

BANK LOAN PRICING AND PROFITABILITY AND THEIR CONNECTIONS WITH BASEL II AND THE SUBPRIME MORTGAGE CRISIS

BA. Tau, M.Sc.

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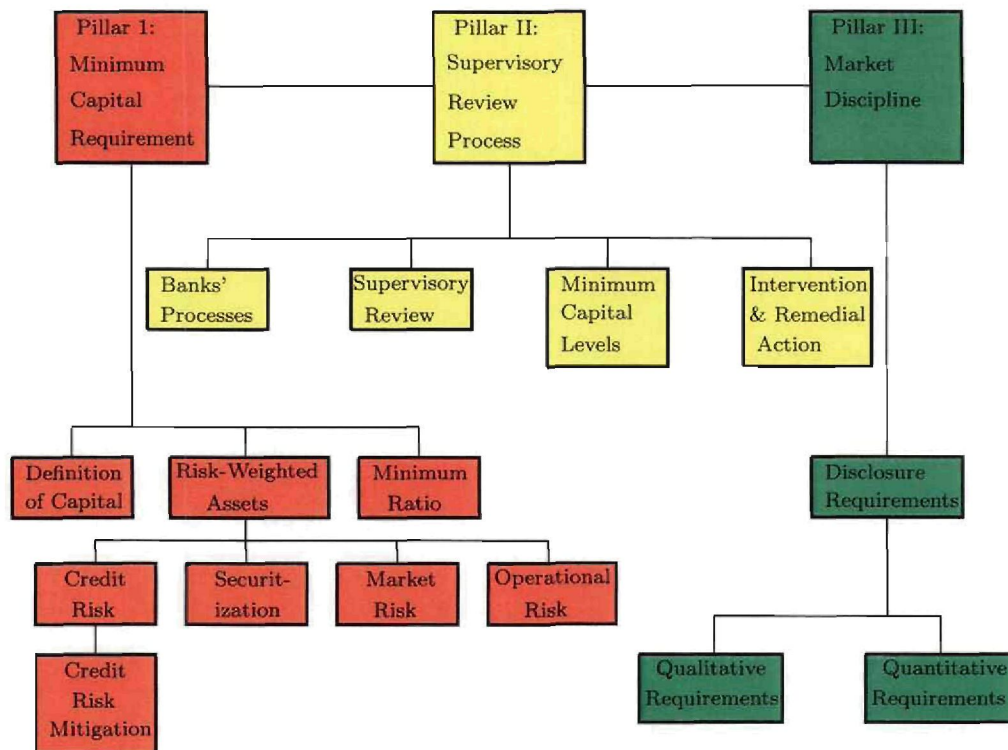


Figure 1: Diagrammatic Overview of the Basel II Capital Accord

Supervisor: Prof. Mark A. Petersen

Co-Supervisor: Dr. Ilse M. Schoeman

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Abstract

A topical issue in financial economics is the development of appropriate stochastic dynamic models for banking items and behavior. The issue here is to fulfill the need to generalize the more traditional discrete-time models of banking activity to a Lévy process setting. In this thesis, under the assumption that the loan market is imperfectly competitive, we investigate the evolution of banking items such as bank assets (cash, bonds, shares, Treasuries, reserves, loans and intangible assets), liabilities (demand deposits) and bank capital (bank equity, subordinate debt and loan loss reserves). Here we consider the influence of macroeconomic factors and profitability as well as its indicators return on assets (ROA) and return on equity (ROE).

As far as bank assets are concerned, we note that loan pricing models usually reflect the financial funding cost, risk premium to compensate for the risk of default by the borrower, a premium reflecting market power exercised by the bank and the sensitivity of the cost of capital raised to changes in loans extended. On the other hand, loan losses can be associated with an offsetting expense called the loan loss provision (LLP), which is charged against nett profit. This offset will reduce reported income but has no impact on taxes, although when the assets are finally written off, a tax-deductible expense is created. An important factor influencing loan loss provisioning is regulation and supervision. Measures of capital adequacy are generally calculated using the book values of assets and equity. The provisioning of loans and their associated write-offs will cause a decline in these capital adequacy measures, and may precipitate increased regulation by bank authorities. Greater level of regulation generally entail additional costs for the bank. Currently, this regulation mainly takes the form of the Basel II Capital Accord that has been implemented on the worldwide basis since 2008.

It is clear that bank profitability is a major indicator of financial crises for households, companies and financial institutions. An example of this from the 2007–2008 subprime mortgage crisis (SMC) is the U.S. bank, Wachovia Corp., who reported a big loss as from the first quarter of 2007 and eventually was bought by the world's largest bank, Citigroup, on 29 September 2008. A further example from the SMC is that both the failure of the Lehman Brothers investment bank and the acquisition in September 2008 of Merrill Lynch and Bear Stearns by Bank of America and JP Morgan Chase, respectively, were preceded by a decrease in profitability and an increase in the price of loans and loan losses. The subprime mortgage crisis is characterized by contracted liquidity in the global credit markets and banking system. The level of liquidity in the banking sector affects the ability of banks to meet commitments as they become due without incurring substantial losses from liquidating less liquid assets. Liquidity, therefore, provides the defensive cash or near-cash resources to cover banks' liability. An undervaluation of real risk in the subprime market is cascading, rippling and ultimately severely adversely affecting the world economy. The downturn in

the U.S. housing market, risky lending and borrowing practices, and excessive individual and corporate debt levels have caused multiple adverse effects tumbled as the US housing market slumped. Banks worldwide are hoarding cash and showing a growing reluctance to lend, driving rates that institutions charge to each other on loans to record highs. Also, global money markets are inoperative, forcing increased injections of cash from central banks. The crisis has passed through various stages, exposing pervasive weaknesses in the global financial system and regulatory framework.

The stochastic dynamics of the aforementioned banking items assist in formulating a maximization problem that involves endogenous variables such as profit consumption, the value of the bank's investment in loans and provisions for loan losses as control variates. In particular, we demonstrate that the bank is able to maximize its expected utility of discounted profit consumption over a random time interval, $[t, \tau]$, and terminal profit at time τ . Here the term profit consumption refers to the consumption of the bank's profits by dividend payments on equity and interest and principal payments on subordinate debt. The associated Hamilton-Jacobi-Bellman (HJB) equation has a smooth solution when the optimal controls are computed by means of power, logarithmic and exponential utility functions. This enables us to make a direct comparison between the economic properties of the solutions for different choices of the utility function.

In keeping with the main theme of this thesis, we simulate the financial indices ROE and ROA that are two measures of bank profitability. We further discuss optimization with power utility where we show the convergence of the Markov Chain Approximation Method (MCAM) and the impact of varying the model parameters in the form of loan loss severity, β , and loan loss frequency, ϕ . We investigate the connections between the banking models and Basel II capital accord as well as the current subprime mortgage crises. As a way of conclusion, we provide remarks about the main issues discussed in the thesis and speculate about future research directions.

The contents of this thesis is based on 3 peer-reviewed journal articles (see [105], [106] and [107]) and 1 peer-reviewed conference proceedings paper (see [104]). In addition, the paper [108] is currently being prepared for submission to an accredited journal.

KEYWORDS: Loan Pricing; Loan Losses and their Provisioning; Profitability; Regulatory Capital; Basel II Capital Accord; Subprime Mortgage Crisis.

2000 AMS SUBJECT CLASSIFICATION: 60G44, 90A09, 93B15.

Opsomming

'n Aktuele aspek van finansiële ekonomie is die ontwikkeling van 'n geskikte stogasties dinamiese model wat bankgedrag bepaal. Daar is 'n behoefte om die meer tradisionele diskrete tydmodelle in bank aktiwiteite te veralgemeen na Lévy prosesse. Onder die aanname dat die uitleenmark gebrekkig kompetend is, handel hierdie navorsing oor die evolusie van bankitems soos bates (kontant, verbande, aandele, Tesourier, reserwes, lenings en onaan-tasbare bates), aanspreeklikhede (aanvraag deposito's) en bankkapitaal (bankwaardes, ondergeskikte skuld aan leningsverliesreserwes). Ons beskou die invloed van makro-ekonomiese faktore en winsgewendheid asook die aanwysers van "return on assets" (ROA) en "return on equity" (ROE). Sover dit bankbates betref merk ons op dat uitleenkostemodelle reflekteer gewoonlik die finansiële befondsingskoste, risiko-premies om te kompenseer vir die bestek risiko van die lener, 'n premie wat die mark kragte wat die bank uitoefen, reflekteer asook die sensitiwiteit van die verhoogde kapitaalkoste teen veranderings in verlengde lenings.

Aan die ander kant kan leningsverliese geassosieer word met 'n kompensasië-uitgawe bekend as die leningsverliesvoorsiening (LVV), wat gevra word teen netto wins. Hierdie kompensasië sal gerapporteerde inkomste verminder maar het geen inpak op belasting nie, alhoewel wanneer die bates finaal afgeskryf word, 'n belasting aftrekbare uitgawe geskep word. 'n Belangrike faktor wat leningsverliese beïnvloed, is regulering en toesighouding. Boekwaardes van bates en aandeelhouding word in die algemeen gebruik om die mate van voldoende kapitaal te bepaal. Die voorsiening van lenings en die geassosieerde afskryfwaardes sal 'n afname in die voldoende kapitaal maatstawwe veroorsaak, en mag verhoogde regulering deur die bank outoriteite verhaas. Hoër vlakke van regulering beteken addisionele kostes vir die bank. Huidiglik neem hierdie regulasie hoofsaaklik die vorm aan van die Basel II kapitaal ooreenkoms wat wêreldwyd in 2008 geïmplementeer is. Dit is duidelik dat 'n bank se winsgewendheid 'n hoof aanwyser is vir die finansiële krisis van huishoudings, maatskappye en finansiële instansies.

'n Voorbeeld hiervan vanuit die 2007-2008 subprima verbandkrisis van die V.S.A bank, Wachovia Corp., wat groot verliese sedert die eerste kwartaal van 2007 gerapporteer het, en uiteindelik deur die wêreld se grootste bank, Citigroup, op 29 September 2008 gekoop is. 'n Verdere voorbeeld van die subprima verbandkrisis is dat die ondergang van beide Lehman Brothers beleggingsbank en die oornome in September 2008 van Merrill Lynch en Bear Stearns deur die Bank of America en JP Morgan Chase, respektiewelik, voorafgegaan was deur 'n verhoging in winsgewendheid en 'n verhoging in die prys van lenings en leningsverliese. Die subprima verbandkrisis word gekenmerk deur gekontrakteerde likiditeit in die globale kredietmarkte en banksisteme.

Die vlak van likiditeit in die banksektor affekteer die vermoë van banke om hulle verbindnisse na te kom wanneer dit gedoen moet word, sonder om substansiële verliese te lei deur nie van mindere likide-bates te laat likwiede nie. Likiditeit voorsien dus die verdedigingskon-

tant of naby-kontant bronne om die bank se aanspreeklikheid te dek. 'n Onder evaluering van werklike risiko's in die subprima mark kaskadeer, het 'n rimpel effek en uiteindelik 'n kritiese effek op die wêreld ekonomie. Die omkeer in die V.S.A se behuisingsmark, onveilige lenings en uitleenpraktyke, en uitermatige individuele en maatskappy skuldvlakke het meervoudige ongunstige effekte veroorsaak namate die V.S.A se huismarkte getuimel het. Banke wêreldwyd klou aan kontant en toon 'n onwilligheid om uit te leen, en dit dryf koerse wat instansies van mekaar vra vir lenings tot rekord vlakke. Globale geldmarkte funksioneer nie voldoende nie en dit forseer kontant inspuitings vanaf sentrale banke. Die krisis het deur verskeie stadiums gegaan wat deurdringende swakhede in die globale finansiële stelsel en reguleringsraamwerk ontbloot het. Die stogastiese dinamika van bogenoemde bankitems het bygedra om 'n maksimeringsprobleem te formuleer wat oorsprongveranderlikes soos profytverbruiking, die waarde van 'n bank se investering in lenings en voorsiening vir leningsverliese, as beheer veranderlikes gebruik. In besonder demonstreer ons dat 'n bank instaat is om sy verwagte gebruik van korting deposito-verbruik te maksimeer gedurende die tydsinterval, $[t, \tau]$, en die finale wins by tydstep τ . Die term profytverbruiking verwys na die benutting van die bank se profyt deur dividende wat betaal word aan aandeelhouders en rente en aanvanklike betalings op ondergeskikte skulde. Hier het die geassosieerde Hamilton-Jacobi-Bellman (HJB) vergelyking 'n gladde oplossing wanneer die optimale kontrole bereken word deur middel van magte, logaritmiëse en eksponensiële funksies. Dit stel ons instaat om 'n direkte vergelyking te maak tussen die ekonomiese eienskappe van die oplossing vir verskillende keuses van gebruik-funksies. In lyn met die hooftema van hierdie tesis, simuleer ons die finansiële aanwysers, ROE en ROA, twee aanwysers van bankwins. Verder word optimering bespreek waar die konvergensie van die Markov Kettingbenaderingsmetode (MCAM) en die impak van variasies van die model se parameters in die vorm van leenverliese, β , en die leenverlies frekwensie, ϕ , aangedui word. Ons bestudeer die verbindings tussen die bankmodelle en die Basel II kapitaal ooreenkoms sowel as die huidige subprima verband krisis. In afsluiting maak ons enkele opmerkings oor die onderwerpe van die studie en spekuleer oor moontlike verdere studies.

Acknowledgments

Firstly, I would like to thank God for His grace in enabling me to complete this thesis.

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I am indebted to my supervisor, Prof. Mark A. Petersen of the School of Computer, Mathematical and Statistical Sciences at Potchefstroom Campus of the North-West University (NWU-PC), for the guidance provided during the completion of this dissertation. My gratitude goes to Financial Modeling and Optimization Research Group (FMORG) at NWU-PC for their unconditional support during the latter part of this thesis. Also, I would like to thank the members of staff in the School of Information Technology at the Vaal Campus of the North-West University (NWU-VC) for providing moral and logistical support during my studies.

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Preface

One of the contributions made by the NWU-PC to the activities of the stochastic analysis community has been the establishment of an active research group FMORG that has an interest in institutional finance. In particular, FMORG has made contributions about modeling, optimization, regulation and risk management in insurance and banking. Students who have participated in projects in this programme under Prof. Petersen's supervision are listed below.

Level	Student	Graduation	Title
MSc	T Bosch	May 2003	Controllability of HJMM Interest Rate Models
MSc	CH Fouche	May 2006	Continuous-Time Stochastic Modeling of Capital Adequacy Ratios for Banks
MSc	MP Mulaudzi	May 2008	A Decision Making Problem in the Banking Industry
PhD	CH Fouche	May 2008	Dynamic Modeling of Banking Activities
PhD	F Gideon	Sept. 2008	Optimal Provisioning for Deposit Withdrawals and Loan Losses in the Banking Industry
PhD	T Bosch	May 2009	Management and Auditing of Bank Assets and Capital
MSc	MC Senosi	May 2009	Discrete Dynamics of Bank Credit and Capital and their Cyclicity
PhD	BA Tau	Current	Bank Loan Pricing and Profitability and Their Connections with Basel II and the Subprime Mortgage Crisis
PhD	MP Mulaudzi	Current	Lévy Process Based Banking Models & Relationships with the Subprime Mortgage Crisis and Basel II
PhD	MC Senosi	Current	Discrete-Time Banking Models and Connections with the Subprime Mortgage Crisis and Basel II
Postdoc	J Mukuddem-Petersen	2006-8	Health Economics

Declaration

I declare that, apart from the assistance acknowledged, the research contained in the thesis is my own unaided work. It is being submitted in partial fulfillment of the requirements for the degree Philosophiae Doctor in Applied Mathematics at the Potchefstroom Campus of the North West University. It has not been submitted before for any degree or examination to any other University.

Nobody, including Prof. MA. Petersen (Supervisor), but myself is responsible for the final version of this thesis.

Signature.....

Date.....

Key Definitions

An *adjustable-rate mortgage* (ARM) is a mortgage whose rate is adjustable throughout its term.

An *interest-only ARM* allows the homeowner to pay just the interest (not principal) during an initial period.

Borrowers borrow from lenders while *lenders* lend to borrowers.

Central banks are primarily concerned with price and financial stability.

Cost of funds is the interest cost that a bank must pay for the use of funds (money).

Credit crunch is a term used to describe a sudden reduction in the general availability of loans (or credit) or sudden increase in the cost of obtaining loans from banks (usually via raising interest rates).

The *delinquency rate* includes loans that are at least one payment past due but does not include loans somewhere in the process of foreclosure.

Foreclosure is the legal proceeding in which a mortgagee, or other loanholder¹, usually a lender, obtains a court ordered termination of a mortgagor's equitable right of redemption. Usually a lender obtains a security interest from a borrower who mortgages or pledges an asset like a house to secure the loan. If the borrower defaults and the lender tries to repossess the property, courts of equity can grant the owner the right of redemption if the borrower repays the debt. When this equitable right exists, the lender cannot be sure that it can successfully repossess the property, thus the lender seeks to foreclose the equitable right of redemption. Other loanholders can and do use foreclosure, such as for overdue taxes, unpaid contractors' bills or overdue HOA dues or assessments. The foreclosure process as applied to residential mortgage loans is a bank or other secured creditor selling or repossessing a parcel of real property (immovable property) after the owner has failed to comply with an agreement between the lender and borrower called a "mortgage" or "deed of trust". Commonly, the violation of the mortgage is a default in payment of a promissory note, secured by a lien on the property. When the process is complete, the lender can sell the property and keep the proceeds to pay off its mortgage and any legal costs, and it is typically said that "the lender has foreclosed its mortgage or lien". If the promissory note was made with a recourse clause then if the sale does not bring enough to pay the existing balance of principal and fees the mortgagee can file a claim for a deficiency judgment.

Gross revenue is the funds generated by all banking operations before deductions for expenses.

¹In law, a lien is a form of security interest granted over an item of property to secure the payment of a debt or performance of some other obligation. The owner of the property, who grants the lien, is referred to as the loanor and the person who has the benefit of the lien is referred to as the loanee.

Herfindahl-Hirschman Index is a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers.

Market Concentration is a function of the number of firms and their respective shares of the total reserves in a market. To be practically useful, a market concentration measure should be decreasing in the number of firms in the market. Additionally, it should also be decreasing (or at least nonincreasing) with the degree of symmetry between the firms' shares.

Mark-to-market is the process of adjusting the value of a security or derivative contract to its current market value.

The *leverage* of a financial institution refers to its debt-to-capital reserve ratio. An institution is *highly leveraged* if this ratio is high.

Subprime lending is the practice of making loans to borrowers who do not qualify for market interest rates owing to various risk factors, such as income level, size of the down payment made, credit history and employment status.

Securitization is a structured finance process, which involves pooling and repackaging of cash-flow producing financial assets into securities that are then sold to investors. In other words, securitization is a structured finance process in which assets, receivables or financial instruments are acquired, classified into pools, and offered for sale to third-party investment. The name "securitization" is derived from the fact that the form of financial instruments used to obtain funds from investors are securities.

A *hedge borrower* borrows with the intent of making debt payments from cash flows from other investments.

A *speculative borrower* borrows based on the belief that he/she can service interest on the loan but with the principal being continually rolled over into new investments.

A *Ponzi borrower* (named after Charles Ponzi) relies on the appreciation of the value of their assets (e.g. real estate) to refinance or pay-off his/her debt but cannot repay the original loan.

Ninja loans are loans extended to people that typically have No Income, No Job and/or No Assets.

For a *payment option loan* the homeowner can pay a variable amount, but any interest not paid is added to the principal.

Overcollateralization is the pledging of collateral in excess of debt issued.

Underwriters determine if the risk of lending to a particular borrower under certain parameters is acceptable.

Index of Abbreviations

AHMI - American Home Mortgage Investment Corporation;
AIG - American International Group;
AIRB - Advanced Internal Ratings Based Approach;
AMTPA - Alternative Mortgage Transaction Parity Act;
APE - Average Absolute Error;
ARM - Adjustable Rate Mortgage;
ARFA - Aggregate Risk-Free Assets;
ARA - Aggregate Risky Assets;
BE - Bank Exposure;
CAR - Capital Adequacy Ratio;
CDO - Collateralized Debt Obligations;
CEO - Chief Executive Officer;
CF - Commodities Finance;
CFC - Countrywide Financial Corporation;
CIA - Community Investment Act;
CRA - Community Reinvestment Act;
CRL - Centre for Responsible Lending;
DIDMCA - Depository Institutions Deregulation and Monetary Control Act;
DJIA - Dow Jones Industrial Average;
DoL - Department of Labor;
ECB - European Central Bank;
ECIA - External Credit Assessment Institution;
EENHTB - Equity Exposure Not Held in the Trading Book;
ESA - Economic Stimulus Act;
ESP - Economic Stimulus Package;
ELGD - Expected Loss Given Default;
Fannie Mae - Federal National Mortgage Association;
FBI - Federal Bureau of Investigations;
FDIC - Federal Deposit Insurance Corporation;
FEC - Federal Election Commission;
FIRB - Foundation Internal Ratings Based Approach;
FIRREA - Financial Institutions Reform, Recovery and Enforcement Act;
FM - Financial Market;
FMORG - Financial Modeling and Optimization Research Group;
FOA - Friends of Angelo;
FRBD - Federal Reserve Bank of Dallas;
Freddie Mac - Federal Home Loan Mortgage Corporation;
GDP - Gross Domestic Product;
GIR - Government & Industry Responses;

GSA - Glass-Steagall Act;
 HELOC - Home Equity Line of Credit;
 HFSC - House Financial Services Committee;
 HJB - Hamilton-Jacobi-Bellman;
 HM - Housing Market;
 HNA - Hope Now Alliance;
 HUD - US Department of Housing and Urban Development;
 IBBEA - Interstate Banking and Branching Efficiency Act;
 i.i.d - independent and identically distributed;
 IKBDI - IKB Deutsche Industriebank;
 IMBI - IndyMac Bancorp Incorporated;
 IMF - International Monetary Fund;
 Indymac - Independent National Mortgage Corporation;
 IPRE - Income Producing Real Estate;
 IRB - Internal Ratings Based Approach;
 IRS - Internal Revenue Service;
 JSE - Johannesburg Securities Exchange;
 LGD - Loan Loss Given Default;
 LLP - Loan Loss Provision;
 MAE - Mean Absolute Error;
 MAPE - Mean Absolute Percentage Error;
 MBA - Mortgage Bankers Association;
 MBIA - Municipal Bond Insurance Association;
 MBS - Mortgage-Backed Securities;
 MCAM - Markov Chain Approximation Method;
 MGIC - Mortgage Guaranty Insurance Corporation;
 NAR - National Association of Realtors;
 NCA - National Credit Act;
 NCB - National City Bank;
 NCFC - New Century Financial Corporation;
 NIATBCF-Nett Income After Taxes and Before Cost of Funds;
 NP - Nett Profit;
 OF - Object Finance;
 OFHEO - Office of Federal Housing Enterprize Oversight;
 ORE - Other Retail Exposure;
 OTS - Office of Thrift Supervision;
 PD - Probability of Default;
 PF - Project Finance;
 QRRE - Qualifying Revolving Retail Exposure;
 RBS - Royal Bank of Scotland;
 RCAC - Realtors Commercial Alliance Committee;

RMSE - Root Mean Square Error;
ROA - Return on Assets;
ROE - Return on Equity;
RRM - Retail Residential Mortgage;
RTC - Resolution Trust Corporation;
RWAs - Risk-Weighted Assets;
SAB - South African Breweries;
SE - Sovereign Exposure;
SLHVCRE - Specialized Lending High Volatility Commercial Real Estate;
SLNIHVCRE - Specialized Lending Not Including High Volatility Commercial Real Estate;
SMC - Subprime Mortgage Crisis;
SMECT - Small to Medium Size Enterprizes with Corporate Treatment;
SMERT - Small to Medium Size Enterprizes with Retail Treatment;
TA - Total Assets;
TARP - Toxic Asset Rescue Plan
TIC - Theil Inequality Coefficient;
TRA - Tax Reform Act;
UAE - United Arab Emirates;
VaR - Value-at-Risk;
VEB - Vnesheconombank;
WEF - World Economic Forum.

Index of Symbols

A^i - Assets in the i -th Loan Subportfolio;

$A = \sum_{i=1}^m A^i$ - Total Assets;

A^{ri} - Return on Assets;

A - Aggregate Risk-Free Assets;

A_t^i - Aggregate Risk-Free Asset price at time t , in the i -th loan subportfolio;

$\mathcal{A}^i$ - Set of Admissible Controls in the i -th Loan Subportfolio;

$\hat{A}$ - Aggregate Risky Assets;

$\hat{A}_t^i$ - Aggregate Risky Asset price at time t , in the i -th loan subportfolio;

a^r - Capital Charge to Cover Credit Risk;

B^i - Bonds in the i -th Loan Subportfolio;

$B = \sum_{i=1}^m B^i$ - Total Bonds;

$\mathcal{B}$ - Borel sets;

b - Propensity to Retain Earnings;

C^i - Cash in the i -th Loan Subportfolio;

$C = \sum_{i=1}^m C^i$ - Total Cash;

$c^{2\sigma i}$ - Cost of raising funds in the secondary market;

c^{ai} - Cost of Administration in the i -th Loan Subportfolio;

c^E - The Product of the Cost of Capital (Equity) Raised;

c^{Ki} - Cost of Capital in the i -th Loan Subportfolio;

c^{ii} - Cost of Insolvency in the i -th Loan Subportfolio;

c^{li} - Cost of Liquidation in the i -th Loan Subportfolio;

c^{Pi} - Cost of Provisioning for Loan Losses in the i -th Loan Subportfolio;

$c^{\omega i}$ - Cost of Deposit Withdrawals in the i -th Loan Subportfolio;

$c^{\Lambda i}$ - Marginal Cost in the i -th Loan Subportfolio;

D^i - Demand Deposits in the i -th Loan Subportfolio;

$D = \sum_{i=1}^m D^i$ - Total Demand Deposits;

d^i - Default-to-Total Loan Value Ratio in the i -th Loan Subportfolio;

d^i - Dividends Paid on the i -th Loan Subportfolio;

$\mathbf{E}[c^{ii}]$ - Expected Cost of Insolvency in the i -th Loan Subportfolio;

$\mathbf{E}(d)$ - Expected Default Premium in the i -th Loan Subportfolio;

E^i - Bank Equity in the i -th Loan Subportfolio;

$$E = \sum_{i=1}^m E^i \text{ - Total Bank Equity;}$$

E^{ri} - Return on Equity;

F^i - Cumulative Distribution Function in the i -th Loan Subportfolio;

F^i - Depreciation of Fixed Assets in the i -th Loan Subportfolio;

$f^i(u)$ - Probability Density Function in the i -th Loan Subportfolio;

$(\mathcal{F}_t^i)_{t \geq 0}$, - Filtration in the i -th Loan Subportfolio;

$\tilde{F}$ - Jump Size Distribution Function;

I^i - Intangible Assets in the i -th Loan Subportfolio;

$\tilde{J}_j$ - Jump Sizes which are i.i.d. with Distribution Function $\tilde{F}$;

k^{IIi} - Consumption of Profit in the i -th Loan Subportfolio;

K^i - Capital in the i -th Loan Subportfolio;

$$K = \sum_{i=1}^m K^i \text{ - Total Capital;}$$

p^{Si} - Percentage of Bank Assets which are Consumed by the Aggregate Loan Losses in the i -th Loan Subportfolio;

$p^{K Ri} \in [0, 1]$ - Proportion of the Bank Capital including Loan Loss Reserves used to deal with Unexpected Losses in the i -th Loan Subportfolio;

L^i - Standard Lévy Process in the i -th Loan Subportfolio;

$L'(\cdot)$ - Density Function of the Log-normal Distribution in the i -th Loan Subportfolio;

L' - Lévy process;

M - Remaining Maturity ;

M - Macroeconomic Activity;

$M_{L_t \wedge C^{pi}}$ - Moment Generating Function;

N^i - Poisson Process in the i -th Loan Subportfolio;

N - Poisson Process;

n - Number of Shares;

N - Herfindahl-Hirschman Loan Market Concentration Index in the i -th Loan Subportfolio;

O^i - Subordinate Debt in the i -th Loan Subportfolio;

$$O = \sum_{i=1}^m O^i \text{ - Total Subordinate Debt;}$$

O - Operational Risk;

O^l - Operating Loss;

P^i - Loan Loss Provisioning in the i -th Loan Subportfolio;

$P(d)$ - Probability of Default;

q - Solvency Probability ;

R^i - Reserves in the i -th Loan Subportfolio;

$$R = \sum_{i=1}^m R^i \text{ - Total Reserves;}$$

R^{pi} - Reserve Requirements on Public Accounts in the i -th Loan Subportfolio;
 r - Risk-Free Interest Rate;
 r^{Bi} - Bond Rate in the i -th Loan Subportfolio;
 r^{Ci} - Cash Rate in the i -th Loan Subportfolio;
 r^T - Treasury Rate;
 r^A - Aggregate Risk-Free Interest Rate;
 $r^{\hat{A}}$ - Aggregate Risky Interest Rate;
 r^{Ii} - Rate of Change of Intangible Assets in the i -th Loan Subportfolio;
 r^{di} - Loan Loss Rate in the i -th Loan Subportfolio;
 r^{Pi} - Penalty Rate in the i -th Loan Subportfolio;
 r^{Si} - Rate of Change of Shares in the i -th Loan Subportfolio;
 r^{Ti} - Treasury Rate in the i -th Loan Subportfolio;
 $r^{\Lambda i}$ - Loan Rate in the i -th Loan Subportfolio;
 r^{wi} - Secondary Market Rate in the i -th Loan Subportfolio;
 S^i - Aggregate Loan Losses in the i -th Loan Subportfolio;
 S^{ei} - Expected Loan Losses in the i -th Loan Subportfolio;
 S^{ui} - Unexpected Loan Losses in the i -th Loan Subportfolio;
 S^i - Shares in the i -th Loan Subportfolio;
 $S = \sum_{i=1}^m S^i$ - Total Shares;
 T - Terminal Time;
 T^i - Treasuries in the i -th Loan Subportfolio;
 $T = \sum_{i=1}^m T^i$ - Total Treasuries;
 u^i - Unanticipated Deposit Withdrawals in the i -th Loan Subportfolio;
 $U^{(1)}(k^{\Pi i})$ - Utility Function of Consumption of Profit in the i -th Loan Subportfolio;
 $U^{(2)}(\Pi^i)$ - Utility Function of Profit in the i -th Loan Subportfolio;
 V^i - Value Function in the i -th Loan Subportfolio;
 Z^i - Standard Brownian Motion in the i -th Loan Subportfolio;
 Z - Brownian Motion;
 α^i - Utility Parameter in the i -th Loan Subportfolio;
 $\tilde{\alpha}^i$ - Shift Parameter which Represents Macroeconomic Factor such as Changes in Macroeconomic Activities, M in the i -th Loan Subportfolio;
 $\tilde{\beta}^i$ - Shift Parameter which Represents the Business Cycle in the i -th Loan Subportfolio;
 β^i - Loan Loss Severity in the i -th Loan Subportfolio;
 χ^i - Market Requirement as a Gross Return on Capital in the i -th Loan Subportfolio;
 δ^i - Idiosyncratic discount rate that is not a market parameter, but rather part of the utility functional in the i -th Loan Subportfolio;
 δ^{ei} - Dividend Payment on E^i in the i -th Loan Subportfolio;

δ^{si} - Interest and Principal Payment on O^i in the i -th Loan Subportfolio;
 η^i - Rate of Inclination Towards Bankruptcy in the i -th Loan Subportfolio;
 η_h^i - Hazard Rate in the i -th Loan Subportfolio;
 η_e^i - Elasticity of Loan Demand in the i -th Loan Subportfolio;
 γ^i - Reserve-Demand Deposit Ratio in the i -th Loan Subportfolio;
 γ^{vi} - Constant Jump Coefficient in the i -th Loan Subportfolio;
 Γ^i - Liabilities in the i -th Loan Subportfolio;
 $\Gamma = \sum_{i=1}^m \Gamma^i$ - Total Liabilities;
 $\mathfrak{J}^i$ - Loan Supply in the i -th Loan Subportfolio.
 Λ^i - Loans in the i -th Loan Subportfolio;
 $\Lambda = \sum_{i=1}^m \Lambda^i$ - Total Loans;
 Λ^{ci} - Borrower's Agreement to Repay in the i -th Loan Subportfolio;
 Λ_t^i - Total Loan Value that Corresponds to Creditors that Regularly Repay their Loans in the i -th Loan Subportfolio;
 μ^i - Total Expected Returns on A in the i -th Loan Subportfolio;
 μ_e^i - Total Expected Returns on E in the i -th Loan Subportfolio;
 μ^{ai} - Rate Term for Auxiliary Profits in the i -th Loan Subportfolio;
 ω^{Ii} - Risk-Weight of Intangible Assets in the i -th Loan Subportfolio;
 ω^{Ci} - Risk-Weight of Cash in the i -th Loan Subportfolio;
 ω^{Si} - Risk-Weight of Shares in the i -th Loan Subportfolio;
 ω^{Ri} - Risk-Weight of Reserves in the i -th Loan Subportfolio;
 ω^{Ti} - Risk-Weight of Treasuries in the i -th Loan Subportfolio;
 $\omega^{\Lambda i}$ - Risk-Weight of Loans in the i -th Loan Subportfolio;
 Π^{ni} - Value of Net Profit After Tax in the i -th Loan Subportfolio;
 Π^i - Terminal Profit in the i -th Loan Subportfolio;
 ϕ^i - Loan Loss Frequency in the i -th Loan Subportfolio;
 $\phi(\xi)$ - Characteristic Function of Distribution;
 ψ^i - Bank Shares in the Loan Market in the i -th Loan Subportfolio;
 Ψ - Lévy or characteristic exponent of L ;
 ρ^{ri} - Regulatory Ratio in the i -th Loan Subportfolio;
 ρ^i - Total Loan Value-to-Total Loan Value Ratio in the i -th Loan Subportfolio;
 ϱ^i - Risk premium in the i -th Loan Subportfolio;
 ϱ^{vi} - Instantaneous Return in the i -th Loan Subportfolio;
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 σ^{ai} - Volatility of A in the i -th Loan Subportfolio;
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Chapter 1

INTRODUCTION

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In this thesis, we consider the financial economic problem of developing a nonlinear dynamic model for banking items and behavior by means of stochastic analytic methods. A motivation for studying this problem is to extend the discrete-time models used in the analysis of bank behavior and regulation (see, for instance, [2] and [33]) to a more general class of models, in particular a Lévy process setting. Preliminaries about these stochastic processes are presented in Subsection 1.2.1 and covered in a greater detail in [106] (see also, [105], [107]). In our offering, by contrast to [97], in the presence of competition imbalances, the value of the bank is dependent on its financial structure (see, for instance, [122]). Several discussions related to bank modeling problems in discrete- and continuous-time settings have recently surfaced in the literature (see, for instance, [2], [33], [61] and [120]). To a certain extent, the banking model that we derive is an analogue of the one presented in [2] (see, also, [33]). In particular, the latter mentioned contribution analyzes the effect of monetary policy in an economy underpinned by banks operating in an imperfectly competitive loan market. In the thesis, a present value formula for continuous cash flows with continuous discounting plays an important role. In this regard, [61] comments on traditional discounted cash flow models and their relation with the option value embedded in banks. Furthermore, in [120], a discrete-time dynamic bank model of imperfect competition is presented.

Under the assumption that the loan market is imperfectly competitive, we present stochastic models involving balance sheet banking items such as bank assets (cash, bonds, shares, Treasuries, reserves and loans), liabilities (demand deposits) and bank capital (bank equity, subordinate debt, loan loss reserve and related binding capital constraints) under the influence of macroeconomic factors and their relationship with profitability and its indicators ROA and ROE. In turn, the aforementioned models enable us to formulate an optimization problem that seeks to establish optimal bank profit consumption on a random time interval $[t, \tau]$, and terminal profit at τ by choosing the appropriate profit consumption, value of the bank's investment in loans and provisions for loan losses, see [106] for more details. Here profits are only expressed as a function of assets and liabilities. The term profit consumption refers to the consumption of the bank's profits by dividend payments on equity and interest and principal payments on subordinate debt. Despite the extent of the existing literature on these issues, the use of discrete-time bank models beyond two-periods is limited.

A further motivation for our study is the fact that bank profitability is a major indicator of financial crises for households, companies and financial institutions. Bank profitability is influenced by various factors such as bank characteristics, macroeconomic conditions, taxes, regulation of deposit provisions for loan losses and several underlying regulatory, legal and institutional indicators. For our purposes, bank profitability may be defined by the system of equations

$$\begin{aligned}
& \text{Income Before Taxes \& Cost of Funds} \\
& \quad = \text{Gross Revenue} - \text{Expenses;} \\
& \text{Income After Taxes \& Before Cost of Funds} = \\
& \text{Income Before Taxes \& Cost of Funds} - \text{Tax-Free Securities} - \text{Taxes;} \\
& \text{Nett Income After Taxes \& Before Cost of Funds} = \\
& \text{Income Before Taxes \& Cost of Funds} - \text{Actual Tax-Free Securities;} \\
& \text{Nett Income After Taxes \& Before Cost of Funds} \\
& \quad = \text{Nett Profit} + \text{Cost of Funds;} \\
& \text{Retained Earnings} = \text{Nett Profit} - \text{Dividends} \\
& \quad - \text{Interest and Principal Payments on Subordinate Debt.}
\end{aligned}$$

From the second last equation, it is clear that

$$\begin{aligned}
& \text{Nett Profit (NP)} & (1.1) \\
& = \text{Nett Income After Taxes \& Before Cost of Funds (NIATBCF)} - \text{Cost of Funds (CF)}.
\end{aligned}$$

Roughly speaking, the cost of funds is the interest that a bank must pay for the use of funds (money) while the gross revenue is the funds generated by all banking operations before deductions for expenses. Our contribution mainly involves a discussion of the nett income after taxes and before the cost of funds (NIATBCF) contained in (1.1) as a component of nett profit. In this regard, an important open problem in financial economics is to develop a nonlinear profitability model by means of general semi-martingale theory. This is motivated by the fact that nonlinear models reflect reality more closely than linear models. A popular approach to the study of profitability dynamics and optimization involves a loan market that is assumed to be imperfectly competitive. As a consequence, profits are ensured by virtue of the fact that the net loan interest margin is greater than the marginal resource cost of deposits and loans. An example from the SMC is that both the bankruptcy of the Lehman Brothers bank and the acquisition in September 2008 of Merrill Lynch and Bear Sterns by Bank of America and JP Morgan, respectively, was preceded by a decrease in the profitability (together with an increase in loan losses) of the troubled bank. A similar trend was discerned for the U.S. mortgage companies, Fannie Mae and Freddie Mac, who were taken over by the U.S. government at the beginning of September 2008. Also, the U.S. Federal Reserve's rescue of the American International Group, Inc. (AIG) suggests that insurance companies are not immune to similar financial crises. In order to address the aforementioned problem, we construct stochastic models for banking items such as assets,

liabilities and capital.

Another motivating factor is that a broader stochastic calculus can potentially make the dynamic models tractable and widen the scope for risk analysis and regulation. For banks, this regulation takes the form of the Basel II Capital Accord (see [8], [10]) and [101]), that is to be implemented on a worldwide basis by 2007, with South African implementation date being 1st January 2008. In that case, the proposed regulation adopts a three pillared approach with the ratio of bank capital to risk weighted assets, RWAs, also called the capital adequacy ratio, CAR, playing a major role as an index of the adequacy of capital held by banks. The CAR forms the cornerstone of the minimum capital requirement (Pillar 1 for Basel II) and has the form

$$\text{Capital Adequacy Ratio} = \frac{\text{Indicator of Absolute Amount of Capital}}{\text{Indicator of Absolute Level of Risk}}.$$

This ratio provides an indication of whether the absolute amount of bank capital is adequate when compared to a measure of absolute risk. Our study expresses the CAR as

$$\text{CAR}(\rho) = \frac{\text{Bank Capital } (K)}{\text{Total RWAs } (a^r + mVaR + 0)},$$

where the credit, market and operational RWAs, are denoted by a^r , $mVaR$ and 0, respectively. In situations where the value of ρ is unsatisfactorily small, regulators may pressurize banks to increase the value of their CARs. Basel II introduces two other pillars that involve internal assessments of capital adequacy (subject to supervisory review: Pillar 2) and market discipline (through enhanced transparency: Pillar 3) as important components of prudential regulation (see, for instance, [45]). The impact of a risk-sensitive framework such as Basel II on macroeconomic stability of banks is an important issue. For instance, the question of the procyclical effects of the new capital adequacy regulation is of major interest. In this regard, it is likely that during a recession a decrease in CARs and an increase in regulatory requirements necessitated by the fall in the risk profile of assets may increase the possibility of a credit crunch and result in poor economic growth. Also, since RWAs are sensitive to risk changes, the CAR may increase while the actual levels of bank capital may decrease. This means that a given CAR can only be sustained if banks hold more regulatory capital.

1.1 RELATION TO PREVIOUS LITERATURE

In this section, we consider the association between our contribution and previous literature. The issues that we highlight include loan pricing, loan losses and their provisioning, profitability, regulatory capital, Basel II and the SMC.

1.1.1 Brief Literature Review of Loan Pricing

Recent several contributions have dealt with loan pricing in the Basel II Capital Accord context. For instance, [121] analyzes the loan pricing implication of Basel II assuming a perfectly competitive market for business loans. Their model implies that low risk firms will achieve reductions in their loan rates by borrowing from banks adopting the IRB approach, while high risk firms will avoid increases in their loan rates by borrowing from banks adopting the standardized approach of Basel II.

Loan pricing is often influenced by contract costs (see, for instance, [34]). The paper establishes that the loan spread depends on a bank's screening and monitoring incentives, which varies across differentially regulated classes of banks. This behavior leads to significant price disparities in the loan market. Further, this contribution examines the impact of monitoring costs on the pricing of bank loans. It establishes that the bank loan spread charged is relatively lower for borrowing firms

- i. with more assets in place relative to future investment options,
- ii. with publicly traded equity and/or debt, and
- iii. with higher debt ratings.

