.5	190	1140	0.23
	Large	290	0.5	145	870	0.23
	Small	90	0.5	45	270	0.21
Semi-liquid assets (cat)	All banks	180	0	0	540	0.0
	Large	139	0	0	417	0.0
	Small	41	0	0	123	0.0
Semi-liquid assets (mat)	All banks	169	0	0	507	0.0
	Large	154	0	0	462	0.0
	Small	15	0	0	45	0.0
Liquid assets	All banks	260	-0.5	-130	780	-0.16
	Large	210	-0.5	-105	630	-0.16
	Small	50	-0.5	-25	150	-0.15
Liquid liabili- ties	All banks	199	-0.5	-99.5	567	-0.14
	Large	165	-0.5	-82.5	495	-0.12
	Small	34	-0.5	-17	102	-0.09
Semi-liquid liabilities	All banks	399	0	0	1197	0.0
	Large	280	0	0	840	0.0
	Small	119	0	0	357	0.0
Illiquid li- abilities	All banks	111	-0.5	-55.5	333	-0.18
	Large	91	-0.5	-45.5	273	-0.17
	Small	20	-0.5	-10	60	-0.08
Equity	All banks	102	-0.5	-51	306	-0.16
	Large	68	-0.5	-34	204	-0.15
	Small	34	-0.5	-17	102	-0.11
Illiquid guar- antees	All banks	210	0.5	105	630	0.17
	Large	150	0.5	75	450	0.16
	Small	60	0.5	30	180	0.11
Semi-liquid guarantees	All banks	160	0	0	480	0.0
	Large	110	0	0	330	0.0
	Small	50	0	0	150	0.0
Liquid guar- antees	All banks	19	-0.5	-9.5	57	-0.15
	Large	16	-0.5	-8	48	-0.14
	Small	3	-0.5	-1.5	9	-0.10
Liquid de- rivatives	All banks	10	-0.5	-5	39	-0.05
	Large	10	-0.5	-5	31	-0.05
	Small	0	-0.5	0	0	0.0

Table 7 contains the components of liquidity creation for 2009, including their Rand amounts, weights and contributions to all liquidity creation measures. This table can be used to gauge the importance of the individual on-balance sheet and off-balance sheet liquidity creation components. Because the liquidity creation formulas include both positive and negative weights, the weighted Rand value of individual components may be close to or even exceed total liquidity creation. For example, the weighted rand amount of illiquid assets using the "cat" measures (R155bn) is relative close to the banking sector's overall liquidity creation based on the "cat nonfat" measure (R180bn). Off the balance sheet, weighted illiquid guarantees are also quite large, which explains why excluding off-balance sheet activities cause liquidity creation to drop.

5. CONCLUSION

An important banking role in the wider economy is to create liquidity.⁹ In this paper, comprehensive measures of bank liquidity creation were developed using a model developed by Berger and Bouwman in 2006. This model was applied to eight South African banks listed on the JSE from 2004 to 2009 to determine whether these banks were able to create liquidity before and during the financial crisis. To construct liquidity measures, the model used classifies all bank activities as liquid, semi-liquid, and illiquid based on the ease, cost and time for customers to obtain liquid funds from the bank, and the ease, cost, and time for banks to dispose of their obligations in order to meet these liquid demands.

For activities other than loans, the model combines information regarding product category and maturity. Four alternative measures of liquidity creation were constructed which alternatively classify loans by product category ("cat") or maturity ("mat"), and alternatively include of balance sheet activities ("fat") or excludes these activities ("nonfat").

Despite a significant increase in measured liquidity creation over the sample period for all four measures, a significant decrease over the final three years (2007 – 2009) was measured and the liquidity levels determined in 2009 are still higher than those measured in 2004. For all four measures, liquidity creation peaked at around the end of 2007, but decreased from there, providing a good indication that banks were starting to encounter problems in creating sufficient liquidity. Analysis of the individual components of liquidity creation over time (not shown in this paper in the interest of brevity), suggests that three components of liquidity creation in particular are responsible for this pattern: 1) illiquid assets; 2) illiquid off-balance sheet guarantees and 3) liquid assets.

The major growth in liquidity creation from 2004 to 2007 was largely driven by strong increases in illiquid assets (weight = $\frac{1}{2}$) and illiquid off-balance sheet guarantees (weight = $\frac{1}{2}$) that outweighed the smaller increases in liquidity creation in liquid assets (weight = $-\frac{1}{2}$). Over 2007 to 2009, illiquid assets showed virtually no growth, illiquid guarantees increased slightly, while the growth in liquid assets continued, causing a mild decline in liquidity creation in the final three years.

⁹ See for example Diamond and Rajan (1983) and Gatev, Scheurman and Strahan (2004).

The model also distinguishes between large banks and small banks with the classification based on market value. Of the total liquidity created by the market (measured by all four measures) almost 85% was created by the four large banks; however, liquidity creation by small banks increased in almost every year over the sample period and they show a smaller decrease in liquidity creation during the financial crisis.

A possible reason why the large banks were able to create more liquidity is that all these banks have a much larger retail depositor base than the small banks (ABSA and Standard Bank are the largest retail banks in SA) and these banks enjoy the large retail deposit base to create liquidity. Although the small banks also have a large retail depositor base, they have less than 20% of the South African market share. Smaller banks may be able to maintain their rate of liquidity creation during the financial crisis because they experienced much less retail client delinquencies and had to raise much less impairments and/or write off losses compared to their larger counterparts.