The contribution [110] argues that loan prices from secondary markets for credit risk transfer are influenced by liquidity and supply/demand effects not present in primary markets and loans themselves are often collateralized and subject to covenants, and thus have their own risk characteristics. Recent contributions present loan pricing both under imperfectly and perfectly competitive loan markets with this thesis examining the former scenario.

1.1.2 Brief Literature Review of Loan Loss and their Provisioning

A fair level of provisions for delinquent loans is an essential input in calculating bank liquidity capital and profitability. Loan loss provisioning is directly related to estimates of loan loss given default (LGD). A literature on LGD on bank loans is developing but, surprisingly it has not been exploited to address, at the micro level, the issue of provisioning at time of default and the default date.

Amongst the literature available is the paper [1] (see, also, [29] and [103]) which lays down a methodology for modeling loan loss provisions for banks. This paper exploits the 1990 change in capital adequacy regulations in order to construct more effective tests of capital and earnings management and its effect on bank loan loss provisions. They find support for the hypothesis that loan loss provisions are used for capital management but do not find evidence of earnings management via loan loss provisions. Furthermore, they document the reasons for the conflicting results on these effects observed in prior studies. Additionally, they find that loan loss provisions are negatively related to both future earnings changes

and contemporaneous stock returns which contradicts the signaling results documented in prior work.

The contribution [3] expresses the concern that inefficient loan loss accounting may have a material impact on reported capital and earnings. Research prior to that of the authors has examined banks' incentives to manipulate LLP and the resulting impact. However, most of this research has focussed on management incentives and other determinants of LLP decisions without addressing the relevant factors associated with best-practiced or efficient LLP decision making. In [3] a stochastic frontier model is identified that examines the efficiency of the LLP decisions of bank managers. Furthermore, the authors explore the relationship between efficient LLP decision-making and relevant factors that could potentially explain any efficiency. The evidence presented by the authors indicates that there is considerable inefficiency in loan loss decision-making among the sample institutions.

1.1.3 Brief Literature Review of Profitability

As far as the literature on profitability, is concerned we firstly highlight the paper [69] (see, also, [65]). Here it is demonstrated by means of a technical argument that the bank's profits will not decrease if the growth rate of sales is higher than the absolute growth rate of the bank's lending rate. The growth rate measure the increase in sales over a specific period of time, often but not necessarily annually. The mathematical discussion contained in the paper provides a condition for a bank remaining profitable. Their main assertions are supported by an econometric analysis that utilizes panel data from the Western European banking sector.

In general, bank profit is computed by taking the difference between the income and all expenses for the bank. The paper [37] claims that profitability by bank function is determined by subtracting all direct and allocable indirect expenses from total gross revenue generated by that function. This computation results in the nett revenue (yield) that excludes cost of funds. From the nett yield the cost of funds is subtracted to determine the nett profit of the bank by function. Coyne represents four major leading functions, viz., investments, real estate mortgage loans, installment loans and commercial and agricultural loans. This thesis has a strong connection with [37] in that we restrict bank functions to loan subportfolio activities that may include all functions mentioned by Coyne except investments. Also, [42] has a discussion on the determinants of commercial bank profitability in common with this thesis. Several discussions related to bank modeling problems in discrete- and continuous-time settings have recently surfaced in the literature (see, for instance, [2], [33], [61] and [120]). In this regard, in [120], a discrete-time dynamic bank model of imperfect competition is presented. To a certain extent, the banking model that we derive is an analogue of the one presented in [2] (see, also, [33]). In particular, the latter mentioned contribution analyzes the effect of monetary policy in an economy underpinned by banks operating in an imperfectly competitive loan market. In the thesis, a present value formula for continuous

cash flows with continuous discounting plays an important role. In this regard, [61] comments on traditional discounted cash flow models and their relation with the option value embedded in banks.

1.1.4 Brief Literature Review of Regulatory Capital

The most important role of capital is to mitigate the moral hazard problem that results from asymmetric information between banks, depositors and borrowers. The Modigliani-Miller theorem forms the basis for modern thinking on capital structure (see [97]). In an efficient market, their basic result states that, in the absence of taxes, insolvency costs and asymmetric information, the bank value is unaffected by how it is financed. In this framework, it does not matter if bank capital is raised by issuing equity or selling debt or what the dividend policy is. By contrast, in our contribution, in the presence of loan market frictions, the value of the bank is dependent on its financial structure (see, for instance, [23], [46], [92] and [122]) for banking. In this case, it is well-known that the bank's decisions about lending and other issues may be driven by the CAR (see, for instance, [40], [41], [101], [120] and [123]). Further evidence of the impact of capital requirements on the lending activities of banks are provided by [67] and [132].

A new line of research into credit models for monetary policy has considered the association between bank capital and loan demand and supply (see, for instance, [2], [25], [31], [33], [140], [141] and [142]). This credit channel is commonly known as the bank capital channel and propagates that a change in interest rates can affect lending via bank capital. We also discuss the effect of macroeconomic activity on a bank's capital structure and lending activities (see, for instance, [66]). With regard to the latter, for instance, there is considerable evidence to suggest that macroeconomic conditions impact the probability of default and loss given default on loans (see, for instance, [66] and [82]). Throughout our contribution, gross domestic product (GDP) may be considered to be a proxy for macroeconomic activity. In particular, shocks to the macroeconomy may be classified as either a GDP demand shock (for example, a change in purchases by governments or consumer confidence) or a GDP supply shock (for example, a dramatic shift in the oil price).

It is a widely accepted fact that certain financial indicators (for instance, credit prices, asset prices, bond spreads, ratings from credit rating agencies, provisioning, profitability, capital, leverage and risk weighted capital adequacy ratios, other ratios such as write-off/loan ratios and perceived risk) exhibit cyclical tendencies. In particular, "procyclicality" has become a buzzword in discussions around the new regulatory framework offered by Basel II and Solvency 2. In the sequel, the movement in a financial indicator is said to be "procyclical" if it tends to amplify business cycle fluctuations. A consequence of procyclicality is that banks tend to restrict their lending activity during economic downturns because of their concern about loan quality and the probability of loan defaults. This exacerbates the recession since credit constrained businesses and individuals cut back on their investment activity. On the other hand, banks expand their lending activity during boom periods,

thereby contributing to a possible overextension of the economy that may transform an economic expansion into an inflationary spiral. Our interest in cyclicity extends to its relationship with credit prices, risk weightings, provisioning, profitability and capital (see, for instance, [6], [25], [26], [31], [32] and [33]).

As an example, we incorporate in our models, the fact that provisioning behaves procyclically by falling during economic booms and rising during recessions. Several discussions related to bank optimal control problems in discrete- and continuous-time settings have recently surfaced in the literature (see, for instance, [27], [66], [92], [102] and [120]). Also, some recent papers using dynamic optimization methods in analyzing bank regulatory capital policies include [113] for Basel II and [6], [38] and [90] for Basel market risk capital requirements. In [120], a discrete-time dynamic banking model of imperfect competition is presented, where the banks can invest in a prudent or a gambling asset. For both these options, a maximization problem that involves the bank value for shareholders is formulated. On the other hand, [102] examines a problem related to the optimal risk management of banks in a continuous-time stochastic dynamic setting. In particular, we minimize market and capital adequacy risk that involves the safety of the assets held and the stability of sources of capital, respectively. In this regard, we suggest an optimal portfolio choice and rate of bank capital inflow that will keep the loan level as close as possible to an actuarially determined reference process. This set-up leads to a nonlinear stochastic optimal control problem whose solution may be determined by means of the dynamic programming algorithm.

1.1.5 Brief Literature Review of the Basel II Capital Accord

Contributions on procyclicality started appearing in the literature more frequently since the advent of Basel II. Most of the studies in this paradigm have focused on Pillar 1 (see Subsubsection 1.2.4.2 below for a discussion of Pillar 1) of the Internal Rating Based (IRB) treatment of commercial loans. Here regulatory capital charges are determined at the individual loan level and are given by a formula with the inputs

- borrower's one-year probability of default (PD);
- loan instrument's expected loss given default (ELGD);
- remaining maturity, (M);
- asset-value correlation, ρ , which parameterizes dependence across borrowers;
- bank's target one-year solvency probability, q .

Under Basel II, q is fixed to 99.9% and ρ is specified as a decreasing function of PD (for more details, see [11]). The IRB capital formula is deduced by considering the large-portfolio asymptotic dynamics of a Merton model with a single common risk-factor. Since

the release of the Second Consultative Paper [9]), many empirical studies have assessed the size of procyclicality in the IRB capital formula. In these studies, a wide range of estimated responses to a cyclical downturn is presented. For instance, required capital can increase in some simulations, and in others can actually decline. The paper [78] highlights sample and methodology differences across studies that account for some of the variations in results. These include the credit quality of the sample portfolio and the location, time period and rating system from which historical data was extracted. Furthermore, some differences across studies may be due to amendments to Basel II. As [78] observes, if one retains defaulted loans in the sample, then one should measure the cumulative demands on bank capital over the simulated period. The accumulated charge-offs would have been incurred under the rules of Basel II as well. From a policy perspective, they are interested only in the additional procyclicality associated with a change in capital regime. Work carried out in [64] claims that if the goal is to estimate the additional procyclicality associated with the change in capital regime, then one needs to simulate active portfolio management as it occurs under the current regulatory regime. The papers [64] and [78] are in agreement that portfolio management should not be made endogenous to the regulatory rule, but disagree on the appropriate alternative benchmark. The [64] claims that there is a lack of empirical evidence to make definitive conclusions, but suggests that banks tend to tighten lending standards during a recession and loosen lending standards in a boom. In this regard, the news bulletin [13] demonstrates that the average quality of new credit extension decreases at the start of a recession. Taking a more behavioral view of credit extension, the paper [15] finds evidence for a institutional memory hypothesis under which standards soften as time passes subsequent to a bank's most recent period of excessive loan losses. In this regard, the ability to distinguish between high and low risk borrowers weakens over time as loan officers do not take the lessons learnt from the last credit cycle into consideration. When large losses are again experienced, standards are tightened drastically, and the cycle begins again (see, for instance, [79]). Results in [78] support this conjecture. In addition to studying procyclicality on their simulated passive portfolios, The paper [78] calculates the time-series of IRB required capital for Deutsche Bank's actual German commercial loan portfolio. They conclude that, even under the risk-insensitive Basel I, internal management processes result in banks responding to a downturn in a way that would dampen the cyclicity of IRB capital requirements.

1.1.6 Brief Literature Review of the Subprime Mortgage Crisis

The subprime mortgage crisis began with the bursting of the United States housing bubble (see, for instance, [100] and [88]) and high default rates on "subprime" and adjustable rate mortgages, ARM. Loan incentives, such as easy initial terms, in conjunction with an acceleration in rising housing prices encouraged borrowers to assume difficult mortgages on the belief they would be able to quickly refinance at more favorable terms. However, once housing prices started to drop moderately in 2006-2007 in many parts of the U.S.,

refinancing became more difficult. Defaults and foreclosure activity increased dramatically, as easy initial terms expired, home prices failed to go up as anticipated, and ARM interest rates reset higher. Foreclosures accelerated in the United States in late 2006 and triggered a global financial crisis through 2007 and 2008. During 2007, nearly 1.3 million U.S. housing properties were subject to foreclosure activity, up 79 % from 2006 (see [118] for more details).

The mortgage lenders that retained credit risk (the risk of payment default) were the first to be affected, as borrowers became unable or unwilling to make payments. Major banks and other financial institutions around the world have reported losses of approximately U.S. \$ 435 billion as of 17 July 2008 (see [93] and [111]). Owing to a form of financial engineering called securitization, many mortgage lenders had passed the rights to the mortgage payments and related credit/default risk to third-party investors via mortgage-backed securities (MBS) and collateralized debt obligations (CDO). Corporate, individual and institutional investors holding MBS or CDO faced significant losses, as the value of the underlying mortgage assets declined. Stock markets in many countries declined significantly.

The widespread dispersion of credit risk and the unclear effect on financial institutions caused reduced lending activity and increased spreads on higher interest rates. Similarly, the ability of corporations to obtain funds through the issuance of commercial paper was affected. This aspect of the crisis is consistent with a credit crunch. The liquidity concerns drove central banks around the world to take action to provide funds to member banks to encourage lending to worthy borrowers and to restore faith in the commercial paper markets. The U.S. government also bailed-out key financial institutions, assuming significant additional financial commitments.

The subprime crisis has adversely affected several inputs in the economy, resulting in downward pressure on economic growth. Fewer and more expensive loans tend to result in decreased business investment and consumer spending. The initial leveling off in the housing market has become a downturn in many areas due to a surplus inventory of homes. The reduction and shift in demand versus supply has resulted in a significant decline in new home construction (see, for instance, [19]).

With interest rates on a large number of subprime and other ARM due to adjust upward during the 2008 period, U.S. legislators, the U.S. Treasury Department, and financial institutions are taking action. A systematic program to limit or defer interest rate adjustments was implemented to reduce the effect. In addition, lenders and borrowers facing defaults have been encouraged to cooperate to enable borrowers to stay in their homes. Banks have sought and received over \$ 250 billion in additional funds from investors to offset losses (see [93] for more information). The risks to the broader economy created by the financial market crisis and housing market downturn were primary factors in several decisions by the U.S. Federal Reserve to cut interest rates and the Economic Stimulus Package (ESP) passed by Congress and signed by President George W. Bush on 13 February 2008 (see, for instance, [53], [136] and [4]). Following a series of ad-hoc market interventions to bailout

particular firms, a \$ 700 billion proposal was presented to the U.S. Congress in September, 2008. These actions are designed to stimulate economic growth and inspire confidence in the financial markets.

1.2 PRELIMINARIES

In this section, we discuss preliminaries about stochastic processes, bank balance sheets, indicators of bank profitability, the structure of Basel II as well as the SMC. Throughout our contribution, we use the notational convention “subscript t or s ” to represent (possibly) random processes, while “bracket t or s ” are used to denote deterministic processes. In the sequel, we also often refer to the i -th loan subportfolio that primarily contains the loans in that subportfolio denoted by Λ^i . In addition, the i -th loan subportfolio can be associated with bank assets such as cash, bonds, shares, Treasuries, reserves and intangible assets with notation C^i , B^i , S^i , T^i , R^i and I^i , respectively. The same notational convention for other items in the i -th loan subportfolio as above will apply to the liabilities (demand deposits denoted by D^i) and regulatory capital (equity, subordinate debt and loan loss reserves with notation E^i , O^i and R^i , respectively). Possible values for $i = 1, \dots, m$ from a Basel II perspective are given in the system (1.8).

1.2.1 Preliminaries about Stochastic Processes

This subsection on preliminaries about stochastic processes is useful for the dynamic bank models discussed in Chapters 2 (see, for instance Subsection 2.1.5), 3 and 4. We start with a number of key definitions. Throughout our contribution, we suppose for the sample space Ω , σ -algebra $\mathbf{F}$, filtration $\mathbb{F} = (\mathcal{F}_t)_{t \geq 0}$ and real probability measure $\mathbf{P}$, that $(\Omega, \mathbf{F}, \mathbb{F}, \mathbf{P})$ is a filtered probability space.

A Poisson process is a stochastic process with a discontinuous path and is used as a building block for constructing more complex jump processes, e.g., Lévy processes.

Definition 1.2.1 (Definition of a Poisson Process): Let $(t_j)_{1 \leq j \leq k}$ be a sequence of independent exponential random variables with parameter λ and $T_k = \sum_{j=1}^k t_j$. The process $(N_t)_{t \geq 0}$ which is given by

$$N_t = \sum_{k=1}^{\infty} 1_{t \geq T_k}$$

is called a Poisson process with intensity λ .

In line with definition above, a Poisson process is a counting process that counts the number

of random time (T_k) that occur between 0 and t , when $(T_k - T_{k-1})_{k \geq 1}$ is an i.i.d. sequence of exponential variables.

Definition 1.2.2 (Definition of a Compound Poisson Process): A compound Poisson process with intensity $\lambda > 0$ and jump size distribution function $\tilde{F}$ is a process N_t^c which is governed by

$$N_t^c = \sum_{j=1}^{N_t} \tilde{J}_j,$$

where $\tilde{J}_j$ represents the jump sizes which are i.i.d. with distribution function $\tilde{F}$ and (N_t) is a Poisson process with intensity λ , which does not depend on $(\tilde{J}_j)_{j \geq 1}$.

Next, we define an infinitely divisible distribution and a Lévy process.

Definition 1.2.3 (Definition of a Infinitely Divisible Distribution): Assume that $\phi(\xi)$ is the characteristic function of a distribution, ξ . If for every positive integer n , $\phi(\xi)$ is also the n -th power of a characteristic function, we say that the distribution is infinitely divisible.

Definition 1.2.4 (Definition of a Lévy Process): For each infinitely divisible distribution, a stochastic process, $L = (L_t)_{0 \leq t}$, is called a Lévy process if it

- initiates at zero,
- has independent and stationary increments and
- has $(\phi(u))^t$ as a characteristic function for the distribution of an increment over $[s, s + t]$, $0 \leq s, t$, such that

$$L_{t+s} - L_s.$$

Every Lévy process is a semi-martingale and has a càdlàg version (right continuous with left hand limits) which is itself a Lévy process. We will assume that the type of such processes that we work with are always càdlàg. As a result, sample paths of L are continuous a.e. from the right and have limits from the left.

Definition 1.2.5 (Jump of a Lévy Process): The jump of L_t at $t \geq 0$ is defined by

$$\Delta L_t = L_t - L_{t-}.$$

Definition 1.2.6 (Characteristic Exponent of a Lévy Process): Since L has stationary independent increments its characteristic function must have the form

$$\mathbf{E}[\exp\{-i\xi L_t\}] = \exp\{-t\Psi(\xi)\}$$

for some function Ψ called the Lévy or characteristic exponent of L .

Definition 1.2.7 (Lévy-Khintchine Formula): The Lévy-Khintchine formula is given by

$$\begin{aligned} \Psi(\xi) = i\gamma\xi + \frac{c^2}{2}\xi^2 + \int_{|x|<1} \left[1 - \exp\{-i\xi x\} - i\xi x\right] \nu(dx) \\ + \int_{|x|\geq 1} \left[1 - \exp\{-i\xi x\}\right] \nu(dx), \quad \gamma, c \in \mathbf{R} \end{aligned} \quad (1.2)$$

and for some σ -finite measure ν on $\mathbf{R} \setminus \{0\}$ with

$$\int \inf\{1, x^2\} \nu(dx) = \int (1 \wedge x^2) \nu(dx) < \infty.$$

Definition 1.2.8 (Lévy Triplet and Measure): An infinitely divisible distribution has a Lévy triplet of the form

$$[\gamma, c^2, \nu]$$

where the measure ν is called the Lévy measure.

The Lévy-Khintchine formula given by equation (1.2), is closely related to the Lévy process, L . This is particularly true for the Lévy decomposition of L . In particular, the description of the decomposition of the Lévy process, L , (see the Lévy-Khintchine representation (1.7) below) corresponds with that of [126, Chapter 4]. This decomposition is described in the rest of this paragraph. From equation (1.2) above, it is clear that L must be a linear combination of a Brownian motion and a quadratic jump process X which is independent of the Brownian motion.

Definition 1.2.9 (Quadratic Pure Jump Process): A process is classified as quadratic pure jump if the continuous part of its quadratic variation $\langle X \rangle^c \equiv 0$, so that its quadratic variation becomes

$$\langle X \rangle_t = \sum_{0 < s \leq t} (\Delta X_s)^2,$$

where $\Delta X_s = X_s - X_{s-}$ is the jump size at time s .

If we separate the Brownian component, Z , from the quadratic pure jump component X we obtain

$$L_t = X_t + cZ_t,$$

where X is quadratic pure jump and Z is standard Brownian motion on $\mathbb{R}$. Next, we describe the Lévy decomposition of Z . Let $Q(dt, dx)$ be the Poisson measure on $\mathbb{R}^+ \times \mathbb{R} \setminus \{0\}$ with expectation (or intensity) measure $dt \times \nu$. Here dt is the Lebesgue measure and ν is the Lévy measure as before. The measure $dt \times \nu$ (or sometimes just ν) is called the compensator of Q . The Lévy decomposition of X specifies that

$$\begin{aligned} X_t &= \int_{|x| < 1} x \left[Q((0, t], dx) - t\nu(dx) \right] + \int_{|x| \geq 1} x Q((0, t], dx) + t\mathbf{E} \left[X_1 - \int_{|x| \geq 1} x\nu(dx) \right] \\ &= \int_{|x| < 1} x \left[Q((0, t], dx) - t\nu(dx) \right] + \int_{|x| \geq 1} x Q((0, t], dx) + \gamma t, \end{aligned} \quad (1.3)$$

where

$$\gamma = \mathbf{E} \left[X_1 - \int_{|x| \geq 1} x\nu(dx) \right].$$

The parameter γ is called the drift of X . In addition, in order to describe the Lévy decomposition of L , we specify more conditions that L must satisfy. The most important supposition that we make about L is that

$$\mathbf{E}[\exp\{-hL_1\}] < \infty, \quad \text{for all } h \in (-h_1, h_2), \quad (1.4)$$

where $0 < h_1, h_2 \leq \infty$. This implies that L_t has finite moments of all orders and in particular, $\mathbf{E}[X_1] < \infty$. In terms of the Lévy measure ν of X , we have, for all $h \in (-h_1, h_2)$, that

$$\begin{aligned} \int_{|x| \geq 1} \exp\{-hx\} \nu(dx) &< \infty; \\ \int_{|x| \geq 1} x^\alpha \exp\{-hx\} \nu(dx) &< \infty, \quad \forall \alpha > 0; \\ \int_{|x| \geq 1} x \nu(dx) &< \infty. \end{aligned}$$

The above assumptions lead to the fact that equation (1.3) can be rewritten as

$$X_t = \int_{\mathbf{R}} x \left[Q((0, t], dx) - t\nu(dx) \right] + t\mathbf{E}[X_1] = M_t + at,$$

where we have that

$$M_t = \int_{\mathbf{R}} x \left[Q((0, t], dx) - t\nu(dx) \right]$$

is a martingale and $a = \mathbf{E}[X_1]$.

In the specification of our model, we assume that the Lévy measure $\nu(dx)$ of L satisfies

$$\int_{|x| > 1} |x|^3 \nu(dx) < \infty. \quad (1.5)$$

As in the above, this allows a decomposition of L of the form

$$L_t = cZ_t + M_t + at, \quad 0 \leq t \leq T, \quad (1.6)$$

where $(cZ_t)_{0 \leq t \leq T}$ is a Brownian motion with standard deviation $c > 0$, $a = \mathbf{E}(L_1)$ and the martingale

$$M_t = \int_0^t \int_{\mathbf{R}} x M(ds, dx), \quad 0 \leq t \leq T,$$

is a square-integrable. Here, we denote the compensated Poisson random measure on $[0, \infty) \times \mathbf{R} \setminus \{0\}$ related to L by $M(dt, dx)$. Subsequently, if $\nu = 0$ then we will have that $L_t = Z_t$, where Z_t is appropriately defined Brownian motion.

Definition 1.2.10 (Stochastic Exponential): For the Lévy process, L , that initiates at zero, the stochastic exponential of L (written as $\xi(L)$) is the (unique) Lévy process $\widehat{L}$ that is a solution of

$$\widehat{L}_t = 1 + \int_0^t \widehat{L}_{t-} dL_t.$$

The stochastic exponential is also known as the Doléans-Dade exponential (see, for instance, [117]). The contribution [60] indicates that if L is real-valued and has a characteristic triplet, (γ, σ^2, ν) , then it follows that the Doléans-Dade exponential, $\widehat{L}$, is a Lévy process with characteristic triplet $(\widehat{\gamma}, \widehat{\sigma}^2, \widehat{\nu})$. In this case, we have that

- $\widehat{\gamma} - \gamma = \frac{1}{2}\sigma^2 + \int_{\mathbb{R}} \left[\left(\exp\{x\} - 1 \right) 1_{\{|\exp\{x\}-1|<1\}} - x 1_{\{|x|<1\}} \right] \nu(dx);$
- $\widehat{\sigma}^2 = \sigma^2;$
- $\widehat{\nu}(\varphi) = \nu\left(\left\{x \in \mathbb{R} \mid \exp\{x\} - 1 \in \varphi\right\}\right)$ for any Borel set $\varphi \subset \mathbb{R}^*$.

In the book [126, Chapter 4], the following literature holds on the discussion of Lévy process theory. For all ω in the probability space denote by $\Delta L(t, \omega) = L(t, \omega) - L(t-, \omega)$ the jump of the process L at time $t > 0$. For all Borel sets $\mathcal{B} \subset [0, \infty) \times \mathbb{R} \setminus \{0\}$ set

$$M(\mathcal{B}, \omega) = \{(t, \Delta L(t, \omega)) \in \mathcal{B}\}.$$

Lévy theory dictates that M is a Poisson random measure with intensity

$$m(dt, dx) = dt\nu(dx),$$

where ν is the Lévy measure of the process L . Note that m is σ -finite and $M(\mathcal{B}, \cdot) = \infty$ a.s. when $m(\mathcal{B}) = \infty$. For $\mathcal{B} = [t_1, t_2] \times \mathcal{J}$, where $0 \leq t_1 < t_2 < \infty$ and a Borel set $\mathcal{J} \subset \mathbb{R} \setminus \{0\}$. Then

$$M(\mathcal{B}, \omega) = \{(t, \Delta L_t(\omega)) : t \in [t_1, t_2], \Delta L_t(\omega) \in \mathcal{J}\}$$

counts the jump size in $\mathcal{J}$ which happens in the time interval $t_1 \leq t \leq t_2$. Therefore, $M(\mathcal{B}, \omega)$ is a Poisson random variable with mathematical expectation $(t_2 - t_1)\nu(\mathcal{J})$. Now, the Lévy-Khintchine representation in equation (1.2) corresponds to the representation

$$\begin{aligned}
L_t = & \gamma t + \sigma Z_t + \sum_{0 \leq s \leq t} \Delta L_s 1_{\{|\Delta L_s| > 1\}} \\
& + \int_0^t \int_{|x| \leq 1} x(M(ds, dx) - \nu(dx)ds), \quad t \geq 0.
\end{aligned} \tag{1.7}$$

1.2.2 Preliminaries about Bank Balance Sheets

In this subsection, we provide some basic facts on banks balance sheets necessary for dealing with Chapter 2. The Basel II capital accord (see, for instance, [8] and [10]) permits internal models, that satisfy certain criteria, to be used to determine the riskiness of bank portfolios and the required capital cushion. In this spirit, we necessarily consider dynamic models of assets (uses of funds) and liabilities (sources of funds) that are balanced by bank capital (see, for instance [46]) according to the well-known relation

$$\text{Total Bank Assets } (A) = \text{Total Liabilities } (\Gamma) + \text{Total Bank Capital } (C).$$

In our contribution, these items on the bank balance sheet can specifically be identified as

$$A_t = \Lambda_t + S + C + B + T_t + R_t; \quad \Gamma_t = D_t; \quad K_t = n_t E_{t-} + O_t + R_t^l,$$

where Λ , S , C , B , T , R , D , n , E , O and R^l are loans, shares, cash, bonds, Treasuries, reserves, demand deposits, number of equity shares, bank equity, subordinate debt and loan loss reserves, respectively.

1.2.3 Preliminaries about Indicators of Bank Profitability

This subsection shows that bank profitability should be considered as an important indicator of the financial crises (see [43]). In this regard, we use the returns on equity, ROE and the returns on assets, ROA, to measure the bank profitability for illustrative purposes. In Section 4.1, through the help of South African Reserve Bank (SARB) data (see [137]) about the ROE, ROA, capital adequacy ratio and composite business cycle for the period Jan 2002 - Mar 2007, we plot the trend of bank profitability against the trends for the latter two financial variables. These enable us to see how bank profitability varies with respect to the variation of the composite business cycle and capital adequacy ratio.

In this regard, our research has a strong connection with the two main measures of the bank profitability. In the sequel, we express the first measure which is ROE in terms of the difference between the NIATBCF and cost of funds. Thus

$$\text{ROE } (E_t^{ri}) = \frac{\text{NIATBCF } (\Pi_t^{ni}) - \text{Cost of Funds } (\Theta^i)}{\text{Equity Capital } (E_t^i)}.$$

The ROE provides information about how much shareholders are earning on their investment in the bank equity. The second measure is the ROA that is represented by

$$\text{ROA } (A_t^{ri}) = \frac{\text{NIATBCF } (\Pi_t^{ni}) - \text{Cost of Funds } (\Theta^i)}{\text{Bank Assets } (A_t^i)}.$$

The ROA provides information about how much profit is generated per average by each unit of assets. Therefore, the ROA is an indicator of how efficiently a bank is being managed. In the sequel, E_t^{ri} , Π_t^{ni} , Θ^i , E_t^i , A_t^{ri} , and A_t^i denote the returns on equities, NIATBCF, cost of funds, equities capital, returns on assets and assets of the i -th loan subportfolio, respectively.

1.2.4 Preliminaries about the Structure of the Basel II Capital Accord

This subsection is based on the discussion paper [71] (see, also, [72]). The most significant innovation of Basel II is the departure from a sole reliance on capital adequacy ratios. Basel II consists of three mutually reinforcing pillars (see the diagrammatic overview of Basel II in Figure 1.1 below), which together should contribute to safety and soundness in the financial system. To ensure that risks within an entire banking group are considered, Basel II is extended on a consolidated basis to holding companies of banking groups.

Firstly, we note that the IRB approach of the Basel II Capital Accord (see [9]) identifies 15 credit risk exposure types (loan subportfolios). In this regard, it is possible to decompose the (total) loans, Λ , as

$$\Lambda = \sum_{i=1}^m \Lambda_i,$$

where m is the number of loan subportfolios with i being the index of each loan subportfolio so that $i = 1, 2, \dots, m$. The 15 identified credit risk exposure types (loan subportfolios) may be listed as

- $i = 1$: Project Finance (PF);
- $i = 2$: Object Finance (OF);
- $i = 3$: Commodities Finance (CF);
- $i = 4$: Income Producing Real Estate (IPRE);
- $i = 5$: Specialized Lending High Volatility
Commercial Real Estate (SLHVCRE);
- $i = 6$: Specialized Lending Not Including
High Volatility Commercial
Real Estate (SLNIHVCRE);
- $i = 7$: Bank Exposure (BE);
- $i = 8$: Sovereign Exposure (SE);
- $i = 9$: Retail Residential Mortgage (RRM);
- $i = 10$: Home Equity Line of Credit (HELOC);
- $i = 11$: Other Retail Exposure (ORE);
- $i = 12$: Qualifying Revolving Retail Exposure (QRRE);
- $i = 13$: Small to Medium Size Enterprizes with
Corporate Treatment (SMECT);
- $i = 14$: Small to Medium Size Enterprizes with
Retail Treatment (SMERT);
- $i = 15$: Equity Exposure Not Held in
the Trading Book (EENHTB)

(1.8)

with $i = 1-6$ and $i = 9-12$ constituting corporate and retail exposures, respectively.

1.2.4.1 Diagrammatic Overview of the Basel II Capital Accord

Basel II provides a range of options for determining not only the capital requirements for credit and market risk but also operational risk. This allows banks and supervisors to select approaches that are most appropriate for their operations and their financial market infrastructure. Banks have to adopt an approach commensurate with their size and sophistication, and they will not be allowed to revert to a simpler approach once they have been approved for a more advanced approach without supervisory approval. Basel II allows, to a limited degree, for national discretion in the way in which each of the approaches is applied.

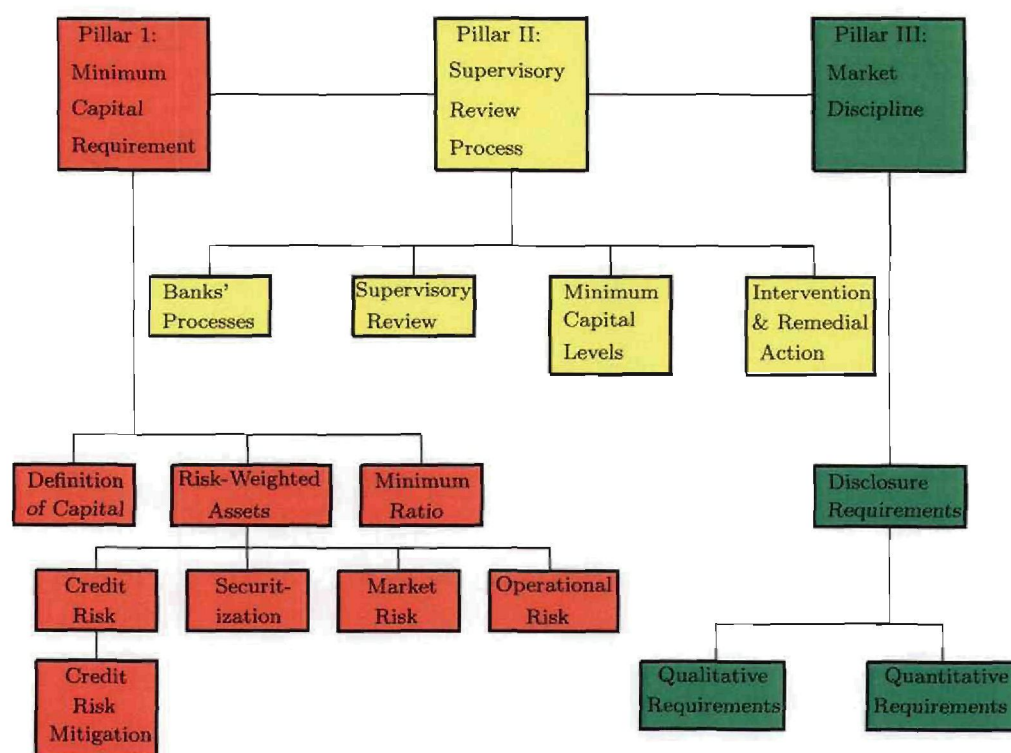


Figure 1.1: Diagrammatic Overview of the Basel II Capital Accord (Source: SARB)

1.2.4.2 Pillar 1 - Minimum Capital Requirements

Pillar 1 sets out the minimum capital requirements. Basel I is based on a capital ratio where the numerator represents the amount of capital a bank has available and the denominator is a measure of the risks a bank faces and is referred to as risk weighted assets.

Under Basel II, the regulations that define the numerator of the capital ratio essentially remain unchanged. Furthermore, the ratio for the minimum capital required has not changed. The modifications, therefore, lie in the definition of risk-weighted assets. Whereas Basel I (as amended by the 1996 market risk amendment) explicitly covered only two types of risk in the definition of risk weighted assets, namely credit and market risk, Basel II includes an explicit treatment of operational risk. Basel II introduced three distinct options (of increasing risk sensitivity) for the calculation of credit risk and three others for operational risk.

1.2.4.3 Credit Risk

In this subsection, we consider Basel II credit risk from the point of view of the standardized and internal ratings based approaches. Firstly, we provide a diagrammatic overview of credit risk.

Standardized Approach

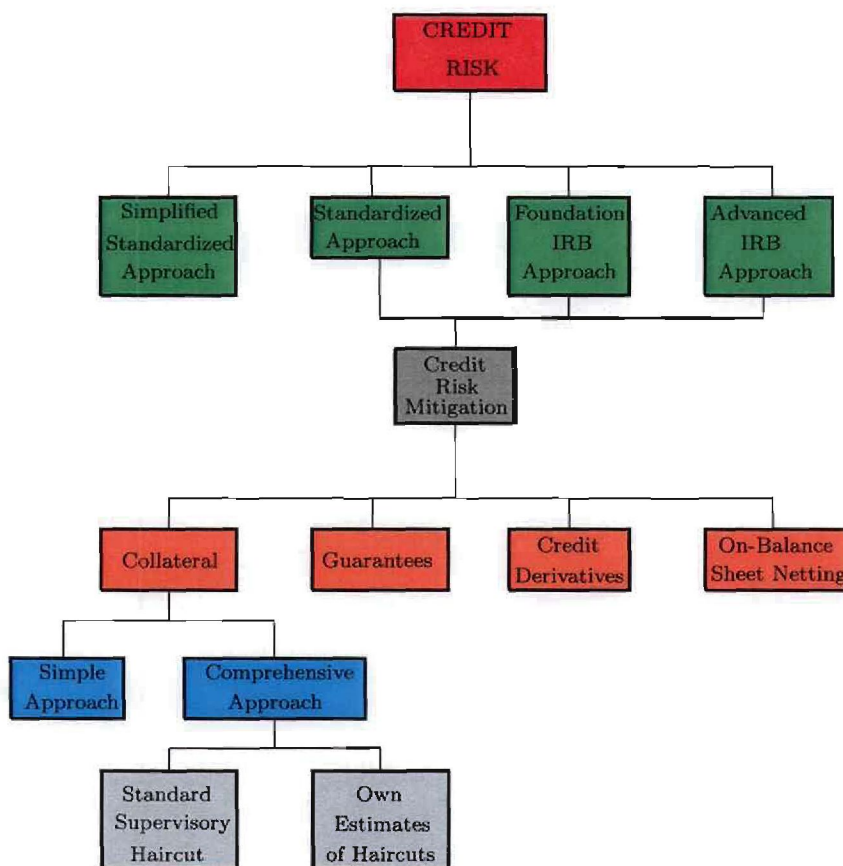


Figure 1.2: Diagrammatic Overview of Basel II Credit Risk

The Standardized approach is similar to Basel I in that banks are required to slot their credit exposures into risk categories based on observable characteristics of the exposures. This approach establishes fixed risk weights corresponding to each risk category and makes use of external credit assessments to enhance risk sensitivity. The bank allocates a risk weight to each of its assets and off-balance sheet positions and produces a sum of risk weighted asset values. A risk weight of 100 % means that an exposure is included in the risk weighted assets at its full value, which translates into a capital charge equal to 8 % of that value. The risk weights are refined by reference to a rating provided by an external credit assessment institution (ECAI)¹.

¹ An external credit assessment institution (ECAI) has to comply with strict criteria to be recognized. National supervisors are responsible for determining whether an ECAI meets the criteria. For a list of the criteria, see page 23 of Basel II. Also, supervisors will be responsible for assigning eligible ECAI's assessments to the risk weights under the standardized risk weighting framework. The mapping process should be objective. It also allows, to a limited degree, for national discretion in the way in which each of these options may be applied. Banks must have a robust system in place to validate the accuracy and consistency of rating systems, processes, and the estimation of all relevant risk components. A bank must

Internal Ratings Based Approach

One of the most innovative (and problematic) aspects of Basel II is the IRB approach to credit risk, which includes two variants, namely a foundation (FIRB) and an advanced (AIRB) approach. The IRB approach differs significantly from the standardized approach in that banks' internal assessments of key risk drivers serve as primary inputs to the capital calculation in the former approach (see, for instance, [124] for more information). As the approach is based on banks' own internal assessments, the potential for more risk-sensitive capital requirements is substantial. The IRB approach does not, however, allow banks themselves to determine all the elements needed to calculate their own capital requirements. Instead, the risk weights and thus capital charges are determined through the combination of quantitative inputs provided by banks and formulas specified by the Basel Committee. The formulas or risk weight functions translate a bank's inputs into a specific capital requirement and are based on modern risk management techniques that involve a statistical and thus quantitative assessment of risk.

1.2.4.4 Pillar 2 - Supervisory Review Process

The supervisory review process requires supervisors to ensure that each bank has sound internal processes in place to assess the adequacy of its capital based on a thorough evaluation of its risks. Basel II stresses the importance of bank management developing an internal capital assessment process and setting targets for capital that are commensurate with the bank's particular risk profile and control environment. Supervisors would be responsible for evaluating the extent to which banks are assessing their capital adequacy needs relative to their risks, and to intervene where necessary.

1.2.4.5 Pillar 3 - Market Discipline

The purpose of Pillar 3 is to complement the minimum capital requirements (Pillar 1) and the supervisory review process (Pillar 2) and aims to bolster market discipline (see, for instance, [109] and [112]) through enhanced disclosure by banks. Effective disclosure is essential to ensure that market participants can better understand banks' risk profiles and the adequacy of their capital positions.

1.2.5 Preliminaries about the Subprime Mortgage Crisis

In this subsection, we provide a diagrammatic overview of and sketch a background to the SMC. Furthermore, we briefly consider the connections between our banking models and the SMC.

demonstrate to its supervisor that the internal validation process enables it to consistently and meaningfully assess the performance of internal rating and risk estimation systems.

1.2.5.1 Diagrammatic Overviews of Matters Related to the Subprime Mortgage Crisis

A diagrammatic overview of the SMC may be represented as follows.

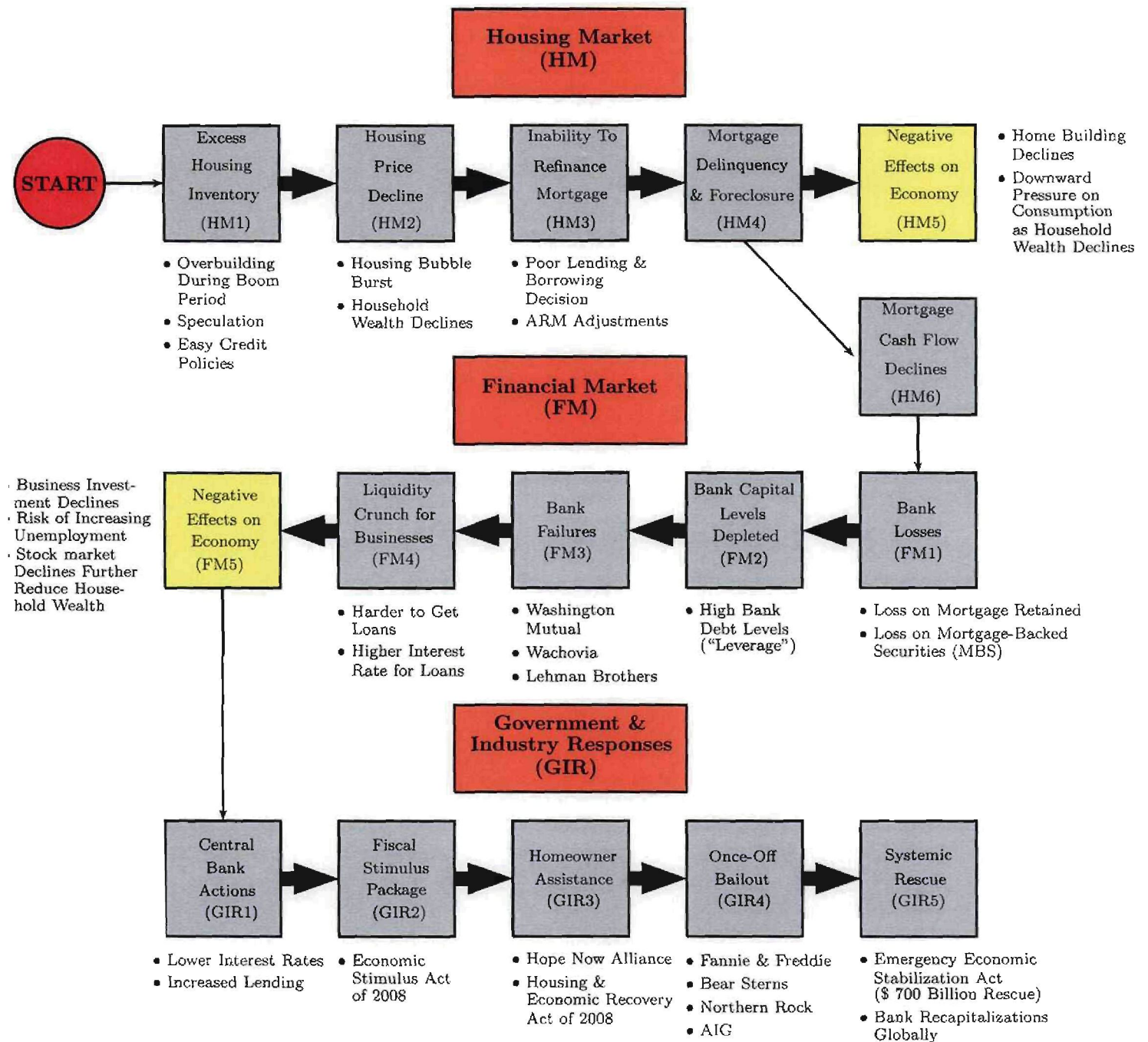


Figure 1.3: Diagrammatic Overview of the Subprime Mortgage Crisis

Next, a diagrammatic overview of the financial leverage profit engine will be given.

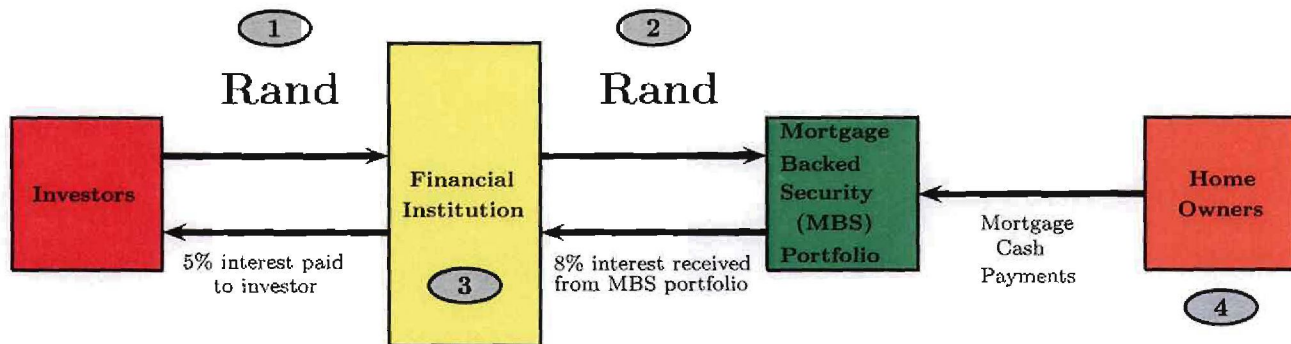


Figure 1.4: Diagrammatic Overview of the Financial Leverage Profit Engine

- 1) Let us assume that an investment bank borrows money from an investor or money market fund and agrees to pay a 5 % interest rate. The MBS portfolio is collateral, which the investors can seize in the event of a default on interest payments.
- 2) The investment bank uses the funds to expand its MBS portfolio, which is paying an 8 % interest rate. The 3 % difference between the amounts is called the spread.
- 3) In our case, for every R 100.00 invested in this manner, the investment bank makes R 3.00 profit margin. This provides an incentive to borrow and invest as much as possible, known as leveraging. This was considered safe during the early 2007 housing boom, as MBS portfolios typically received high credit ratings and defaults were minimal. Since investment banks do not have the same capital reserve requirements as depository banks, many borrowed and lent amounts exceeding 30 times their net worth. By contrast, depository banks rarely lend more than 15 times their net worth. Freddie Mac was leveraged nearly 70 times its net worth.
- 4) With increasing delinquencies and foreclosures during 2007-2008, the value of the MBS portfolios declined. Investors became concerned and in some cases demanded their money back, resulting in margin calls (need to sell/liquidate the MBS portfolios) to pay them. At such a high leverage amount, many investment banks and mortgage companies suffered huge losses, bankruptcy, or merged with other institutions.
- 5) Because MBS securities became "toxic" due to uncertainty in the housing market, they became illiquid and their values dropped. The market value is penalized by the inability to sell the MBS; it may be less than the value the actual cash inflow would merit.
- 6) The ability of financial institutions to obtain funds in this manner via MBS has been dramatically curtailed. Spreads have narrowed, as investors are demanding higher returns to lend money to highly leveraged institutions.

A diagrammatic overview of borrowing under securitization strategies may be represented as follows.

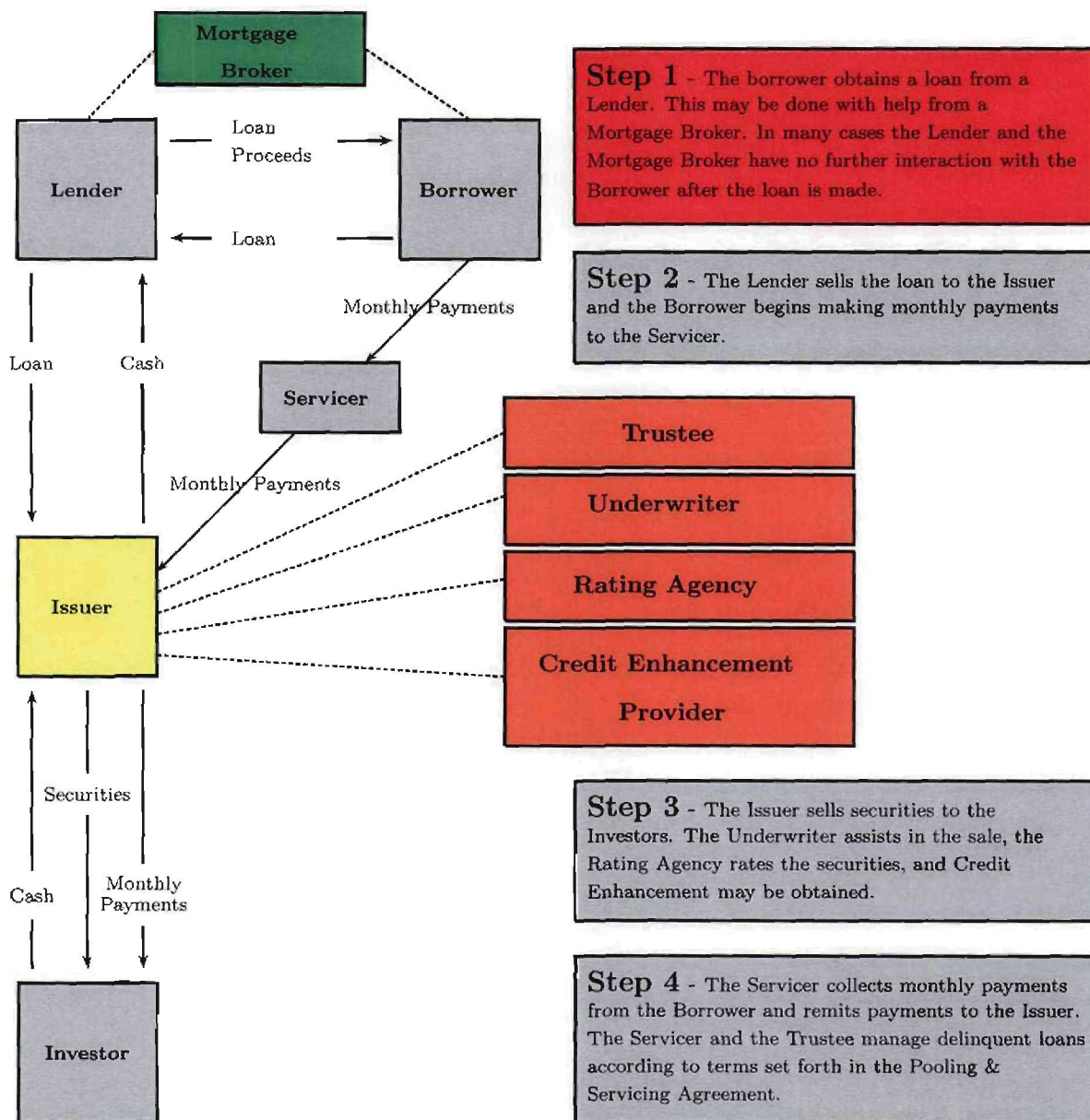


Figure 1.5: Diagrammatic Overview of Borrowing Under Securitization Strategies

1.2.5.2 Background to the Subprime Mortgage Crisis

The SMC was initiated by the deflation of the United States housing bubble (see, for instance, [100] and [88]) and high default rates on subprime and ARM. Loan incentives, such as easy initial terms and low loan rates, in combination with escalating housing prices encouraged borrowers to assume difficult mortgages on the belief they would be able to quickly refinance at more favorable terms (see HM1 in Figure 1.3). Great concern was also expressed about the rapid growth in business loans at commercial banks with excessively easy credit standards. Some analysts claim that competition for lenders had greatly increased, causing banks to reduce loan rates and ease credit standards in order to issue new credit. Others are of the opinion that as the economic expansion continued and past loan losses were forgotten, banks exhibited a greater propensity for risk. However, once U.S. housing prices started to fall moderately in 2006-2007, refinancing became more difficult (see HM2 and HM3 in Figure 1.3). Defaults and foreclosure activity increased dramatically, as easy initial terms expired, home prices failed to go up as anticipated, and ARM interest rates reset higher. Foreclosures accelerated in the United States in late 2006 and triggered a global financial crisis through 2007 and 2008 (see Appendix D, for timeline of subprime mortgage crisis events). During 2007, nearly 1.3 million U.S. housing properties were subject to foreclosure activity, up 79 % from 2006 (see [118] for more details; also HM4 in Figure 1.3). The mortgage lenders that retained credit risk were the first to be affected, as borrowers became unable or unwilling to make payments (see HM5 and HM6 in Figure 1.3).

Major banks and other financial institutions around the world have reported losses of approximately U.S. \$ 435 billion as of 17 July 2008 (see [54] and [111]; also FM1 in Figure 1.3). Owing to a form of financial engineering called securitization, many mortgage lenders had passed the rights to the mortgage payments and related credit risk to third-party investors via MBS and CDO. Corporate, individual and institutional investors holding MBS or CDO faced significant losses, as the value of the underlying mortgage assets declined. Stock markets in many countries declined significantly (see FM2 in Figure 1.3). The financial sector began to feel the consequences of this crisis in February 2007 with the \$ 10.5 billion write-down of HSBC, which was the first major CDO or MBA related loss to be reported. During 2007, at least 100 mortgage companies have either shut down, suspended operations or been sold. Top management has not escaped unscathed, as the CEOs of Merrill Lynch and Citigroup were forced to resign within a week of each other. Various institutions followed-up with merger deals. In addition, Northern Rock and Bear Stearns have required emergency assistance from central banks. IndyMac was shut down by the Federal Deposit Insurance Corporation (FDIC) on 11 July 2008. On 14 September 2008, Lehman Brothers filed for bankruptcy after more than 150 years in business as a consequence of losses stemming from the SMC (see FM3 in Figure 1.3). Subsequent to this many U.S. and other banks throughout the world also failed. The widespread dispersion of credit risk and the unclear effect on financial institutions caused reduced lending activity and increased spreads on higher

interest rates. Similarly, the ability of corporations to obtain funds through the issuance of commercial paper was affected. This aspect of the crisis is consistent with a credit crunch. There are a number of reasons why banks may suddenly make obtaining a loan more difficult or increase the costs of obtaining a loan. This may be due to an anticipated decline in the value of the collateral used by the banks when issuing loans; an increased perception of risk regarding the solvency of other banks within the banking system; a change in monetary conditions (for example, where the central bank suddenly and unexpectedly raises interest rates or capital requirements); the central government imposing direct credit controls and instructing the banks not to engage in further lending activity. The subprime crisis has adversely affected several inputs in the economy, resulting in downward pressure on economic growth. Fewer and more expensive loans tend to result in decreased business investment and consumer spending (see FM4 and FM5 in Figure 1.3).

The liquidity concerns drove central banks around the world to take action to provide funds to member banks to encourage lending to worthy borrowers and to restore faith in the commercial paper markets (see GIR1 in Figure 1.3). With interest rates on a large number of subprime and other ARM due to adjust upward during the 2008 period, U.S. legislators, the U.S. Treasury Department, and financial institutions took action. A systematic program to limit or defer interest rate adjustments was implemented to reduce the effect. In addition, lenders and borrowers facing defaults have been encouraged to cooperate to enable borrowers to stay in their homes. Banks have sought and received over \$ 250 billion in additional funds from investors to offset losses (see [93] for more information). The risks to the broader economy created by the financial market crisis and housing market downturn were primary factors in several decisions by the U.S. Federal Reserve to cut interest rates and the ESP passed by Congress and signed by President Bush on 13 February 2008 (see, for instance, [4], [53] and [136]; also GIR2 in Figure 1.3). Bush also announced a plan voluntarily and temporarily to freeze the mortgages of a limited number of mortgage debtors holding ARMs. A refinancing facility called FHA-Secure was also created. This action is part of an ongoing collaborative effort between the U.S. government and private industry to help some subprime borrowers called the Hope Now Alliance (see GIR3 in Figure 1.3). The U.S. government also bailed-out key financial institutions, assuming significant additional financial commitments (see GIR4 in Figure 1.3). Following a series of ad-hoc market interventions to bailout particular firms, a \$ 700 billion systemic rescue plan was accepted by the U.S. House of Representatives on 3 October 2008. These actions are designed to stimulate economic growth and inspire confidence in the financial markets (see GIR5 in Figure 1.3). By October 2008, banks in Europe, Asia, Australia and South America had followed the example of the U.S. government by putting rescue plans in place.

1.3 MAIN PROBLEMS AND OUTLINE OF THE THESIS

In this section, we identify the main problems solved and give an outline of the thesis. Problems 1.3.1 and 1.3.4 were initially solved in [106].

1.3.1 Main Problems

The main problems to emerge from the discussions in the previous sections that are solved in this study can be formulated as follows:

Problem 1.3.1 (Dynamic Modeling of Banking Items): *Can we construct stochastic dynamic models to describe banking items in an economically sound manner ? (Subsection 1.2.2 in Chapter 1).*

Problem 1.3.2 (Dynamic Modeling of Bank Profits): *Can we construct a stochastic dynamic model to describe the evolution of bank profit that considers provisioning for loan losses and macroeconomic conditions ? (Subsection 2.4.1 in Chapter 2).*

Problem 1.3.3 (Banking Profit Maximization Problem): *Which choices about the profit consumption, investment in loans and provisions for loan losses must be made in order to maximize banking profit on a random time interval ? (Theorems 3.2.1 and 3.2.9 in Chapter 3).*

Problem 1.3.4 (Connections with Basel II and the SMC): *How do the banking models developed in this thesis relate to the Basel II capital accord and the SMC ? (Sections 5.1 and 5.2 in Chapter 5).*

1.3.2 Outline of the Thesis

The current chapter is introductory in nature. The rest of the thesis is structured as follows.

1.3.2.1 Outline of Chapter 2

Chapter 2 discusses the issues that are related to bank balance sheets, such as assets, liabilities, regulatory capital and profit. This chapter is based on the research completed in [107] and [106]. In section 2.1, we look at the general bank assets, loan demand and supply, risk weighted asset, aggregate bank assets, bank asset price processes and bank asset portfolio. Subsection 2.1.1 discusses the on- and off-balance sheet bank assets. In subsubsection

2.1.1.1, we give the notations for the rates of returns on cash, bonds and shares, we also give the notations for the proportions of investment in cash, bonds and shares, from the i -th loan subportfolio. Subsubsections 2.1.1.2, 2.1.1.3 and 2.1.1.4 discuss the intangible assets, Treasuries and reserves, respectively. Subsection 2.1.2 discusses how the bank obtains the deposits it use to issue loans. Figure 1.4 assists us to understand how the bank operates in terms of obtaining the deposits and using them to issue loans. Subsubsection 2.1.2.1 investigates loan demand and supply. Loan pricing, bank loan losses and their provisioning and mortgage-backed securities are discussed in subsubsections 2.1.2.2, 2.1.2.3 and 2.1.2.4, respectively. Subsection 2.1.3 considers risk weighted assets that are defined by placing each on- and off-balance sheet item into a risk category. A table is provided with few illustrative risk categories, their risk weights and representative items. Subsection 2.1.4 provides a description of aggregate risk-free and risky assets and their corresponding rates which are discuss in details in subsubsections 2.1.4.1 and 2.1.4.2, respectively. The last subsections 2.1.5 and 2.1.6 under section 2.1 look at bank assets pricing processes and bank asset portfolio, respectively. Section 2.2 discusses bank liabilities which are given as demand deposits. Section 2.3 gives a brief discussion on the bank capital, it starts by discussing total bank capital in subsection 2.3.1 and under subsection 2.3.2, we look into binding capital constraints. Finally, in section 2.4, we present a model for the profit dynamics of banks that make provision for loan losses and a model for those which make no provision for loan losses. We look into aggregate risk-free assets, profit dynamics and profitability indicators given by ROA and ROE.

1.3.2.2 Outline of Chapter 3

The contents of Chapter 3 which discuss maximizing banking profit on a random time interval, were thoroughly covered in [106]. We start by listing a set of assumptions for the problem and then state the problem (see Problem 3.1.1) that will be solved in the chapter. In this regard, we will discuss the optimal provisioning process and formulate different theorems and their proofs. Theorem 3.2.1 deals with optimal profit consumption and profit. Theorem 3.2.3 as well as corollaries 3.2.4 and 3.2.5 look at the optimal provisioning process. The former argues that an increase in the instantaneous prices of provisioning reduces the instantaneous inclination towards provisioning, whereas the latter highlights that the inclination towards provisioning decreases with increasing profit under certain conditions. Next, in subsections 3.2.2, 3.2.3 and 3.2.4 we discuss optimization under different scenarios such as, optimization with exponential utility, optimization with power utility and optimization with logarithmic utility. We do so by stating various theorems, under different subsections. In subsection 3.2.2 we state and prove theorem 3.2.7 that considers optimization with respect to exponential utility. Next, we state theorem 3.2.9 in subsection 3.2.3, which looks at optimization in terms of power utility. Eventually in this subsection we give the optimal profit formula in corollary 3.2.10. Moreover, corollary 3.2.12 looks at optimization with respect to logarithmic utility.

1.3.2.3 Outline of Chapter 4

In Chapter 4, we firstly consider numerical and illustrative examples of provisioning (see section 4.1). In addition, we simulate two indicators of profitability, viz., ROA and ROE. Section 4.2 contains the convergence of the Markov Chain Approximation Method, MCAM, and the impact of varying the model parameters. Specifically, we discuss the example involving optimization with power utility in subsection 4.2.1. In Subsection 4.2.2 we look at the impact of varying the model parameters; firstly the impact of varying loss severity β^i in subsubsection 4.2.2.1 and then in subsubsection 4.2.2.2 we investigate the impact of varying the loss frequency ϕ^i .

1.3.2.4 Outline of Chapter 5

Chapter 5 demonstrates the connections between the banking models and Basel II and the SMC. Section 5.1 starts the process by looking at banking models derived in the thesis and their connections with the Basel II Capital Accord. Under subsections 5.1.1 and 5.1.2, we discuss bank regulatory capital and the procyclicality of Basel II regulation, respectively. Subsection 5.1.1 shows in particular how has the Basel II's bank capital requirement replaced the reserve requirement as discussed in subsection 2.1.1, it tells us more about the requirement that the bank regulators need to hold a certain level of capital as a protection against the cost of financial distress. Subsection 5.1.2 looks at the standardized approach to credit risk as opposed to Basel II capital accord's approach to credit risk discussed in subsection 2.3.2, the pros and cons of this approach are given. Subsection 5.1.3 illustrates bank management practice by looking at a procedure that can be identified with the three-pillared approach of the Basel II Capital Accord. In addition, we look at the minimum capital requirement (Pillar 1), supervisory review (Pillar 2) and market discipline (Pillar 3), as covered under subsubsections 5.1.3.2, 5.1.3.3 and 5.1.3.4, respectively. We demonstrate the connection between our banking models and the current SMC in subsection 5.2.1. Finally, under this chapter we investigate the connections between Basel II and SMC in section 5.3, we test the role that Basel II might have played in the current credit crunch.

1.3.2.5 Outline of Chapter 6

Chapter 6 contains conclusions that we can draw from the study. We also point out which further research problems may be addressed.

1.3.2.6 Outline of Chapter 7

The bibliography in Chapter 7 contains all the articles, books and other sources used throughout the thesis.

1.3.2.7 Outline of Chapter 8

Finally, Chapter 8 contains appropriate appendices. Appendix A deals with MCAM where we give an algorithm that needs to be employed in order to draw Figures 4.3 in 4.2.1.1. Appendix B discusses the alternative banking model to the one derived in the body of the thesis for the banking items. Appendix C looks current credit crunches occurring in world economies and in the Southern African economy. We look in particular at the impact of credit crunches on the Southern African banking and financial systems. Appendix D outlines the timeline of both the pre-subprime and subprime mortgage crisis events over a forty year period, from 1968 to 2008.

Chapter 2

A STOCHASTIC BANKING MODEL

2.1 BANK ASSETS

2.1.1 General Bank Assets

2.1.1.1 Shares, Bonds and Cash

2.1.1.2 Intangible Assets

2.1.1.3 Treasuries

2.1.1.4 Reserves

2.1.2 Loans and Their Pricing

2.1.2.1 Loan Demand and Supply

2.1.2.2 Loan Pricing

2.1.2.3 Bank Loan Losses and their Provisions

2.1.2.4 Mortgage-Backed Securities (MBS)

2.1.3 Risk Weighted Assets

2.1.4 Aggregate Bank Assets

2.1.4.1 Aggregate Risk-Free Bank Assets

2.1.4.2 Aggregate Risky Bank Assets

2.1.5 Bank Asset Price Processes

2.1.6 Bank Asset Portfolio

2.2 LIABILITIES

2.2.1 Demand Deposits

2.3 BANK CAPITAL

2.3.1 Total Bank Capital

2.3.2 Binding Capital Constraints

2.4 PROFIT

2.4.1 Profit Dynamics

2.4.2 Profitability Indicators: ROA and ROE

In this chapter, we discuss bank items such as assets (cash, bonds, shares, intangible assets, Treasuries, reserves, loans, risk weighted assets, aggregate risk-free assets, bank asset portfolio and total risk weighted assets), liabilities (demand deposits), regulatory capital (equity, subordinate debt and loan loss reserves) and profit (dynamics and the indicators ROA and ROE). The current chapter has strong connections with accomplished research in [104], [105], [106], [107] and [108].

2.1 BANK ASSETS

This section is based on the contents of paper [106]. Below, we discuss issues that are related to shares, cash, bonds, intangible assets, Treasuries and reserves, loans, risk weighted assets, aggregate bank assets, bank asset price process as well as bank asset portfolio. In order to model the uncertainty associated with these items we consider the filtered probability space $(\Omega, \mathbf{F}, (\mathcal{F}_t)_{0 \leq t \leq T}, \mathbf{P})$.

2.1.1 General Bank Assets

In this subsection, we discuss on- and off-balance sheet bank assets such as cash, bonds and shares, intangible assets, Treasuries, and reserves. Because they have different characteristics and tend to perform differently as economic conditions vary, each one can be an important part of a balanced portfolio for banks.

2.1.1.1 Shares, Bonds and Cash

Of the first three general bank asset classes, shares, S , have historically been the most prominent performers over the long term. Since the returns from shares usually exceed the returns from both bonds and cash and have significantly outpaced inflation, they are important to a portfolio for growth of capital over time. Over the short term, however, shares can be volatile and as a result there is regulation related to banks holding shares.

Whereas shares represent equity, or part ownership of the companies that issue them, bonds, B , represent debt. Municipalities and governments all use bonds as a way to raise cash. When banks buy bonds, they are lending money to the issuer in exchange for fixed interest payments over a set number of years and a promise to pay the original amount back in the future. Bonds are valuable to banks more for the income they provide than for growth potential. Since the income they pay is fixed it is generally reliable and steady. The primary risk in bond market investing comes from interest rate changes. When interest rates rise, a bond's market value decreases. Another potential risk of owning bonds is default, which can occur when the bond issuer is no longer able either to pay the interest or repay the principal. The latter is negated by the fact that banks mainly buy government and municipal bonds with a very small likelihood of default.

Cash, C , is a term assigned to very short-term savings instruments such as money market securities. These investments can be used to meet near-term financial needs or to protect a portion of an investment portfolio from price fluctuation. The downside of cash securities is that they offer no real opportunities for long-term growth. Though economic conditions and factors such as changing interest rates can impact both shares and bonds, these markets perform independently of each other and can therefore serve as a balance within the portfolio of a bank.

In the sequel, we denote the deterministic rates of return on cash and bonds for the i -th loan subportfolio by r^{Ci} and r^{Bi} respectively, and the stochastic rate of return on shares by r^{Si} .

2.1.1.2 Intangible Assets

In the contemporary banking industry, shareholder value is often created by intangible assets which consist of patents, trademarks, brand names, franchises and economic goodwill (more specifically, core deposit customer relationships, customer loan relationships as differentiated from the loans themselves, etc.). Economic goodwill consists of the intangible advantages a bank has over its competitors such as an excellent reputation, strategic location, business connections, etc.. In addition, such assets can comprise a large part of the bank's total assets and provide a sustainable source of wealth creation. Intangible assets are used to compute Tier 1 bank capital and have a risk weight of 100 % according to Basel II regulation (see Table 2.1). In practice, valuing these off-balance sheet items constitutes one of the principal difficulties with the process of bank valuation by a stock analyst. The reason for this is that intangibles may be considered to be "risky" assets for which the future service potential is hard to measure. Despite this, our model assumes that the measurement of these intangibles is possible (see, for instance, [68] and [146]). Below, we denote the value of intangible assets, for the i -th loan subportfolio, by I^i and the return on these assets by $r^{Ii}I^i$.

2.1.1.3 Treasuries

Treasuries, T^i , coincide with securities that are issued by national Treasuries at a rate denoted by r^{Ti} . In essence, they are the debt financing instruments of the federal government. There are four types of Treasuries, viz., Treasury bills, Treasury notes, Treasury bonds and savings bonds. All of the Treasuries besides savings bonds are very liquid and are heavily traded on the secondary market.

2.1.1.4 Reserves

Bank reserves are the deposits held in accounts with a national institution (for instance, the Federal Reserve) plus money that is physically held by banks (vault cash). Such reserves

are constituted by money that is not lent out but is earmarked to cater for withdrawals by depositors. Since it is uncommon for depositors to withdraw all of their funds simultaneously, only a portion of total deposits may be needed as reserves. As a result of this description, we may introduce a reserve-demand deposit ratio, γ^i , for which

$$R^i = \gamma^i D^i.$$

The bank uses the remaining deposits to earn profit, either by issuing loans or by investing in assets such as Treasuries and stocks.

2.1.2 Loans and Their Pricing

In the sequel, we assume that the bank operates in the primary market. In this regard, the bank raises deposits from the individuals and uses these deposits to issue the loans (see Figure 1.4). In addition, the bank operates in the secondary market in order to bridge the gap between surpluses and deficits in its reserves. This involves transactions with other banks (interbank), with the central bank (monetary loans or deposits with the central bank), and in the financial markets (for instance, purchases and sales of Treasuries).

2.1.2.1 Loan Demand and Supply

The financial variables that are used to determine the loan demand, ζ^i , and supply, $\mathfrak{L}^i$, are

- $r^{\Lambda i}$ — bank's own loan rate;
- r^{di} — rate of inflow of deposits;
- $\tilde{\alpha}^i, \tilde{\beta}^i$ — macroeconomic and business cycle shift parameters.

Next, we denote the demand function for bank credit in the i -th loan subportfolio by $\zeta^i(r^{\Lambda i}, \tilde{\alpha}^i)$. The shift parameter, $\tilde{\alpha}^i$, represents macroeconomic factors such as changes in macroeconomic activities, $\mathbf{M}$, and conditions in the capital markets, v^i . The relationship between the demand function, ζ^i , bank's own loan rate, $r^{\Lambda i}$, and macroeconomic shift parameter, $\tilde{\alpha}^i$, may be given mathematically as

$$\frac{\partial \zeta^i}{\partial r^{\Lambda i}} < 0, \quad \frac{\partial \zeta^i}{\partial \mathbf{M}} > 0 \quad \text{and} \quad \frac{\partial \zeta^i}{\partial v^i} < 0. \quad (2.1)$$

From the inequalities above, we see that when the banks increase their own loan rates then loan demand will decrease and vice versa. Furthermore, when macroeconomic conditions

improve the loan demand will increase and vice versa. Lastly, when the capital markets deteriorate then the loan demand will increase and vice versa.

Also, we define the supply function of the public's deposits of the i -th loan subportfolio by $\mathfrak{J}^i(r^{di}, \tilde{\beta}^i)$. In this case, the shift parameter, $\tilde{\beta}^i$, represents the business cycle, and its relationship with $\mathfrak{J}^i(r^{di}, \tilde{\beta}^i)$ is written as

$$\frac{\partial \mathfrak{J}^i}{\partial \tilde{\beta}^i} > 0.$$

This shows that during an economic upturn the bank will supply more credit, but less credit during a downturn. A further relation between the rate of inflow of deposits, r^{di} , and $\mathfrak{J}^i(r^{di}, \tilde{\beta}^i)$ is as follows

$$\frac{\partial \mathfrak{J}^i}{\partial r^{di}} > 0.$$

In this regard, when the rate of inflow of deposits increases, the banks will supply more credit to the borrowers.

In our contribution, we represent the activity of the bank in the secondary market by

$$\Upsilon^i = \left[\Lambda^i - (1 - R^{pi}) \mathfrak{J}^i \right], \quad (2.2)$$

where R^{pi} is the reserve requirements on public deposits in the i -th loan subportfolio. Equation (2.2) can be positive, negative or zero. Also, equation (2.2) reveals how the banks operate in the secondary market. In this regard, if $\Upsilon^i > 0$ then the bank has a shortage of fund sources in the primary market, and will have to raise funds in the secondary market at interest rate r^{wi} via for instance, interbank borrowing. Moreover, if $\Upsilon^i < 0$ then the bank has excess fund sources and is able to buy assets in the secondary market via, for instance, deposits with the central bank, Treasuries, earning an interest rate r^{wi} .

Remark 2.1.1 (Loan Demand and Supply): *The bank realizes its profit by virtue of the fact that the net loan interest margin is greater than the marginal resource cost of deposit and loans. Also, the dynamics of the price process of the loan supply is represented as geometric Brownian motion. Consequently, we are able to deduce the value of the bank's investment in loans. A bank experiences shocks that affect the value of the loan demand, ζ^i , when the minimum capital requirements for Basel II are calculated by using risk weighted assets.*

2.1.2.2 Loan Pricing

We assume that the bank holds capital, K^i , in the i -th loan subportfolio as required by the regulator, which serves as a cushion against unexpected losses primarily from credit extension. Also, suppose the bank is risk neutral and its objective function is maximizing its expected profits. In this regard, in the i -th loan subportfolio, the relationship between the bank's own loan rate, $r^{\Lambda i}$, risk-free base rate, r_t , and probability of default, $P(d^i)$, may be expressed as

$$r^{\Lambda i} = \frac{(1 + r_t)}{(1 - P(d^i))} - 1 \quad \text{and} \quad \frac{\partial r^{\Lambda i}}{\partial P(d^i)} > 0,$$

where $P(d^i)$ is the probability of default of loans in the i -th loan subportfolio. For profit maximizing banks, in the i -th loan subportfolio, the loan rate, $r^{\Lambda i}$, is determined by the risk premium (or yield differential), ϱ^i , given by

$$\varrho_t^i = r^{\Lambda i} - r_t, \quad (2.3)$$

the industry's market power as determined by its concentration, N , the market elasticity of demand for loans, η^{ei} , the risk-free base rate, r_t , the cost of raising funds in the secondary market, c^{2oi} , and the product of the cost of capital (equity) raised, c^{Ei} , and the sensitivity of the required capital to changes in the amount of loans extended,

$$\frac{\partial K^i}{\partial \Lambda^i}. \quad (2.4)$$

In this situation, we may express the bank's own loan rate, $r^{\Lambda i}$, as

$$r_t^{\Lambda i} = \varrho^i + (1 + r_t) \frac{N^i}{\eta_e^i} + c^{2oi} + c^{Ei} \frac{\partial K^i}{\partial \Lambda^i} + \mathbf{E}(d^i), \quad (2.5)$$

where

$$N^i = \sum_{i=1}^n (S^i)^2$$

is the Herfindahl-Hirschman index of the concentration in the loan market,

$$s^i = \frac{\partial \Lambda^i}{\partial \Lambda}$$

is the market share of bank i in the loan market. However, in our contribution we only consider one bank, therefore $N = 1$. Furthermore, the elasticity of demand for loans is given by

$$\eta_e^i = - \left(\frac{\partial \Lambda^i}{\partial r^{\Lambda^i}} \right) \left(\frac{r^{\Lambda^i}}{\Lambda^i} \right).$$

Also, in our model, beside the risk premium, we include $\mathbf{E}(d^i)$ which constitutes the amount of provisioning that is needed to match the average expected losses in the i -th loan subportfolio, d^i , faced by loans.

2.1.2.3 Bank Loan Losses and Their Provisioning

Next, we discuss expected and unexpected loan losses which are modeled via the density function of the lognormal distribution, L' , and a homogeneous Poisson process, N^h , respectively.

We consider the expected loan losses from the perspective of the borrower. Suppose that, after providing liquidity, the bank grants the i -th loan subportfolio, Λ_0^i , at the interest rate on loan subportfolio or loan rate, r^{Λ^i} . This rate is assumed to be a random variable which is distributed according to some cumulative distribution function, F^i . Due to the expenses related to monitoring and screening, we assume that these loan subportfolios incur a constant administrative costs, c^{ai} . These costs largely depend on the nature of the loan subportfolio issued. For instance, for a loan subportfolio with a guarantee the costs of monitoring and screening are generally higher than for a loan subportfolio with no guarantee. Furthermore, we assume that the borrowers agree to repay, Λ_c^i , that is the product of the borrowed funds, Λ_0^i , and an exponential growth factor, $\exp\{r^{\Lambda^i}T\}$, so that

$$\Lambda_c^i = \Lambda_0^i \exp \left\{ r^{\Lambda^i} T \right\}.$$

The borrowers would like to invest the borrowed funds in assets with value, $\tilde{A}_t$, at time t and $\tilde{A}_T$ at the terminal time (of maturity of the loan contract), T . We assume that the value of these assets follow a geometric Lévy process given by

$$d\tilde{A} = \tilde{A} \left\{ \varrho^{vi} dt + \sigma^{vi} dZ_t^{vi} + \gamma^{vi} \int_{\mathbb{R}} y^i \tilde{M}(dt, dy^i) \right\},$$

where ϱ^{vi} , σ^{vi} and γ^{vi} are the nett instantaneous return, indicator of the volatility and constant jump coefficient of the value of borrowers' assets. In the event of default, the bank will receive the value of the borrowers' assets minus the cost of bankruptcy. The expected costs of insolvency, $\mathbf{E}[c^{ii}]$, at T are assumed to equal the administrative costs, c^{ai} , times the probability that insolvency will occur, Λ_c^i . In this case, symbolically we have that

$$\mathbf{E}[c^{ii}] = c^{ai} \Lambda_c^i \int_0^{\Lambda_c^i} \mathbf{L}'^i(\tilde{A}) d\tilde{A},$$

where $\mathbf{L}'^i(\cdot)$ is the density function of the log-normal distribution and c^{ii} denotes the costs of insolvency at period T . Furthermore, we denote the expected loan losses of the i -th loan subportfolio by, S^{ei} , and express it as

$$S^{ei} = \mathbf{E}[\min(\tilde{A}_T - \Lambda_c^i, 0)] - \mathbf{E}[c^{ii}] = \int_0^{\Lambda_c^i} \left\{ \tilde{A}_T - (1 + c^{ai}) \Lambda_c^i \right\} \mathbf{L}'^i(\tilde{A}_T) d\tilde{A}. \quad (2.6)$$

In the sequel, we assume that unexpected loan losses are recorded at the times

$$0 = T_0 < T_1 < T_2 < \dots,$$

where the corresponding unexpected loan loss amounts are describe by the non-negative random variables

$$l_1^i < l_2^i < \dots,$$

called the unexpected loan loss sizes. Let

$$N_t^h = \sup\{n \geq 1 : T_n < t\}, \quad \sup(\emptyset) \equiv 0,$$

be the number of loan losses recorded during the interval $[0, t]$. Throughout our contribution, we will denote the value of the generic unexpected loan losses by S^{ui} . The aggregate unexpected loan losses is modeled by a compound Poisson process, S^{ui} , as

$$S_t^{ui} = \begin{cases} \sum_{j=1}^{N_t^h} l_j^i, & N_t^h > 0; \\ 0, & N_t^h = 0. \end{cases} \quad (2.7)$$

Here $(l_n^i)_{n \in \mathbb{N}}$ is a sequence, independent of N^h , of positive i.i.d. random variables with a distribution function F^i and a mean $\mu = \mathbf{E}[l] < \infty$, modeling the values of the unexpected loan losses. The times between loan losses

$$T_n - T_{n-1}, \quad n \geq 1$$

are i.i.d. exponentially distributed random variables with parameter $\iota > 0$. The processes $(T_n)_{n \geq 1}$ and $(l_n^i)_{n \geq 1}$ are independent. It follows that the unexpected loan loss number process, $N^h = (N_t^h)_{t \geq 0}$, is a homogeneous Poisson process with an intensity $\iota > 0$, which means that

$$\mathbf{P}(N_t^h = p^{S_i}) = \exp\{-\iota t\} \frac{(\iota t)^k}{p^{S_i}!}, \quad p^{S_i} = 0, 1, 2, \dots$$

so that $(S_t^{ui})_{t \geq 0}$ is a compound Poisson process, which is also a Lévy process.

We compute the aggregate loan losses of the i -th loan subportfolio as the sum of the unexpected and expected loan losses in the form

$$S_t^i = S_t^{ei} + S_t^{ui}, \quad (2.8)$$

where S^{ei} and S^{ui} are given by (2.6) and (2.7), respectively. As a result of this definition, we can write a straightforward expression for aggregate loan losses, S^i , in (2.8) as

$$S_t^i = \begin{cases} \int_0^{\Lambda_c^i} \left\{ \tilde{A}_T - (1 + c^{ai}) \Lambda_c^i \right\} \mathbf{L}'^i(\tilde{A}_T) d\tilde{A} + \sum_{j=1}^{N_t^h} l_j^i, & N_t^h > 0; \\ \int_0^{\Lambda_c^i} \left\{ \tilde{A}_T - (1 + c^{ai}) \Lambda_c^i \right\} \mathbf{L}'^i(\tilde{A}_T) d\tilde{A}, & N_t^h = 0. \end{cases} \quad (2.9)$$

Moreover, the aggregate loan losses may be written as the fraction of bank assets in the i -th loan subportfolio, that is

$$S_t^i = p^{Si} A_t^i, \quad (2.10)$$

where $p^{Si} \geq 0$ represents the percentage of bank assets which are consumed by the aggregate loan losses. From (2.9) and (2.10), we have that

$$p^{Si} = \begin{cases} \frac{\int_0^{\Lambda_c^i} \left\{ \tilde{A}_T - (1 + c^{ai}) \Lambda_c^i \right\} L'^i(\tilde{A}_T) d\tilde{A} + \sum_{j=1}^{N_t^h} l_j^i}{A_t^i}, & N_t^h > 0; \\ \frac{\int_0^{\Lambda_c^i} \left\{ \tilde{A}_T - (1 + c^{ai}) \Lambda_c^i \right\} L'^i(\tilde{A}_T) d\tilde{A}}{A_t^i}, & N_t^h = 0. \end{cases}$$

In the sequel, if $p^{Si} = 0$, the aggregate loan loss is zero. In this regard, banks experience no loan losses in their i -th loan subportfolios, and the bank assets will be consumed by, for instance, investment losses and deposit withdrawals. On the other hand, when $p^{Si} > 0$, bank assets will suffer from, for instance, investment losses, deposit withdrawals and aggregate loan losses. Furthermore, we can consider the value of loan losses as

$$S_s^i(M_t) = r^{di}(M_t) \Lambda_t^i, \quad (2.11)$$

where S^i is independent of N . The formula for, $S_s^i(M_t)$, presented in (2.11) can be expressed in terms of profit, Π^i , as $S_s^i(\Pi_t^i)$, by virtue of the evidence from empirical studies which suggest that a strong correlation between M_t and Π_t^i exists (see the discussion on the procyclicality of bank profitability in, for instance, [23] and [26]). Also, we assume that the default or loan loss rate, $r^{di} \in [0, 1]$, increases when macroeconomic conditions deteriorate according to

$$0 \leq r^{di}(M_t) \leq 1, \quad \frac{\partial r^{di}(M_t)}{\partial M_t} < 0.$$

As was the case with the relationship between profit and macroeconomic activity, the above description of the loan loss rate is consistent with empirical evidence that suggests that bank losses on loan portfolios are correlated with the business cycle under any capital adequacy regime (see, for instance, [23], [26] and [32]).