Many large US and European financial institutions received bailouts and capital injections from their respective governments during the credit crisis as these institutions were not able to create sufficient liquidity. These institutions suffered severe financial losses, placing both US and European banking sectors under severe pressure. The liquidity creation measures explained in this paper helps explain why the South African banking sector was able to create sufficient liquidity during the financial crisis and created much more liquidity than its European and US counterparts. Although all four liquidity creation measures show a steep decrease in liquidity creation from about the middle of 2007, the liquidity created in the final year of observation (2009) is about on average 45% greater than that created in 2004 (believed to be part of the so-called 'boom' period).

None of the South African banks explored in this paper had received any financial support of the Government of South Africa neither the South African Reserve Bank (SARB), which demonstrate the South African banking sector is much more healthier than its US and European counterparts.

These liquidity measures may also be used to address a number of other issues that are beyond the scope of this paper, but may be pursued in future research. These include, but are not limited to, a comparative analysis of bank liquidity creation across nations, the impact of liquidity creation on economic growth and the assessment of liquidity created by markets relative to banks.

Lastly, the authors are aware that the liquidity measures discussed here may not accurately reflect the manner in which South African Banks created liquidity before and during the financial crisis as the period under review was characterised by various other factors. These factors include the concurrent rise in securitisation, considerable changes in the South African Reserve Bank's (SARB) stance on monetary policy, historic low interest rates during the period and severe curtailing of local inter-bank dealing. It remains possible that these factors may have had an impact on the way in which South African Banks created and disseminated liquidity. This possibility will be the subject of future research.

REFERENCES

- ADRIAN, T. and Shin, H.S., 2008. Liquidity and financial cycles, BIS working paper, #256.
- ALLEN, F., and Gale, D. 2004. Financial intermediaries and markets, *Econometrica* 72:1023-1061.
- ALLEN, F., and Santomero, A.M. 1998. The theory of financial intermediation, *Journal of banking and Finance*, 21:1461-1485.
- ALLEN, L., and Bali, T., 2007. Cyclicalities in catastrophic and operational risk measurements, *Journal of Banking and Finance*, 31, 1191 – 1235.
- AMIN, S. 2008. Financial Collapse, Systemic crisis. Internet: <http://www.globalresearch.com>, accessed July 2, 2010.
- BCBS, 2000. Sound Practices for Managing Liquidity in Banking Operations, Bank for International Settlements. Internet: <http://www.bis.org/press/p091217.htm>, accessed July 11, 2010.
- BERGER, A.N., and Bouwman, H.S. 2006. The measurement of bank liquidity creation and the effect of capital, US Federal Reserve System. Internet: <http://fic.wharton.upenn.edu/fic/papers/07/0702>, accessed July 16, 2010.
- BHATTACHARYA, S., and Thakor, A.V. 1993. Contemporary banking theory, *Journal of Financial Intermediation*, 3:2-50.
- BORIO, C., 2009. Ten propositions about liquidity crises, *BIS Working Papers*, No. 293, Monetary and Economic Department. Internet: <http://www.bis.org/publ/work293.pdf>, accessed on 12 July 2010.
- BRUNNERMEIER, M.K., 2009. Deciphering the liquidity and credit crunch 2007-2008, *Journal of Economic Perspectives*, 23(1): 77–100.
- CIFUENTES, R., Ferrucci, G and Shin, H.S. 2005. Liquidity risk and contagion, *Journal of the European Economic Association*, 3, 556-66.
- COLOMIRIS, C.W. and Khan, C.M. 1991. The role of demandable debt in structuring optimal banking arrangements, *American Economic Review*, 81:497-513.
- DAILY KOS, 2009. When did the financial crisis really start? Internet: <http://www.dailykos.com/story/2009/2/12/125228/516/46/696617>, accessed March 1, 2010.
- DEEP, A, and Schaefer, G. 2004. Are banks liquidity transformers?, Harvard University working paper.
- DIAMOND, D.W., and Dybvig, P.H. 1983. Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, 91:401-419.
- DIAMOND, D. 1984. Financial intermediation and delegation monitoring, *Review of Economic Studies* 51: 393-414.
- DIAMOND, D.W. and Rajan, R.D., 2009. The Credit Crisis: Conjectures about Causes and Remedies, *American Economic Review*, American Economic Association, 99, 2, 606 – 60.
- DIAMOND, D.W., and Rajan, R.D. 2001. Liquidity risk, liquidity creation and financial fragility: a theory of banking, *Journal of Political Economy*, 109: 287-327.
- GATEV, E., Scheurmann, T, and Strahan, P. 2004. Managing Bank Liquidity Risk: How deposit-loan synergies vary with market conditions, The National Bureau of economic Research. Internet: <http://www.nber.org/papers/w12234>, accessed August 4, 2010.
- GORTON, G. and Winton, A. 2000. Liquidity provision, bank capital, and the macroeconomic, University of Minnesota, *Working paper*.
- HUANG, X., Zhou, H., and Zhu, H. 2010. Assessing the systemic risk of a heterogeneous portfolio of banks during the recent financial crisis. *BIS Working papers*. #296. Internet: <http://www.BIS.org>, accessed March 2, 2010.

KASHYAP, A.K., Rajan, G. and Stein, J.C. 2002. Banks as liquidity providers: and explanation for the coexistence of lending and deposit-taking, *Journal of Finance*, 57:33-73.

MONEYWEEK, 2007. Is this the start of the credit crisis? Internet: <http://financialmediaandcomms.blogspot.com/2008/09/global-credit-crunch-when-did-it-start.html>, accessed on March 12, 2010.

RAMAKRISHNAN, R.T., and Thakor, V. 1984. Information reliability and theory of financial intermediation, *Review of Economic Studies* 51: 415-432.

RUPELLO, R. 2004. Capital requirements, market power, and risk-taking in banking, *Journal of Financial Intermediation*, 13:156-182.

VAN VUUREN, G. and Chan-Aston, P. 2010. Modelling systemic liquidity risk, *South African Journal of Economics*, forthcoming.