The bank's investment in loans may yield substantial returns but may also result in loan

losses. In line with reality, our dynamic banking model allows for loan losses for which provision can be made. The need to create provisions arises because the loans are not recorded at market value, typically because imputed market values are either empirically difficult to obtain due to an absence of traded markets or a reliance on judgemental assumptions. Bad and doubtful bank loans defines two categories of LLP. Specific provisions are made for debts which have been identified as impaired or non-performing. General provisions are made for those doubtful debts which may turn out to be non-performing on the basis of historical performance or current economic conditions, although debt servicing is currently taking place. The distinction is that specific provisions are made for losses which have actually already occurred whereas general provisions are made for those loans which may occur in the future. Banks increase their provision for loan losses in order to write-off loans closer to market values; the loan should be valued at the price it would command if traded in the open market.

The accompanying default risk is modeled as a compound Poisson process, where N is a Poisson process with a deterministic frequency parameter ϕ^i . In this case, if the provisions for loan losses are defined so that they equal the difference between the face and current values of the loan, (2.5) can easily be rearranged to demonstrate that provisions equal the difference between the discounted present value of expected loan losses, l^i , and the discounted present value of the expected risk premiums. This description leads to the formula

$$\begin{aligned} P_t^i(l) = F_t^i(l^i) - \Lambda_t^i(l^i) &= \mathbf{E} \left[\int_t^T \exp\{-\delta^i(s-t)\} l_s^i ds \right] \\ &- \mathbf{E} \left[\int_t^T \exp\{-\delta^i(s-t)\} D_s^i ds \right]. \end{aligned} \quad (2.12)$$

where F_t^i is a depreciation of fixed assets.

Furthermore, we assume that the contribution made by the bank to the provision for loan losses takes the form of a continuous expense that can be expressed as

$$\left[1 + \theta^i(s) \right] \phi^i(s) \mathbf{E}[P_s^i(S^i)],$$

where θ^i is a loading term dependent on the level of credit risk, $\theta^i(t) \geq 0$ and P_t^i is the actual provision for loan losses. This means that if the bank suffers a loan loss of $\Lambda^i = l^i$ at time t , the provisions, $P_t^i(l^i)$, covers these losses. The actual manner in which banks make provision for loan losses can differ greatly. However, there is invariably some cost incurred by the bank in administering the process. In this regard, we denote the costs associated

with bank provisioning for loan losses by, c^{Pi} , (see, for instance, [23], [32] and [87]).

2.1.2.4 Mortgage-Backed Securities (MBS)

A mortgage-backed security (MBS) is an asset-backed security whose cash flows are backed by the principal and interest payments of a set of mortgage loans. Payments are typically made monthly over the lifetime of the underlying loans. Residential mortgages in the United States have the option to pay more than the required monthly payment (curtailment) or to pay off the loan in its entirety (prepayment). Because curtailment and prepayment affect the remaining loan principal, the monthly cash flow of an MBS is not known in advance, and therefore presents an additional risk to MBS investors. Commercial mortgage-backed securities (CMBS) are secured by commercial and multifamily properties (such as apartment buildings, retail or office properties, hotels, schools, industrial properties and other commercial sites). The properties of these loans vary, with longer-term loans (5 years or longer) often being at fixed interest rates and having restrictions on prepayment, while shorter-term loans (1-3 years) are usually at variable rates and freely prepayable.

The connection between this thesis and MBS is, firstly, that $i = 4, 5, 6, 9$ in (1.8) constitutes a set of mortgage loans that is discussed in the previous paragraph. Secondly, the financial leverage profit engine (see Figures 1.3 and 1.4) involving MBS play a major role in the SMC discussed in Section 5.2.

2.1.3 Risk Weighted Assets

We consider RWAs that are defined by placing each on- and off-balance sheet item into a risk category. The more risky assets are assigned a larger weight. Table 2.1 below provides a few illustrative risk categories, their risk weights and representative items.

Risk Category	Risk Weight	Banking Items
1	0 %	Cash, Bonds, Treasuries, Reserves
2	20 %	Shares
3	50 %	Home Loans
4	100 %	Intangible Assets
5	100 %	Loans to Private Agents

Table 2.1: Risk Categories, Risk Weights and Representative Items

As a result, RWAs are a weighted sum of the various assets of the banks. In the sequel, we denote the risk weight on intangible assets, cash, bonds, shares, loans, Treasuries and reserves by ω^{Ii} , ω^{Ci} , ω^{Bi} , ω^{Si} , ω^{Ai} , ω^{Ti} and ω^{Ri} , respectively. In particular, we can identify a special risk weight on loans, $\omega^{Ai} = \omega^i(M_t)$, that is a decreasing function of current

macroeconomic conditions so that

$$\frac{\partial \omega^i(\mathbf{M}_t)}{\partial \mathbf{M}_t} < 0. \quad (2.13)$$

This is in line with the procyclical notion that during booms, when macroeconomic activity increases, the risk weights will decrease. On the other hand, during recessions, risk weights may increase because of an elevated probability of default and/or loss given default on loans.

In the sequel, it may be more useful to represent the RWAs in the following way. We recall that the charge to cover credit risk equals the sum of the bank's long and short trading positions multiplied by risk weights for specific assets. As a result, if we let $\omega \in [0, 1]^m$ denote the $m \times 1$ vector of asset risk weights, then the capital charge to cover credit risk at time t equals

$$a^r = \omega^T \left(\rho_t^{a+} + \rho_t^{a-} \right), \quad (2.14)$$

where for any ρ^a we denote by ρ^{a+} the $m \times 1$ vector with components

$$\rho^{a+} = \max[0, \rho^a] \text{ (long trading positions)}$$

and by ρ^{a-} the $m \times 1$ vector with components

$$\rho^{a-} = \max[0, -\rho^a] \text{ (short trading positions).}$$

2.1.4 Aggregate Bank Assets

In this subsection, we provide a description of aggregate risk-free and risky assets and their corresponding rates. The objective is to identify the key characteristics of broad swings in the prices of these assets that may be masked by differences in the behavior of individual prices so as to highlight their relationship to macroeconomic performance and monetary policy. Two basic criteria for selecting the assets included in the aggregate should be that they make up a sizeable proportion of said assets and they should be traded with some frequency on primary and secondary markets. There are two methods of defining and constructing the aggregate. The first is to define the aggregate price as a measure of the values of the underlying assets. Secondly, we may define the aggregate price as a measure of the change in the value of the risk-free and risky assets themselves. Nevertheless, as a purely practical matter, it would be of interest to know whether the differences in methodology

produce substantial differences in the implied behavior of the aggregate assets over time. The calculation of the weights for these assets may be based on flow-of-funds balance sheets.

2.1.4.1 Aggregate Risk-Free Bank Assets

We suppose that the aggregate risk-free asset (ARFA) is given in terms of cash, C , bonds, B , Treasuries, T , and reserves, R . The aggregate risk-free asset, A , can be written as

$$A = a^1 C + a^2 B + a^3 T + a^4 R, \quad 0 \leq a^1, a^2, a^3, a^4 \leq 1, \quad (2.15)$$

where a^1 , a^2 , a^3 and a^4 are weights for the respective risk-free bank assets. The corresponding aggregate risk-free asset interest rate term may be expressed as

$$r^A = f(r^C, r^B, r^T, r^R).$$

We assume that the price of the ARFA at time t , A_t^i , in the i -th loan subportfolio, follows the process

$$dA_t^i = r^{Ai} A_t^i dt \quad \text{for some fixed } r^{Ai} \geq 0.$$

2.1.4.2 Aggregate Risky Bank Assets

We assume that the aggregate risky asset (ARA) may be expressed as the weighted sum of loans, Λ , shares, S , and intangible assets, I . In this case, the aggregate risky asset, $\hat{A}$, has the form

$$\hat{A} = \hat{a}^1 \Lambda + \hat{a}^2 S + \hat{a}^3 I, \quad 0 \leq \hat{a}^1, \hat{a}^2, \hat{a}^3 \leq 1, \quad (2.16)$$

where $\hat{a}^1$, $\hat{a}^2$ and $\hat{a}^3$ are corresponding weights. In an analogous way, the ARA interest rate term may be expressed as

$$r^{\hat{A}} = g(r^{\Lambda}, r^S, r^I).$$

In the i -th loan subportfolio, the ARA price, $\hat{A}_t^i$, follows the process

$$d\widehat{A}_s^i = \widehat{A}_s^i \left\{ (\mu + \sigma a)ds + \sigma dM_s + c\sigma dZ_s \right\}, \quad s \geq t, \quad \widehat{A}_t^i = \widehat{A}^i, \quad (2.17)$$

where $\mu \geq r^A$ and $\sigma > 0$ are constants and a, c, M as well as Z are as described in equation (1.6) of Subsection 1.2.1.

2.1.5 Bank Asset Price Processes

The bank's investment portfolio is constituted by $p + 1$ assets that include cash, bonds, Treasuries and reserves (constituting aggregate risk-free assets) as well as shares, loans, intangible assets (constituting aggregate risky assets). We pick the first asset to be the aggregate risk-free asset, A , that earns a constant, continuously-compounded interest rate of r^A . Profit maximizing banks consider their rates of return on assets to be the sum of the risk-free aggregate asset rate, $r^A \bar{1}$ and the drift, μ . Here the unitary vector and drift are given by

$$\bar{1} = (1, 1, \dots, 1)^T$$

and

$$\mu = (\mu_1, \mu_2, \dots, \mu_m)^T,$$

where

$$\mu_i = \begin{cases} \varrho^i + (1 + r_t) \frac{N^i}{\eta^i} + c^{2\varrho^i} + c^{Ei} \frac{\partial K^i}{\partial A^i} + \mathbf{E}(d^i), & i\text{-th asset is a loan,} \\ r_i^a, & i\text{-th asset is not a loan,} \end{cases}$$

respectively. Also, ϱ^i is the risk premium for the i -th asset subportfolio, r_i^a is the auxiliary rate of return of the non-loan asset i and the expected loan loss average is given by

$$\mathbf{E}(d) = (\mathbf{E}(d^1), \mathbf{E}(d^2), \dots, \mathbf{E}(d^m))^T.$$

The $p > m$ assets beside the aggregate risk-free assets, A are risky and their price process, X (taking the reinvestment of dividends into account), is driven by a Lévy process with drift vector, $r^A \bar{1} + \mu$ and diffusion matrix, σ , as in

$$X_t = X_0 + \int_0^1 I_s^X \left(r^A \bar{1} + \mu + \sigma a \bar{1} \right) ds + c \int_0^1 I_s^X \sigma dZ_s + \int_0^1 I_s^X \sigma dM_s, \quad (2.18)$$

where I_t^X denotes the $p \times p$ diagonal matrix with entries X_t and M is an p -dimensional Lévy process. Furthermore, we assume that $\text{rank}(\sigma) = p$ and the bank is allowed to engage in continuous frictionless trading over the planning horizon.

2.1.6 Bank Asset Portfolio

In the sequel, we suppose that ρ^a is the p -dimensional stochastic process that denotes the current value of the risky assets including loans, Λ , shares, S , and intangible assets, I . In this case, the dynamics of the current value of the bank's entire asset portfolio, A , over any reporting period may be given by

$$dA_t = A_t \left\{ r^A + \rho_t^{aT} (\mu + \sigma a) \right\} dt + c A_t \rho_t^{aT} \sigma dZ_t + A_t \rho_t^{aT} \sigma dM_t - r^A D_t dt, \quad (2.19)$$

where the face value of the demand deposits, D , is as described in Subsection 2.4 below, and $r^A D_t dt$ represents the interest paid to depositors.

2.2 LIABILITIES

In this thesis, the only liability we consider is demand deposits.

2.2.1 Demand Deposits

The bank takes demand deposits, D_t^i , at a constant marginal cost, c^{Λ^i} , that may be associated with cheque clearing and bookkeeping. It is assumed that deposit taking is not interrupted even in times when the interest rate on demand deposits or deposit rate, r_t^{Di} , is less than the bond rate, r_t^{Bi} . We suppose that the dynamics of the deposit rate process, $r^{Di} = \{r_t^{Di}\}_{t \geq 0}$, is determined by the geometric Brownian motion process

$$dr_t^{Di} = r_t^{Di} \left\{ \mu^{r^{Di}} dt + \sigma_t^{r^{Di}} dZ_t^{r^{Di}} \right\}, \quad (2.20)$$

where $\mu^{r^{Di}}$ and $\sigma_t^{r^{Di}}$ are the drift coefficient and volatility in the deposit rate, respectively.

We have to consider the possibility that unanticipated deposit withdrawals, u^i , will occur. By way of making provision for these withdrawals, the bank is inclined to hold Treasuries

that are very liquid. In our contribution, we assume that u^i is related to the probability density function, $f^i(u)$, that is independent of time. For sake of argument, we suppose that the unanticipated deposit withdrawals have a uniform distribution with support $[\underline{D}^i, \overline{D}^i]$ so that the cost of liquidation, c^i , or additional external funding is a quadratic function of Treasuries. In addition, for any t , if we have that

$$u^i > T_t^i,$$

then bank assets are liquidated at some penalty rate, r_t^{pi} . In this case, the cost of deposit withdrawals is

$$c^{wi}(T_t^i) = r_t^{pi} \int_{T_t^i}^{\infty} [u^i - T_t^i] f^i(u) du = \frac{r_t^{pi}}{2D^i} [\overline{D}^i - T_t^i]^2. \quad (2.21)$$

Remark 2.2.1 (Demand Deposit Rate): *In some quarters, the demand deposit rate, r^{Di} , described in (2.20) from Section 2.2, is considered to be a strong approximation of bank monetary policy. Since such policy is usually affected by macroeconomic activity, $\mathbf{M}$, we expect the aforementioned items to share an intimate connection. However, in our analysis, we assume that the shocks σ^{Di} and $\sigma^{\mathbf{M}}$ to r^{Di} and $\mathbf{M}$, respectively, are uncorrelated. Essentially, this means that a precise monetary policy is lacking in our bank model. This interesting relationship is the subject of further investigation. The way to proceed in this situation is to assume the existence of a correlation $q \in [-1, 1]$ between $Z^{r^{Di}}$ and $Z^{\mathbf{M}}$. Here we may set*

$$\mathbf{E} \left(Z_t^{r^{Di}}, Z_s^{\mathbf{M}} \right) = q \min(t, s) \quad \text{and} \quad Z_t^{r^{Di}} = \sqrt{1 - q^2} Z_t^{\mathbf{M}}.$$

When $q^2 \neq 1$ the risk in the deposit rate cannot be diversified by trading in the financial market. We further note that a vital component of the process of deposit withdrawals is liquidity. The level of liquidity in the banking sector affects the ability of banks to meet commitments as they become due (such as deposit withdrawals) without incurring substantial losses from liquidating less liquid assets. Liquidity, therefore, provides the defensive cash or near-cash resources to cover banks' liabilities.

2.3 BANK CAPITAL

In this subsection, we discuss total bank capital and binding capital constraints for a bank. For the purposes of our study, we define bank capital, K , as the difference between the accounting value of the assets and liabilities.

2.3.1 Total Bank Capital

In this section, we discuss total bank capital. The bank's total capital, K^i , has the form

$$K_t^i = K_t^{T1i} + K_t^{T2i} + K_t^{T3i},$$

where K_t^{T1i} , K_t^{T2i} and K_t^{T3i} are Tier 1, Tier 2 and Tier 3 capital, respectively. Tier 1 (T1) capital is the book value of bank capital defined as difference between the accounting value of the assets and liabilities. In our contribution, Tier 1 capital is represented at t^- 's market value of the bank equity, $n_t E_{t^-}^i$, where n_t is the number of shares and E_t^i is the market price of the bank's common equity at t . Tier 2 (T2) and Tier 3 (T3) capital consists of preferred stock and subordinate debt (collectively known as supplementary capital). Subordinate debt is the subordinate to deposits and hence faces greater default risk. Tier 2 capital, O_t^i , issued at t^- is represented by bonds that pay an interest rate, r^{Oi} , (see [2]).

In the sequel, we take the bank capital, K , in period t to be

$$K_t^i = n_t E_{t^1}^i + O_t^i + R_t^{li}, \quad (2.22)$$

where $n_t E_{t^1}^i$ is the market value of the bank equity and constitutes Tier 1 capital in period t^1 , O_t^i is the subordinate debt and is a constituent of Tier 2 capital as is the loan loss reserves, R_t^{li} .

2.3.2 Binding Capital Constraints

The bank capital constraint is defined by the inequality

$$K_t^i \geq \rho \left[a_t^i + 12.5(mVaR + 0) \right], \quad (2.23)$$

where

$$a_t^i = \omega^{Ii} I_t^i + \omega^{Si} S_t^i + \omega^{\Lambda i} \Lambda_t^i + \omega^{Ti} T_t^i + \omega^{Ri} R_t^i,$$

and ω^{Ii} , $\omega^{\Lambda i}$, ω^{Ti} and ω^{Ri} are the risk weights for intangible assets, loans, Treasuries and reserves, respectively, $\rho = 0,08$, $mVaR$ is as described in Chapter 1 and 0 is the operational risk. If we assume that the risk weights associated with intangible assets, Treasuries, reserves and loans may be taken to be $\omega^I \neq 0$, $\omega^{Ti} = \omega^{Ri} = 0$ and $\omega^{\Lambda i} = \omega^i(M_t)$, respectively, then equation (2.23) becomes

$$K_t^i \geq \rho \left[\omega^i(M_t) \Lambda_t^i + \omega^{Ii} I_t^i + \omega^{Si} S_t^i + 12.5(mVaR + 0) \right]. \quad (2.24)$$

Remark 2.3.1 (Capital and Reserve Requirements): Under Basel II, bank capital requirements have replaced reserve requirements (see Subsection 5.1.3.2) as the main constraint on the behavior of banks. A first motivation for this is that bank capital has a major role to play in overcoming the moral hazard problem arising from asymmetric information between banks, creditors and debtors. Also, bank regulators require capital to be held to protect themselves against the costs of financial distress, agency problems and the reduction of market discipline caused by the safety net. As before, it is only proper to provide for deposit withdrawals.

2.4 PROFIT

In this section, we look at bank profitability and its stochastic dynamics. In Subsection 2.4.1, we use r^A as given in Subsection 2.1.4.1, to determine the profit dynamics for banks that make provisions for loan losses and those that do not. Subsection 2.4.2, discusses the profitability indicators as given by ROA and ROE. In the sequel, we express the profit consumption, $k_t^{\Pi i}$, as

$$k_t^{\Pi i} = f(O^i, d^i), \quad (2.25)$$

where d^i is the dividends paid due to activities in the i -th loan subportfolio. The term $k_t^{\Pi i}$ in (2.25) represents the consumption of the bank's profit via interest and principal payments on subordinate debt and dividend distribution.

2.4.1 Profit Dynamics

Suppose, in the i -th loan subportfolio, that the value of the bank's investment in aggregate risk-free assets, A^i , and aggregate risky assets, $\hat{A}^i$, as well as aggregate loan losses, S^i , cost of withdrawals, $c^{wi}(S_t^i)$, and profit consumption, $k^{\Pi i}$, are given by (2.15), (2.17), (2.9), (2.21) and (2.25), respectively. In this case, the expression for the profit dynamics of banks that make provision for loan losses may be represented as

$$\begin{aligned}
d\Pi_s^i &= \left[r_s^A \Pi_s^i + (r_s^{\hat{A}i} - c^{\hat{A}i} - r_s^A) \hat{A}_s^i + \mu^{ai}(s) - k_s^{\Pi i} - [1 + \theta^i(s)] \phi^i(s) \mathbf{E}[P_s^i(S^i)] + a\sigma_s^i \right] ds \\
&\quad - c^{wi}(S_s^i) + \sigma_s^i \hat{A}_s^i dM_s + c\sigma_s^i \hat{A}_s^i dZ_s - \left\{ S_s^i(\Pi_s^i) + P_s^i(S_s^i(\Pi_s^i)) \right\} dN_s, \\
s &\geq t, \Pi_t^i = \pi^i,
\end{aligned} \tag{2.26}$$

where $\mu^{ai}(s)$ is the rate term for auxiliary profits that may be generated from activities such as special screening, monitoring, liquidity provision and access to the payment system. Also, this additional profit may be generated from imperfect competition, barriers to entry, exclusive access to cheap deposits or tax benefits. On the other hand, the expression for the profit dynamics of banks that make no provision for loan losses may be given by

$$\begin{aligned}
d\Pi_s^i &= \left[r_s^A \Pi_s^i + (r_s^{\hat{A}i} - c^{\hat{A}i} - r_s^A) \hat{A}_s^i + \mu^{ai}(s) - k_s^{\Pi i} + a\sigma_s^i \right] ds \\
&\quad - c^{wi}(S_s^i) + \sigma_s^i \hat{A}_s^i dM_s + c\sigma_s^i \hat{A}_s^i dZ_s - S_s^i(\Pi_s^i) dN_s, \quad s \geq t, \Pi_t^i = \pi^i,
\end{aligned} \tag{2.27}$$

Remark 2.4.1 (Profitability Model): The stochastic model for profit in (2.26) can be considered to be the natural analogue of the corresponding discrete-time model presented in [2] (see, also, [33]). Furthermore, in the next subsection, we provide formulae for the two main measures of the bank's profitability.

2.4.2 Profitability Indicators: ROA and ROE

In this subsection, we consider ROA and ROE as indicators of profitability. Let $A^{ri} = (A_t^{ri}, t \geq 0)$ be the process representing ROA. Then net profit after taxes per unit of assets may be represented by

$$\text{ROA } (A_t^{ri}) = \frac{\text{NIATBCF } (\Pi_t^i) - \text{Cost of Funds } (\Theta^i)}{\text{Bank Assets } (A_t^i)}. \tag{2.28}$$

The ROA provides information about how much profit is generated per average by each unit of assets. Therefore the ROA is an indicator of how efficiently a bank is being managed. Let $E^{ri} = (E_t^{ri}, t \geq 0)$ be the process representing ROE. Then the net profit after taxes per unit of equity capital may be given by

$$\text{ROE } (E_t^{ri}) = \frac{\text{NIATBCF } (\Pi_t^i) - \text{Cost of Funds } (\Theta^i)}{\text{Equity Capital } (E_t^i)}. \tag{2.29}$$

From this relationship it follows that the lower the equity capital, the higher the ROE, therefore the owners of the bank (equity holders) may not want to hold too much equity capital. However, the equity capital cannot be too low, because the level of bank capital funds is subjected to capital adequacy regulation. Currently, this regulation takes the form of the Basel II Capital Accord (see [10]) that was implemented in 2007 on a worldwide basis. Also, from [83] and [62], it follows that there are other measures of profitability.

Chapter 3

MAXIMIZING BANKING PROFIT

3.1 STATEMENT OF THE OPTIMIZATION PROBLEM

3.1.1 List of Assumptions

3.1.2 Optimization Problem Statement

3.1 SOLUTION TO THE OPTIMIZATION PROBLEM

3.2.1 Optimal Provisioning Process

3.2.2 Optimization with Exponential Utility

3.2.3 Optimization with Power Utility

3.2.4 Optimization with Logarithmic Utility

In this chapter, we make use of the modeling of the preceding discussion to solve a bank optimization problem, we state various theorems and corollaries under different subsections. We suppose that the time horizon determined by the random time of bankruptcy τ of the bank. The contents of this chapter have been thoroughly dealt with in [106].

3.1 STATEMENT OF THE OPTIMIZATION PROBLEM

In this section, we list the assumptions on the optimization problem,

3.1.1 List of Assumptions

In this subsection, we provide a list of assumptions relevant to the problem statement. Some of the assumptions were stated in the preceding chapter, however we would like to reemphasize on them.

- For the aggregate risky asset (ARA) weights, we assume that

$$\hat{a}^1 = \hat{a}^2 = 0; \hat{a}^3 = 1$$

so that

$$\hat{\mathbf{A}} = \mathbf{\Lambda}.$$

In other words, in this chapter, our primary concern is the loan component of the aggregate risky assets.

- We assume that the bank is able to invest in aggregate risk-free assets (ARFA) as well as loans (compare with the above assumption). The price of the ARFA at time t , A_t^i , in the i -th loan subportfolio follows the process

$$dA_t^i = r^{Ai} A_t^i dt \text{ for some fixed } r^{Ai} \geq 0.$$

In the i -th loan subportfolio, the price of a loan, Λ_t^i , follows the process

$$d\Lambda_s^i = \Lambda_s^i \left\{ (\mu - c^\Lambda) ds + \sigma dZ_s \right\}, \quad s \geq t, \quad \Lambda_t^i = \Lambda^i,$$

where $\mu \geq r^\Lambda$ and $\sigma > 0$ are constants and Z is the standard Brownian motion driving the loans, Λ .

- We assume the Poisson process, N , is independent of Z .
- Furthermore, we assume that the contribution made by the bank to the provision for loan losses, P , takes the form of a continuous expense that can be expressed as

$$\left[1 + \theta^i(s)\right] \phi^i(s) \mathbf{E}[P_s^i(S^i)],$$

where θ^i is a loading term dependent on the level of credit risk, $\theta^i(t) \geq 0$ and P_t^i is the actual provision for loan losses. This means that if the bank suffers a loan loss of $\Lambda^i = l^i$ at time t , the provisions, $P_t^i(l^i)$, covers these losses.

- Suppose, in the i -th loan subportfolio, that the value of the bank's investment in loans, Λ^i , and aggregate risk-free assets, A^i , as well as aggregate loan losses, S^i , cost of withdrawals, $c^{wi}(S_t^i)$, and profit consumption, $k^{\Pi i}$, are given by (2.11), (2.15), (2.9), (2.21) and (2.25), respectively. For sake of argument, we consider a special case of (2.26) in which $c^{wi}(S_t^i) = 0$, $r_s^A = r^A$, $r_s^{\hat{\Lambda}i} = r^{\Lambda i}$, $c^{\hat{\Lambda}i} = c^{\Lambda i}$ and $\sigma_s^i = \sigma^i$. In this regard, we have that

$$\begin{aligned} d\Pi_s^i &= \left[r^A \Pi_s^i + (r^{\Lambda i} - c^{\Lambda i} - r^A) \Lambda_s^i + \mu^{\Lambda i}(s) - k_s^{\Pi i} - [1 + \theta^i(s)] \phi^i(s) \mathbf{E}[P_s^i(S^i)] + a\sigma^i \right] ds \\ &\quad + \sigma^i \Lambda_s^i dM_s + c\sigma^i \Lambda_s^i dZ_s - \left\{ S_s^i(\Pi_s^i) + P_s^i(S_s^i(\Pi_s^i)) \right\} dN_s, \\ s &\geq t, \Pi_t^i = \pi^i, \end{aligned} \tag{3.1}$$

- We also assume that the utility of profit consumption and the utility of profit are additively separable.

3.1.2 Optimization Problem Statement

We assume that the bank seeks to optimize (over allowable $\{k_t^{\Pi i}, \Lambda_t^i, P_t^i\}$) its expected utility of the profit consumption during a random time interval $[t, \tau]$ and terminal profit at time τ . The set of admissible controls, $\mathcal{A}^i$, has the form

$$\mathcal{A}^i = \left\{ (k_t^{\Pi i}, \Lambda_t^i, P_t^i) : \text{measurable w.r.t. } \mathcal{F}_t, (3.1) \text{ has a unique sln} \right\}. \tag{3.2}$$

The associated objective function of this problem is given by

$$\begin{aligned}
V^i(\pi^i, t) = & \sup_{\{k_t^{\Pi^i}, \Lambda_t^i, P_t^i\}} \mathbf{E} \left[\int_t^\tau \exp\{-\delta^i(s-t)\} U^{(1)}(k_s^{\Pi^i}) ds \right. \\
& \left. + \exp\{-\delta^i(\tau-t)\} U^{(2)}(\Pi_\tau^i) | \Pi_t^i = \pi^i \right], \tag{3.3}
\end{aligned}$$

where $U^{(1)}$ and $U^{(2)}$ are twice-differentiable, increasing, concave utility functions and $\delta^i > 0$ is the rate at which the profit consumption and terminal profit are discounted. The function $U^{(1)}$ measures the utility of profit consumption, while $U^{(2)}$ measures the utility of profit. The challenge now is to determine whether we can obtain a smooth solution or analytical solution for the resulting HJB equation. In the sequel, we obtain an analytic solution for the choices of power, logarithmic and quadratic utility functions. In this regard, we align our optimization procedure with the methodology suggested in such contributions as [24].

The stochastic optimization problem for bank profit consumption and terminal profit on a random time interval, $[t, \tau]$ is presented as follows.

Problem 3.1.1 (Optimal Profit Consumption and Profit): Suppose that $\mathcal{A}^i \neq \emptyset$, where the admissible class of control laws, $\mathcal{A}^i$ is given by (3.2). Also, consider the SDE for the Π^i -dynamics from (3.1) and the objective function, $V^i : \mathcal{A}^i \rightarrow \mathbf{R}_+$, given by (3.3). In this case, solve

$$\sup_{\{k_t^{\Pi^i}, \Lambda_t^i, P_t^i\}} V^i(\Pi^i; k_t^{\Pi^i}, \Lambda_t^i, P_t^i),$$

and the optimal control law $(k_t^{\Pi^{i*}}, \Lambda_t^{i*}, P_t^{i*})$, if it exists,

$$(k_t^{\Pi^{i*}}, \Lambda_t^{i*}, P_t^{i*}) = \arg \sup_{\{k_t^{\Pi^i}, \Lambda_t^i, P_t^i\}} V^i(\Pi^i; k_t^{\Pi^i}, \Lambda_t^i, P_t^i) \in \mathcal{A}^i.$$

Remark 3.1.2 (Discount Rate): Problem 3.1.1 above (see, also, Problem 1.3.4) addresses issues about banking activities that are related to the optimal implementation of financial economic principles. The parameter δ^i is an idiosyncratic discount rate that is not a market parameter, but rather part of the utility functional. Note that an assumption is that $U^{(1)}$ and $U^{(2)}$ are additively separable which is not necessarily true for all banks.

3.2 SOLUTION TO THE OPTIMIZATION PROBLEM

In this subsection, we determine a solution to Problem 3.1.1 for a random time horizon $[t, \tau]$. In Theorem 3.2.1 below, $D_t V^i(\pi^i, t)$, $D_{\pi^i} V^i(\pi^i, t)$ and $D_{\pi^i \pi^i} V^i(\pi^i, t)$ denote first and second order partial derivatives of V^i with respect to the variables t and π^i where appropriate. For example, $D_{\pi^i \pi^i} V^i(\pi^i, t)$ is the second partial derivative of V^i with respect to π^i .

Theorem 3.2.1 (Optimal Profit Consumption and Profit): *Suppose that the objective function, $V^i(\pi^i, t)$, is described by (3.3). In this case, a solution to the optimization problem is of the form*

$$\Lambda_t^{i*} = -\frac{(r^{\Lambda i} - c^{\Lambda i} - r^A)}{\sigma^{2i}} \frac{D_{\pi^i} V^i(\Pi_t^{i*}, t)}{D_{\pi^i \pi^i} V^i(\Pi_t^{i*}, t)}, \quad (3.4)$$

in which Π_t^{i*} is the optimally controlled profit. Also, the optimal profit consumption, $\{k_t^{\Pi^{i*}}\}$, solves the equation

$$D_k U^{(1)}(k_t^{\Pi^{i*}}) = D_{\pi^i} V^i(\Pi_t^{i*}, t). \quad (3.5)$$

Proof. In our proof, via the dynamic programming approach, V solves the HJB equation

$$\left\{ \begin{aligned} & \delta^i V^i(\pi, t) = D_t V^i(\pi^i, t) + \max_{\Lambda^i} \left[(r^{\Lambda i} - c^{\Lambda i} - r^A) \Lambda D_{\pi^i} V^i(\pi^i, t) + \frac{1}{2} \sigma^{2i} \Lambda^{2i} D_{\pi^i \pi^i} V^i(\pi^i, t) \right] \\ & + \max_{k^{\Pi^i}} \left[U^{(1)}(k^{\Pi^i}) - k^{\Pi^i} D_{\pi^i} V^i(\pi^i, t) \right] + \left(r^A \pi^i + \mu^{ai}(t) \right) D_{\pi^i} V^i(\pi^i, t) \\ & + \max_{P^i} \left[\phi^i(t) \left\{ \mathbf{E} V^i \left(\pi^i - (S^i - P^i(S^i)), t \right) - V^i(\pi^i, t) \right\} \right. \\ & \left. - \left(1 + \theta^i(t) \right) \phi^i(t) \mathbf{E}[P^i(S^i)] D_{\pi^i} V^i(\pi^i, t) \right] + \eta_h^i(t) \left[U^{(2)}(\pi^i) - V^i(\pi^i, t) \right] \\ & \lim_{s \rightarrow \infty} \mathbf{E} \left[\exp \left\{ - \int_t^s (\delta^i + \eta_h^i(u)) du \right\} V^i(\Pi_s^{i*}, s) | \Pi_t^{i*} = \pi^i \right] = 0, \end{aligned} \right. \quad (3.6)$$

where $\eta_h^i(t)$ is a hazard rate, or force of bankruptcy for a bank at time t .

We note that the objective function, V^i , is increasing and concave with respect to profit π^i , because the utility functions $U^{(1)}$ and $U^{(2)}$ are increasing and concave and because the differential equation for profit is linear with respect to the controls. Thus the optimal investment strategy in (3.4) holds. $\square$

[36] and [77] provide an argument based on martingale approach, which we can use to proof Theorem 3.2.1. In order to determine an exact solution for our optimization problem in

Theorem 3.2.1, we are required to make a specific choice for the utilities $U^{(1)}$ and $U^{(2)}$. Essentially these utilities can be almost any function involving k^{Π^i} and Π^i , respectively. However, in order to obtain smooth analytic solutions to the maximization problem, in the ensuing discussion, we choose power, logarithmic and exponential utility functions and analyze the effect of the different choices.

Remark 3.2.2 (HJB Equations and Verification Theorems): *We note from Theorem 3.2.1 of Section 3.2, that [24] can be used to derive the associated HJB equation (compare (3.6)). In addition, certain verification theorems claim that if the objective function, V^i , is smooth and the related HJB equation has a smooth solution, $\tilde{V}^i$, then under certain regularity conditions, $V = \tilde{V}^i$. We are able to appeal to the theory of viscosity solutions in those cases for which a smooth solution does not exist.*

3.2.1 Optimal Provisioning Process

Suppose that the profit dynamics of banks that make provision for loan losses is represented by (2.26) and the dynamics of banks that make no provision is given by (2.27). With regard to the optimal provisioning process, $P^{i*} = \{P_t^{i*}\}_{0 \leq t \leq \tau}$, we have the following theorem.

Theorem 3.2.3 (Optimal Provisioning Process): *The optimal provisioning process, P^* , is either no provisioning or per-loss provisioning, in which the provisioning costs may vary with respect to time. Specifically, at a given time, the optimal provisioning costs $c^{P^{i*}} = \{c_t^{P^{i*}}\}_{0 \leq t \leq \tau}$ solves*

$$\left(1 + \theta^i(t)\right) D_{\pi^i} V^i(\Pi_t^{i*}, t) = D_{\pi^i} V(\Pi_t^{i*} - c_t^{P^i}, t). \quad (3.7)$$

No provisioning is optimal at time t if and only if

$$\left[1 + \theta^i(t)\right] D_{\pi^i} V^i(\Pi_t^{i*}, t) \geq D_{\pi^i} V^i(\Pi_t^{i*} - \text{ess sup } \Lambda(\Pi_t^{i*}, t), t).$$

Proof. The result in Theorem 3.2.3 are common in discrete-time models (see, for instance, [23], [32] and [87]), namely that provisioning behaves procyclically by falling during economics booms and rising during recessions. [127] deliver a proof in economics literature. The same result can easily be shown that it holds in a continuous-time settings. $\square$

Λ^i is not necessarily a continuous random variable in this instance. Also if $\theta^i(t) = 0$, then $c_t^{P^{i*}} = 0$; that is, provisioning is optimal if the risk premium rate is actuarially fair.

Corollary 3.2.4 (Optimal Provisioning Process): *An increase in the instantaneous price of provisioning reduces the instantaneous inclination towards provisioning.*

Proof. The properties of the objective function, V^i , do not change when $\theta^i(t)$ increases for a small time duration t . Furthermore, since $D_{\pi^i \pi^i} V^i(\pi^i, t) < 0$, we have that c_t^{Pi*} also increases during a small change of time t . $\square$

In the next corollary, we consider the value function V^i and we draw a particular interest in showing that if the value function V^i exhibits decreasing absolute risk aversion with respect to profit, then the inclination towards provisioning decreases with increasing profit. The argument presented in [116] about the absolute risk aversion of V^i with respect to π^i as being

$$-\frac{\pi^i D_{\pi^i \pi^i} V^i(\pi^i, t)}{D_{\pi^i} V^i(\pi^i, t)}$$

is adopted here. We formally state the corollary as follows, which clearly parallels the corresponding result in the static case.

Corollary 3.2.5 (Optimal Provisioning Process): *Suppose that c_t^{Pi*} exists. In this case, if V^i in (3.3) exhibits decreasing absolute risk aversion with respect to profit, then the inclination towards provisioning decreases with increasing profit.*

Proof. Differentiating the equation

$$\left(1 + \theta^i(t)\right) D_{\pi^i} V^i(\pi^i, t) = D_{\pi^i} V^i(\pi^i - c_t^{Pi*}, t).$$

with respect to π^i , we obtain

$$\begin{aligned} \frac{\partial c_t^{Pi*}}{\partial \pi^i} &\propto \left(1 + \theta^i(t)\right) D_{\pi^i \pi^i} V^i(\pi^i, t) - D_{\pi^i \pi^i} V^i(\pi^i - c_t^{Pi*}, t) \\ &= \left(1 + \theta^i(t)\right) D_{\pi^i \pi^i} V^i(\pi^i, t) - D_{\pi^i \pi^i} V^i(G[(1 + \theta^i(t)) D_{\pi^i} V^i(\pi^i, t), t], t) \end{aligned}$$

in which G is the inverse of $D_{\pi^i} V^i(\pi^i, t)$ with respect to profit. Let $\pi^i = G(\nu^i, t)$; then

$$\begin{aligned}
\frac{\partial c_t^{P^{i*}}}{\partial \pi^i} &\propto \left(1 + \theta^i(t)\right) D_{\pi^i \pi^i} V^i(G(\nu^i, t), t) - D_{\pi^i \pi^i} V(G[(1 + \theta^i(t)) D_{\pi^i} V^i(G(\nu^i, t), t), t], t) \\
&\propto \left(1 + \theta^i(t)\right) \frac{D_{\pi^i \pi^i} V^i(G(\nu^i, t), t)}{D_{\pi^i} V^i(G(\nu^i, t), t)} - \frac{D_{\pi^i \pi^i} V^i(G[(1 + \theta^i(t)) \nu^i, t], t)}{D_{\pi^i} V^i(G(\nu^i, t), t)} \\
&\propto \frac{D_{\pi^i \pi^i} V^i(G(\nu^i, t), t)}{D_{\pi^i} V^i(G(\nu^i, t), t)} - \frac{D_{\pi^i \pi^i} V^i(G[(1 + \theta^i(t)) \nu^i, t], t)}{\left(1 + \theta^i(t)\right) \nu^i} \\
&\propto -\frac{D_{\pi^i \pi^i} V^i(G[(1 + \theta^i(t)) \nu^i, t], t)}{D_{\pi^i \pi^i} V^i(G[(1 + \theta^i(t)) \nu^i, t], t)} - \frac{D_{\pi^i \pi^i} V^i(G(\nu^i, t), t)}{D_{\pi^i} V^i(G(\nu^i, t), t)} \\
&\geq 0
\end{aligned}$$

because G decreases with increasing profit and V^i exhibits decreasing risk aversion with respect to profit. $\square$

We are now in a position to make our respective choices for the three scenarios mentioned earlier, namely exponential, power and logarithmic utility functions.

Remark 3.2.6 (Provisioning): *Provisioning by banks may take place to a greater or lesser degree. The provisioning identity in (3.7) has a financial economic interpretation. The left-hand side of the identity, i.e.,*

$$\left(1 - \theta^i(t)\right) D_{\pi^i} V(\Pi_t^{i*}, t)$$

represents the marginal cost of decreasing the cost of provisioning (or increasing provisioning for loan losses). On the other hand, the right-hand side

$$D_{\pi^i} V(\Pi_t^{i*} - c_t^{P^i}, t)$$

is the marginal benefit of increasing provisioning for loan losses. Thus optimality in the provisioning process occurs when the marginal cost equals the marginal benefit.

3.2.2 Optimization with Exponential Utility

Suppose

$$U^{(1)}(k^{\Pi^i}) = 0 \text{ and } U^{(2)}(\Pi^i) = -\frac{1}{\gamma^i} \exp \left\{ -\gamma^i \pi^i \right\}, \quad \gamma^i > 0. \quad (3.8)$$

We can verify the following result.

Theorem 3.2.7 (Optimization with Exponential Utility): *Suppose the exponential utilities are given as in (3.8) and assume that the loan loss S^i is independent of profit, with the probability distribution of S^i being a deterministic function of time. In this case, we have*

$$V^i(\pi^i, t) = f(t) \exp^{-\gamma^i \pi^i} \quad (3.9)$$

in which $f(t)$ solves

$$f' + G(t)f = \frac{\eta_{\mathbf{h}}^i(t)}{\gamma^i} \quad (3.10)$$

and

$$\begin{aligned} G(t) = & \phi^i(t) \left[\exp \gamma^i c^{Pi*} - 1 + (1 + \theta^i(t))(S^i(t) - c_t^{Pi*})\gamma^i \right] \\ & - \frac{(r^{\Lambda i} - c^{\Lambda i})^2}{2\sigma^{2i}} + \pi(t)\gamma^i + \eta_{\mathbf{h}}^i(t) + \delta^i. \end{aligned} \quad (3.11)$$

We assume that the parameter values are such that $f(t) < 0$. Moreover, we have that optimal provisioning cost is given by

$$c_t^{Pi*} = \min \left[\frac{1}{\gamma^i} \ln(1 + \theta^i(t)), \text{ess sup } S^i(t) \right]. \quad (3.12)$$

the optimal bank investment in loans is

$$\Lambda_t^{i*} = \frac{r^{\Lambda i} - c^{\Lambda i}}{\sigma^{2i}\gamma^i}, \quad (3.13)$$

and the optimal consumption is given by

$$k_t^{\Pi i*} = 0 \quad (3.14)$$

Proof.

The proof proceeds via standard arguments from stochastic optimization theory in continuous time. For instance, the formula for the optimal provisioning cost, c_t^{Pi*} , in (3.12) is a direct consequence of Theorem 3.2.3. Also, the optimal bank investment in loans, Λ_t^{i*} , given by (3.13) can be derived from an application of equation (3.4) in Theorem 3.2.1 to the expression for $V^i(\pi^i, t)$ in (3.9). From $U^{(1)}(k^{\Pi i}) = 0$, it follows that the optimal profit consumption is identically 0 as in (3.14). $\square$

Remark 3.2.8 (Optimal Cost of Provisioning): *It is evident from the preceding discussion in Subsection 3.2.2 that the optimal cost of provisioning, $c^{Pi*}(t)$, and the optimal bank loan investment strategy, $\Lambda^{i*}(t)$, in (3.12) and (3.13), respectively, are both deterministic functions and independent of profit. Also, the optimal profit consumption, $k^{\Pi i*}$, is identically zero. Since Λ_t^{i*} does not depend on profit it is also independent of bank provisioning for loan losses. Computations involving exponential utility usually lead to independence from profit because the absolute risk aversion (equal to γ^i) is constant (see [116]). Another consequence of the choice of exponential utility is that $c^{Pi*}(t)$ is independent of the parameters of the loan process. Note that as bank risk aversion (measured by γ^i) increases, the bank's loan investment decreases. Moreover, as the provisioning cost, c^{Pi} , decreases, the bank's inclination towards provisioning increases. Also, as the load, $\theta^i(t)$, increases, the inclination towards provisioning decreases because it becomes more expensive. In this regard, Corollary 3.2.4 holds for permanent increases in $\theta^i(t)$ because the profit effect is zero. Note also that as the horizon τ increases, the provisioning costs and the allocation to loans decrease. As a result, it seems that a bank with a longer horizon behaves more conservatively.*

3.2.3 Optimization with Power Utility

In this regard, for a choice of power utility we have that

$$\bar{U}^{(1)}(k^{\Pi i}) = \frac{k^{\alpha i}}{\alpha^i} \text{ and } \bar{U}^{(2)}(\Pi^i) = b \frac{\pi^{\alpha i}}{\alpha^i} \quad (3.15)$$

for some $\alpha^i < 1$, $\alpha^i \neq 0$, and for some $b \geq 0$. The parameter b represents the weight that the bank gives to terminal profit versus profit consumption and can be viewed as a measure of the bank's propensity to retain earnings. This leads to the following important result

Theorem 3.2.9 (Optimization with Power Utility): *Suppose the additional profit rate is zero, the power utilities are given as in (3.15) and assume that the loan loss is proportional*

to profit via

$$S_s^i(\Pi_t^i) = \beta^i(t)\Pi_t^i,$$

for some deterministic loan loss severity function, β^i , where $0 \leq \beta^i(t) \leq 1$. In this case, we have that

$$\overline{V}^i(\pi^i, t) = \frac{\pi^{\alpha^i}}{\alpha^i} \overline{\xi}^i(t), \quad (3.16)$$

in which $\overline{\xi}^i$ solves the non-linear, nonhomogeneous differential equation

$$\overline{\xi}^{i'} - \overline{H}\overline{\xi}^i + (1 - \alpha^i)\overline{\xi}^{\frac{\alpha^i}{\alpha^i-1}} + b\eta_h^i(t) \quad (3.17)$$

with

$$\overline{H} = H(t) + \eta_h^i(t),$$

in which H is given by

$$\begin{aligned} H(t) = & \delta^i + \phi^i(t) - \kappa^i \alpha^i + (1 + \theta^i(t))\phi^i(t)\alpha^i \max\left(0, (1 + \theta^i(t))^{\frac{1}{1-\alpha^i}} - (1 - \beta^i(t))\right) \\ & - \phi^i(t) \max\left((1 + \theta^i(t))^{\frac{1}{1-\alpha^i}}, 1 - \beta^i(t)\right) \end{aligned}$$

and

$$\kappa^i = r^A + \frac{(r^{\Lambda^i} - c^{\Lambda^i} - r^A)^2}{2\sigma^{2i}(1 - \alpha^i)}.$$

We assume the parameters are such that $\overline{\xi}(t) > 0$. Thus, the optimal provisioning cost is

$$c_t^{Pi*} = \min \left[1 - (1 + \theta^i(t))^{\frac{1}{\alpha^i-1}}, \beta^i(t) \right] \Pi_t^{i*}. \quad (3.18)$$

the optimal consumption is given by

$$k_t^{\Pi i*} = D_{\pi^i} \overline{V^i}^{\frac{1}{1-\alpha^i}} = \overline{\xi^i}(t)^{-\frac{1}{1-\alpha^i}} \Pi_t^{i*}, \quad (3.19)$$

the optimal bank investment in loans is

$$\Lambda_t^{i*} = \frac{r^{\Lambda i} - c^{\Lambda i} - r^{\Lambda}}{\sigma^{2i}(1 - \alpha^i)} \Pi_t^{i*} \quad (3.20)$$

Proof. The proof relies on standard arguments from stochastic optimization theory. Also, (3.19) is determined by using (3.5) with power utility. $\square$

We note that with the choice of power utility the optimal provisioning cost, profit consumption, and investment in loans given by c^{Pi*} , $k^{\Pi i*}$ and Λ^{i*} , respectively, can all be expressed as a linear function of the optimal profit, Π^{i*} . We also note that, these quantities are affected by the hazard rate η_h^i . Moreover, Λ^{i*} and c^{Pi*} are affected by bankruptcy through $k^{\Pi i*}$'s impact on profit. Finally, we note that the optimal provisioning cost c^{Pi*} is independent of the macroeconomic conditions and the optimal bank investment Λ^{i*} in loans is independent of the loan loss given default. The following corollary to Theorem 3.2.9 comments on the relationship between formulas for the optimal bank investment in loans, Λ^{i*} , obtained in (3.4) and (3.20).

Corollary 3.2.10 (Optimization with Power Utility): *Suppose that the optimal bank investment in loans, Λ^{i*} , given by (3.4) and (3.20) are equal. Then a formula for the optimal profit is given by*

$$\Pi_t^{i*} = \frac{\sigma^{2i}(1 - \alpha^i)(n_t E_{t-}^i + O_t)}{\rho^i \omega(M_t)(r^{\Lambda i} - c^{\Lambda i} - r^{\Lambda})}. \quad (3.21)$$

Remark 3.2.11 (Functions of Optimal Profit): *The optimal provisioning cost, $c^{Pi*}(t)$, profit consumption, $k^{\Pi i*}$, and investment in loans, Λ^{i*} , obtained in Theorem 3.2.9 of Subsection 3.2.3, can each be represented as a linear function of optimal profit. A possible explanation for this is that the choice of a power utility function naturally leads to constant relative risk aversion (see, for instance, [116]). Symbolically, this can be expressed as*

$$-\frac{\pi D_{\pi^i \pi^i} U(\pi^i)}{D_{\pi^i} U(\pi^i)} = 1 - \gamma^i.$$

In this regard, we note that an increase in relative risk aversion results in the proportion of profit from loans decreases. Accompanying this is an increase in the demand for provisioning

with a commensurate decrease in the cost of provisioning, c_t^{Pi*} . Another observation is that $\bar{\xi}^i$, and hence $\bar{V}^i$ from (3.16) and $k^{\Pi i*}$ in (3.19) are affected explicitly by the horizon τ . Also, c^{P*} and Λ^{i*} given by (3.18) and (3.19), respectively, are affected by τ only through $k^{\Pi i*}$ impact on profit. Note also that $\bar{\xi}$, and hence $k^{\Pi i*}$ and $\bar{V}$, depend on the frequency and severity parameters for loan losses, ϕ^i and β^i , respectively. Moreover, we see that the optimal provisioning costs, c^{Pi*} , is independent of the loan price parameters and the optimal loan investment, Λ^{i*} , is independent of loan losses.

From Corollary 3.2.10 of Subsection 3.2.3, we conclude that optimal profits will depend on aspects of banking items such as loans, bank capital, regulatory capital adequacy indices, risk weighted assets and treasury securities. In this regard, we note that on the right-hand side of formula (3.21) for optimal bank profit, only bank capital, $n_t E_{t-1}^i + O_t^i$, and the risk weight, $\omega(M_t)$, is time dependent. We can use this fact when analyzing this result in terms of procyclicality in bank profitability. In the case where bank capital is fixed, an immediate consequence of the aforementioned result, is that as the risk weight increases (macroeconomic activity assumed to decrease via the inequality (2.13) in Subsection 2.1.3), bank profitability decreases. In other words, there will be a commensurate decrease in profits as macroeconomic conditions deteriorate. On the other hand, in the case where the risk weight is fixed, bank profitability increases (decreases) as bank capital increases (decreases). These observations are in line with recent research on the procyclicality of risk weightings, profitability and capital in such contributions as [23], [25], [26], [31], [32] and [33].

3.2.4 Optimization with Logarithmic Utility

Corollary 3.2.12 Suppose we let $\alpha^i \rightarrow 0$ in Theorem 3.2.9, so that

$$\tilde{U}^{(1)i}(k^{\Pi}) = \ln k^{\Pi i} \text{ and } \tilde{U}^{(2)i}(\Pi) = b \ln \Pi^i. \quad (3.22)$$

Then, the optimal provisioning cost and bank investment in loans are consistent with our results for $\alpha^i \neq 0$

The optimal consumption is given by

$$k_t^{\Pi i*} = D_{\pi^i} \tilde{V}^{i-1}(\pi^i, t) = \tilde{\xi}^i(t)^{-1} \Pi_t^{i*} \quad (3.23)$$

Here $\tilde{\xi}^i(t)$ is given by

$$\tilde{\xi}^i(t) = b \bar{A}_{x+t}^{\delta^i} \quad (3.24)$$

From (3.24) we define an indemnity which the bank is compensated with, in case it faces bankruptcy at a random time τ with the rate of discount equal to δ^i . In a special case of

constant hazard rate η_h^i we have that $\tilde{\xi}^i(t)^{-1} = \frac{\eta_h^i + \delta^i}{1 + b\eta_h^i}$. Thus if $\delta^i b < 1$, $\tilde{\xi}^{i-1}$ increases with η_h^i ; therefore, a bank with a longer horizon consumes a smaller proportion of profit.

Remark 3.2.13 (Optimal Profit Consumption): *From Corollary 3.2.12 in Subsection 3.2.4, we observe that the optimal profit consumption, $k^{\Pi i*}$, does not depend on the frequency and severity loan loss parameters, ϕ^i and β^i , respectively. By contrast, the exact opposite was true when $\gamma^i \neq 0$ with power utility. However, as in the latter case, we see that $\tilde{\xi}^i$, and hence $\tilde{V}^i$ and c^{i*} , are explicitly influenced by the horizon τ . Furthermore, π^{i*} and c^{Pi*} are affected by τ only through $k^{\Pi i*}$'s impact on profit. More specifically, if $\delta^i b > 1$, then $\tilde{\xi}^i$ is a decreasing function of τ . As a consequence, a larger proportion of profit is consumed by depository activity for a bank with a longer horizon. Similarly, if $\delta^i b < 1$, then a bank with a longer horizon consumes a smaller proportion of profit. It is not clear what the reason for this phenomenon is. We note that b in (3.22) measures the bank's propensity towards deposit taking and holding while δ^i measures the banks preference for the immediate versus deferred profit consumption.*

Chapter 4

NUMERICAL AND ILLUSTRATIVE EXAMPLES

4.1 NUMERICAL EXAMPLES: ROA AND ROE

4.1.1 Forecast Evaluation

4.2 CONVERGENCE OF THE MCAM AND IMPACT OF VARYING THE MODEL PARAMETERS

4.2.1 Example: Optimization with Power Utility

4.2.1.1 Convergence of the MCAM

4.2.2 Impact of Varying the Model Parameters

4.2.2.1 Impact of Varying the Loan Loss Severity β^i

in the i -th Loan Subportfolio

4.2.2.2 Impact of Varying the Loan Loss Frequency ϕ^i

in the i -th Loan Subportfolio

In this chapter, we simulate the bank's profitability indicators ROA and ROE. We consider numerical and illustrative examples of the models for banking activities derived in Chapter 3. This chapter has strong connection with [108].

4.1 NUMERICAL EXAMPLES: ROA AND ROE

In this section, we simulate ROA and ROE by considering SARB data (see [137]) for a 63 month period by using Matlab. In our stochastic simulation model, we estimate the coefficients of our model using data from 1 January 2002 to 31 March 2007. There are a few methods for simulating stochastic differential equation (SDE). First, we assume that the ROA and the ROE do have jumps that are Gaussian distributed. We therefore simulate the stochastic differential equations (8.16) and (8.18) by using Merton's model. Note that in Merton's model the driving Lévy process is a compounded Poisson process.

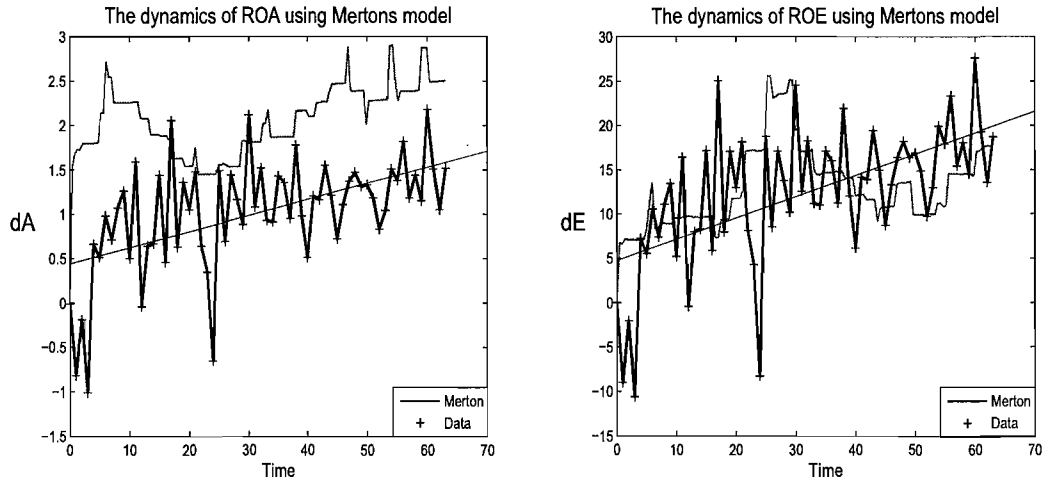


Figure 4.1: Solutions of (8.16) and (8.18) with a Fitted Linear Trend Line

Although Lévy based models are structurally superior, the estimation procedures are complicated. The calibrated Lévy model is very sensitive to the numerical starting point in the minimization algorithm or small changes in the input data. Using SA Reserve Bank's data and by calibrating Merton's model we get the following parameter choices $\alpha = 0.06895$ (ROA) or $\alpha = 0.12275$ (ROE) with starting value -0.01 (ROA case) or 0.01 (ROE), $\beta = 0.0101$ (ROA) or $\beta = 0.069$ (ROE) and the average jump size $\tilde{J}_j \stackrel{i.i.d.}{\sim} N(-0.00032, 0.12^2)$ (ROA) or $\tilde{J}_j \stackrel{i.i.d.}{\sim} N(0.0001, 0.2^2)$ (ROE). For another intensity the results of the minimization will be different. From Figure 4.1 it follows that Merton's model reproduces some of the turning points.

Secondly, we assume that the ROA and the ROE do not have jumps. In this case our SDEs

(8.17) and (8.19) are driven by Brownian motions. We apply Euler-Maruyama Method to simulate these SDEs over $[0, T]$ discretized Brownian path using time steps of size $Dt = R*dt$ for some positive integer R and $dt = \frac{T^i}{2^8}$. For a SDE of the form

$$dA_t = f(A_t^i)dt + g(A_t^i)dB_t, \quad 0 \leq t \leq T,$$

the Euler-Maruyama method takes the form

$$A_j^i = A_{j-1}^i + f(A_{j-1}^i)\varrho^i t + g(A_{j-1}^i)(B(t_j) - B(t_{j-1})),$$

where $j = 1, 2, \dots, \frac{2^8}{R}$.

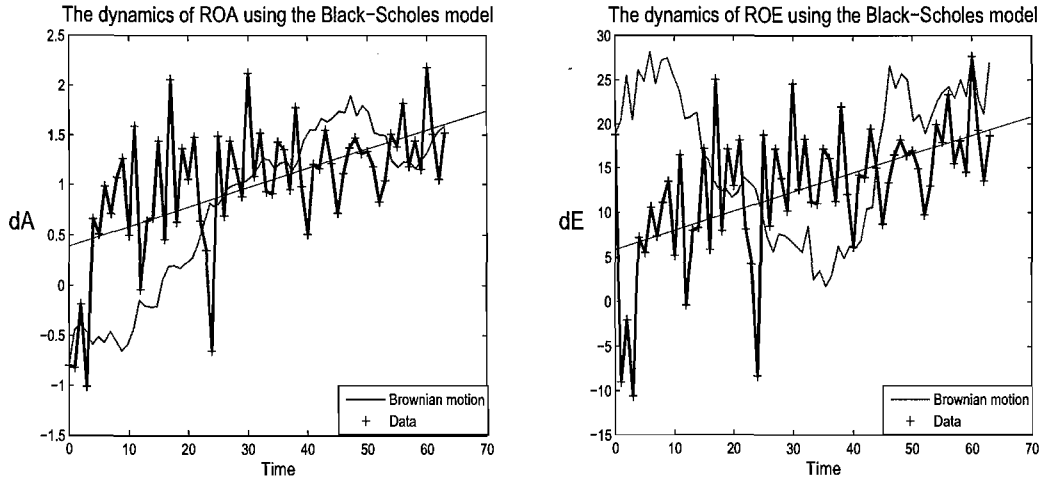


Figure 4.2: Solutions of (8.17) and (8.19) with a Fitted Linear Trend Line

The data in Table 4.1 on the ROA and ROE from the SA Reserve Bank was used in our simulation.

For the Black-Scholes model we made the following parameter choices $\sigma_e^i = 3.09$, $\mu_e^i = 0.12$, $\sigma_a^i = 0.22$, $\mu_r^i = -0.004$. Also, for the Euler-Maruyama method we chose the value of net profit after tax as $\Pi_t^{ni} = 16878$, the dividend payments on E^i as $\delta_e^i = 0.05$, the interest and principal payments on O^i as $\delta_s^i = 1.06$, the interest rate as $r = 0.06$, the subordinate debt $O^i = 135$ and the bank equity $E^i = 1164$.

4.1.1 Forecast Evaluation

We construct a forecast evaluation of ROA (or ROE) over the forecasted period January 2006 to March 2007. Suppose the forecast period is $j = T + 1, T + 2, \dots, T + h$, where h is the number of forecasts made for the relevant period. Denote the actual and forecasted value in period t as Y_t and $\hat{Y}_t$, respectively. For comparative purposes (see [115]), the

DATE	ROA/ROE	DATE	ROA/ROE	DATE	ROA/ROE
Jan-2002	-0.82/-9.01	Jan-2003	0.64/8.00	Jan-2004	1.49/18.79
Feb-2002	-0.19/-2.07	Feb-2003	0.67/8.31	Feb-2004	0.69/8.53
Mar-2002	-1.01/-10.59	Mar-2003	1.44/17.18	Mar-2004	1.44/17.14
Apr-2002	0.66/7.22	Apr-2003	0.46/5.88	Apr-2004	1.16/13.78
May-2002	0.51/5.53	May-2003	2.06/25.06	May-2004	0.88/10.21
Jun-2002	0.98/10.58	Jun-2003	0.63/7.98	Jun-2004	2.12/24.57
Jul-2002	0.71/7.39	Jul-2003	1.36/17.1	Jul-2004	1.08/12.57
Aug-2002	1.07/11.10	Aug-2003	1.05/12.98	Aug-2004	1.52/18.28
Sep-2002	1.26/13.43	Sep-2003	1.48/18.16	Sep-2004	0.93/11.17
Oct-2002	0.50/5.22	Oct-2003	0.64/8.13	Oct-2004	0.91/11.01
Nov-2002	1.59/16.43	Nov-2003	0.35/4.30	Nov-2004	1.43/17.15
Dec-2002	-0.04/-0.39	Dec-2003	-0.65/-8.29	Dec-2004	1.35/16.05
Jan-2005	0.95/11.24	Jan-2006	1.31/16.37	Jan-2007	1.51/19.27
Feb-2005	1.78/21.96	Feb-2006	1.33/16.92	Feb-2007	1.05/13.52
Mar-2005	0.98/12.02	Mar-2006	1.18/14.88	Mar-2007	1.52/18.69
Apr-2005	0.51/6.16	Apr-2006	0.83/9.76		
May-2005	1.20/14.16	May-2006	1.04/12.95		
Jun-2005	1.16/13.92	Jun-2006	1.51/19.96		
Jul-2005	1.55/19.45	Jul-2006	1.38/17.92		
Aug-2005	1.21/14.99	Aug-2006	1.82/23.36		
Sep-2005	0.72/8.72	Sep-2006	1.18/15.47		
Oct-2005	1.11/13.31	Oct-2006	1.44/18.09		
Nov-2005	1.37/16.42	Nov-2006	1.15/14.51		
Dec-2005	1.47/18.21	Dec-2006	2.18/27.65		

Table 4.1: ROA and ROE (Source: SA Reserve Bank)

reported forecast error statistics are computed as in Table 4.2.

The smaller the error, the better the forecasting ability of that model according to this criterion. The first two forecast error statistics depend on the scale of the dependent variable however the remaining two statistics are scale invariant. The TIC always lies between zero and one, where zero indicates a perfect fit. In Table 4.3 we give the relevant values of RMSE, MAE, MAPE and TIC.

In Figure 4.2, we plotted the actual ROA (or ROE) values versus the Black-Scholes model values for the period 2002:01 - 2007:03. From Figure 4.2 and Table 4.3 where we used the model without jumps it follows that the RMSE for the ROA is 0.4428 and for the ROE it is 7.1675 and the MAPE for the ROA is 26.85 % and 42.37 % for the ROE.

In Figure 4.1, we also plotted the actual ROA (or ROE) values versus the Merton's model values for 2002:01 - 2007:03. From Figure 4.1 and Table 4.3 where we used this model with jumps it follows that the RMSE for the ROA is 0.345 and 5.8531 for the ROE and the

Root Mean Squared Error (RMSE)	$\sqrt{\sum_{t=T+1}^{T+h} \frac{(\hat{Y}_t - Y_t)^2}{h}}$
Mean Absolute Error (MAE)	$\sum_{t=T+1}^{T+h} \frac{ \hat{Y}_t - Y_t }{h}$
Mean Absolute Percentage Error (MAPE)	$100 * \sum_{t=T+1}^{T+h} \frac{ \hat{Y}_t - Y_t }{Y_t} / h$
Theil Inequality Coefficient (TIC)	$\frac{RMSE}{\sqrt{\sum_{t=T+1}^{T+h} \frac{Y_t^2}{h} + \sum_{t=T+1}^{T+h} \frac{Y_t^2}{h}}}$

Table 4.2: Source [115], Chapter 12

Model	RMSE	MAE	MAPE (%)	TIC
Black-Scholes (ROA)	0.4428	0.347	26.8548	0.1561
Black-Scholes (ROE)	7.1675	6.3471	42.3682	0.1751
Merton (ROA)	0.345	0.2767	22.84	0.119
Merton (ROE)	5.8531	4.9295	27.3325	0.176

Table 4.3: Forecast error statistics

MAPE for the ROA is 22.84 % and 27.33 % for the ROE.

Note that the MAPE (%) decreases from 26.85 % to 22.84 % and the RMSE value decreases from 0.44 to 0.345 for the ROA. Furthermore, in the ROE case the MAPE (%) decreases from 42.37 % to 27.33 % and the RMSE value decreases from 7.1675 to 5.8531. We therefore conclude that in the ROA case and even more for the ROE case Merton's model outperform the forecasting capability of the Black-Scholes model. However, we still observe a significant difference from the data values. Note that calibrations to other data sets can favor the Black-Scholes model more.

4.2 CONVERGENCE OF THE MCAM AND IMPACT OF VARYING THE MODEL PARAMETERS

In this section we present the numerical results for optimization with power utility. This technique was discussed in [106] and as it was mentioned in that paper, there is no closed form solution for the value function and the optimal controls. In the sequel we obtain an

analytical solution for the choices of power utility function. In this regard we align our optimization procedure with the methodology suggested in such contributions as [24]

We would like to restrict our attention to the stationary problem in which the model parameters: the rate of inclination towards bankruptcy η , the loss frequency ϕ^i , the credit risk compensation term θ^i and the exogenous income μ^a are all constant. In this case the HJB equation is an ODE. We employ MCAM of [85] (see also [86] and [55]) to numerically approximate the value function and controls. The MCAM is described in Appendix A.

The following equation gives the HJB

$$\left\{ \begin{aligned} & \delta^i V^i(\pi^i, t) = D_t V^i(\pi^i, t) + \max_{\Lambda^i} \left[(r^{\Lambda^i} - c^{\Lambda^i} - r^{\Lambda^i}) \Lambda D_{\pi^i} V^i(\pi^i, t) + \frac{1}{2} \sigma^{2i} \Lambda^{2i} D_{\pi^i \pi^i} V^i(\pi^i, t) \right] \\ & + \max_{k^{\Pi^i}} \left[U^{(1)}(k^{\Pi^i}) - k^{\Pi^i} D_{\pi^i} V^i(\pi^i, t) \right] + \left(r^{\Lambda^i} \pi^i + \mu^{ai}(t) \right) D_{\pi^i} V^i(\pi^i, t) \\ & + \max_{P^i} \left[\phi^i(t) \left\{ \mathbf{E} V^i \left(\pi^i - (S^i - P^i(S^i)), t \right) - V^i(\pi^i, t) \right\} \right. \\ & \left. - \left(1 + \theta^i(t) \right) \phi^i(t) \mathbf{E}[P^i(S^i)] D_{\pi^i} V^i(\pi^i, t) \right] + \eta_h^i(t) \left[U^{(2)}(\Pi^i) - V^i(\pi^i, t) \right] \\ & \lim_{s \rightarrow \infty} \mathbf{E} \left[\exp \left\{ - \int_t^s (\delta^i + \eta_h^i(u)) du \right\} V^i(\Pi_s^{i*}, s) | \Pi_t^{i*} = \pi^i \right] = 0, \end{aligned} \right. \quad (4.1)$$

4.2.1 Example: Optimization with Power Utility

In this example, we consider a bank which suffer a severe loan loss $\beta^i \in (0, 1]$, affecting its profit and which seeks to maximize its expected utility of consumption and terminal profit over its lifetime. We assume that its utility of consumption and profit are given by

$$U^{(1)}(k^{\Pi^i}) = \frac{k^{\alpha i}}{\alpha^i} \quad \text{and} \quad U^{(2)}(\Pi^i) = b \frac{\Pi^{\alpha i}}{\alpha^i},$$

respectively. We consider the stationary case i.e. $\mu^{ai} = 0$. In this case, one can verify that the function

$$V^i(\pi^i) = a \frac{\pi^{\alpha i}}{\alpha^i} \quad (4.2)$$

solves (4.1) where a solves

$$a \left[r^{\Lambda i} \alpha^i - \delta^i + \frac{(r^{\Lambda i} - c^{\Lambda i} - r^{\Lambda i})^2}{2\sigma^{2i}} \frac{\alpha^i}{1 - \alpha^i} + \phi^i A^i - \eta^i \right] + (1 - \alpha^i)^{\frac{\alpha^i}{\alpha^i - 1}} + \eta^i b = 0 \quad (4.3)$$

and

$$A^i = \max \left\{ 1 - \beta^i, (1 + \theta^i)^{\frac{1}{\alpha^i - 1}} \right\}^{\alpha^i} - 1 - (1 + \theta^i) \alpha^i \left(\beta^i - \left[1 - (1 + \theta^i)^{\frac{1}{\alpha^i - 1}} \right] \right) \quad (4.4)$$

Moreover, the optimal controls are given by

$$\Lambda_t^{i*} = \frac{(r^{\Lambda i} - c^{\Lambda i} - r^{\Lambda i})}{\sigma^{2i}(1 - \alpha^i)} \Pi_t^{i*}, \quad (4.5)$$

$$k_t^{\Pi i*} = a^{\frac{1}{\alpha^i - 1}} \Pi_t^{i*} \quad (4.6)$$

and

$$c_t^{Pi*} = \min \left\{ \beta^i, 1 - (1 + \theta^i)^{\frac{1}{\alpha^i - 1}} \right\} \Pi_t^{i*}. \quad (4.7)$$

In the experiments that follow, we demonstrate the convergence of the MCAM to the solution given above and we examine the impact of varying the model parameters.

We fix as our base scenario the following choice of parameters:

Credit Risk Compensatory Term	θ^i	0.25
Loan Loss Frequency	ϕ^i	0.10
Aggregate Risk-Free Assets Rate	r^{Λ}	0.06
Loan Rate	$r^{\Lambda i}$	0.14
Marginal Cost	$c^{\Lambda i}$	0.06
Loan Supply Volatility	σ^i	0.28
Rate of Inclination Towards Bankruptcy	η^i	0.05
Discounted Rate of k_t, π_t	δ^i	0.05
Propensity to Save	b	1.00
Loan Loss Severity	β^i	0.50
Utility Parameter	α^i	0.50

Table 4.4: Parameters for the Base Scenario

We choose the parameter values, and α^i in particular, to ensure convergence of the numerical method; see [55]. Observe that by (4.7)

$$\begin{aligned}
c_t^{Pi*} &= \min \left\{ \beta^i, 1 - (1 + \theta^i)^{\frac{1}{\alpha^i - 1}} \right\} \Pi_t^{i*} \\
&= \min \{0.50, 0.36\} \Pi_t^{i*} \\
&= 0.36 \Pi_t^{i*}
\end{aligned} \tag{4.8}$$

thus, the optimal strategy to make provision against a loss of 50% of the bank's profit is 36% partial provision.

$V(\pi)$	Λ^{i*}	$k^{\Pi i*}$	c^{Pi*}	Π^i
0	0	0	0	0
57.17	4	0.76	9	25
80.86	8	1.53	18	50
99.03	12	2.29	27	75
114.35	16	3.06	36	100
127.84	20	3.82	45	125
140.05	24	4.59	54	150
151.27	28	5.35	63	175
161.71	32	6.12	72	200
171.52	36	6.88	81	225
180.80	40	7.65	90	250
189.62	44	8.41	99	275
198.05	48	9.18	108	300

Table 4.5: Value Function and the Optimal Controls

4.2.1.1 Convergence of the MCAM

Figure 4.3 shows the approximate and actual value function and optimal controls for $\pi^i \in [0, 300]$. We note that the error at the right hand boundary is caused by the fact that the transition probability there prohibits the profit from exceeding 300. In effect, we are truncating the domain on which the HJB equation is defined and imposing an artificial boundary at $\pi^i = 300$; see Appendix A for details. However, the convergence is excellent away from the boundary; for that reason, in the experiments that follow, we approximate the value function and optimal controls on the $[0, 300]$, but restrict our attention to the $[0, 100]$. We used a mesh size of $d\pi^i = 0.10$.

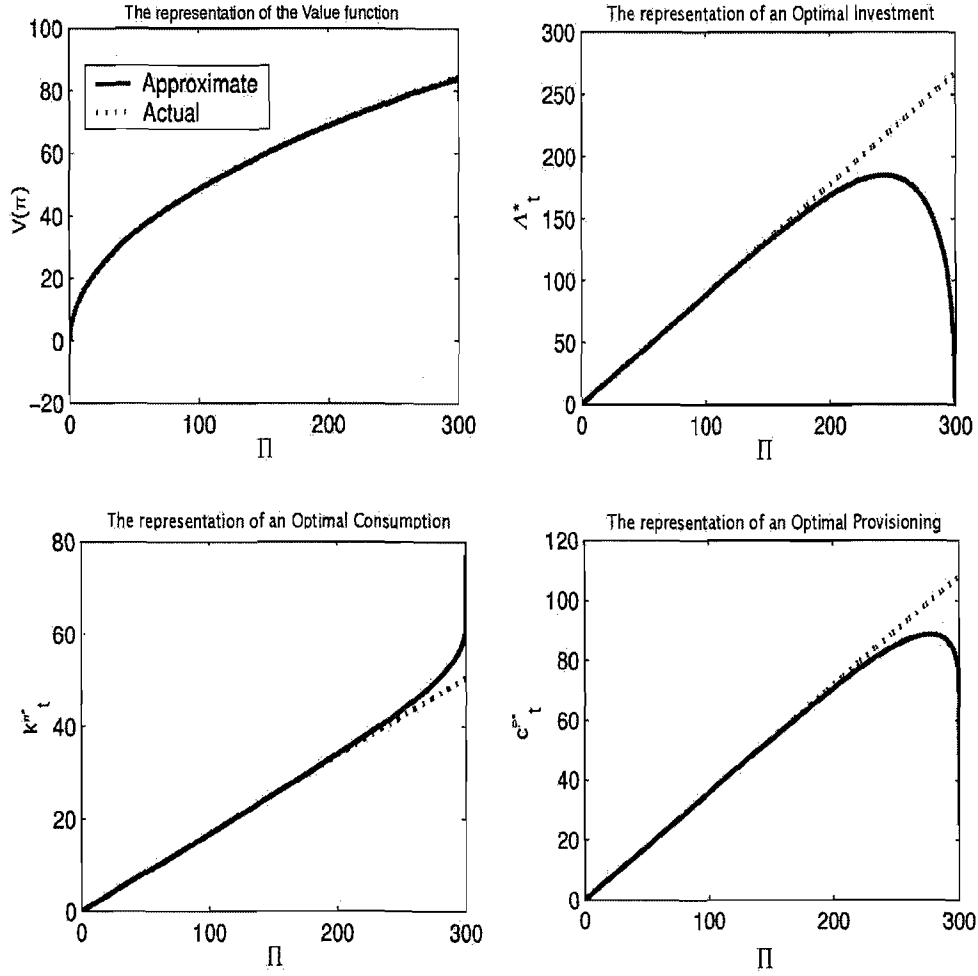


Figure 4.3: Approximate and Actual Value Function and Optimal Controls for $\pi \in [0, 300]$

4.2.2 Impact of Varying the Model Parameters

In various numerical experiments, we examined the impact of the individual model parameters α^i , θ^i , β^i , ϕ^i , η^i , σ^i , and b from the base scenario describe above. In each case, we verify the convergence of the approximate value function and optimal controls to the actual solution as in the first set of graphs.

4.2.2.1 Impact of Varying the Loan Loss Severity β^i in the i -th Loan Support-portfolio

From (4.8), we see that if $\beta^i > 0.36$, partial provisions for loan losses at 36% is optimal. However, if $\beta^i < 0.36$, no provisions for loan losses is optimal, i.e. $c_t^{P^i*} = \beta^i \Pi_t^{i*}$.

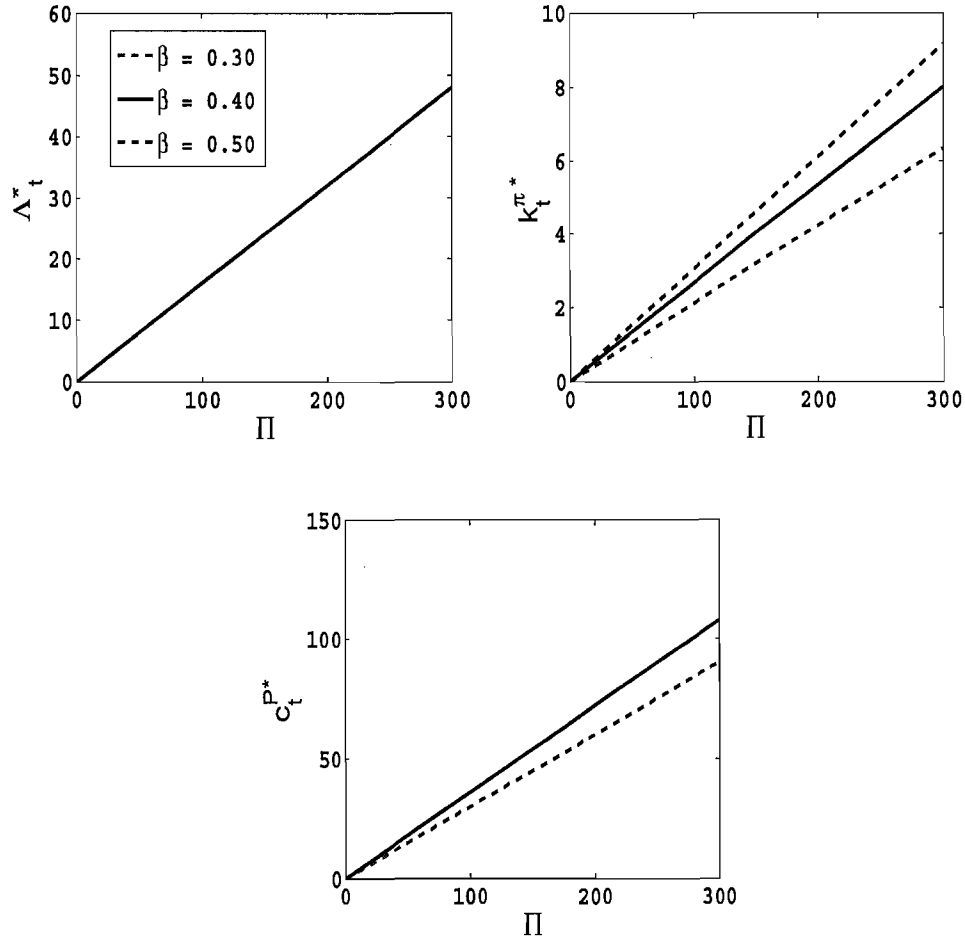


Figure 4.4: Impact of Changing the Loan Severity β^i

4.2.2.2 Impact of Varying the Loan Loss Frequency ϕ^i in the i -th Loan Sub-portfolio

From (4.8), we see that optimal provisioning is independent of the Poisson parameter ϕ^i ; the graph in the figure (4.5) confirms this. The graph in the figure (4.5) shows that if the loss frequency increases, the bank should consume more. However, if $\beta^i < 0.36$, no provisions for loan losses is optimal, i.e. $c_t^{P^i*} = \beta^i \Pi_t^*$.

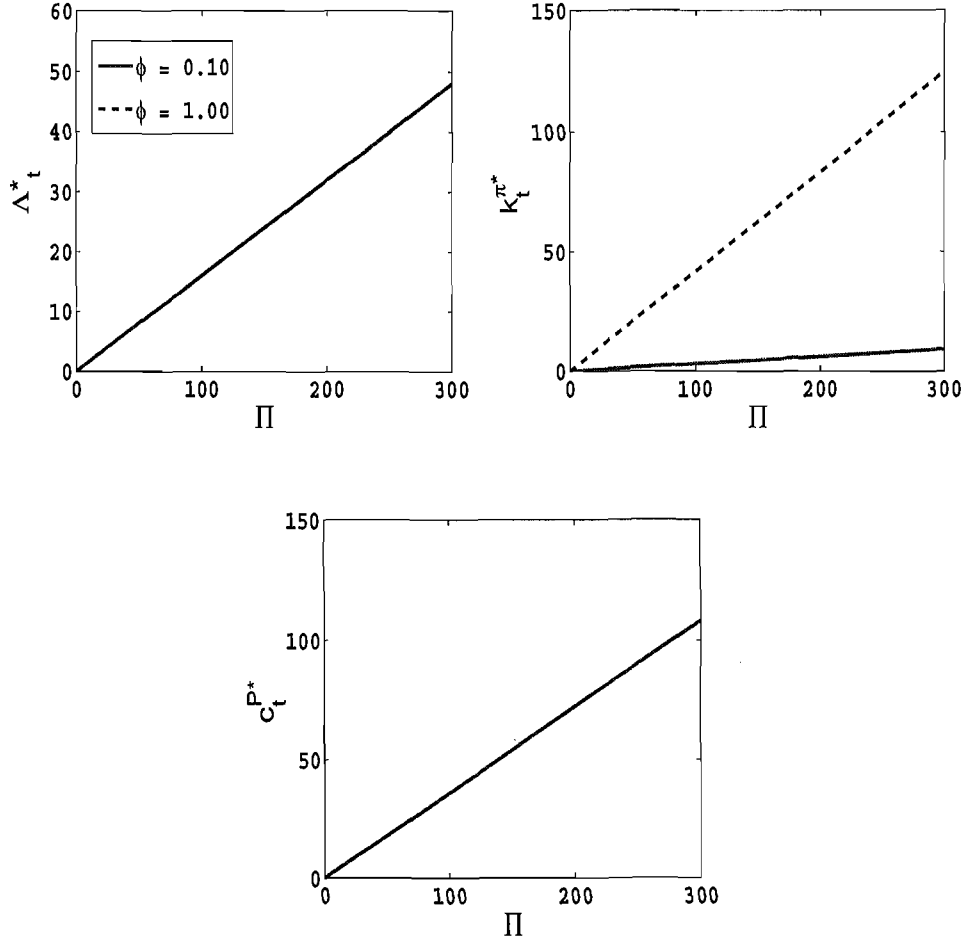


Figure 4.5: Impact of Changing the Loan Loss Frequency ϕ^i

Remark 4.2.1 (Convergence of the MCAM and Impact of Varying the Model Parameters): In figure 4.3, we present the simulations of the approximate and actual value function and optimal controls for $\pi^i \in [0, 300]$. We observe that the error at the right hand boundary is caused by the fact that the transition probability there prohibits the profit from exceeding 300. In effect, we are truncating the domain on which the HJB equation is defined and imposing an artificial boundary at $\pi^i = 300$.