VON THADDEN, E. 2004. Bank capital adequacy regulation under the new Basel Accord, *Journal of Financial Intermediation*, 13:90-95.

CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

The onset of the 'credit crunch' in mid 2007 heralded a sudden, severe and prolonged reduction in the availability of credit affecting all components of the global economy. The origins of the credit crisis are diverse and many, but it is now widely accepted that among the major causes were lax lending conditions, unusually low interest rates (which – maintained at low levels for longer than usual periods – spurred a massive increase of asset prices), low global inflation, elevated oil prices, widespread complacency in financial regulation and naïveté in the assignment of credit ratings of credit derivatives. The credit crisis has tipped the economies of many countries into recession and even those that have fared relatively better than others, are still affected by the lack of credit availability and diminished imports and exports. The credit crisis hit its peak through the months of September and October 2008. Global stock markets were slower to react: substantial losses were recorded throughout the early part of 2009 until the nadir was reached in mid-March of that year. The crisis caused several major institutions to fail (and be subsequently acquired under duress): many of these were subject to takeovers by their relevant sovereigns, including – amongst others – Lehman Brothers, Merrill Lynch, Fannie Mae, Freddie Mac and American International Group, AIG.

Since the start of the crisis, world financial markets have been battered by severe credit and liquidity crises (commonly referred to collectively as the 'credit crisis'). The combination of events that precipitated these crises was slow to accumulate and – despite several warnings signals – difficult to forecast. Many market practitioners and academics attribute the financial crisis of 2007 through 2009 to credit risk as it is generally believed that banks lent too aggressively to borrowers who could not afford such loans. An alternative view-point holds that the crisis was further aggravated by banks which could not create the required liquidity to see them through the financial crisis. It is almost certain that all financial (or credit) crises are characterised by a large number of credit losses, which precipitate a shortage of bank liquidity as banks must fund losses incurred. These crises are also characterised by market uncertainty – especially in banking sectors – resulting in banks lending less to each other, which then results in a shortage of liquidity. It is, therefore, important that banks are able to create liquidity and even more important for banks to create liquidity in distressed periods.

In the light of these events this thesis posed the following research question/problem: How did the stressed economic conditions that resulted from the financial crisis of 2007 to 2009 impact on international bank risk measurement and management? How will it reform the international risk environment?

This thesis explored four fields of banking risks and risk management methodologies and examined the impact that the financial crisis had on these. These contributions are outlined in the sections that follow.

6.1.1 THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON OPERATIONAL RISK LOSS DISTRIBUTIONS

The depth and duration of the credit crisis has highlighted a number of problems in modern finance. Banks have been accused of excessive risk taking, rating agencies of severe conflicts of interest, central banks of

neglecting the inflation of asset price bubbles and national supervisors of lax regulatory controls. Credit and market losses have been considerable. Operational losses have also surged as surviving corporates merge or acquire less fortunate ones without the requisite controls. Furthermore, as more jobs get made redundant it is believed that people are getting forced to play their hand to get involved in internal fraud as their sources of income has dried up drastically and stealing from the institution seems to be their last resort.

In Chapter 2, it can be seen that the frequency of operational losses pre and during the crisis relatively remained the same with the vast majority of operational losses occurring at low frequency with occasional “bad days”. The severity distributions of operational losses pre and during the crisis were different in that the severities increased during the crisis, giving the loss distribution a “fatter” tail. During the crisis the frequency remained relatively constant, but loss severity increased significantly. Average losses increased from \$0.17bn pre crisis to \$1.80bn during the crisis. What this illustrates is that the world economic crisis had an impact on operational risk as the severity of operational losses during the crisis became much more severe. While each financial crisis exhibits unique characteristics, the same essential features tarnish all significant downturns.

Some of the reasons for this include, but are not limited to, failure of management to identify and isolate key *problem* individuals and key *solution* individuals. The knock-on effect is invariably overworked and disgruntled staff, leading to other problem sources being overlooked or ignored entirely. Also, the (then) current climate (August 2009) of increased corporate failure and subsequent elevated merger and acquisition activity provides opportunities for operational risk to flourish. In such cases, senior management should allow sufficient time for handover. New business heads should ensure that access to skilled resources (such as process understanding, accounting expertise, document review, data analytics and field studies and the ability to report independently i.e. outside of existing hierarchies) are maintained. Senior management should also recognise the significant incentives and opportunities for aggrieved redundant staff to steal invaluable Intellectual Property (IP) on departing and should monitor instances of electronic access to valuable data.

In conclusion, never before has it been documented that operational risk will increase during distressed economic conditions – therefore this study makes a significant contribution to the operational risk management field by proving that operational risk will increase during distressed economic conditions. The causes for the increase in operational risk during distressed times that were highlighted in this study will serve as early warning indicators and will assist banks and risk managers to proactively identify operational risk and will force senior management to allocate more time and resources to the management of operational risk in times when their company is experiencing difficult times.

6.1.2 THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON CREDIT RISK IN BASEL II.

The robustness of the Basel II accord, issued by the Basel Committee on Banking Supervision (BCBS) in 2005, in protecting banks during volatile economic periods has been challenged in the ongoing credit crisis. Advanced approaches to measuring and managing credit risk in particular have drawn criticism for being too complex and irrelevant. Catastrophic failures of inadequate capital allocation and management were exposed

and culpability for the cause, severity and duration of the crisis placed on regulatory bodies, credit rating agencies, bank CEOs and others. Financial institutions began to question the validity and relevance of the underlying credit risk principles which form the basis of Basel II. These principles were devised to provide banks and other financial institutions (e.g. insurance companies) with methodologies to manage credit risk adequately by providing guidance for assessing credit risk (including equations for determining risk capital for more advanced approaches). Since many institutions' capital levels proved woefully inadequate during the crisis, these principles are now – inevitably – being challenged. However, during December 2009, the BCBS approved for consultation a package of proposals to strengthen global capital and liquidity regulations with the goal of promoting a more resilient banking sector, which form part of its response to address the lessons learned from the crisis and to strengthen the Basel II framework.