Figures 4.4 and 4.5 present simulations of the impact of varying the model parameters. In figure 4.4 we see that the varying of the loan loss severity β^i does not affect the optimal investment in loans. This is so because the optimal investment in loan is independent of loan loss severity, see equation 4.5. Optimal profit consumption varies as the loan loss severity varies, for small loan loss severity the optimal profit consumption is seen to be low

and high for larger loan loss severity. From the same figure we see that the bank tends to make large provisions for large loan loss severity.

In figure 4.5, we see once again that there is no impact on the optimal investment in loans and optimal cost of provisioning when the loan loss frequency varies, this is the case because both the optimal controls are independent of the loan loss frequency see equations 4.5 and 4.7, respectively. However, there is a notable impact on the optimal consumption as the loan loss frequency changes.

Chapter 5

OUR BANKING MODELS AND THEIR CONNECTIONS WITH BASEL II AND THE SUBPRIME MORTGAGE CRISIS

5.1 OUR BANKING MODELS AND THEIR CONNECTIONS WITH BASEL II

5.1.1 Bank Regulation Capital

5.1.2 Procyclicality of Basel II Regulation

5.1.3 Illustration of Bank Management Practice in a Basel II Paradigm

5.1.3.1 Setting the Scene

5.1.3.2 Pillar 1 - Minimum Capital Requirement

5.1.3.3 Pillar 2 - Supervisory Review

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5.2 OUR BANKING MODELS AND THEIR CONNECTIONS WITH THE SUBPRIME MORTGAGE CRISIS

5.2.1 Connection with the Subprime Mortgage Crisis

5.3 CONNECTIONS BETWEEN BASEL II AND THE SUBPRIME MORTGAGE CRISIS

Chapter 5 draws its content from the models derived in chapter 2, the Basel II capital accord and the current subprime mortgage crisis. This chapter aims to fully illustrate the relevance of the research carried out since 2006, which resulted in 3 peer-reviewed journal articles (see [105], [106] and [107]) and 1 peer-reviewed conference proceedings paper (see [104]), as part of future research directions we have already embarked on preparing a paper (see [108]) which is due for submission to an accredited journal. This paper draws immensely from this thesis.

5.1 OUR BANKING MODELS AND THEIR CONNECTIONS WITH BASEL II

In this section, we consider connections between the bank valuation model and the Basel II Capital Accord, we analyze the connections between our banking model and the Basel II capital accord. These relationships are forged via the

- description of total bank capital given by (2.22) in Subsection 2.3.1;
- description of the bank capital constraint given by (2.23) and (2.24) in Subsection 2.3.2;
- procyclicality described in Subsection 2.3.2.

5.1.1 Bank Regulatory Capital

Despite the analysis in subsection 2.3.1 of section 2.3, bank capital is notoriously difficult to define, monitor and measure. For instance, the measurement of equity depends on how all of a bank's financial instruments and other assets are valued. The description of the shareholder equity component of bank capital, E , given by ((2.22), description of total bank capital), is largely motivated by the following two observations. Firstly, it is meant to reflect the nature of the book value of equity. Our intention is also to recognize that the book and market value of equity is highly correlated.

Under Basel II, bank capital requirements have replaced reserve requirements (see subsection 2.1.1) as the main constraint on the behavior of banks (see, for instance, [28]). A first motivation for this is that bank capital has a major role to play in overcoming the moral hazard problem arising from asymmetric information between banks, creditors and debtors. Also, bank regulators require capital to be held to protect themselves against the costs of financial distress, agency problems and the reduction of market discipline caused by the safety net. Subsection 2.3.2 suggests that a close relationship exists between bank capital holding and macroeconomic activity in the loan market (see equation (2.24) describing the bank capital constraint).

5.1.2 Procyclicality of Basel II Regulation

Chapter 2 discussed the procyclicality induced by the Basel II capital accord's approach to credit risk in subsection 2.3.2. In this regard, the standardized approach to credit risk differentiates assets not only according to the borrower but according to riskiness proxied by credit rating agencies' assessment of the borrower. This approach represents an improvement in the sense that corporations are rated. However, it is deficient with respect to the viewpoint that ratings properly reflect risk and the inducing of procyclical capital charges which will lead to overlending during booms and underlending during recessions. Also, the capital formula for the IRB approach to credit risk is problematic. In short, the IRB capital formula is deduced by considering the large-portfolio asymptotic dynamics of a Merton model with a single common risk-factor. Many empirical studies have confirmed that this formula gives rise to procyclicality.

In addition, Basel II dictates that a macroeconomic shock will affect the loan risk weights in the CAR. In general, a negative (positive) shock results in the tightening (loosening) of the capital constraint (see equation (2.24) describing the bank capital constraint). As a consequence, in terms of a possible binding capital constraint, banks are free to increase (decrease) the loan supply when macroeconomic conditions M_t improve (deteriorate). On the other hand, if the risk weights are constant, a shock does not affect the loan supply but rather results in a change in the loan rate when the capital constraint binds. It is not always true that Basel II risk-sensitive weights lead to an increase (decrease) in bank capital when macroeconomic activity in the loan market increases (decreases). A simple explanation for this is that macroeconomic conditions do not necessarily only affect loan demand but also influence the total capital constraint (see equation (2.24) describing the bank capital constraint). Furthermore, banks do not necessarily need to raise new capital to expand their loan supply, since a positive macroeconomic shock may result in a decrease in the RWAs with a commensurate increase in CARs (compare the minimum capital constraint as expressed in (2.23) and (2.24)). Similarly, banks are not compelled to decrease their capital when the loan demand decreases since the capital constraint usually tightens in response to a negative macroeconomic shock. A further complication is that an improvement in the latter conditions may result in an increase in the loan demand and, as a consequence, an increase in the probability that the capital constraint may be binding (see equations (2.1) and (2.24) for the loan demand and bank capital constraint, respectively). Banks may react to this situation by increasing capital to maximize profits (compare the definition of ROE indicator of profitability). Our main conclusion is that bank capital is procyclical because it is dependent on fluctuations in loan demand which, in turn, is reliant on macroeconomic activity (see equation (2.24) describing the bank capital constraint).

5.1.3 Illustration of Bank Management Practice in a Basel II Paradigm

In this section, we provide an illustration of some of the features of bank management practice referred to in the above. Our analysis has several connections with the arguments about risk management and regulatory policy in [41] and [123] (see also [46], [48] and [94]). Firstly, we illustrate issues related to credit risk by considering the probability of default of granted loans, this is demonstrated by the current credit crunch in the U.S., a point we look at. The second feature of our example involves the implications of and the interactions between the three pillars of Basel II regulation for bank management that includes a consideration of a regulatory capital constraint. In this regard, we highlight the dynamic interaction between a regulator (who acts in the interest of the public) and bank owner (who, by assumption, acts in the interest of the shareholder). Here, we emphasize that information provided by the bank manager about the level of bank capital, K^i , is important for the decision by the supervisor on whether to allow the bank to continue to function or enforce bank closure. Finally, throughout the example, risk incentives, risk shifting and other constraints on banking behavior are referred to. With regard to the latter, realistic constraints associated with the eliciting of additional debt and equity, profitability, incentive compatibility and financing are brought to bear on bank management practice.

5.1.3.1 Setting the Scene

Throughout the ensuing illustration, the bank capital, K^i , will consist solely of equity capital and subordinate debt. Also, the bank assets are constituted by loans to private agents and intangible assets, $\Lambda_t^i + I_t^i$. Furthermore, we follow a procedure that can be identified with the three-pillared approach of the Basel II capital accord (see, for instance, [41]). Pillar 1 (minimum capital requirement) involves the application of a quantitative minimum capital requirement based on public information that determines whether a bank will continue to operate or not. This pillar is related to the likely prompt corrective action that will be taken by supervisors in the event of banks becoming significantly or critically undercapitalized. In this regard, Table 5.1 below makes a distinction between the capitalization states of banks with respect to several benchmark regulatory ratios.

In Table 5.1, we have that TCAR, T1CAR and TE are the abbreviations for the total CAR (also known as the leverage ratio), Tier 1 CAR and tangible equity, respectively. Here the TCAR and T1CAR is the regulatory capital-to-total assets ratio and T1 capital-to-total assets ratio, respectively. As is the case for the TCAR and T1CAR, the CAR, ρ , in the first column of Table 5.1 gives an indication (in terms of the level of capitalization of the bank) of significant values for the benchmark CAR. In Pillar 2 (supervisory review), the bank decides on whether the bank capital held is sufficient to invest in a certain credit risk-type or whether it is necessary to elicit capital by issuing debt and raising equity. At this stage, we distinguish between failed, capital-constrained and capital-unconstrained banks. Pillar 3 (market discipline) offers the supervisor another opportunity to terminate banking

CATEGORIES	ρ		T1CAR		TCAR		TE
Well-Capitalized	$\geq 0,1$	and	$\geq 0,06$	and	$\geq 0,06$		–
Adequately Capitalized	$\geq 0,08$	and	$\geq 0,04$	and	$\geq 0,04$		–
Undercapitalized	$\geq 0,06$	and	$\geq 0,03$	and	$\geq 0,03$		–
Significantly Undercapitalized	$< 0,06$	or	$\geq 0,03$	or	$\geq 0,03$	and	$> 0,02$
Critically Undercapitalized							$\leq 0,02$

Table 5.1: Categories of Banking Benchmark Regulatory Ratios

operations based on disclosure about the posterior probability of failure of the bank (see [48] for more details).

5.1.3.2 Pillar 1 - Minimum Capital Requirement

Most banks consider the level of capital to be the binding constraint in deciding on whether to issue a loan or not. In order for a loan to be granted, the risk adjusted rate of return on a particular loan must exceed the return on capital. In the sequel, suppose that $A_t^i = \omega^{\Lambda^i} \Lambda_t + \omega^{I^i} I_t^i$, and also $\omega^{\Lambda^i} = \omega^{I^i} = 1$. Therefore, $A_t^i = \Lambda_t^i + I_t^i$. The Basel II capital accord contains the total capital constraint that, in our case, relates the CRC, A^r , to capital, K^i , via the inequality

$$K^i(t) \geq \rho\{\Lambda_t^i + I_t^i\} \text{ or, equivalently, } \kappa(t) \geq \rho, \quad (5.1)$$

where ρ denotes a CAR regulatory benchmark. The setting of a regulatory benchmark is an attempt to encourage banks to hold a RC-to-CRC ratio, ρ , of at least 8 % (see, for instance, [10], [14] and [45]). Several approaches to the management of bank closure and its relationship with the minimum capital requirement (Pillar 1) described in Basel II exist. In the event of closure, the loans to private agents and intangible assets, $\Lambda_t^i + I_t^i$, are liquidated at a cost of $\Lambda^i\{\Lambda_t^i + I_t^i\}$, where Λ^i is determined exogenously. The implementation of Pillar 1 via the liquidation cost approach will mainly be impacted by the level of bank capital and the CAR. In this regard, the supervisor has to decide whether capital, K^i , as described by (2.24), covers the cost of liquidation, $\Lambda^i\{\Lambda_t^i + I_t^i\}$. If we have, for $t \in [0, t_1)$, that

$$K^i(t) \geq \Lambda^i\{\Lambda_t^i + I_t^i\} \text{ or, equivalently, } \kappa(t) = \frac{K^i(t)}{\Lambda_t^i + I_t^i} \geq \Lambda^i, \quad (5.2)$$

then the bank exceeds the minimum capital requirement and is able to continue operating. If condition (5.2) fails, closure may occur since it is unlikely that the bank will be able to re-capitalize itself.

5.1.3.3 Pillar 2 - Supervisory Review

In this subsection, we consider the interaction between the capital adequacy management of a bank with respect to its fundamental function of granting loans and supervisory constraints on, for instance, eliciting debt and equity (see [48] for more details). Having exceeded a minimum regulatory capital requirement in the first stage, under supervisory constraint, the bank may now acquire a new credit risk type, $\Lambda_t^{1i} + I_t^{1i}$. The return on $\Lambda_t^{1i} + I_t^{1i}$ is reliant on whether the profit, Π^i , is either

$$\Pi^i(t) = \Pi_p^i(t) \geq 0 \text{ or } \Pi^i(t) = \Pi_n^i(t) < 0. \quad (5.3)$$

The social value of acquisition $\Lambda_t^{1i} + I_t^{1i}$ is $(1 - \psi^i)\Pi_p^i(t) - \psi^i\Pi_n^i(t)$, where ψ^i is the anterior probability of bank failure. In this regard, Π_p^i and Π_n^i from (5.3) correspond to the favored (low ψ^i) and the unfavored (high ψ^i) bank operational states, respectively. Here we suppose that the bank has no direct costs associated with failure (see [122] for more details). Next, the bank assesses whether its level of capital is high enough to invest in $\Lambda_t^{1i} + I_t^{1i}$ by determining whether the $\Lambda_t^{1i} + I_t^{1i}$ -capital constraint

$$\kappa(t) = \frac{K^i(t)}{\Lambda_t^{1i} + I_t^{1i}} \geq 1 \quad (5.4)$$

is satisfied (compare (5.4) to the total capital constraint (5.1) described above). If inequality (5.4) holds, there is no need to elicit additional debt or equity. If, on the other hand, we have

$$\frac{\Lambda^i\{\Lambda_t^i + I_t^i\}}{\Lambda_t^{1i} + I_t^{1i}} \leq K^i(t) < 1$$

the bank has to acquire additional financing from, for instance, debt- and shareholders. In this regard, the market may impose certain restrictions on the amount of debt and equity that the bank can raise. This eliciting constraint is intended to discourage the bank from investing in riskier assets which have a higher default probability (see, for instance, [73]). For sake of argument, we suppose that $\Lambda_t^{1i} + I_t^{1i}$ is replaced by another credit-risk type, $\tilde{\Lambda}_t^{1i} + \tilde{I}_t^{1i}$, with a higher return $\tilde{\Pi}_p^i(t) > \Pi_p^i(t)$ and a higher probability of failure $\tilde{\psi}^i > \psi^i$. Let K^{i*} be the additional debt and equity elicited with G being defined by

$$\text{Gross Return to Share- and Debt-holders} = \begin{cases} G, & \text{in favored operational state;} \\ 0, & \text{otherwise.} \end{cases}$$

Next, we introduce two constraints that are commensurate with prudent bank management practice. In order to make $\tilde{\Lambda}_t^{1i} + \tilde{I}_t^{1i}$ less attractive in the absence of elicited debt and equity, we require that the returns on $\Lambda_t^{1i} + I_t^{1i}$ and $\tilde{\Lambda}_t^{1i} + \tilde{I}_t^{1i}$ satisfy the profitability constraint given by

$$(1 - \psi^i)\Pi_p^i(t) \geq (1 - \tilde{\psi}^i)\tilde{\Pi}_p^i(t).$$

On the other hand, to discourage the shifting of risk in the presence of debt and equity, $G > 0$ must satisfy the incentive compatibility constraint expressed as

$$0 < G(t) \leq \Pi_p^i(t) - \frac{1 - \tilde{\psi}^i}{\tilde{\psi}^i - \psi^i} \left[\tilde{\Pi}_p^i(t) - \Pi_p^i(t) \right]. \quad (5.5)$$

The aforementioned debt and equity satisfy individual rationality if, at equilibrium, it guarantees an outcome such that the profit for the debt- and shareholders exceeds a certain level. This concept is useful when the debt- and shareholders have the option to terminate their involvement. In our case, such rationality leads to

$$(1 - \psi^i)G(t) \geq \chi^i K^{i*}(t), \quad (5.6)$$

where the market requirement $\chi^i > 1$ is the gross return on capital. Inequalities (5.5) and (5.6) together suggest that the maximum additional amount of debt and equity, $\tilde{K}^{i*}$, the bank may raise, may be expressed as

$$K^{i*}(t) \leq \frac{1 - \psi^i}{\chi^i} \left[\Pi_p^i(t) - \frac{1 - \tilde{\psi}^i}{\tilde{\psi}^i - \psi^i} \left\{ \tilde{\Pi}_p^i(t) - \Pi_p^i(t) \right\} \right] := \tilde{K}^{i*}(t).$$

In essence, stage 2 distinguishes between failed, capital-constrained and capital-unconstrained bank types whose classification depends on how their level of capital compares with regulatory benchmarks. We are in a position to look at all these types, i.e. bank failure as demonstrated by the Lehman Brothers Holdings. The second type we look at is capital-constrained bank as demonstrated by Merrill Lynch

Failed Bank

A bank for whom the capital adequacy ratio, κ , induced by $\Lambda_t^{1i} + I_t^{1i}$, is subject to the condition

$$K^i(t) < 1 - \frac{\tilde{K}^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}}$$

cannot raise enough debt and equity to invest in $\Lambda_t^{1i} + I_t^{1i}$ and fails. If this happens, bank managers receive the market value of $K^i(t) - \Lambda^i\{\Lambda_t^i + I_t^i\}$ which is positive because the bank exceeded the minimum capital requirement from the first pillar. The supervisor has to cover certain costs when a bank fails. For instance, if upon failure, the resulting operational state is favorable, the opportunity costs of total profits that have been lost in the liquidation process is charged to the supervisor but credit is given for the net social value at closure

$$\{\Lambda_t^{1i} + I_t^{1i}\} - \Lambda^i\{\Lambda_t^i + I_t^i\}. \quad (5.7)$$

The supervisor may also incur a deadweight loss, l_{dw} , where, for instance, external income with positive returns are foregone when a favored bank is closed or legal disputes arise from a bank that was deemed to be viable after closure.

Capital-Constrained Bank

The bank that has insufficient capital, κ , to invest in $\Lambda_t^{1i} + I_t^{1i}$, may face a financing constraint,

$$1 > K^i(t) \geq 1 - \frac{K^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}},$$

and may be subject to an implicit capital requirement from the market of the form

$$K^i(t) \geq 1 - \frac{K^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}} \geq 1 - \frac{\tilde{K}^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}}.$$

Such a bank satisfies the minimum market capital requirement, but is capital-constrained and must issue debt and raise equity to invest in $\Lambda_t^{1i} + I_t^{1i}$ in loans. If the constrained bank is allowed to operate and it fails, the supervisor must deal with both the operating loss, $\mathcal{O}^l$, (which the bank's owners do not bear because of assumed limited liability) and the cost of liquidation, $\Lambda^i\{\Lambda_t^i + I_t^i\}$. Compared with (5.7), if the bank fails it follows that the net social

value at closure is given by

$$K^i(t) + K^{i*}(t) - \Lambda^i\{\Lambda_t^i + I_t^i\}$$

and the loss is $-\mathcal{D}^l - \{\Lambda_t^{1i} + I_t^{1i}\}$. In the constrained case, the total social investment, including debt and equity is $\Lambda_t^{1i} + I_t^{1i}$.

Capital-Unconstrained Bank

Finally, a bank with a $\Lambda_t^{1i} + I_t^{1i}$ -induced CAR, κ , that satisfies

$$K^i(t) \geq 1 \tag{5.8}$$

is unconstrained and may invest in $\Lambda_t^{1i} + I_t^{1i}$ without raising additional debt and equity. In that case, the excess bank capital

$$K^i(t) - \{\Lambda_t^{1i} + I_t^{1i}\} \tag{5.9}$$

may be invested in a riskless asset (such as ARFA) that provides a zero net return. If the bank is unconstrained, the aggregate social value is always more than the constrained case by the amount of excess capital given by (5.9). However, if the unconstrained bank invests any excess capital in a riskless asset with zero net return then all consequences are exactly larger by (5.9).

5.1.3.4 Pillar 3 - Market Discipline

Pillar 3 aims to strengthen market discipline by insisting on enhanced disclosure by banks. The disclosure requirements will enable market role players to access information about the bank's capital adequacy and risk exposures. If the bank successfully complies with the conditions above, in the third stage the bank acquires information that is relevant to its continued operational management. This information informs the ultimate regulatory decision on whether to take corrective action or enforce bank closure (see [48] for more details). The newly acquired information may be in the form of a signal

$$I^{i*} = \begin{cases} Y, \\ N. \end{cases} \tag{5.10}$$

This signal depends on the observed value of I^{i*} and results in a posterior probability of bank failure that may be expressed as $p^{ii} = P(\text{failure}|I^{i*} = i)$, $i = Y$ or N . Depending on its incentives, the bank discloses the correct or incorrect value of I^{i*} to the supervisor. Since by definition

$$\psi^i = p_Y P(I^{i*} = Y) + p_N P(I^{i*} = N)$$

we have that $p_Y \leq \psi^i \leq p_N$. Our illustrative example of bank management practice is concluded by briefly mentioning the role that the information signal, I^{i*} , in (5.10), can play in the interaction between the supervisor and bank manager. Before a decision about corrective action or bank closure is made, the supervisor requests the value of I^{i*} from the bank manager. If the supervisor's decision rule is incentive-compatible it must not impose a penalty on the disclosure of the authentic value of I^{i*} .

5.2 OUR BANKING MODELS AND THEIR CONNECTIONS WITH THE SUBPRIME MORTGAGE CRISIS

The SMC is an ongoing financial crisis characterized by contracted liquidity in global credit markets and banking systems. A downturn in the U.S. housing market, risky practices by lenders and borrowers and excessive individual and corporate debt levels have affected the world economy adversely on a number of levels. The SMC, which originated in the last few years of the 20th century but has become more apparent throughout 2007 and 2008, has passed through various stages. During these stages pervasive weaknesses in the global financial system and regulatory framework has been exposed. The connections between this crisis and our banking models are mainly forged via the bank's

- risk premium from (2.3) in Subsubsection 2.1.2.2 (see HM1 and HM2 in Figure 1.3);
- required capital sensitivity to changes in the amount of loans extended as given by (2.4) in Subsubsection 2.1.2.2 (see FM2 in Figure 1.3);
- prime loan rate from (2.5) in Subsubsection 2.1.2.2;
- loan demand represented by ζ^i and supply $\mathfrak{T}^i$ in Subsection 2.1.2;
- loan losses and default rate given by (2.11) in Subsubsection 2.1.2.3;
- loan loss provisions from (2.12) in Subsubsection 2.1.2.3;
- liquidity as described by Remark 2.2.1 (see FM4 in Figure 1.3);
- profit given by (2.26) in Section 2.4.

5.2.1 Connections Between Our Models and the Subprime Mortgage Crisis

The connections between our banking models and the SMC are complicated. However, a first step towards understanding this relationship is that we are able to identify the problematic loan subportfolios. In this regard, it is possible to decompose the (total) loans, Λ , discussed above as

$$\Lambda = \sum_{i=1}^m \Lambda^i,$$

where m is the number of loan subportfolios with i being the index of each loan subportfolio so that $i = 1, 2, \dots, m$. We note that the Basel II IRB approach to credit risk (see [12]) dictates that $m \leq 15$. In particular, this approach identifies 15 credit risk exposure types (loan subportfolios) that are given by (1.8).

As a result of the SMC, market trade in almost all of these loan subportfolios became sluggish. In particular, a problematic loan subportfolio corresponds to $i = 4$ which encompasses income producing real estate. Furthermore, in commercial real estate (i.e., $i = 5$ and $i = 6$) there is a slowing due to the tightening credit and slowing growth, the former a direct result of the SMC. Although capital remains available for residential loans, the credit crunch is pronounced in commercial lending. Moreover, $i = 7$ which corresponds to interbank lending had been identified as a problematic subportfolio. This is because banks were not lending to each other during the early stages of the crisis (see FM4 in Figure 1.3).

The risk premium, ϱ^i , from (2.3) has had a part to play the SMC (see HM1 in Figure 1.3). This premium is part of the expression for the bank's loan rate, r^{Λ^i} , and its size is an indication of credit risk. A study by the U.S. Federal Reserve indicated that the average difference in mortgage interest rates between subprime and prime mortgages (the "subprime markup" or "risk premium") declined from 2.8 percentage points (280 basis points) in 2001, to 1.3 percentage points in 2007. In other words, the risk premium required by lenders to offer a subprime loan declined. This occurred even though subprime borrower and loan quality declined overall during the 2001-2006 period, which should have had the opposite effect. The combination is common to classic boom and recession credit cycles (see [44]).

The sensitivity of the required capital to changes in the amount of loans extended from (2.4) is an important issue in the SMC. Bank capital levels were depleted with banks experiencing high debt levels (see FM2 in Figure 1.3). As a consequence, for many banks (2.4) began to take on negative values.

Despite the discussion above, the most significant relationships between our results and the credit crisis are established via the bank's loan rate, r^{Λ^i} , given by (2.5) (see also HM1, HM3, FM4 and GIR1 in Figure 1.3). This loan rate may be expressed as

$$r_t^{\Lambda i} = \varrho^i + (1 + r_t) \frac{N}{\eta_e^i} + (1 + c^{rwi}) + c^{Ei} \frac{\partial K^i}{\partial \Lambda^i} + E(d^i).$$

In general terms, r^Λ can be written as a function of credit risk, market structure (power), cost of debt, cost of equity and the sensitivity of capital to loans extended. The representation of the bank's interest setting intimates that banks will experience positive returns in good times when the actual rate of default, r^{di} , is lower than the provisioning for expected losses, $\mathbf{E}(d^i)$, and may not be able to cover their expected losses when $r^{di} > \mathbf{E}(d^i)$ (see equation (2.11) for loan losses and default rate). In the latter case, bank capital may be needed to cover these excess (and unexpected) losses. If this capital is not enough then the bank will face insolvency.

A combination of factors resulting from the SMC have led to problems in the commercial real estate market as regards loan demand, ζ^i , (see also HM3, FM4, GIR1 and GIR5 in Figure 1.3). According to the National Association of Realtors (NAR) there is a slowing in commercial real estate due to the tightening credit and slowing growth, the former a direct result of the SMC. Although capital remains available for residential loans, the credit crunch is pronounced in commercial lending. Patricia Nooney, chairperson of the Realtors Commercial Alliance Committee (RCAC), portrayed the decline as unusual since

“transactions are being curtailed not for lack of demand, but for serious challenges in obtaining financing” (see [80] for more information).

Next, we discuss loan losses and default rate given by (2.11) in Subsubsection 2.1.2.3 (see HM4, FM1, FM3, GIR3 and GIR5 in Figure 1.3). An acceleration in loan growth, as was experienced prior to the SMC, eventually leads to a surge in loan losses (see, for instance, (2.11) for loan losses and default rate) resulting in reduced bank profits (see equation (2.26) for bank profit) and precipitating a new round of bank failures. As experience during the mortgage crisis has shown, such a slump in banking could not only threaten the deposit provisions for loan losses fund but also slow the economy by entrenching credit crunches. The view that faster loan growth leads to higher loan losses should not be taken lightly; nor should it be accepted without question. If loan growth increases because banks become more willing to lend, credit standards should fall and loan losses should eventually rise. For many distressed banks suffering because of the SMC, increased loan loss provisions from (2.12) and (2.13) translate to a decrease in earnings.

Contracted liquidity in the global credit markets and banking system (as described by Remark 2.2.1; see also FM4 in Figure 1.3) is an ongoing economic problem. These liquidity concerns drove central banks around the world to take action to provide funds to member banks to encourage lending to worthy borrowers and to restore faith in the commercial paper markets (see GIR1 in Figure 1.3).

As far as profitability given by (2.26) is concerned, during the SMC profits at the 8 533 U.S. banks insured by the FDIC fell from \$ 35.2 billion to \$ 646 million (89 %) during Quarter 4 of 2007 when compared with the previous year. This was largely due to soaring loan losses and provisions for loan losses. This fall in profits contributed to the worst bank and thrift quarterly performance since 1990. In 2007, these banks earned approximately \$ 100 billion, which represented a decline of 31 % from the record profit of \$ 145 billion in 2006. Profits decreased from \$ 35.6 billion to \$ 19.3 billion during the first quarter of 2008 versus the previous year, a decline of 46 % (see [49] and [50] for more detail). The contribution [23] considers the following strategy to be optimal for banks to shield their profits from loan losses. The loan loss reserves, R^l , is built up in every period that $P > S$. On the other hand, when $P = S$ the bank is allowed to draw on R^l from the current period and for $S > P$ it has to access $p^{KRi}K$, where $p^{KRi} \in [0, 1]$ is the proportion of the bank capital, K , including loan loss reserves used to deal with unexpected losses. For the latter scenario, at some point the bank will face insolvency.

5.3 CONNECTIONS BETWEEN BASEL II AND THE SUB-PRIME MORTGAGE CRISIS

The Basel II Capital Accord was devised as a one-size-fits-all capital adequacy standard for global financial institutions. However, critics are now asking if Basel II has backfired by allowing firms to lower capital requirements, leaving them in a crunch now that some investments have gone bad. At issue is whether the new rules allowed, for instance, some European firms where Basel II regulations had already begun to be rolled out to put less capital into loss reserves for highly-rated debt, including U.S. mortgage-backed securities, exacerbating a crunch that at first seemed contained in the United States.

Swiss-based UBS on Friday, 29 February 2008 estimated that the credit crisis that has been rocking markets, and adversely affecting M&A markets worldwide, is far from over, forecasting losses that could exceed \$ 600 billion globally. Abby Joseph Cohen, chief U.S. investment strategist at Goldman Sachs, speaking at a New York business conference on Thursday, 28 February 2008, said, based on anecdotal evidence, it appeared that the SMC had caused a higher degree of problems for non-U.S. financial firms. The write-downs that European financial institutions have had to take on bad U.S. mortgage debt was something that Cohen attributed to Basel II, as the regulations gave firms some freedom when it came to raising capital for top-rated securities. The problem according to Cohen was that

“The ratings were wrong.”

She added it was not yet clear how the crisis will play out.

“The final chapter has not been written,”

she said. In the meantime, Basel II's potential flaw is starting to get a lot of attention.

"Mortgage fallout exposes holes in new bank-risk rules"

read a page 1 story in the Wall Street Journal on Tuesday, 26 February 2008. An earlier Financial Times op-ed was titled

"Turmoil reveals the inadequacy of Basel II."

US Federal Reserve Vice-Chairman, Donald Kohn, stepped up to defend Basel II on Tuesday, 26 February 2008, calling the rules an

"important step forward to make capital requirements more risk sensitive."

But if critics of Basel II are on to something, Basel which is also home to UBS, the European bank hardest hit by the credit crisis could find itself with problems.

The number of shocks to the banking system in advanced economies recently such as the

1. nationalization of Northern Rock Bank in England;
2. losses by a rogue trader from SocGen;
3. reconstruction of two smaller German banks after over-exposure to the subprime crisis;
4. increase in short term interest rates as banks are increasingly reluctant to lend to each other in money markets;
5. the increase rates of interest on business and mortgage loans in excess of official central bank changes;
6. sale of Bear Sterns, a prominent New York investment bank and a leader in the subprime mortgage securitization, to JP Morgan Chase in a bargain basement sale officially supported by the US Federal Reserve.

All this collectively is indicative of a banking system which has misjudged risks, has mis-priced risk, has been unable to assess the creditworthiness of other banks. Is this just a case of banks having overextended themselves and made poor calls at critical points ? On the contrary, changes in international banking regulation brought about under the auspices of Basel II have allowed banks systematically to underestimate risk and loan loss provisions and to make inadequate provision of capital reserves to meet unexpected losses. Banks have been implicitly encouraged to place growth ambitions ahead of prudent management of their affairs. There are two changes under Basel II which deserve consideration.

1. The first is to allow banks to employ credit ratings to measure individual banks credit risk.
2. The second is to allow banks to use advanced statistical models to determine risk of default or failure in the event of external shocks.

Concerns about credit ratings are not new; they were previously raised during the Enron scandal of 2002 and the Asian Financial Crisis of 1997. But under the Basel II Capital Accord, banks have been allowed to use credit ratings to determine the risk attached to their loans and hence to calculate minimum capital requirements. An example of how this worked is outline below.

1. Banks sell mortgages off their balance sheet to a securitization vehicle which is rated AAA. Consequently, the bank needs to keep minimal capital reserves against this.
2. If the bank lends the securitization vehicle the funds to complete the purchase, the bank needs to make minimal, if any, provisions for capital reserves.
3. When the securitization loses its AAA rating the bank is then required to make substantial provisions for capital reserves up to 8 % of the loan. If the loan to the securitization vehicle is considered doubtful, then the bank must make explicit provisions for the expected loss.
4. Also banks have been allowed to carry out their own risk assessment of other parts of their operation by using sophisticated statistical techniques which aim to calculate the risk of loss in the event of some external shock e.g. a rise in market interest rates, a shock to financial markets or a recession in the economy. As one might expect, banks used assumptions which cast their assessed risks in the best possible light. The general effect has been to allow banks to come up with models showing they face a lower risk which means they have to hold smaller amounts of capital.
5. Banks like to hold less capital because it doesn't dilute control it increases leverage (able to use more borrowed funds) and hence profits when things are going well. However, when macroeconomic conditions deteriorate, as they are in 2008, banks have to overcompensate by holding higher than the minimum capital reserves. Since they are unable to raise new capital on the open market (think how an issue of shares would be regarded when the price of existing bank shares have taken a severe tumble), banks have to cut back on new loans and try to increase their profit margins, i.e., increase interest rates beyond the level that is prescribed.
6. The process is contagious. Banks become unwilling to transact with other bank because each suspects that the others have been up to the same tricks as they have so that balance sheets lose transparency. The interbank market comes to a halt and liquidity dries up especially as banks now need to hoard cash.

This analysis is not mere speculation. For instance, the US Presidents Working Group on Financial Markets on Tuesday, 11 March 2008, in a classic case of shutting the stable door after the horse has bolted, has made extensive recommendations for the reform of the credit rating industry, the use of statistical risk models and has called for parts of the Basel II Capital Accord to be sent back to the Bank for International Settlements (BIS) for another look.

Chapter 6

CONCLUSIONS AND FUTURE DIRECTIONS

6.1 CONCLUDING REMARKS

- 6.1.1 Concluding Remarks About Chapter 1
- 6.1.2 Concluding Remarks About Chapter 2
- 6.1.3 Concluding Remarks About Chapter 3
- 6.1.5 Concluding Remarks About Chapter 4
- 6.1.6 Concluding Remarks About Chapter 5
- 6.1.8 Concluding Remarks About Chapter 7
- 6.1.7 Concluding Remarks About Chapter 8

6.2 FUTURE DIRECTIONS

In this chapter, we provide few brief concluding remarks and comment about possible topics for future research.

6.1 CONCLUDING REMARKS

In this thesis, we analyzed the effect of macroeconomic shocks on models for bank assets, liabilities and capital. Furthermore, we solved a stochastic optimization problem that, amongst other things, maximized profit under constraint. We simulated ROA and ROE by considering SARB data (see [137]) for a 63 month period. Finally, the most important outcomes of the paper were discussed from an economic perspective that mainly involved contemporary bank capital adequacy regulation.

6.1.1 Concluding Remarks About Chapter 1

In Chapter 1, we set the stage for the thesis, we provided the relation and relevance of the study in the present day economic crisis. We reviewed literature about loan pricing, loan loss and their provisioning, profitability, regulatory capital Basel II capital accord and SMC. We gave the preliminaries about the stochastic processes, bank balance sheets, bank profitability, the structure of the Basel II capital accord and SMC. The diagrammatic overviews given in subsubsections 1.2.4.1 and 1.2.4.3 helped us immensely to understand the Basel II capital accord and Basel II credit risk from the point of view of the standardized and internal ratings based approaches, respectively. We further gave diagrammatic overviews of SMC, financial leverage profit engine and borrowing under securitization strategies in subsubsection 1.2.5.1. We further looked at the core problems this study looked to address, we outlined four problems in particular. Finally, we outlined the structure of the thesis.

6.1.2 Concluding Remarks About Chapter 2

In Chapter 2, we set out to provide the stochastic banking model. We studied the stochastic dynamics of banking items such as bank assets (cash, bonds, shares, intangible assets, Treasuries, reserves, loans, RWAs, aggregate bank assets, bank asset price processes and bank asset portfolio), liabilities (demand deposits), bank capital (total bank capital and binding capital constraints) and profit (profit dynamics and profitability indicators given by ROA and ROE). Section 2.1 dealt broadly with the assets the bank holds both on its on- and off-balance sheets. In particular we looked at the proportions invested in cash, bonds and shares from the i -th loan subportfolio at time t in Subsubsection 2.1.1.1.

We discussed each of the first three general bank assets, we learned that shares, S , have historically been the most prominent performers over the long term. Since the returns from shares usually exceed the returns from both bonds and cash and have significantly outpaced inflation, they are important to a portfolio for growth of capital over time. Over

the short term, however, shares can be volatile and as a result there is regulation related to banks holding shares. Unlike shares which represent equity or part ownership of the companies that issue them, bonds, B , represent debt. We learned that bonds are issued by municipalities and governments as a way to raise cash. Banks in turn buy bonds, using the raised deposit to pay the issuer in exchange for fixed interest payments over a set number of years and a promise to pay the original amount back in the future. Bonds are valuable to banks more for the income they provide than for growth potential. Since the income they pay is fixed it is generally reliable and steady. The primary risk in bond market investing comes from interest rate changes. When interest rates rise, a bond's market value decreases. The last general bank asset of the three is cash, C , which is often used as a very short-term savings instruments such as money market securities. We learned that these investments can be used to meet near-term financial needs or to protect a portion of an investment portfolio from price fluctuation. The downside of cash securities is that they offer no real opportunities for long-term growth. Though economic conditions and factors such as changing interest rates can impact both shares and bonds, these markets perform independently of each other and can therefore serve as a balance within the portfolio of a bank.

These three general bank assets serve specific role in the portfolio of a bank, which can be summarized as follows: Shares are important for growth of capital over time, bonds are important for the income they provide than for growth potential and cash is used for the protection of a portion of an investment portfolio from price fluctuation.

In Subsubsection 2.1.1.2, we discussed the shareholder value which is often created by intangible assets which consist of patents, trademarks, brand names, franchises and economic goodwill (more specifically, core deposit customer relationships, customer loan relationships as differentiated from the loans themselves, etc.). Economic goodwill consists of the intangible advantages a bank has over its competitors such as an excellent reputation, strategic location, business connections, etc. In addition, such assets can comprise a large part of the bank's total assets and provide a sustainable source of wealth creation. We denoted the value of intangible assets, in the t -th period, on the i -th loan subportfolio by I_t^i and the return on these assets by $r_t^{I^i} I_t^i$.

Subsubsection 2.1.1.3, gave the types of Treasuries we are dealing with, their purpose and denoted them in general by r^{Ti} . In Subsubsection 2.1.1.4, we looked at the bank reserves; we defined these as the deposit held in accounts with a national institution (for instance, the Federal Reserve) plus money that is physically held by banks (vault cash).

Subsection 2.1.2, started by highlighting that banks raise deposit from the individuals and uses the raised deposits to issue loans. We made use of figure 1.4, to help understand how this is done. The loan demand and supply is looked at in subsubsection 2.1.2.1, the loan demand is denoted by ζ^i and loan supply by $\mathfrak{J}^i$. We discussed the loan pricing in subsubsection 2.1.2.2. We examined the bank loan losses and their provisioning in subsubsection

2.1.2.3. MBS are discussed in subsubsection 2.1.2.4, it is highlighted in that subsubsection, that the mortgage-backed security (MBS) is an asset-backed security whose cash flows are backed by the principal and interest payments of a set of mortgage loans. Subsection 2.1.3, considered RWAs that are defined by placing each on- and off-balance sheet item into a risk category. Subsection 2.1.4, provided a description of aggregate risk-free and risky assets and their corresponding rates, which were discussed in more details in subsubsections 2.1.4.1 and 2.1.4.2, respectively. The objective was to identify the key characteristics of broad swings in the prices of these assets that may be masked by differences in the behavior of individual prices so as to highlight their relationship to macroeconomic performance and monetary policy. Lastly under section 2.1.2, we looked at the bank asset price processes and bank asset portfolio in subsections 2.1.5 and 2.1.6, respectively. Subsection 2.2, discusses the only liability we have, i.e. demand deposit, which is denoted by D_t^i .

Subsection 2.3 looked at the total bank capital and binding capital constraints in subsubsections 2.3.1 and 2.3.2, respectively. We concluded chapter 2 by looking at the profit, its dynamics and the profitability indicators ROA and ROE in subsections 2.4.1 and 2.4.2, respectively.

6.1.3 Concluding Remarks About Chapter 3

In chapter 3, we solved bank optimization problem by using the stochastic banking model discussed in chapter 2. In section 3.1, we stated the optimization problem with its solution provided in section 3.2. Several theorems and corollaries are stated and proved in this chapter. We looked at the optimal provisioning process in subsection 3.2.1, i.e. how the bank makes provision for the loan losses, the situation that most of the U.S. banks and other financial institutions find themselves in. We see some of them rescued by being taken over by other banks, we find that on September 15th, a day which has been dubbed Meltdown Monday by some News outlets (see, also, [89] and [39]), the 94 year-old Merrill Lynch agreed to sell itself to Bank of America for \$ 50 billion. Also, on that day Lehman Brothers, facing a refusal by the federal government to bail it out, filed for Chapter 11 bankruptcy protection (compare [91]). Treasury Secretary Hank Paulson cited moral hazard as a reason for not bailing out Lehman Brothers (see [125]). Meanwhile Goldman Sachs and JP Morgan Chase tried but failed to raise \$ 70 billion to lend AIG (compare [58]).