Despite accusations that the accord was largely responsible for the crisis, Chapter 3 explores which of Basel II's credit risk approaches were more successful in allocating capital. It was found that, in general, compliance with Basel II actually protected banks during the crisis with simpler approaches enjoying greater success than more advanced ones in protecting banks against credit risk.

Since Basel II is regarded as still being fairly new (implementation mainly started in 2006) and since most of data that was used in the implementation came from a very booming financial period (i.e. significant economic growth in all major economies, low unemployment across the globe, banks with strong balance sheet and large quantities of liquidity, etc.), and although many theoretical stressed tests were done, banks and regulators were never really able to test the effectiveness of Basel, or which of its approaches are better in allocating credit risk capital. Therefore, this study makes a considerable contribution to the credit risk management field by being the first to scientifically test the effectiveness of Basel in allocating credit risk data through a severe economic downturn. Furthermore, it is commonly believed that the more advanced approaches should be more effective in allocating credit risk capital; however, this study makes a further contribution by indicating that the simpler (standardized) approaches demonstrated a higher success rate in allocating credit risk capital, which will change the common believe on these approaches.

6.1.3 THE EFFECT OF STRESSED ECONOMIC CONDITIONS ON SYSTEMIC RISK WITHIN THE SOUTH AFRICAN BANKING SECTOR.

Many reasons have been posted for the recent financial crisis, the most common being the bursting of the US housing bubble, which resulted in high default rates on subprime and adjustable mortgages and led to severe contagion effects which rapidly eroded market confidence. Furthermore, a series of factors caused the financial system to both expand and become increasingly fragile, a process known as *financialisation*¹ which policymakers did not recognise nor did they acknowledge the increasingly important role played by financial institutions (such as investment banks and hedge funds, also known as the shadow banking system). Some re-

¹ Financialisation is defined as the increasing role of financial motives, financial markets, financial sectors and financial institutions in the operating of domestic and international economies.

searchers believe these institutions had become as important as commercial (depository) banks in providing credit to the US economy, but they were not subject to the same regulations. Another interpretation, different from the mainstream explanation, is that the financial crisis is merely a symptom of another, deeper crisis, i.e. a systemic crisis of capitalism itself; the constant decrease in GDP growth rates in Western countries since the early 1970s created a growing surplus of capital which did not have sufficient profitable investment outlets in the real economy. The alternative was to place this surplus into the financial market, which became more profitable than productive capital investment, especially with subsequent deregulation. This phenomenon has led to recurrent financial bubbles (such as the internet bubble of the early 2000s) and it is believed to be a deep cause of the financial crisis of 2007-2010.

There is a renewed drive to measure systemic risk in the banking sector in the light of the connected failures or at least to define a systemic risk indicator for the banking sector as the increase in the perceived systemic risk, particularly after the failure of Lehman Brothers, was mainly driven by heightened risk aversion and reduced liquidity. Measuring systemic risk as the price of insurance against distressed losses in the South African banking sector, Chapter 4 attempted to determine whether the financial crisis has in fact resulted in an increase in systemic risk. Using probabilities of default and asset return correlations as systemic risk indicators, it is found that the financial crisis *has* indeed increased systemic risk in South Africa. The impact was, however, less severe than that experienced in other large international banks.

Chapter 4 is a momentous contribution to the systemic risk management field as it demonstrates a very effective approach to measure systemic risk – something that was previously not possible. Most risk managers are aware of the fact that it is impossible to manage a risk if it cannot be measured; therefore the approach that is used in this study will assist systemic risk managers in the future. Furthermore, this study is also the first to measure systemic risk during distressed economic conditions in the South African banking sector, and since systemic risk demonstrated a significant increase during this time, it will force senior management and risk managers alike to focus much more on the management of systemic risk, especially during distress times.

6.1.4 LIQUIDITY CREATION IN SOUTH AFRICAN BANKS UNDER STRESSED ECONOMIC CONDITIONS

Modern financial intermediation theory asserts that banks play an important role in the economy by creating liquidity through the funding of illiquid loans with liquid demand deposits. More generally, banks create liquidity on the balance sheet by transforming less liquid assets into more liquid liabilities. Some researchers suggest that banks may also create significant liquidity on the balance sheet through loan commitments and similar claims to liquid funds. The BCBS recently argued that liquidity, or the ability to fund increases in asset values and meet obligations as they come due, is crucial to the ongoing viability of any bank or banking organisation. Sound liquidity management can reduce the probability of serious funding problems; indeed, the importance of liquidity transcends individual banks, since a liquidity shortfall at a single institution can have system-wide repercussions.

However, the financial crisis placed severe pressure on global bank liquidity. Many banks were unable to create sufficient liquidity and had to receive Government support or face default. Chapter 5 attempts to determine the impact of the financial crisis on liquidity creation within South African banks using a model previously applied to US banks. Four measures of liquidity creation are discussed and applied to data spanning 2004 – 2009. Although created liquidity decreases steeply from 2007, liquidity levels in 2009 remain about 45% higher than those of 2004. The four large South African banks created about 80% of the total market liquidity.

As mentioned throughout this study, since the start of the financial crisis, most international banks were criticized that they did not create enough liquidity to serve as buffer for large credit losses and also to serve as protection during a time when almost all bank activities came to a standstill. This study is the first to measure bank liquidity creation in the South African banking sector and is also the first to measure bank liquidity creation during distressed economic conditions. This study further contributes to the liquidity risk management field by demonstrating a very effective model to measure how effective banks are in creating liquidity.

6.2 RECOMMENDATIONS

6.2.1 OPERATIONAL RISK

Some of the reasons for the increase in operational risk during stressed financial conditions include the failure of management to identify and isolate key problem individuals and key solution individuals. The knock-on effect is invariably overworked and disgruntled staff, leading to other problem sources being overlooked or ignored entirely. Also, the current climate (September 2010) of increased corporate failure and subsequent elevated merger and acquisition activity provides opportunities for operational risk to flourish. In such cases, senior management should allow sufficient time for handover. New business heads should ensure that access to skilled resources (such as process understanding, accounting expertise, document review, data analytics and field studies and the ability to report independently i.e. outside of existing hierarchies) are maintained. Senior management should also recognise the significant incentives and opportunities for aggrieved redundant staff to steal invaluable Intellectual Property (IP) on departing and should monitor instances of electronic access to valuable data.

6.2.2 CREDIT RISK IN BASEL II

Many banks, while still meeting Basel I minimum requirements, had already reviewed their credit standards in order to make them consistent with the incoming Basel II discipline (and ultimately being Basel II AA complaint). It is therefore likely that some banks, in an attempt to transform well established credit processes and risk management methodologies, may have misjudged the actual exposures to new risk types (or new manifestations of traditional risks). This does not imply that the Basel II framework should be discarded, but rather it confirms the need for the 'testing' phase of the new rules to be a more rigorous affair. Furthermore, with regards to simplified supervisory tools, such as the 'leverage ratio', which are becoming increasingly

popular, the authors do believe that these are likely to raise the same problems posed by Basel I (e.g. the low sensitivity to risk). While it cannot exclude that such tools could be used as a complement to Basel II, especially during stressed times when internal models are not fully reliable, the authors are sceptical that they can serve as a full substitute for a risk sensitive regulation. The solution may not lie in drafting new rules (under Basel III), but possibly in less of a reliance on complex mathematical and statistical models when assessing credit risk, and more of a focus on experience and client knowledge.

6.2.3 SYSTEMIC RISK

The model used in this study to measure systemic risk within the South African banking sector uses the eight banks listed on the Johannesburg Stock Exchange (JSE) probability of defaults (PDs) and asset return correlations, where the last are derived from equity return correlations. It is possible to use Credit Default Swap (CDS) spreads to derive risk-neutral PDs in place of the physical PDs that were used in this study; however, this presents a problem in the South African banking sector. At the time of writing (Aug 2010), there was only one bank which reported CDS data. This provides insufficient data for the effective determination of the relevant parameters. A further recommendation is being made that future research should aim to use CDS spreads to derive risk neutral PDs as the PDs that are derived from CDS spreads are supposed to be less volatile than physical PDs, which will result in a less volatile systemic risk indicator.

6.2.4 LIQUIDITY RISK

The liquidity measures developed and discussed in this study may also be used to address a number of other issues that are beyond the scope of this study, but may be pursued in future research. These include, but are not limited to, a comparative analysis of bank liquidity creation across nations, the impact of liquidity creation on economic growth and the assessment of liquidity created by markets relative to banks. Lastly, the authors are aware that the liquidity measures discussed in the study may not accurately reflect the manner in which South African Banks created liquidity before and during the financial crisis as the period under review was characterised by various other factors. These factors include the concurrent rise in securitisation, considerable changes in the South African Reserve Bank's (SARB) stance on monetary policy, historic low interest rates during the period and severe curtailing of local inter-bank dealing. It remains possible that these factors may have had an impact on the way in which South African Banks created and disseminated liquidity. This possibility will be the subject of future research.

6.3 CONTRIBUTION

The ways in which the four studies which constitute this thesis and contribute to bank risk management theory and practice, are shown in Table 6.1.

Table 6.1: Summary of thesis contributions.

Attribute	Problem statement	Analysis	Contribution
Constructing operational loss frequency and severity distributions before and during the crisis	Establish whether there has been a change in the nature of operational risk pre and during the crisis by assessing the frequency and severity of operational losses	Published in <i>South African Journal of Economic and Management Sciences</i> . 13 (4), Dec 2010.	Since the establishment of operational risk as a primary banking risk, this study provides the first ever scientific and documented evidence that a downturn in the economy gives rise to an increase in operational risk.
Constructing credit loss frequency and severity distributions before and during the crisis	Question the validity and relevance of the underlying credit risk principles which form the basis of the Basel II Accord	To be published in <i>South African Journal of Economic and Management Sciences</i> . 14 (6), March 2011.	Provides bound braking evidence on the effectiveness of Basel II in allocating credit risk capital through an economic downturn. It is also the first study to distinguish between the effectiveness in allocating credit risk capital by the standardised and more advanced approaches.
Measuring systemic risk as the price of insurance against distressed losses by using probabilities of default and asset return correlations as systemic risk indicators	Determine whether the financial crisis has resulted in an increase in systemic risk in the South African Banking sector	Accepted for publication in <i>South African Journal of Economics</i> . 12 (1), March 2011	This paper is a momentous contribution to the systemic risk management field as it demonstrates a very effective approach to measure systemic risk. Furthermore, this study is also the first to measure systemic risk during distressed economic conditions in the South African banking sector, and since systemic risk demonstrated a significant increase during this time, it will force senior management and risk managers alike to focus much more on the management of systemic risk, especially during distress times.
Four measures of liquidity creation are discussed and applied to data spanning 2004 – 2009	Provide a measure of bank liquidity creation before and during the financial crisis by adapting and calibrating an existing model and by applying it to South African bank data	Submitted for publication in <i>South African Journal of Economics</i> .	This study is the first to measure bank liquidity creation in the South African banking sector and is also the first to measure bank liquidity creation during distressed economic conditions. This study further contributes to the liquidity risk management field by demonstrating a very effective model to measure how effective banks are in creating liquidity.