One day later, The Fed found itself forced to bail out insurance giant AIG by providing an emergency loan of \$ 85 billion (compare [30]), which will be repaid by selling off assets of the company (see [58]). After concluding that a disorderly failure of AIG could aggravate the current financial and economic crisis (compare [51]), The Fed decided to intervene. This intervention gave the U.S. government a 79.9 % equity stake at AIG (see [58]).

We looked at optimizing using three different utility functions, namely exponential, power and logarithmic in subsections 3.2.2, 3.2.3 and 3.2.4; respectively.

6.1.4 Concluding Remarks About Chapter 4

In Chapter 4, we provided the numerical illustrative example of bank profitability in terms of ROA and the ROE. We simulated ROA and ROE by considering SARB data (see [137]) for a 63 month period.

We report that the deterioration in asset quality concentrated in real estate loan portfolio continued to take a toll on the earnings performance of many insured institutions in the first quarter of 2008. Higher loan-loss provisions were the primary reasons, that industry earnings for the quarter totaled only \$ 19.3 billion, compared to \$ 35.6 billion in 2007. FDIC-insured commercial banks and savings institutions set aside \$ 37.1 billion in loan-losses provisions during the fourth quarter of 2008, more than four times the \$ 9.2 billion set aside in the first quarter of 2007, which proved slightly more than \$ 36.3 billion set aside in the fourth quarter of 2007, the amount that was three times higher than \$ 9.9 billion for fourth quarter of 2006.

The average ROA was 0.59%, falling from 1.2 % in the first quarter of 2007. The first quarter's ROA is the second lowest since the fourth quarter of 1991, when it stood at a record low of negative 0.19 %, the first lowest ROA being recorded in the fourth quarter of 2007, was 0.18 %. The downward trend in profitability was relatively broad; slightly more than half of all insured institutions (50.4 %) reported year-over-year declines in quarterly earnings compared to 51.2 % reported on the fourth quarter of 2007 and 50.7 % reported on the fourth quarter of 2006. However, the magnitude of the decline in the industry earnings was attributable to a relatively small number of large institutions. Almost two of every three institutions with more than \$ 10 billion in assets reported net income in the first quarter of 2008 compared to one out of every four institutions in the fourth quarter of 2007. These declines are exacerbated by the current credit crises in the U.S. markets.

Next, we looked at the convergence of MCAM, we presented the simulations of the approximate and actual value function and optimal controls in subsubsection 4.2.1.1. We also, looked at the impact of varying model parameters. We examined the impact of varying loan loss severity β^i . We saw from figure 4.4 that varying β^i does not affect the optimal investment in loans. This is so because the optimal investment in loan is independent of loan loss severity, see equation (4.5). Optimal profit consumption varies as the loan loss severity varies, for small loan loss severity the optimal profit consumption is seen to be low and high for larger loan loss severity. From the same figure we saw that the bank tends to make large provisions for large loan loss severity.

Finally, we examined the impact of varying loan loss frequency ϕ^i . From figure 4.5, we saw that there was no impact on the optimal investment in loans and optimal cost of provisioning when the loan loss frequency varies, this is the case because both the optimal controls are

independent of the loan loss frequency see equations 4.5 and 4.7, respectively. However, there was a notable impact on the optimal consumption as the loan loss frequency changed.

6.1.5 Concluding Remarks About Chapter 5

In Chapter 5, we demonstrated the connections between the banking models and Basel II and the subprime mortgage crisis. Section 5.1 started the process by looking at banking models derived in the thesis and their connections with Basel II capital accord. Under the subsections 5.1.1 and 5.1.2, we discussed the bank regulation capital and the procyclicality of Basel II regulation, respectively. We conceded to the fact that, despite the analysis in subsubsection 2.3.1 of section 2.3, bank capital is notoriously difficult to define, monitor and measure. The measurement of equity depended on how all of a bank's financial instruments and other assets are valued. The description of the shareholder equity component of bank capital, E , given by ((2.22), description of total bank capital), is largely motivated by the following observations. That, it is meant to reflect the nature of the book value of equity. Our intention is also to recognize that the book and market value of equity is highly correlated.

In subsection 5.1.2 we noted that chapter 2 has discussed the procyclicality induced by the Basel II capital accord's approach to credit risk in subsection 2.3.2. In this regard, the standardized approach to credit risk differentiates assets not only according to the borrower but according to riskiness proxied by credit rating agencies' assessment of the borrower. This approach represents an improvement in the sense that corporations are rated. However, it is deficient with respect to the viewpoint that ratings properly reflect risk and the inducing of procyclical capital charges which will lead to overlending during booms and underlending during recessions. Also, the capital formula for the IRB approach to credit risk is problematic. In short, the IRB capital formula is deduced by considering the large-portfolio asymptotic dynamics of a Merton model with a single common risk-factor. Many empirical studies have confirmed that this formula gives rise to procyclicality.

Subsection 5.1.3 illustrated the bank management practice in a Basel II paradigm, by looking at a procedure that can be identified with three-pillared approach of the Basel II capital accord. We looked at the minimum capital requirement (Pillar 1), supervisory review (Pillar 2) and market discipline (Pillar 3), these are covered under subsubsections 5.1.3.2, 5.1.3.3 and 5.1.3.4, respectively. In subsubsection 5.1.3.3, we considered three types of bank; failed bank, a bank for whom the capital adequacy ratio, κ , induced by $\Lambda_t^{1i} + I_t^{1i}$, is subject to the condition

$$K^i(t) < 1 - \frac{\tilde{K}^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}}$$

cannot raise enough debt and equity to invest in $\Lambda_t^{1i} + I_t^{1i}$ and fails. If this happens, bank

managers receive the market value of $K^i(t) - \Lambda^i\{\Lambda_t^i + I_t^i\}$ which is positive because the bank exceeded the minimum capital requirement from the first pillar. The supervisor has to cover certain costs when a bank fails.

The second is capital-constrained bank, this bank has insufficient capital, κ , to invest in $\Lambda_t^{1i} + I_t^{1i}$, may face a financing constraint,

$$1 > K^i(t) \geq 1 - \frac{K^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}},$$

and may be subject to an implicit capital requirement from the market of the form

$$K^i(t) \geq 1 - \frac{K^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}} \geq 1 - \frac{\tilde{K}^{i*}(t)}{\Lambda_t^{1i} + I_t^{1i}}.$$

Such a bank satisfies the minimum market capital requirement, but is capital-constrained and must issue debt and raise equity to invest in $\Lambda_t^{1i} + I_t^{1i}$ in loans.

Lastly, we consider the capital-unconstrained bank. This is a bank with a $\Lambda_t^{1i} + I_t^{1i}$ -induced CAR, κ , that satisfies

$$K^i(t) \geq 1$$

is unconstrained and may invest in $\Lambda_t^{1i} + I_t^{1i}$ without raising additional debt and equity. In that case, the excess bank capital

$$K^i(t) - \{\Lambda_t^{1i} + I_t^{1i}\}$$

may be invested in a riskless asset (such as treasuries) that provides a zero net return. If the bank is unconstrained, the aggregate social value is always more than the constrained case by the amount of excess capital given by (5.9). However, if the unconstrained bank invests any excess capital in a riskless asset with zero net return then all consequences are exactly larger by (5.9). Basel II keeps banks on check about how they raise their capital. As a way of concluding this chapter we demonstrated the connection between the banking models and the current subprime mortgage crisis in subsection 5.2.1.

6.1.6 Concluding Remarks About Chapter 7

In Chapter 7, we have shown different references used in the thesis.

6.1.7 Concluding Remarks About Chapter 8

In Chapter 8, we provided appendices. Appendix A details the MCAM algorithm and iteration in subsections 8.1.1 and 8.1.2, respectively. Appendix B, discusses the alternative banking model. Section 8.3 is Appendix C, which discusses credit crunches and Southern African banking industry and financial system. Finally, Appendix D looks at the timeline of both the pre-subprime and subprime mortgage crisis events, over forty year period, from 1968 to 2008.

6.2 FUTURE DIRECTIONS

The main thrust of future research will involve models of bank items driven by Lévy processes (see, for instance, Protter in [117, Chapter I, Section 4]). Such processes have an advantage over the more traditional modeling tools such as Brownian motion in that they describe the non-continuous evolution of the value of economic and financial items more accurately. For instance, because the behavior of bank loans, profit, capital and CARs are characterized by jumps, the representation of the dynamics of these items by means of Lévy processes is more realistic. As a result of this, recent research has strived to replace the existing Brownian motion-based bank models (see, for instance, [41], [57], [92] and [123]) by systems driven by more general processes. Also, a study of the optimal capital structure should ideally involve the consideration of taxes and costs of financial distress, transformation costs, asymmetric bank information and the regulatory safety net. Another research area that is of ongoing interest is the (credit, market, operational, liquidity) risk minimization of bank operations within a regulatory framework (see, for instance, [75] and [102]). A further possible field of study arises from the bank capital literature that motivates capital and internal financing as important in bank decisions by invoking specific market imperfections or mispricings such as costly equity-financing frictions, dead-weight costs from insolvency and risk-insensitive deposit provisions for loan losses premiums. Furthermore, the assumed asset, equity and liability processes and the bank's objectives and control variates will be dependent on the specific market or pricing conditions being assumed. These effects are not fully recognized in our contribution and requires further attention.

Chapter 7

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Chapter 8

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8.1 APPENDIX A: MARKOV CHAIN APPROXIMATION METHOD (MCAM)

In this chapter, we start off by discretizing the state (wealth) space into a finite set of values $\{\xi_0, \xi_1, \xi_2, \dots, \xi_N\}$ and assume that in a small time interval Δt , wealth changes from ξ_i to ξ_j with transition probability p_{ij} . We have:

$$V(\xi_i) \approx \sup_{\{k_i, \lambda_i, C_i^{P^*}\}} \left\{ \Delta t \eta U^{(2)}(\xi_i) + \Delta t U^{(1)}(k_i) + \exp\{-(\eta + \delta)\Delta t\} \left(\phi \Delta t V(\xi_i - C_i^{P^*}) + (1 - \phi \Delta t) \mathbf{E} \left[V(\xi) | \Pi_t = \xi_i \right] \right) \right\}$$

in which $\mathbf{E} \left[V(\xi) | \Pi_t = \xi_i \right] = \sum_{j=0}^N p_{ij} V(\xi_j)$. We carry out the intuition as follows.

Over the time interval $[0, \Delta t]$, the approximate utility from profit consumption is $\Delta t U^{(1)}(k_i)$. If bankruptcy occurs in the small interval $[0, \Delta t]$, which happens with probability $1 - \exp\{-\eta \Delta t\} \approx \eta \Delta t$, the bank has approximate utility of terminal wealth $U^{(2)}(\xi_i)$. If bankruptcy does not occur in $[0, \Delta t]$, which happens with probability $\exp\{-\eta \Delta t\}$, we examine the outcome on the interval $[\Delta t, \tau]$ and discount it back to time zero (hence the factor of $\exp\{-\delta \Delta t\}$). If Poisson loss occurred in $[0, \Delta t]$, which happens with probability $\phi \Delta t$, the bank makes an optimal provisioning at a cost of C^{P^*} and continues maximizing its expected utility. If Poisson loss did not occur on $[0, \Delta t]$, which happens with probability $1 - \phi \Delta t$, again, the bank continues maximizing its expected utility.

We wish to compute the approximate value function $V_i = V(\xi_i)$ and to recover the optimal controls $k_i^* = k^*(\xi_i)$, $\eta_i^* = \eta^*(\xi_i)$ and $C_i^{P^*} = C^{P^*}(\xi_i)$ for $i = 0, 1, 2, \dots, N$. We sketch the algorithm below.

8.1.1 Markov Chain Approximation Method Algorithm

1. Fix the controls k_i , η_i and C_i^P .
2. Compute the value function for these fixed controls, i.e. compute

$$J_i := \left\{ \Delta t \eta U^{(2)}(\xi_i) + \Delta t U^{(1)}(k_i) + \exp\{-(\eta + \delta)\Delta t\} \left(\phi \Delta t J(\xi_i - C_i^P) + (1 - \phi \Delta t) \sum_{j=0}^N p_{ij} J_j \right) \right\} \quad (8.1)$$

The transition probabilities p_{ij} depends on the model parameters $r^\Lambda - c^\Lambda$, r^T , σ , μ^a , θ and ϕ , the mesh size $d\pi$ and the strategies k_i , λ_i and P_i , we briefly describe the choice of p_{ij} below.

Remark 8.1.1 *The computation of the value function for the fixed controls is the same as solving the $(N \times 1) \times (N \times 1)$ linear system (8.1) for the unknown vector J .*

3. Given J , compute new policies λ_i , P_i that maximize J , i.e. compute the augment of the maximum of J . The expression that results for the updated λ_i is simply a discretized version of the first order necessary condition

$$\lambda_t^* = -\frac{((r^\Lambda - c^\Lambda) - r^T)}{\sigma^2} \frac{D_\pi V(\Pi_t^*, t)}{D_{\pi\pi} V(\Pi_t^*, t)},$$

Note that since the wealth space is discretized with mesh $d\pi$, each P_i must be an integral multiple of $d\pi$.

4. Repeat, starting at step 2 with the updated controls, until the change in the vector J is sufficiently small. (We used a tolerance of 10^{-6} .)

We remark that if we choose the transition probabilities p_{ij} so that the approximating chain is locally consistent with the continuous wealth process (i.e., so that the first two moments are close, see [86] for details), then the value function and optimal controls for the discretized problem converge to the value function and optimal controls for the continuous problem. Moreover, under our choice of transition probabilities, solving the linear system (8.1) is equivalent to solving the *HJB* equation under fixed controls, i.e., to solving

$$\begin{aligned} \delta J = & \left[\left\{ ((r^\Lambda - c^\Lambda) - r^T)\lambda_i + \mu^a + r^T\pi - k - (1 + \theta)\phi(\beta\pi - P_i) \right\} J' \right. \\ & \left. + \frac{1}{2}\sigma^2\lambda_i^2 J'' + \phi \left\{ J(\pi - P_i) - J(\pi) \right\} \right] + \eta \left[b \frac{\pi^\alpha}{\alpha} - J \right] + \frac{k^\alpha}{\alpha}. \end{aligned} \quad (8.2)$$

via a modified finite difference scheme.

Finally, we remark that it is tempting to apply a straightforward finite difference method directly to the *HJB* equation, but [84] points out, for many problems in stochastic optimal control, the associated *HJB* equations have only a formal meaning and standard methods of numerical analysis are not usable to prove convergence; moreover, the classical methods might not converge. However, as [86] and [70] point out, when a carefully-chosen, “renormalized” finite difference is used, the coefficients of the resulting discrete equation serve as the transition probabilities that satisfy the local consistency conditions in the discretized dynamic programming equation (8.1). Indeed, this is the case for our example.

8.1.2 Iteration

$$J_i := \left\{ \Delta t \eta U^{(2)}(\xi_i) + \Delta t U^{(1)}(k_i) + \exp\{-(\eta + \delta)\Delta t\} \left(\phi \Delta t J(\xi_i - C_i^P) + (1 - \phi \Delta t) \sum_{j=0}^N p_{ij} J_j \right) \right\}$$

for $i = 0$ we have.

$$J_0 := \Delta t \eta b \frac{\xi_0^\alpha}{\alpha} + \Delta t \frac{k_0^\alpha}{\alpha} + \phi \Delta t J(\xi_0 - C_0^P) \exp\{-(\eta + \delta)\Delta t\} + \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{0j} J_j - \phi \Delta t \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{0j} J_j$$

for $i = 1$ we obtain:

$$J_1 := \Delta t \eta b \frac{\xi_1^\alpha}{\alpha} + \Delta t \frac{k_1^\alpha}{\alpha} + \phi \Delta t J(\xi_1 - C_1^P) \exp\{-(\eta + \delta)\Delta t\} + \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{1j} J_j - \phi \Delta t \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{1j} J_j$$

for $i = 2$ we obtain:

$$J_2 := \Delta t \eta b \frac{\xi_2^\alpha}{\alpha} + \Delta t \frac{k_2^\alpha}{\alpha} + \phi \Delta t J(\xi_2 - C_2^P) \exp\{-(\eta + \delta)\Delta t\} + \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{2j} J_j - \phi \Delta t \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{2j} J_j$$

⋮
⋮
⋮

for $i = N$ we obtain:

$$\begin{aligned}
J_N &:= \Delta t \eta b \frac{\xi_N^\alpha}{\alpha} + \Delta t \frac{k_N^\alpha}{\alpha} + \phi \Delta t J(\xi_N - C_N^P) \exp\{-(\eta + \delta)\Delta t\} \\
&+ \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{Nj} J_j - \phi \Delta t \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{Nj} J_j
\end{aligned}$$

Let us consider J_0

$$\begin{aligned}
J_0 &:= \Delta t \eta b \frac{\xi_0^\alpha}{\alpha} + \Delta t \frac{k_0^\alpha}{\alpha} + \phi \Delta t J(\xi_0 - C_0^P) \exp\{-(\eta + \delta)\Delta t\} \\
&+ \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{0j} J_j - \phi \Delta t \exp\{-(\eta + \delta)\Delta t\} \sum_{j=0}^N p_{0j} J_j
\end{aligned}$$

$$J_0 := a_0 + b_0 + cJ(\xi_0 - C_0^P) + e \sum_{j=0}^N p_{0j} J_j$$

where

$$a_0 = \Delta t \eta b \frac{\xi_0^\alpha}{\alpha}$$

$$b_0 = \Delta t \frac{k_0^\alpha}{\alpha}$$

$$c = \phi \Delta t \exp\{-(\eta + \delta)\Delta t\}$$

$$d = \exp\{-(\eta + \delta)\Delta t\}$$

$$e = d - c$$

Hence in general this can be written as:

$$J_i := a_i + b_i + cJ(\xi_i - C_i^P) + e \sum_{j=0}^N p_{ij} J_j \quad (8.3)$$

8.2 APPENDIX B: ALTERNATIVE BANKING MODEL

In our model, we consider the filtered probability space $(\Omega, \mathbf{F}, (\mathcal{F}_t)_{0 \leq t \leq \tau}, \mathbf{P})$. As usual, we assume that $\mathbf{P}$ is a real probability measure, $\mathbb{F} = (\mathcal{F}_t)_{0 \leq t \leq \tau}$ is the natural filtration, $\mathcal{F}_0$ is trivial and $\mathcal{F}_\tau = \mathbf{F}$. The *jump process* $\Delta L = (\Delta L_t, t \geq 0)$ associated with a Lévy process, L , is defined by $\Delta L_t = L_t - L_{t-}$, for each $t \geq 0$, where $L_{t-} = \lim_{s \uparrow t} L_s$ is the left limit at t . Let $L = (L_t)_{0 \leq t \leq \tau}$ with $L_0 = 0$ a.s. be the càdlàg version of a Lévy process. Also, we assume that the Lévy measure ν satisfies

$$\int_{|x| < 1} |x|^2 \nu(dx) < \infty, \quad \int_{|x| \geq 1} \nu(dx) < \infty. \quad (8.4)$$

Furthermore, the following definition of the Lévy-Itô decomposition is important.

Definition 8.2.1 (Lévy-Itô Decomposition (see [35])) *Let (L_t) be a Lévy process and ν its Lévy measure, given by equation (8.4). Then there exist a vector γ and a Brownian motion (B_t) such that*

$$L_t = \gamma t + B_t + L_t^f + \lim_{\epsilon \downarrow 0} L_t^\epsilon,$$

where L_t^f is a compound Poisson process with a finite number of terms and L_t^ϵ is also a compound Poisson process. However, there can be infinitely many small jumps.

An implication of the Lévy-Itô decomposition (see [35]) is that every Lévy process is a combination of a Brownian motion and a sum of independent compound Poisson processes. This imply that every Lévy process can be approximated a jump-diffusion process, that is by the sum of a Brownian motion with drift and a compound Poisson process. In this paper, we will consider Merton's jump-diffusion model (see [95] and [35]) of L . Thus

$$L_t = at + \tilde{s}B_t + \sum_{i=1}^{N_t} Y_i, \quad 0 \leq t \leq \tau, \quad (8.5)$$

where $(B_t)_{0 \leq t \leq \tau}$ is a Brownian motion with standard deviation $\tilde{s} > 0$, $a = \mathbf{E}(L_1)$, $(N_t)_{t \geq 0}$ is a Poisson process counting the jumps of L_t with jump intensity λ . The Y_i (i.i.d. variables) are jump sizes, the distribution of the jump sizes is Gaussian with μ the mean jump size and δ the standard deviation of Y_i .

A typical bank balance sheet identity consists of assets (uses of funds) and liabilities (sources of funds), that are balanced by bank capital (see, for instance [46]), according to the well-known relation

$$\begin{aligned} \text{Value of Assets } (A^i) &= \text{Value of Liabilities } (\Gamma^i) \\ &+ \text{Value of Bank Capital } (K^i). \end{aligned} \quad (8.6)$$

8.2.1 Assets

In this subsection, we discuss bank asset price processes. The bank's investment portfolio is constituted by $m+1$ assets including loans, advances and intangible assets (all risky assets) and Treasuries (riskless asset). We pick the first asset to be the riskless Treasuries, T , that earns a constant, continuously-compounded interest rate of r^T . Profit maximizing banks set their rates of return on assets as a sum of the risk-free Treasuries rate, $r^T \bar{1}$, risk premium, ϱ_r , and the expected default premium, $\mathbf{E}(d)$. Here the unitary vector and risk premium are given by

$$\bar{1} = (1, 1, \dots, 1)^T \text{ and } \varrho_r = (\varrho_1, \varrho_2, \dots, \varrho_m)^T,$$

respectively. Also, we have that the expected default premium is defined by

$$\begin{aligned} \mathbf{E}(d) &= (\mathbf{E}(d_1), \mathbf{E}(d_2), \dots, \mathbf{E}(d_m))^T, \\ &\begin{cases} \mathbf{E}(d_i) \neq 0 & i\text{-th asset is a loan,} \\ \mathbf{E}(d_i) = 0 & i\text{-th asset is not a loan.} \end{cases} \end{aligned}$$

The sum $r^T \bar{1} + \varrho$ covers, for instance, the cost of monitoring and screening of loans and cost of capital. The $\mathbf{E}(d)$ component corresponds to the amount of provisioning that is needed to match the average expected losses faced by the loans. The m assets besides Treasuries are risky and their price process, S^i (reinvested dividends included), follows a geometric Lévy process with drift vector, $r^T \bar{1} + \varrho + \mathbf{E}(d)$ and diffusion matrix, σ_a , as in

$$\begin{aligned} S_t^i &= S_0^i + \int_0^t I_s^i \left(r^T \bar{1} + \varrho_r + \mathbf{E}(d) \right) ds + \\ &\int_0^t I_s^{ii} \sigma_a dL_s + \sum_{0 < s \leq t} \Delta S_s^i 1_{\{|\Delta S_s| \geq 1\}}, \end{aligned} \quad (8.7)$$

where I_t^{Si} denotes the $m \times m$ diagonal matrix with entries S_t^i and L is an m -dimensional Lévy process. Also, ΔS_s is the jump of the process S^i at time $t > 0$ and $1_{\{|\Delta S_s| \geq 1\}}$ is the indicator function of $\{|\Delta S_s| \geq 1\}$. We suppose, without loss of generality, that $\text{rank}(\sigma_a) = m$ and the bank is allowed to engage in continuous frictionless trading over the

planning horizon, $[0, T]$. Next, we suppose that ρ is the m -dimensional stochastic process that represents the current value of risky assets. Put $\mu_a = r^T + \rho^T \left(\varrho_r + \mathbf{E}(d) \right)$, $\sigma^A = \tilde{\sigma}\sigma_a$ and $\mu^A = \mu_a + a\sigma_a$. In this case, the dynamics of the current value of the bank's entire asset portfolio, A^i , over any reporting period may be given by

$$\begin{aligned} dA_t^i &= A_t^i \mu_a dt + A_t^i \sigma_a \left[a dt + \tilde{s} dB_t^A + d \left[\sum_{i=1}^{N_t} Y_i \right] \right] - r^T D_t dt \\ &= A_t^i \left[\mu^A dt + \sigma^A dB_t^A + \sigma_a d \left[\sum_{i=1}^{N_t} Y_i \right] \right] - r^T D_t dt \end{aligned} \quad (8.8)$$

where the face value of the deposits, D^i , is described in the usual way, and $r^T D_t dt$ represents the interest paid to depositors.

8.2.2 Capital

The total value of the bank capital, $K^i = (K_t^i, t \geq 0)$, can be expressed as

$$K_t^i = K_{t1}^i + K_{t2}^i + K_{t3}^i, \quad (8.9)$$

where K_{t1}^i , K_{t2}^i and K_{t3}^i are Tier 1, Tier 2 and Tier 3 capital, respectively. Tier 1 (T1) capital is the book value of the bank's equity, $E^i = (E_t^i, t \geq 0)$, plus retained earnings, $E^{Ri} = (E_t^{Ri}, t \geq 0)$. Tier 2 (T2) and Tier 3 (T3) capital (collectively known as supplementary capital) is, in our case, the sum of subordinate debt, O where $O_t = \exp\{rt\}$ and loan-loss reserves, R^{Li} . However, for sake of argument, we suppose that

$$K_t^i = E_t + E_t^{Ri} + O_t. \quad (8.10)$$

For $\sigma^E = \tilde{\sigma}\sigma_e$ and $\mu^E = (\mu_e + a\sigma_e)$ we describe the evolution of O and E as

$$dO_t^i = r \exp\{rt\} dt, \quad O_0^i > 0 \quad (8.11)$$

and

$$dE_t^i = E_{t-}^i \left[\mu^E dt + \sigma^E dB_t^E + \sigma_e d\left[\sum_{i=1}^{N_t} Y_i\right] \right] \quad (8.12)$$

respectively. Where σ_e , μ_e and B_t^E are the volatility of E^i , the total expected returns on E , and the standard Brownian motion, respectively.

8.2.3 Profit

Let Π^{ni} be the bank's net profit after tax which is used to meet obligations such as dividend payments on bank equity, δ_e , and interest and principal payments on subordinate debt, $(1+r)O^i$. Put $\delta_s = (1+r)$. In this case, we may compute the retained earnings, $E^{Ri} = (E_t^{Ri}, t \geq 0)$, as

$$E_t^{Ri} = \Pi_t^{ni} - \delta_e E_t^i - \delta_s O_t^i \quad (8.13)$$

We assume that the retained earnings remain constant during the planning period so that $dE^{Ri} = 0$. Therefore, the dynamics of the net profit after tax may be expressed as

$$\begin{aligned} d\Pi_t^{ni} &= \delta_e E_{t-}^i \left[\mu^E dt + \sigma^E dB_t^E + \sigma_e d\left[\sum_{i=1}^{N_t} Y_i\right] \right] + \\ &\quad \delta_s r \exp\{rt\} dt. \end{aligned} \quad (8.14)$$

In the remainder of this section, we derive stochastic differential equations for the dynamics of two measures of bank profitability, viz., the ROA and ROE. The procedure that we use to obtain the said equations is related to Ito's general formula (see [117]). An important observation about our foregoing description of the assets and liabilities of a commercial bank, is that it is suggestive of a simple procedure for obtaining a stochastic model for the dynamics of the profitability of such a depository institution. The solution of the SDE (8.14) is

$$\begin{aligned} \Pi_t^{ni} &= E_t^{Ri} + \delta_e E_0^i \exp \left\{ \sigma^E B_t^E + (\mu^E - \frac{1}{2}(\sigma^E)^2)t + \right. \\ &\quad \left. \sigma_e \left[\sum_{i=1}^{N_t} Y_i \right] \right\} + \delta_s \exp\{rt\}. \end{aligned} \quad (8.15)$$

8.2.4 Return-on-Assets (ROA)

The dynamics of the ROA (see equation (2.28)) may be calculated by considering the nonlinear dynamics of the value of total assets represented by (8.8) and the dynamics of the net profit after tax given by (8.14). One can easily check how efficiently a bank has been managed over a certain past time period by monitoring the fluctuations of the ROA. A stochastic system for the dynamics of the ROA for a commercial bank is given below.

Proposition 8.2.2 (Dynamics of ROA using Merton's Model): *Suppose that the dynamics of the value of total assets and the net profit after tax are represented by (8.8) and (8.14), respectively. Then a stochastic system for the ROA of a bank may be expressed as*

$$\begin{aligned}
 dA_t^{ri} = & A_t^{ri} \left[\left(\delta_e E_t^i (\sigma^E)^2 \{ (\sigma^A)^2 \sigma_a^2 dB_t^A - \sigma_a^2 \} + \sigma_a^2 \right. \right. \\
 & + (\sigma^A)^2 - \mu^A + [\Pi_t^{ni}]^{-1} \{ \delta_e \mu^E E_t^i + \delta_e r O_t^i \} \Big) dt \\
 & + \left(d \left[\sum_{i=1}^{N_t} Y_i \right] \delta_e E_t^i \sigma^E \{ \sigma^A \sigma_a dB_t^A - \sigma_a \} \right. \\
 & + [\Pi_t^{ni}]^{-1} \delta_e \sigma^E E_t^i \Big) dB_t^E \\
 & + \left([\Pi_t^{ni}]^{-1} \sigma^E \delta_e E_t^i + \sigma^A \sigma_a dB_t^A - \sigma_a \right. \\
 & + \delta_e E_t^i \sigma^E [\Pi_t^{ni}]^{-1} dB_t^E \{ \sigma^A \sigma_a dB_t^A - \sigma_a \} \\
 & - \delta_e E_t^i [\Pi_t^{ni}]^{-1} \sigma^E \sigma^A dB_t^A \Big) d \left[\sum_{i=1}^{N_t} Y_i \right] \\
 & \left. - \sigma_a dB_t^A \right]. \tag{8.16}
 \end{aligned}$$

Next, we consider the special case where $L_t = B_t$, i.e., $\sum_{i=1}^{N_t} Y_i + at = 0$.

Corollary 8.2.3 (Dynamics of ROA using Black-Scholes Model): *Suppose that $L_t = B_t$ in equations (8.8) and (8.14). Then a stochastic system for the ROA (using Black-Scholes model) of a bank may be expressed as*

$$\begin{aligned}
 dA_t^{ri} = & A_t^{ri} \left[\{ \sigma_a^2 - \varrho_r + [\Pi_t^{ni}]^{-1} (\delta_e \mu_e E_t^i + \delta_s r O_t^i) \} dt \right. \\
 & \left. + [\Pi_t^{ni}]^{-1} \delta_e \sigma_e E_t^i dB_t^E - \sigma_a dB_t^A \right]. \tag{8.17}
 \end{aligned}$$

8.2.5 Return-on-Equity (ROE)

The dynamics of the ROE (see equation (2.29)) may be calculated by considering the equation for the dynamics of the equity capital given by (8.12) and the net profit after tax represented by (8.14) and using Ito's formula (see [117]). A stochastic system for the dynamics of the return on equities for a commercial bank is given below.

Proposition 8.2.4 (Dynamics of ROE using Merton's Model): *Suppose that the dynamics of the value of total assets and the net profit after tax are represented by (8.12) and (8.14), respectively. Then a stochastic system for the ROE of a bank may be expressed as*

$$\begin{aligned}
 dE_t^{ri} = & E_t^{ri} \left[\left([\Pi_t^{ni}]^{-1} \left\{ \delta_e E_t^i \mu^E + \delta_s r O_t^i \right. \right. \right. \\
 & + \delta_e E_t^i (\sigma^E)^2 \{ 2(\sigma^E)^2 + \sigma_e^2 dB_t^E - \sigma_e^2 \} \\
 & \left. \left. - \delta_e E_t^i (\sigma^E)^2 \right\} + [\sigma^E]^2 - \mu_e + \sigma_e^2 \right) dt \\
 & + \left([\Pi_t^{ni}]^{-1} \delta_e \sigma^E E_t^i - \sigma_e \right) dB_t^E \\
 & + \left([\Pi_t^{ni}]^{-1} \sigma^E \delta_e E_t^i - \sigma_e + 2\sigma^E \sigma_e dB_t^E \right) d\left[\sum_{i=1}^{N_t} Y_i\right] \\
 & + \left(\delta_e E_t^i \sigma^E \{ 2\sigma^E \sigma_e dB_t^E - \sigma_e \} \right. \\
 & \left. - \delta_e E_t^i (\sigma^E)^2 \right) dB_t^E d\left[\sum_{i=1}^{N_t} Y_i\right] \Big]. \tag{8.18}
 \end{aligned}$$

Next, we consider the special case where $L_t = B_t$ i.e. $\sum_{i=1}^{N_t} Y_i + at = 0$.

Corollary 8.2.5 (Dynamics of ROE using Black-Scholes Model): *Suppose that $L_t = B_t$ in equations (8.12) and (8.14). Then a stochastic system for the ROE (using Black-Scholes model) of a bank may be expressed as*

$$\begin{aligned}
 dE_t^{ri} = & E_t^{ri} \left[\left([\sigma_e]^2 - \mu_e + [\Pi_t^{ni}]^{-1} \left\{ \delta_s r O_t^i + \delta_e E_t^i \mu_e \right. \right. \right. \\
 & \left. \left. - \delta_e E_t^i (\sigma_e)^2 \right\} \right) dt \\
 & + \left([\Pi_t^{ni}]^{-1} \sigma_e \delta_e E_t^i - \sigma_e \right) dB_t^E \Big]. \tag{8.19}
 \end{aligned}$$

8.3 APPENDIX C: CREDIT CRUNCHES AND SOUTHERN AFRICA

In this section, we discuss credit crunches and the possibility of them arising in South Africa.

8.3.1 Credit Crunches

Credit crunch is a term used to describe a sudden reduction in the general availability of loans (or credit) or sudden increase in the cost of obtaining loans from banks (usually via raising interest rates). There are a number of reasons why banks may suddenly make obtaining a loan more difficult or increase the costs of obtaining a loan. This may be due to

1. an anticipated decline in the value of the collateral used by the banks when issuing loans;
2. an increased perception of risk regarding the solvency of other banks within the banking system;
3. a change in monetary conditions (for example, where the central bank suddenly and unexpectedly raises interest rates or capital requirements);
4. the central government imposing direct credit controls;
5. the central government instructing the banks not to engage in further lending activity.

A credit crunch is often caused by a prolonged period of reckless and inappropriate lending which leads to losses for depository financial institutions and investors in debt when loans cannot be repaid and the full extent of the bad debt becomes apparent. These institutions may then reduce the availability of debt and increase the cost of accessing credit by raising interest rates. In some cases, lenders may be unable to lend further, even if they wish to as a result of earlier losses.

The credit crunch is generally caused by a reduction in the market prices of previously “overinflated” assets and refers to the financial crisis that results from decreasing prices. In this case, it may be wise to “mark to market” - and if necessary, sell or go into liquidation if the capital of the firm in question is insufficient to survive the post-boom phase of the credit (business) cycle. By contrast, a liquidity crisis initiates when a usually well-run firm becomes temporarily incapable of accessing the bridge finance it needs to expand its business or smooth its cash flow payments. In this case, accessing additional credit lines and trading through the crisis can allow the firm to navigate its way through the problem and ensure its continued solvency and viability. It is often difficult to know in the midst of crisis whether distressed firms are experiencing a crisis of solvency or temporary liquidity.

In the case of a liquidity crisis, it may be preferable to attempt to access additional credit lines as opportunities for growth may exist once the liquidity crisis has passed.

A sustained credit crunch is the opposite of cheap, easy and plentiful lending practices (sometimes referred to as “easy money” or “loose credit”). During the upward phase in the credit (business) cycle, asset prices may experience bouts of frenzied competitive, leveraged bidding, inducing hyperinflation in a particular asset market. This can then cause a speculative price “bubble” to develop. As this upswing in new debt creation also increases the money supply and stimulates economic activity, this also tends to temporarily raise economic growth and employment. Often it is only in retrospect that participants in an economic bubble realize that the point of collapse was obvious. In this respect, economic bubbles can have dynamic characteristics. The 2007 subprime lending crisis is considered by many to have caused a credit crunch.

8.3.2 Credit Crunches in South Africa

Our concern about credit crunches, ratings and risk management as well as liquidity and solvency issues in the Southern African financial system originates from the current situation in the U.S. and UK where the subprime lending crisis and the resulting credit crunch has proven to be catastrophic for financial stability. For instance, this crisis resulted in the U.S. Treasury’s seizure of mortgage finance giants the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) early in September 2008. This was followed by the bankruptcy of Lehman Brothers and the takeover of Merrill Lynch and Bear Stearns by Bank of America and JP Morgan Chase, respectively. The fact that the insurance industry is not immune to the financial crisis was borne out by the \$ 85 billion loan by the U.S. Federal Reserve to the American International Group (AIG), the world’s largest insurer. Further evidence of the turmoil in the U.S. banking system has been the concession made to the last two remaining major investment banks, Morgan Stanley and Goldman Sachs, to take deposits in order to boost their capital and facilitate mergers. Also, there has been a wave of bankruptcies and forced mergers of banks, mortgage providers and insurance companies in the UK. For instance, in September 2008, the UK government relaxed regulation in order to allow the merger between financial services groups, Lloyds TSB and HBOS, so that Lloyds could rescue HBOS.

There have been several reasons for the situation described above. In the case of the U.S., illiquid mortgage assets that are difficult to value and even harder to trade have been weighing down financial institutions and placing their economy under duress. The securities associated with these assets were backed by home loans made to buyers with bad credit or without proof of income. This situation partly arose due to loose lending standards and the proliferation of teaser-rate mortgage products that had artificially inflated the U.S. home-ownership market. As a result many new homeowners eventually had trouble making their monthly repayments when home prices started to fall and their teaser rates increased. In

this regard, it is clear that the relationship between the banks and the credit rating agencies during the real estate bubble has had and will have a long-lasting impact on banks' ability to recover from the current crisis. More specifically, the rating agencies, who are remunerated by the loan issuers, gave high ratings to securities backed by subprime mortgages. In order to compensate for this situation, the pace of downgrades by credit agencies on mortgage securities has quickened considerably in recent times. This has created additional problems since every time their portfolios are hit by significant credit downgrades, banks are compelled to raise their capital adequacy ratios. Often this results in the issuance of new equity which leads to dilution as shareholders at Citigroup, Merrill Lynch and Washington Mutual have experienced. It is anticipated that this pressure on institutional balance sheets will continue until the ratio of downgrades to upgrades changes. In September 2008, the situation described above reached crisis proportions with many banks and investment institutions ceasing to make loans to each other as they hoarded cash to protect against any sudden liquidity crunch as well as from opaque problems on their partners' balance sheets.

In response to the collapse of the U.S. home mortgage market, many mainstay financial institutions battled to raise cash or find merger partners because of a decrease in lending and sinking investor confidence. Indeed, the flow of credit to consumers and businesses fell 40 % in the first quarter and another 35 % in the second quarter of 2008. As the stock market slumped, investments in super-safe assets like Treasuries securities and gold increased dramatically. Also, as a measure to counteract panic trading, short selling of U.S. bank equity (in anticipation of equity prices declining) was suspended in September 2008. Incredibly, the largest intervention came when the federal government bought up about \$ 700 billions of the aforementioned mortgage assets from banks, Wall Street firms and other financial institutions at a large discount. The U.S. government intends to hold onto these assets until the market recovers at which time it is envisaged that the mortgage linked assets could be sold at a profit. The plan is intended to assist U.S. banks in shoring up their balance sheets by removing hard-to-value assets. The main objective of this bailout is to address the frequent writedowns and capital raising that have been destabilizing the financial sector. In reality, U.S. banks are experiencing difficulty raising capital because it is not clear how the mortgage assets on their books should be valued. If these bad loans are removed from their books, it is hoped that banks may be willing to lend to other banks, businesses, consumers and financial institutions. Also, it is envisaged that the bailout will help home prices recover since it should lead to lower loan rates and improved consumer confidence. However, the drawbacks are that taxpayers will foot the bill for this bailout which could also encourage moral hazard, where institutions take on extra risks because they believe the government will ultimately rescue them.

8.3.2.1 The Southern African Banking Industry

In the week 6-10 October 2008, the World Economic Forum (WEF) rated South Africa's banks the 15th most secure out of 134 countries rated. In particular, the study placed

Switzerland (16th), Germany (39th), U.S. (40th) and Britain (44th) below South Africa.

While we take ministers of finance and central bank governors at their word that the regional banking sector is better off in terms of regulatory features (local commercial banks will absorb losses on limited U.S. investments but have deposits to fall back on as capital) than the U.S., it is obvious that the continued turmoil in Southern African financial markets will not cease until market conditions in the U.S. improve.

South African bank stocks peaked in October 2007 but had declined by a staggering 40 % by July 2008 (see, for instance, [96]). They had since rebounded by about 25 % and looked cheap by the beginning of October 2008, but may remain so until there is a definite indication that interest rates have peaked and are on their way down. It is conjectured that South African mainstream banks were largely shielded from the effects of the subprime mortgage crisis by solid exchange controls and tougher monetary policy and legislation. However, problems may arise for the banking industry from inflation and increasing loan losses resulting from high interest rates and borrowers struggling to service debts. Another saving grace is that banks can lend money from the SA Reserve Bank.

8.3.2.2 The Southern African Financial System

From a Southern African point of view, a major cause for concern is that primary and secondary markets in the region have responded very strongly to the turmoil in the U.S. economy. Although local bank exposure to subprime lending itself has been minimal, the effect on local markets of the U.S. financial crisis has necessitated the development of a better understanding of the

- likelihood of credit crunches;
- impact of credit ratings by rating agencies;
- effectiveness of risk management and liquidity;
- solvency problems.