6.4 FINAL STATEMENT

The role of risk managers will almost certainly alter in the wake of the severe upheavals which now rock the financial marketplace. Whether this will involve increased prominence and authority of risk managers or a complete reshuffling of the way in which risks are measured (managed and reported) is not yet known. What is clear is that risk management must match the inexorable march of financial innovation in order to remain relevant. This involves understanding clearly what older risk models inform of the underlying risk environment, the adaptation of these older risk models when they cease to be relevant and the development of entirely new risk models when situations require them. Because the risk milieu is vast and complex, the areas of concern addressed in this thesis necessarily constitute only a small fraction of the work that is (constantly)

required. Nevertheless, significant progress toward enhanced portfolio risk management can be – and has been – made via the implementation of the studies detailed in this research.

BIBLIOGRAPHY

- ADRIAN**, T. and Shin, H.S., 2008. Liquidity and financial cycles, BIS working paper, #256.
- ALLEN**, F., and Gale, D. 2004. Financial intermediaries and markets, *Econometrica* 72:1023-1061.
- ALLEN**, F., and Santomero, A.M. 1998. The theory of financial intermediation, *Journal of banking and Finance*, 21:1461–1485.
- ALLEN**, L., and Bali, T. 2007. Cyclicalities in catastrophic and operational risk measurements, *Journal of Banking and Finance*, 31, 1191–1235.
- ALTMAN**, A.C. 2008. Altman foreign affairs – The Great Crash of 2008. Internet: <http://www.foreignaffairs.org>, accessed March 1, 2010.
- AMIN**, S. 2008. Financial Collapse, Systemic crisis. Internet: <http://www.globalresearch.com>, accessed March 2, 2010.
- AVESANI**, R., Pascual, A. and Li, J. 2006. A new risk indicator and stress testing tool: A multifactor Nth-to-default CDS Basket, IMF Working paper, Internet: <http://www.papers.ssrn.com/>, accessed March 10, 2010.
- BARNDORFF-NEILSON**, O., and Shepard, N. 2004. “Econometric analysis of realised co variation: High frequency based covariance, regression, and correlation in financial economics, *Econometrica*, vol. 72, 885–925.
- BCBS**, 2000. Sound Practices for Managing Liquidity in Banking Operations, Bank for International Settlements. Internet: <http://www.bis.org/press/p091217.htm>, accessed July 11, 2010.
- BCBS**, 2001. Consultative Document: Operational risk, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbzca07.pdf>, accessed June 3, 2009.
- BCBS**, 2006a. International convergence of capital measurement and capital standards, Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbssc111.htm>, accessed June 22, 2009.
- BCBS**, 2006b. Observed range of practice in key elements of advanced measurement approaches (AMA), Bank of International Settlements. Internet: <http://www.bis.org/publ/bcbs131.htm>, accessed August 3, 2009.
- BCBS**, 2009. Consultative proposals to strengthen the resilience of the banking sector announced by the Basel Committee, Bank of International Settlements. Internet: <http://www.bis.org/press/p091217.htm>, accessed January 11, 2010.
- BENINK**, H. and Kaufman, G, 2008. Turmoil reveals the inadequacy of Basel II, *Financial Times*, 28 February 2008.
- BERGER**, A.N., and Bouwman, H.S. 2006. The measurement of bank liquidity creation and the effect of capital, US Federal Reserve System. Internet: <http://fic.wharton.upenn.edu/fic/papers/07/0702>, accessed July 16, 2010.
- BHATTACHARYA**, S., and Thakor, A.V. 1993. Contemporary banking theory, *Journal of Financial Intermediation*, 3:2–50.

- BII**, 2009. BIS2 – Best practices for BIS 2 implementation. Internet: http://bis2information.org/content/Credit_Loss_Distribution, accessed October 5, 2009.
- BORIO**, C., 2009. Ten propositions about liquidity crises, *BIS Working Papers*, No. 293, Monetary and Economic Department. Internet: <http://www.bis.org/publ/work293.pdf>, accessed on 12 July 2010.
- BRUNNERMEIER**, M.K., 2009. Deciphering the liquidity and credit crunch 2007-2008, *Journal of Economic Perspectives*, 23(1): 77–100.
- CAGAN**, P. 2009. Managing operational risk through the credit crisis, *The Journal of Compliance Risk & Opportunity*, 3, 2, 19 – 26.
- CAGAN**, P., and Lantsman, Y. 2008. The cyclical of operational risk: the tracking phenomenon. Internet: <http://www.algorithmics.com/EN/publications/whitepapers/registration.cfm?code=wp18>, accessed May 31, 2009.
- CANNATA**, F. and Quagliariello, M., 2009. The role of Basel II in the sub-prime financial crisis: guilty or not guilty? *Garefin Working paper*. University of Bocconi, Milan, Italy.
- CHERNOBAI**, A., Jorion, P., and Fan Yul, P. 2009. The determinants of operational risk in U.S. financial institutions, in press.
- CIFUENTES**, R., Ferrucci, G and Shin, H.S. 2005. Liquidity risk and contagion, *Journal of the European Economic Association*, 3, 556-66.
- CNN MONEY.COM**. 2009. List of Bailed out Banks. Internet: <http://money.cnn.com/news/specials/storysupplement/bankbailout/>, date accessed: October 8, 2009.
- COLANDER**, D., Follmer, H. and Haas, A., 2009. The financial crisis and the systematic failure of economics. *Kiel working paper*. Kiel Institute for the World Economy. Kiel, Germany
- COLOMIRIS**, C.W. and Khan, C.M. 1991. The role of demandable debt in structuring optimal banking arrangements, *American Economic Review*, 81:497–513.
- CRUZ**, M.G. 2002. *Modelling, measuring and hedging operational risk*, John Wiley & Sons Ltd. West Sussex, UK.
- CUMMINS**, J. D., Lewis, C. M., and Wei, R. 2006. The market value impact of operational risk events for U.S. banks and insurers, *Journal of Banking and Finance*, 30, 2605–2634.
- DAILY Kos**, 2009. When did the financial crisis really start? Internet: <http://www.dailykos.com/story/2009/2/12/125228/516/46/696617>, accessed August 1, 2009.
- DE FONTNOUELLE**, P., deJesus-Rueff, D., Jordan, J. and Rosengren, E. 2003. Using loss data to quantify operational risk, Technical Report, Federal Reserve Bank of Boston.
- DE FONTNOUELLE**, P., deJesus-Rueff, D., Jordan, J. and Rosengren, E. 2006. Capital and risk: New evidence on implications of large operational losses, *Journal of Money, Credit, and Banking*, 38, 1819 – 1846.
- DEEP**, A. and Schaefer, G. 2004. Are banks liquidity transformers?, Harvard University working paper.
- DIAMOND**, D. 1984. Financial intermediation and delegation monitoring, *Review of Economic Studies* 51: 393-414.

- DIAMOND, D. W.**, and Rajan, R. D. 2009. The Credit Crisis: Conjectures about Causes and Remedies, *American Economic Review*, American Economic Association, 99, 2, 606 – 60.
- DIAMOND, D.W.**, and Dybvig, P.H. 1983. Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, 91:401–419.
- DIAMOND, D.W.**, and Rajan, R.D. 2001. Liquidity risk, liquidity creation and financial fragility: a theory of banking, *Journal of Political Economy*, 109:287–327.
- DOUGLAS, S.** 2007. UK mergers and acquisitions at all time record, Investment Markets. Available from <http://www.investmentmarkets.co.uk/20070904-771.html>, accessed 7 June, 2009.
- DRIESSEN, J.**, Maenhout, P. and Vilkov, G. 2006. Option-implied correlation and the price of correlation risk, Internet: <http://icf.som.yale.edu/pdf/seminars04-05/Maenhout>, accessed March 9, 2010.
- DUFFIE, D.** 1999. Credit default swap valuation, *Financial Analyst Journal*, 73-87.
- DUFFIE, D.** and Singleton, K. 2003. The Standard & Poor's guide to measuring and managing credit risk. Internet: <http://www.openlibrary.org>, accessed March 3, 2010.
- DUTTA, K.** and Perry, J. 2006. A tale of tails: an empirical analysis of loss distribution models for estimating operational risk capital. Federal Reserve Bank of Boston, Working Paper No 06-13.
- DWYER, P.**, Douglas, T, and Qu, S. 2007. EDFTM 8.0 model enhancements, Moody's KMV Documents.
- EPSTEIN, G.** 2005. Introduction: Financialisation and the World Economy, Cheltenham and Northampton: Edward Elgar.
- ERNST & YOUNG**, 2009. Fraud risk on the increase across Europe as recession bites, survey conducted by Ernst and Young's Fraud department. Internet: [Http://www.ey.com/RU/en/Newsroom/News-releases/Press-Release](http://www.ey.com/RU/en/Newsroom/News-releases/Press-Release), accessed June 1, 2009
- ESTERHUYSEN, J.**, 2007. The management of operational value at risk (OpVaR) in banks. PhD dissertation, North West University, Potchefstroom, South Africa.
- ESTERHUYSEN, J.**, van Vuuren, G. and Styger, P. 2010. The effect of stressed economic conditions on credit risk in Basel II. *South African Journal of Economic and Management Sciences*, South Africa, forthcoming.
- GALBRAITH, J. K.** 1955. *The Great Crash*, Penguin, New York.
- GATEV, E.**, Scheurmann, T, and Strahan, P. 2004. Managing Bank Liquidity Risk: How deposit-loan synergies vary with market conditions, The National Bureau of economic Research. Internet: <http://www.nber.org/papers/w12234>, accessed August 4, 2010.
- GLASSERMAN, P.** 2005. Importance Sampling of Portfolio Credit Risk, *Management Science*, Vol. 51, No 11, 1643-1656.
- GORTON, G.** and Winton, A. 2000. Liquidity provision, bank capital, and the macroeconomic, University of Minnesota, *Working paper*.
- GREENSPAN, A.** 1996. From a speech made to the American Enterprise Institute on December 5, 1996.
- GRIFFIN, C.**, 2008. Basel II capital, adequacy regulations and the credit crisis – cause or cure? Internet: <http://www.charteredaccountants.ie/en/Members/Technical1>, accessed September 4, 2009.

- HILL**, B. M. 1975. A simple general approach to inference about the tail of the distribution, *Annals of Statistics*, 3, 1163 – 1174.
- HUANG**, X., Zhou, H., and Zhu, H. 2009. A framework for assessing the systemic risk of major financial institutions. BIS Working papers, No 281. Internet: <http://www.BIS.org>, accessed March 1, 2010.
- HUANG**, X., Zhou, H., and Zhu, H. 2010. Assessing the systemic risk of a heterogeneous portfolio of banks during the recent financial crisis. *BIS Working papers*. #296. Internet: <http://www.BIS.org>, accessed March 2, 2010.
- HULL**, J. and White, A. 2004. Valuation of a CDO and an n-th to default CDS without Monte Carlo Simulation, *Journal of Derivatives*, 12, 8-23.
- JOBST**, A. A. 2007. Operational Risk - The sting is still in the tail but the poison depends on the dose, *Journal of Operational Risk*, 2, 2, 435 – 449.
- KASHYAP**, A.K, Rajan, G. and Stein. J.C. 2002. Banks as liquidity providers: and explanation for the coexistence of lending and deposit- taking, *Journal of Finance*, 57:33-73.
- KLEINERT**, H. 2004. Path integrals in quantum mechanics, statistics, polymer physics and financial markets, World Scientific, Singapore, Paperback ISBN 981-238-107-4.
- LAMBRIGGER**, D., Shevchenko, P., and Wuthrich, M. 2007. The quantification of operational risk using internal data, relevant external data and expert opinions, *The Journal of Operational Risk*, 2(3), 3-27.
- LEHAR**, A. 2005. Measuring systemic risk: A risk management approach, *Journal of Banking and Finance*, 60, 2213-2253.
- MERTON**, R. 1974. On the pricing of corporate debt: the risk structure of interest rates, *Journal of Finance*, 29, 449-470.
- MONEYWEEK**, 2007. Is this the start of the credit crisis? Internet: <http://financialmediaandcomms.blogspot.com/2008/09/global-credit-crunch-when-did-it-start.html>, accessed on May 19, 2009.
- MOODYS KMV**. 2008. EDF Overview. Internet: <http://www.moodyskmv.com/newsevents/files/EDF>, accessed March 4, 2010.
- MORRIS**, Q., Van Vuuren, & Styger, P. 2009. Further evidence of long memory in the South African Stock Market, *South African Journal of Economics*, 77, 81-101.
- ONADO**, M., 2008. Capital is a problem. Internet: <http://www.lavoce.info>, accessed September 19, 2009.
- PERRY**, J., and de Fontnouvelle, P. 2005. Measuring reputational risk: the market reaction to operational loss announcements, *Working paper*, Federal Reserve Bank of Boston.
- POLLET**, J. and Wilson, M. 2006. Average correlation and stock market returns, *Journal of Finance*, 56, 3, 815-849. Internet: <http://people.physics.anu.edu.au>, accessed, March 8, 2010.
- RAMAKRISHNAN**, R.T., and Thakor, V. 1984. Information reliability and theory of financial intermediation, *Review of Economic Studies* 51: 415-432.

- REPULLO, R.** and Suarez, T. 2008. The procyclical effects of Basel II. IMF Ninth Annual Jacques Polak Research Conference, IMF, Washington DC. Internet: <http://www.imf.org/external/np/siminars>, accessed November 13, 2009
- SIEGEL, F.A.** 1995. Measuring systemic risk using implicit beta. Internet: <http://portal.acm.org/citation>, accessed March 2, 2010
- SOROS, G.**, 2008. The new paradigm for financial markets: the credit crisis of 2008 and what it means, *PublicAffairs*, USA, 15 May 2008.
- STANDARD & POOR'S**, LossStats® Database, Internet: <http://www2standardandpoors.com/portal/site/sp/en/eu/page.product.risksolutions>, accessed November 13, 2009.
- STYGER, P.** and Vosloo P.G., 2005. The bankers guide to the Basel II framework. *The Banking Association of South Africa*, Johannesburg, SA.
- SUBRAMANIAN, A.**, 2009. The world crisis: reforming the international financial system. *Economic and political weekly*, Mumbai, India. Internet: <http://www.piie.com/publications/papers/subramanian>, accessed September 2, 2009.
- TARASHEV, N.** and Zhu, H. 2008b. Specification and calibration errors in measures for portfolio credit risk: The case of the ASRF model, *International Journal of Central Banking*, 4, 129-174.
- THE ECONOMIST**, 2008. *Confessions of a risk manager*, August 7th 2008 print edition.
- VAN GRINSVEN, J.** 2009. Operational risk losses – Not just reporting. Internet: <http://www.riskfriends.comordpress.com/2009/03/10/ops-risk-not-just-reporting/> accessed on April 20, 2009.
- VAN VUUREN, G.** and Chan-Aston, P. 2010. Modelling systemic liquidity risk, *South African Journal of Economics*, forthcoming.
- VON THADDEN, E.** 2004. Bank capital adequacy regulation under the new Basel Accord, *Journal of Financial Intermediation*, 13:90-95.
- WILSON, T.** 1998. Portfolio credit risk, *International Journal of Central Banking*, 4, 129-174.
- YAMAI, Y.** and Yoshihara, T. 2005. Value at risk versus expected shortfall: A practical perspective, *Journal of Banking and Finance*, 29, 997-1015. Internet: <http://www.econpapers.repec.org>, accessed, March 10, 2010.
- ZINGALES, L.**, 2008. "La sospensione del market-to-market" ("The suspension of market-to-market"), *Il Sole24Ore*, 15 October (translation from the Italian version).

ANNEXURE 1 – CONSENT LETTERS FROM JOURNAL EDITORS



SOUTH AFRICAN JOURNAL OF
ECONOMIC AND MANAGEMENT SCIENCES

Department of Economics
University of Pretoria
PRETORIA
0002
sajems@up.ac.za
Tel: +27(12)420 3543
Fax: +27(12) 362 5207

1 October 2010

Dr J Esterhuysen
Absa Capital: Investment Bank
Division of Absa Bank
15 Alice Lane
Sandton 2196

Dear Dr Esterhuysen

RE: Manuscript 61-9 The effect of stressed economic conditions on operational risk loss distributions & manuscript 63-1 The effect of stressed economic conditions on credit risk in Basel II.

In response to your request to re-produce the above two manuscripts accepted for publication in your PhD, this letter serves to inform you that the Journal and editor do not have any formal objections against it.

Yours Sincerely

Prof Steve Koch
Editor and Chief: SAJEMS