On Monday, 29 September 2008, when U.S. lawmakers rejected a \$ 700 billion “toxic asset rescue plan” (TARP), the Dow Jones index lost 7 % of its value, wiping around \$ 1.2 trillion off the value of the New York Stock Exchange. We note that \$ 1.2 trillion is an amount much larger than TARP. Also, the \$ 700 billion is more than double South Africa’s GDP and more than four times the combined value of the country’s five biggest listed companies - BHP Billiton, Anglo American, SAB Miller, Sasol and MTN. The JSE also lost R 199.5 billion that day although 3rd quarter-end window dressing helped to lessen the impact. For the first nine months of 2008, the JSE All Share Index declined by 20 % with the resources index down 23 %. In addition, local commodity stocks, like BHP Billiton, Anglo and Sasol have started to experience sentiment against them.

As reported in [81], South African companies that have been reeling from the international financial crisis, are abandoning deals and rethinking investments that are key to job creation and sustaining economic growth. In the week 29 September to 3 October 2008, Anglo Swiss global mining group, Xstrata¹, scrapped a \$ 10 billion bid for the world's third largest platinum producer, Lonmin, because of financing problems caused by the credit crisis. Also, Tokyo Sexwale's Mvelaphanda group canceled plans to buy Telkom because of the financial meltdown. At the beginning of October, international ratings agency, Moody's, said that while South African bank exposure to the financial crisis may be limited, the impact on the broader economy would be substantial. Moody's claimed that foreign investors' heightened risk aversion will weigh on portfolio inflows while political uncertainty also threatens foreign direct investment. At the same time, lower commodity prices reduce the appeal of mining. Some of South Africa's chief executives said that their companies would be focussing on keeping businesses going, cutting costs and closely monitoring debt in the midst of declining volumes, deteriorating margins and high fixed and funding costs.

The dependence of the health of the Southern African financial system on U.S. and UK markets have been a cause for concern. Indeed, in some cases, Southern African indices haven fallen further from their market highs than the Dow Jones. Further evidence of turmoil has been the downgrading of the banking-to-insurance group FirstRand's credit rating on 19 September 2008 by the rating agency Fitch. The reasons cited for this was the deteriorating macroeconomic conditions and worsening credit situation. Another South African company under duress is Old Mutual, the biggest insurer in the country. Its share price has been declining for the period 2007-2008 and it is one of 29 shares that the UK's Financial Services Authority has said may not be short sold until January 2009. This may partly be because of risk aversion towards investment in South African markets and companies when the global economy is subjected to distress.

Also, the movements in asset prices, credit extension and prudential behavior in Southern African economies have suggested that procyclicality partly induced by new regulation for credit risk has become problematic. In this regard, the Standardized approach to credit risk (that is employed by most small banks in Southern Africa) differentiates assets not only according to the borrower but according to riskiness proxied by credit rating agencies' assessment of the borrower. This approach represents an improvement in the sense that corporations are rated. However, it is deficient with respect to the viewpoint that ratings properly reflect risk and the inducing of procyclical capital charges which will lead to over-lending during booms and underlending during recessions. Also, the capital formula for the Internal Ratings Based (IRB) approach to credit risk (that is employed by most major banks in Southern Africa) is problematic. In short, the IRB capital formula is deduced by considering the large-portfolio asymptotic dynamics of a Merton model with a single common risk-factor. Many empirical studies have confirmed that this formula gives rise to procyclicality. Coupled to all of this is the fact that consumer confidence in South Africa

¹world's fifth largest mining group by market value

has plummeted from its record highs in August 2007.

Moreover, the June 2007 implementation of the National Credit Act (NCA) in South Africa, which might lengthen the foreclosure process for nonperforming loans, is expected to increase banks' ability to assess the creditworthiness of individual households and limit risks from household credit. However, some analysts predict that it may contribute to conditions favorable for a credit crunch in South Africa.

8.4 APPENDIX D: TIMELINE OF SUBPRIME MORTGAGE CRISIS EVENTS

The credit crisis has transformed the global financial landscape, bankrupting established names and prompting unprecedented interventions by governments and central banks to save others from collapse as they buckle under the weight of "toxic debts." This crisis timeline charts the key moments in that process.

8.4.1 1968 Timeline of Pre-Subprime Mortgage Crisis Events

1968: The Government mortgage-related agency, Federal National Mortgage Association (Fannie Mae) is converted from a federal government entity to a stand-alone government sponsored enterprise which purchases and securitizes mortgages to facilitate liquidity in the primary mortgage market. The move takes the debt of Fannie Mae off of the books of the government.

8.4.2 1970 Timeline of Pre-Subprime Mortgage Crisis Events

1970: Federal Home Loan Mortgage Corporation (Freddie Mac) is created by an act of Congress, as a GSE, to buy mortgages on the secondary market, pool them, and sell them as mortgage-backed securities to investors on the open market.

8.4.3 1977 Timeline of Pre-Subprime Mortgage Crisis Events

1977: Community Reinvestment Act passed to encourage banks and savings and loan associations to offer credit to individuals and businesses in lower income areas (12 U.S.C. 2901 et seq.).

8.4.4 1980's Timeline of Pre-Subprime Mortgage Crisis Events

1980: The Depository Institutions Deregulation and Monetary Control Act (DIDMCA) of 1980 granted all thrifts, including savings and loan associations, the power to make consumer and commercial loans and to issue transaction accounts, but with little regulatory

oversight of competing banks; also exempted federally chartered savings banks, installment plan sellers and chartered loan companies from state usury (unlimited interest rates) limits.

1981: Each Federal Reserve bank establishes a Community Affairs Office to ensure compliance with Community Reinvestment Act.

1982: Alternative Mortgage Transaction Parity Act of 1982 (AMTPA) - While DIDMCA provides a framework for higher interest rates, AMTPA preempts state laws that restrict a number of alternative mortgage features that are important subprime lending elements. Its intent was to increase the volume of loan products that reduced the up-front costs to borrowers in order to make homeownership more affordable. Specifically, the legislation allows lenders to originate mortgages with features such as variable interest rates, balloon payments, and negative amortization in any "loan or credit sale secured by an interest in residential real property made, purchased or enforced by covered lenders". AMTPA "allows lenders to make loans with terms that may obscure the total cost of a loan".

1986: Tax Reform Act of 1986 (TRA) - TRA prohibited taxpayers from deducting interest on consumer loans, such as credit cards and auto loans, while it allowed them to deduct interest paid on mortgage loans secured by their principal residence and one additional home. This change provided an incentive for homeowners to take home equity loans and use the proceeds to pay off consumer debt, which usually has higher interest rates than home equity debt.

1985-1991: Savings and Loan Crisis The number of U.S. federally insured savings and loans in the United States declined from 3,234 to 1,645 [8] This was primarily, but not exclusively, due to unsound real estate lending. The market share of S&Ls for single family mortgage loans went from 53 % in 1975 to 30 % in 1990. New homes constructed dropped from 1.8 (in 1986) to 1 million (in 1991), the lowest rated since World War II.

1989: Financial Institutions Reform, Recovery and Enforcement Act ("FIRREA") enacted which established the Resolution Trust Corporation (RTC), closing hundreds of insolvent thrifts and moved regulatory authority to the Office of Thrift Supervision (OTS); required federal agencies to issue Community Reinvestment Act ratings publicly.

8.4.5 1990's Timeline of Pre-Subprime Mortgage Crisis Events

1989-1995: Resolution Trust Corporation closed or otherwise resolved 747 thrifts with total assets of \$ 394 billion.

1992: Federal Housing Enterprises Financial Safety and Soundness Act of 1992 required Fannie Mae and Freddie Mac to devote a percentage of their lending to support affordable

housing increasing their pooling and selling of such loans as securities; Office of Federal Housing Enterprise Oversight (OFHEO) created to oversee them.

1994: Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 (IBBEA) repeals the interstate provisions of the Bank Holding Company Act of 1956 that regulated the actions of bank holding companies. 1995: New Community Reinvestment Act regulations break down home-loan data by neighborhood, income, and race, enabling community groups to complain to banks and regulators about CRA compliance. Regulations also allows community groups that market loans to collect a broker's fee.[15] Fannie Mae allowed to receive affordable housing credit for buying subprime securities.

1997: Mortgage denial rate of 29 percent for conventional home purchase loans. Investors purchased more than \$60 billion of subprime mortgage backed securities, six times more than 1991s volume of \$ 10 billion (private label securities, not GSE backed).

July 1997: The Taxpayer Relief Act of 1997 expanded the capital-gains exclusion to \$ 500,000 (per couple) from \$ 125 000, encouraging people to invest in second homes and investment properties.

November 1997: Freddie Mac helped First Union Capital Markets and Bear, Stearns & Co launch the first publicly available securitization of CRA loans, issuing \$ 384.6 million of such securities. All carried a Freddie Mac guarantee as to timely interest and principal. First Union was not a subprime lender.

1998: Incipient housing bubble as inflation-adjusted home price appreciation exceeds 10 % per year in most West Coast metropolitan areas. Inflation-adjusted home price appreciation exceeds 10 % per year in most West Coast metropolitan areas.

October 1998: "Financial Services Modernization Act" killed in Senate because of no restrictions on Community Reinvestment Act-related community groups written into law.

September 1999: Fannie Mae eases the credit requirements to encourage banks to extend home mortgages to individuals whose credit is not good enough to qualify for conventional loans.

November 1999: Gramm-Leach-Bliley Act "Financial Services Modernization Act" repeals Glass-Steagall Act, deregulates banking, insurance and securities into a financial services industry allow financial institutions to grow very large; limits Community Reinvestment Coverage of smaller banks and makes community groups report certain financial relationships with banks.

8.4.6 2000 Timeline of Pre-Subprime Mortgage Crisis Events

2000: Fannie Mae bought only \$ 600 million of subprime mortgages, primarily on a flow basis. Freddie Mac, in that same year, purchased \$ 18.6 billion worth of subprime loans, mostly Alt A and A- mortgages. Freddie Mac guaranteed another \$ 7.7 billion worth of subprime mortgages in structured transactions. These totals are small compared to the total size (about \$160 billion) of the subprime market.

October 2000: Fannie Mae committed to purchase and securitize \$2 billion of Community Investment Act-eligible loans.

November 2000: Fannie Mae announced that the Department of Housing and Urban Development (“HUD”) would soon require it to dedicate 50 % of its business to low- and moderate-income families and its goal was to finance over \$500 billion in Community Investment Act-related business by 2010.

December 2000: Commodity Futures Modernization Act of 2000 defines interest rates, currency prices, and stock indexes as “excluded commodities,” allowing trade of credit-default swaps by hedge funds, investment banks or insurance companies with minimal oversight, and contributing to 2008 crisis in Bear Stearns, Lehman Brothers and AIG.

1995-2001: Dot-com bubble and collapse

8.4.7 2001-2004 Timeline of Pre-Subprime Mortgage Crisis Events

2000-2003: Early 2000s recession (exact time varies by country).

2000-2001: U.S. Federal Reserve lowers Federal funds rate 11 times, from 6.5 % (May 2000) to 1.75 % (December 2001), creating an easy-credit environment that encouraged less-qualified home buyers and investments in higher yielding subprime mortgages.

2000-2002: Annual home price appreciation of 10 % or more in California, Florida, and most Northeastern states.

June 17 2001: President G.W. Bush sets goal of increasing minority home owners by at least 5.5 million by 2010 through billions of dollars in tax credits, subsidies and a Fannie Mae commitment of \$ 440 billion to establish NeighborWorks America with faith based organizations.

2002-2003: Mortgage denial rate of 14 percent for conventional home purchase loans, half of 1997.

2003: Fannie Mae and Freddie Mac buy \$ 81 billion in subprime securities.

June 2003: Federal Reserve Chair Alan Greenspan lowers federal reserves key interest rate to 1, the lowest in 45 years.

September 2003: Bush administration recommended moving governmental supervision of Fannie Mae and Freddie Mac under a new agency created within the Department of the Treasury. The changes were blocked by Congress.

2003–2007: The Federal Reserve failed to use its supervisory and regulatory authority over banks, mortgage underwriters and other lenders, who abandoned loan standards (employment history, income, down payments, credit rating, assets, property loan-to-value ratio and debt-servicing ability), emphasizing instead lender's ability to securitize and repackage subprime loans.

2004: U.S. homeownership rate peaked with an all time high of 69.2 percent. HUD ratcheted up Fannie Mae and Freddie Mac affordable-housing goals for next four years, from 50 percent to 56 percent, stating they lagged behind the private market; they purchased \$ 175 billion in 2004 – 44 percent of the market; from 2004 to 2006, they purchased \$ 434 billion in securities backed by subprime loans.

October 2004: SEC effectively suspends net capital rule for five firms - Goldman Sachs, Merrill Lynch, Lehman Brothers, Bear Stearns and Morgan Stanley. Freed from government imposed limits on the debt they can assume, they levered up 20, 30 and even 40 to 1.

2004–2005: Arizona, California, Florida, Hawaii, and Nevada record price increases in excess of 25 % per year.

8.4.8 2005 Timeline of Pre-Subprime Mortgage Crisis Events

Tuesday, 1 February 2005 to Monday, 28 February 2005: Warning sign when EWI Subprime Lenders Index tops.

Wednesday, 1 June 2005 to Thursday, 30 June 2005: Warning sign when Dow Jones Homebuilder Index tops.

Monday, 1 August 2005 to Wednesday, 28 August 2005: Warning sign when S&P Homebuilding Index tops.

8.4.9 2006 Timeline of Pre-Subprime Mortgage Crisis Events

Tuesday, 1 August 2006 to Thursday, 31 August 2006: Calm before the storm when Florida Condo Market tops.

Friday, 1 December 2006 to Sunday, 31 December 2006: Calm before the storm when ABX (Mortgage Derivative) Index tops.

8.4.10 2007 Timeline of Subprime Mortgage Crisis Events

Monday, 1 January 2007 to Wednesday, 31 January 2007: Calm before the storm when Banking Index tops.

Wednesday, 3 January 2007: Ownit Mortgage Solutions Inc. files for Chapter 11. Records show that Ownit Mortgage Solutions owed Merrill Lynch around \$ 93 million at the time of filing.

Thursday, 1 February 2007 to Saturday, 31 March 2007: Subprime industry collapses; more than 25 subprime lenders declaring bankruptcy, announcing significant losses or putting themselves up for sale.

Monday, 5 February 2007: Mortgage Lenders Network USA Inc., the country's 15th largest subprime lender with \$ 3.3 billion in loans funded in third quarter 2006, files for Chapter 11.

Wednesday, 7 February 2007: HSBC announces losses linked to U.S. subprime mortgages.

Thursday, 1 March 2007 to Saturday, 31 March 2007: Ben Bernanke suggested more Fannie Mae and Freddie Mac loans be extended to help banks fulfill their Community Investment Act (CIA) obligations by providing them with more opportunities to securitize CRA-related loans. He also said,

“The role of the GSEs in subprime lending and whether to increase or decrease their exposure to such lending are important questions for Congress. The GSEs have been only indirect players in the subprime market, purchasing mainly AAA-debt that has been collateralized with subprime mortgages and leaving the higher risk components of the subprime mortgages to be funded by other market participants.”

Monday, 2 April 2007: New Century Financial, largest U.S. subprime lender, files for chapter 11 bankruptcy.

Tuesday, 3 April 2007: According to CNN Money, business sources report lenders made \$ 640 billion in subprime loans in 2006, nearly twice the level 3 years earlier. Subprime loans amounted to about 20 percent of the nation's mortgage lending and about 17 percent of home purchases; financial firms and hedge funds likely own more than \$ 1 trillion in securities backed by subprime mortgage; about 13 percent of subprime loans are now delinquent, more than five times the delinquency rate for home loans to borrowers with top credit; more than 2 percent of subprime loans had foreclosure proceedings start in the fourth quarter.

Wednesday, 18 April 2007: Freddie Mac fined \$ 3.8 million by far the Federal Election Commission as a result of illegal campaign contributions, much of it to members of the United States House Committee on Financial Services which oversaw Freddie Mac.

Thursday, 17 May 2007: Federal Reserve Chairman Ben Bernanke said growing number of mortgage defaults will not seriously harm the U.S. economy. In fact, he states that the subprime mess is "contained."

Friday, 1 June 2007 to Saturday, 30 June 2007: Two Bear Stearns-run hedge funds with large holdings of subprime mortgages run into large losses and are forced to dump assets. The trouble spreads to major Wall Street firms such as Merrill Lynch, JPMorgan Chase, Citigroup and Goldman Sachs which had loaned the firms money.

Thursday, 7 June 2007: Bear Stearns informs investors in two of its funds, the High-Grade Structured Credit Strategies Enhanced Leverage Fund and the High-Grade Structured Credit Fund that it was halting redemptions.

Thursday, 19 July 2007: Dow Jones Industrial Average closes above 14 000 for the first time in its history.

Friday, 20 July 2007: Merrill Lynch seized \$ 800 million in assets from two Bear Stearns hedge funds that were involved in securities backed by subprime loans.

Wednesday, 25 July 2007: Panic with a U.S. wide bank run.

Wednesday, 1 August 2007 to Friday, 31 August 2007: French bank BNP Paribas freezes withdrawals in three investment funds. Worldwide "credit crunch" as subprime mortgage backed securities are discovered in portfolios of banks and hedge funds around the world, from BNP Paribas to Bank of China. Many lenders stop offering home equity loans and "stated income" loans. Federal Reserve injects about \$ 100B into the money supply for banks to borrow at a low rate.

Monday, 6 August 2007: American Home Mortgage Investment Corporation (AHMI) filed Chapter 11 bankruptcy. The company expected to see up to a \$ 60 million loss for the first quarter 2007.

Wednesday, 8 August 2007: Mortgage Guaranty Insurance Corporation (MGIC, Milwaukee, Wisconsin) announced it would discontinue its purchase of Radian Group after suffering a billion-dollar loss of its investment in Credit-Based Asset Servicing and Securitization (C-BASS, New York)].

Thursday, 9 August 2007: French bank, BNP Paribas, stopped valuing three of its funds and suspended all withdrawals due to “a complete evaporation of liquidity.”

Friday, 10 August 2007: Central banks coordinate efforts to increase liquidity for first time since the aftermath of the September 11, 2001 terrorist attacks. The United States Federal Reserve (Fed) has injected a combined \$ 43 billion, the European Central Bank (ECB) €156 billion (\$ 214.6 billion), and the Bank of Japan 1 trillion Yen (\$ 8.4 billion). Smaller amounts have come from the central banks of Australia, and Canada.

Tuesday, 14 August 2007: Sentinel Management Group suspended redemptions for investors and sold off \$ 312 million worth of assets; three days later it Sentinel filed for Chapter 11 bankruptcy protection. U.S. and European stock indices continued to fall.

Wednesday, 15 August 2007: The stock of Countrywide Financial, which is the largest mortgage lender in the United States, fell around 13 % on the New York Stock Exchange after Countrywide said foreclosures and mortgage delinquencies had risen to their highest levels since early 2002.

Thursday, 16 August 2007: Countrywide Financial Corporation, the biggest U.S. mortgage lender, narrowly avoids bankruptcy by taking out an emergency loan of \$11 billion from a group of banks.

Friday, 17 August 2007: The U.S. Federal Reserve cuts the discount rate by half a percent to 5.75 % from 6.25 % while leaving the federal funds rate unchanged in an attempt to stabilize financial markets.

Wednesday, 29 August 2007: The Australian Hedge Fund, Basis Capital’s “Basis Yield Alpha Fund” applied for bankruptcy protection.

Friday, 31 August 2007: President Bush announces a limited bailout of U.S. homeowners unable to pay the rising costs of their debts. Ameriquest, once the largest subprime lender in the U.S., goes out of business.

Saturday, 1 September 2007 to Sunday, 30 September 2007: Crisis-hit UK bank, Northern Rock, admits financial difficulties as it asks Bank of England for assistance. Share prices fall as customers queue up to withdraw their money.

Saturday, 1 September 2007 to Monday, 3 September 2007: The U.S. Federal Reserve's Economic Symposium in Jackson Hole, WY, addressed the housing recession that jeopardizes U.S. growth. Several critics argued that the Fed should use regulation and interest rates to prevent asset-price bubbles, blamed former U.S. Federal Reserve's chairman, Alan Greenspan's, low interest rate policies for stoking the U.S. housing boom and subsequent bust. Furthermore, Yale University economist, Robert Shiller, warned of possible home price declines of 50 %.

Thursday, 6 September 2007: The U.S. Federal Reserve added \$ 31.25 billion in temporary reserves (loans) to the U.S. money markets which had to be repaid in two weeks.

Friday, 7 September 2007: U.S. Labor Department announced that non-farm payrolls fell by 4 000 in August 2007, the first month of negative job growth since August 2003, due in large part to problems in the housing and credit markets.

Thursday, 13 September 2007: British bank Northern Rock applied to the Bank of England for emergency funds caused by liquidity problems. Concerned customers produced "an estimated 2 billion Pounds withdrawn in just three days."

Friday, 14 September 2007: A run on the bank forms at the United Kingdom's Northern Rock bank precipitated by liquidity problems related to the subprime crisis.

Monday, 17 September 2007: Former U.S. Federal Reserve chairman, Alan Greenspan, said

"... we had a bubble in housing" and warns of "large double digit declines" in home values "larger than most people expect."

Tuesday, 18 September 2007: The U.S. Federal Reserve cuts interest rates by 50 basis points, i.e., half a point (0.5 %), in an attempt to limit damage to the economy from the housing and credit crises.

Friday, 28 September 2007: Television finance personality, Jim Cramer, warns Americans on The Today Show, "don't you dare buy a home you'll lose money," causing a furor among realtors.

Sunday, 30 September 2007: Affected by the spiraling mortgage and credit crises, Internet banking pioneer, NetBank, goes bankrupt and the Swiss bank, UBS, announced that it lost U.S. \$ 690 million in the third quarter.

Monday, 1 October 2007: Swiss bank, UBS, announces losses linked to U.S. subprime mortgages.

Friday, 5 October 2007: Investment bank, Merrill Lynch, reports losses of \$ 5.5 billion. Merrill Lynch announced a U.S. \$ 5.5 billion loss as a consequence of the subprime crisis, which was revised to \$ 8.4 billion on October 24, a sum that credit rating firm Standard & Poor's called "startling".

Tuesday, 9 October 2007: The Dow Jones reaches a record high of 14 164.53.

Wednesday, 10 October 2007: Hope Now Alliance was created by the U.S. Government and private industry to help some sub-prime borrowers.

Monday, 15 October 2007 to Wednesday, 17 October 2007: Citigroup announces \$ 6.5 billion third quarter losses. A consortium of U.S. banks backed by the U.S. government announced a "super fund" of \$ 100 billion to purchase MBS whose mark-to-market value plummeted in the subprime collapse. Both U.S. Federal Reserve chairman, Ben Bernanke, and Treasury Secretary, Hank Paulson, expressed alarm about the dangers posed by the bursting housing bubble. In particular, Paulson said

"the housing decline is still unfolding and I view it as the most significant risk to our economy. ... The longer housing prices remain stagnant or fall, the greater the penalty to our future economic growth."

Wednesday, 24 October 2007: Merrill Lynch announces losses to be over \$ 8 billion.

Wednesday, 31 October 2007: Federal Reserve lowers the federal funds rate by 25 basis points to 4.5 %. S&P500 and DJIA top. Nasdaq tops.

Thursday, 1 November 2007: Federal Reserve injects \$ 41B into the money supply for banks to borrow at a low rate. The largest single expansion by the Fed since \$ 50.35B on September 19, 2001.

Thursday, 15 November 2007: Financial Accounting Standards Board "Fair Value Measurements" standards upgrade the quality of financial reporting through greater transparency. However, this "mark-to-market" accounting may exaggerate the loss in value of an asset, as shown on balance sheets, and trigger a cascade of unnecessary financial losses.

Saturday, 1 December 2007 to Monday, 31 December 2007: The U.S. Federal Reserve creates a TAF to support banks. The U.S. Federal Reserve cuts rates by 25 basis points or 0.25 %.

Thursday, 6 December 2007: President Bush announced a plan to voluntarily and temporarily freeze the mortgages of a limited number of mortgage debtors holding adjustable

rate mortgages (ARM). He also asked Members Of Congress to:

1. pass legislation to modernize the FHA.
2. temporarily reform the tax code to help homeowners refinance during this time of housing market stress.
3. pass funding to support mortgage counseling.
4. pass legislation to reform Government Sponsored Enterprises (GSEs) like Freddie Mac and Fannie Mae.

Monday, 24 December 2007: A consortium of banks officially abandons the U.S. government-supported “super-SIV” mortgage crisis bail-out plan announced in mid-October, citing a lack of demand for the risky mortgage products on which the plan was based, and widespread criticism that the fund was a flawed idea that would have been difficult to execute.

8.4.11 2008 Timeline of Subprime Mortgage Crisis Events

Tuesday, 1 January 2008 to Thursday, 31 January 2008: Swiss bank UBS announces fourth quarter losses at \$ 14 billion. The U.S. Federal Reserve cuts rates by 125 basis points or 1.25 %. U.S. banking reserves become negative. 2.2 million foreclosures reported for the preceding year, viz., 2007.

Wednesday, 2 January 2008 to Monday, 21 January 2008: January 2008 stock market downturn.

Friday, 11 January 2008: Bank of America pays \$ 4 billion for Countryside Financial.

Tuesday, 15 January 2008: Citigroup reports \$ 18.1 billion loss in fourth quarter.

Thursday, 17 January 2008: Merrill Lynch reports \$ 11.5 billion loss in fourth quarter. Washington Mutual posts losses.

Thursday, 24 January 2008: The National Association of Realtors (NAR) announced that 2007 had the largest drop in existing home sales in 25 years, and

“the first price decline in many, many years and possibly going back to the Great Depression.”

Friday, 1 February 2008 to Friday, 29 February 2008: U.S. consumer confidence falls to lowest levels in 15 years. Service industry (ISM Index) contracts to recession levels.

Wednesday, 13 February 2008: U.K. bank Northern Rock is nationalized.

Saturday, 1 March 2008 and Monday, 31 March 2008: UK hedge fund Peloton Partners and U.S. fund Carlyle Capital fail.

Saturday, 1 March 2008 and Wednesday, 18 June 2008: 406 people were arrested for mortgage fraud in an FBI sting across the U.S., including buyers, sellers and others across the wide-ranging mortgage industry.

Monday, 10 March 2008: Dow Jones Industrial Average at the lowest level since October 2006, falling more than 20 % from its peak just five months prior.

Sunday, 14 March 2008: Bear Stearns gets Fed funding as shares plummet.

16 March 2008: Bear Stearns, the U.S.'s fifth largest investment bank collapses and is taken over by JP Morgan. In particular, Bear Stearns gets acquired for \$ 2 a share by JP Morgan Chase in a fire sale avoiding bankruptcy. The deal is backed by Federal Reserve providing up to \$ 30 billion to cover possible Bear Stearns losses.

Tuesday, 1 April 2008: German Deutsche Bank credit losses of \$ 3.9 billion in first quarter.

Sunday, 13 April 2008: U.S. bank Wachovia Corp. reports big loss for quarter.

Tuesday, 6 May 2008: UBS AG Swiss bank announced plans to cut 5,500 jobs by the middle of 2009.

Monday, 12 May 2008: HSBC writes off \$ 3.2 billion in the first quarter linked to exposure to the U.S. subprime market.

Thursday, 22 May 2008: WaMu reports \$ 3.3 billion loss for second quarter.

Wednesday, 18 June 2008: As the chairman of the Senate Banking Committee Connecticut's Christopher Dodd proposed a housing bailout to the Senate floor that would assist troubled subprime mortgage lenders such as Countrywide Bank, Dodd admitted that he received special treatment, perks, and campaign donations from Countrywide, who regarded Dodd as a "special" customer and a "Friend of Angelo." Dodd received a \$ 75,000 reduction

in mortgage payments from Countrywide. The Chairman of the Senate Finance Committee, Kent Conrad, and the head of Fannie Mae, Jim Johnson, also received mortgages on favorable terms due to their association with Countrywide CEO Angelo R. Mozilo.

Thursday, 19 June 2008: Ex-Bear Stearns fund managers were arrested by the FBI for their allegedly fraudulent role in the subprime mortgage collapse. The managers purportedly misrepresented the fiscal health of their funds to investors publicly while privately withdrawing their own money.[93]

Friday, 11 July 2008: IndyMac Bank was shut down by the FDIC. We note that Indymac, a subsidiary of Independent National Mortgage Corporation (Indymac), is placed into the receivership of the FDIC by the Office of Thrift Supervision. It was the fourth largest bank failure in United States history, and the second largest failure of a regulated thrift. Before its failure, IndyMac Bank was the largest savings and loan association in the Los Angeles area and the seventh largest mortgage originator in the United States.

Sunday, 31 August 2008: German Commerzbank AG takes over Dresdner Kleinwort investment bank.

Sunday, 7 September 2008: Fannie Mae and Freddie Mac effectively nationalized by the U.S. Treasury which places them into “conservatorship.” Fannie Mae and Freddie Mac at that point owned or guaranteed about half of the U.S.’s \$ 12 trillion mortgage market.

Tuesday, 9 September 2008: Lehman Brothers shares plummet to lowest level on Wall Street in more than a decade.

Sunday, 14 September 2008: Lehman Brothers files for bankruptcy. Stock markets plummet; Central banks inject billions of dollars into money markets. Merrill Lynch sold to Bank of America amidst fears of a liquidity crisis and Lehman Brothers collapse.

Monday, 15 September 2008: Lehman Brothers files for bankruptcy protection.

Tuesday, 16 September 2008: AIG Corp, the world’s biggest insurer bailed out by the U.S. Federal Reserve. Morgan Stanley and Wachovia enter merger talks. Moody’s and Standard and Poor’s downgrade ratings on AIG’s credit on concerns over continuing losses to MBS, sending the company into fears of insolvency.

Wednesday, 17 September 2008: Halifax Bank of Scotland (HBOS) merges with UK bank Lloyds TSB in an emergency rescue plan representing one-third of the UK’s savings and mortgage market. The U.S. Federal Reserve loans \$ 85 billion to American International Group (AIG) to avoid bankruptcy.

Thursday, 18 September 2008: Fed and other central banks inject billions into global markets to help ease the crunch.

Friday, 19 September 2008: Paulson financial rescue plan unveiled after a volatile week in stock and debt markets.

Monday, 22 September 2008: Japan's Nomura Holdings buys Lehman's Asian operations for up to \$ 525 million.

Thursday, 25 September 2008: Washington Mutual (WaMu) sold to JP Morgan Chase. More specifically, Washington Mutual was seized by the Federal Deposit Insurance Corporation, and its banking assets were sold to JP Morgan Chase for \$ 1.9bn.

Saturday, 27 September 2008: HSBC announces 1 100 job cuts worldwide.

Monday, 29 September 2008: UK's Bradford & Bingley nationalized. Spanish banking giant Santander to buy deposits for \$ 38.2 billion. U.S. House of Representatives rejects a \$ 700 billion plan to bail out the U.S. financial system. The Dow Jones index sees its largest one-day point loss (777.68 points) ever after the House votes down the rescue plan. The S&P 500 has its largest point drop ever and second-largest percentage drop in history. More specifically, Emergency Economic Stabilization Act defeated 228-205 in the U.S. House of Representatives. German bank Hypo Real Estate is bailed out by a consortium of banks. Federal Deposit Insurance Corporation (FDIC) announces that Citigroup Inc., the world's largest bank, would acquire banking operations of Wachovia. Irish government moves to safeguard all bonds, debts and deposits for two years in six banks and building societies. Belgian insurance giant Fortis is bailed out by the governments of the Netherlands, Belgium and Luxembourg. Iceland's third largest bank Glitnir nationalized.

Tuesday, 30 September 2008: Belgian bank, Dexia, bailed out by France, Belgium and Luxembourg. Swiss bank, UBS, expected to announce losses before 2 October 2008 shareholder meeting.

Wednesday, 1 October 2008: The U.S. Senate passes HR1424, their version of the \$ 700 billion bailout bill. The financial crisis is spreading to Europe.

Friday, 3 October 2008: The U.S. Congress passes \$ 700 billion bail-out, President Bush signs it into law. Swiss bank UBS to cut 2000 jobs. Dutch government nationalizes banking and insurance activities of Fortis. The U.S. House of Representatives passes HR1424 and President George W. Bush signs it into law. It contains also easing of the accounting rules that forced companies to collapse because of the existence of toxic mortgage-related investments.

Saturday, 4 October 2008 to Monday, 6 October 2008: Proposed Hypo Real Estate bailout collapses. German Chancellor, Angela Merkel, announces new plan for Hypo bailout worth \$ 69bn. Merkel also announces guarantee of deposits in German banks. UK raises limit on guaranteed bank deposits from £35 000 – £50 000. EU leaders meet in Paris for emergency summit to discuss financial crisis. Battle rages between Citigroup and Wells Fargo over purchase of Wachovia. French bank, BNP Paribas, takes 75 % stake in Fortis.

Monday, 6 October 2008 to Friday, 10 October 2008: Worst week for the stock market in 75 years. The Dow Jones lost 22.1 percent, its worst week on record, down 40.3 % since reaching a record high of 14 164.53 on 9 October 2007. The Standard & Poor's 500 index lost 18.2 percent, its worst week since 1933, down 42.5 percent in since its own high October 9, 2007.

Monday, 6 October 2008: Major markets in Europe, Asia and Latin America sank as traders looked past America's bank bailout bill and focused on Europe's growing financial crisis. Danish government announces plan to guarantee bank deposits. Wells Fargo and Citigroup agree to legal standstill in battle for Wachovia. Bank of America reports 68 % profit drop, stock sale to raise \$ 10bn. Fed will provide \$ 900 billion in short-term cash loans to banks. Bank of America agrees to settle claim of predatory lending charges against recently acquired Countrywide Financial. The settlement was with attorney generals in 11 states. Bank of America agreed to offer more affordable mortgage payments to borrowers who financed with subprime mortgage loans or pay option adjustable rate mortgages serviced by Countrywide and originated before December 31, 2007. Bank of America said that around 400,000 borrowers will be helped by the deal. The Danish government announces plan to guarantee all banking deposits and some inter-bank loans. In return for the guarantees, the countrys banks must establish a rescue fund of \$ 6.5 billion. BNP Paribas agrees to takeover Fortis from the Belgian government for €14.5 billion. This deal makes BNP the largest bank operating in the Eurozone. Iceland, as a measure to ease the 2008 Icelandic financial crisis, passes legislation that allows the government to nationalize, merge, or force ailing banks into bankruptcy. The new bill also allows the government to take over housing loans held by the banks and put them into a government housing fund.

Tuesday, 7 October 2008: Wall Street's drubbing continued with a 500-point loss bringing the Dow's two-day slump to nearly 900 points (a five year low), as the Federal Reserve's plan to loosen credit markets failed to temper investor pessimism. Icelandic bank Landsbanki nationalized; Icesave, Landbank's internet bank, freezes UK customers' accounts. Fed makes emergency move to lend around \$ 1.3 trillion directly to companies. Bank of America reports third quarter earnings of \$ 1.2 billion, less than analyst expectations. In an effort to get through the credit crisis, BofA cut its dividend by half and announced plans to raise an additional \$10bn in capital. The Internal Revenue Service (IRS) relaxes rules on U.S. corporations repatriating money held overseas in an attempt to inject liquidity into the U.S.

financial market. The new ruling allows the companies to receive loans from their foreign subsidiaries for longer periods and more times a year without triggering the 35 % corporate income tax.

Wednesday, 8 October 2008: Treasury freezes assets of Landsbanki in the UK; threatens legal action. UK Treasury announces Pound 500 billion bank rescue package. Central banks in USA (Fed), England, China, Canada, Sweden, Switzerland and the European Central Bank cut rates in a coordinated effort to aid world economy. Fed also reduced its emergency lending rate to banks by half a percentage point, to 1.75 percent. White House considers taking ownership stakes in private banks as a part of the bailout bill. Warren Buffett and George Soros criticized the original approach of the bailout bill. The IMF, in its bleakest forecast in years, sees major global downturn. Japan's Nikkei plunged more than 9 percent and Indonesia's Jakarta composite dropped 10 percent as Asia markets responded to the Dow's lowest close in five years and fears of a global recession. Europe's financial markets suffered more heavy losses despite the world's leading economies slashing interest rates to tackle the global financial crisis. The New York Stock Exchange opened nervously following the interest rate cuts. Markets in Britain, France and Germany closed well down despite the coordinated rate cuts led by the United States. The prime loan rate cuts on this day can be summarized as follows:

8/10/2008 Interest Rate Changes	
Country	Changes
United States:	2 % to 1.5 %
Canada:	3 % to 2.5 %
European Central Bank:	5 % to 4.5 %
England:	5 % to 4.5 %
Switzerland:	2.75 % to 2.25 %
Sweden:	5 % to 4.25 %
China:	7.24 % to 6.93 %
Hong Kong:	3.5 % to 2.5 %
Japan:	Holding at 0.5 %

Thursday, 9 October 2008: Iceland nationalizes its biggest bank Kaupthing.

Friday, 10 October 2008 (Black Friday): G7 finance ministers meet in Washington and issue a five-point plan. Nikkei falls almost 10 %, biggest drop in 20 years. FTSE falls more than 10 %, closes at 8.85 %; worst daily fall since 1987. Oil prices fall to \$ 80 a barrel. Dow crashes nearly 700 points before regaining some lost ground. Icelandic bank Kaupthing is nationalized. Japanese company, Yamato Life, files for bankruptcy becoming what is viewed as the first direct casualty in Japan from the fallout of the U.S. subprime

mortgage crisis. Yamato Life had \$ 2.7 billion in liabilities at the time of the filing. Japanese government officials tried to downplay the bankruptcy as a special case based on Yamatos unique business model but some analysts believed it to be a foreshadowing of things to come in Japan as the credit crisis begins to affect the country.

Saturday, 11 October 2008: The Dow Jones Industrial Average caps its worst week ever with its highest volatility day ever recorded in its 112 year history. Over the last eight trading days, the DJIA has dropped 22 % amid worries of worsening credit crisis and global recession. Paper losses now on U.S. stocks now total \$ 8.4 trillion from the market highs last year. The G7, a group of central bankers and finance ministers from the Group of Seven leading economies, meet in Washington and agree to urgent and exceptional coordinated action to prevent the credit crisis from throwing the world into depression. The G7 did not agree on the concrete plan that was hoped for.

Saturday, 11 October 2008 and Sunday, 12 October 2008: The Fed approves Wachovia takeover by Wells Fargo. 15 EU leaders meet in Paris for emergency summit on crisis. Gordon Brown urges them to adopt similar measures to UK bank rescue plan. Leaders agree to guarantee loans between banks until end of 2009. Germany, France and Italy to announce individual plans Monday. Australia agrees to guarantee deposits for next 3 years. New Zealand guarantees bank deposits for 2 years.

Monday, 13 October 2008: EU stock markets bounce back in response to EU leaders' bailout announcements. UK bails out 3 banks: RBS, HBOS and Lloyds TSB at cost of \$ 63 billion. Bank of England loans \$ 174 million to Icelandic bank Landsbanki to help repay UK depositors. French president, Nicolas Sarkozy, pledges €360 billion in liquidity to French banks. The plan will include €320 billion in guarantees for new bank debt and a €40 billion fund for recapitalizing lenders. In return for the bailout, the French government will demand conditions on the banks such as changes to pay and bonus structures. The prime minister of Spain, Jose Luis Rodriguez Zapatero, announces that Spain will provide up to €100 billion of guarantees for new debt issued by commercial banks in 2008. This plan followed a meeting at the eurozone summit over the weekend to try to develop a coordinated effort to combat the credit crisis. The UK government starts the nationalization process by injecting £37 billion in the nations three largest banks. The UK government will end up owning a majority share in the Royal Bank of Scotland (RBS) and over a 40 % share in Lloyds and HBOS. In return for the bailout, the banks have agreed to cancel dividend payments until the loans are repaid, have board members appointed by the Treasury, and limit executive pay. The European Central Bank attempts to revive credit market by weekly injections of unlimited euro funds at an interest rate of 3.75 %. The ECB president, Jean-Claude Trichet, was also contemplating relaxing the collateral standards to make the funds more accessible to banks. Following its European partners, Italy pledges to intervene as necessary to prevent any bank failures in its country. Finance minister, Giulio Tremonti, said Italy

will guarantee new bank bonds of up to 5 years until the end of 2009 and the Bank of Italy will provide €40 billion in treasury bills to banks to refinance inferior assets that can not be currently used as collateral. In coordination with other eurozone countries, the Dutch government announces it will guarantee interbank lending up to €200 billion. This follows the set up of a €20 billion Dutch fund to help recapitalize banks and insurers. Germany approves a plan to inject €500 billion into credit markets. The plan gives finance minister, Peer Steinbrück, access to a €100 billion stabilization fund and the authority to guarantee up to €400 billion in bank debt. Concessions by banks who tap into this fund include a €500,000 limit on executive pay, a ban on bonuses, and a ban on dividend payments.

Tuesday, 14 October 2008: Iceland in talks with Russia to negotiate emergency loan of \$ 5.44 billion after bank collapses. U.S. follows UK lead by part-nationalizing banks. The U.S. taps into the \$ 700 billion available from the Emergency Economic Stabilization Act and announces the injection of \$ 250 billion of public money into the U.S. banking system. The form of the rescue will include the U.S. government taking an equity position in banks that choose to participate in the program in exchange for certain restrictions such as executive compensation. Nine banks agreed to participate in the program and will receive half of the total funds:

- 1) Bank of America;
- 2) JPMorgan Chase;
- 3) Wells Fargo;
- 4) Citigroup;
- 5) Merrill Lynch;
- 6) Goldman Sachs;
- 7) Morgan Stanley;
- 8) Bank of New York Mellon;
- 9) State Street.

Other U.S. financial institutions eligible for the plan have until November 14 to agree to the terms. United Arab Emirates (UAE) ministry of finance added a \$ 19 billion liquidity

injection to domestic banks bringing the total dollars injected to \$ 32.7 billion. The UAE central bank offered \$ 13.6 billion in liquidity to help domestic banks in September. To protect local deposits, the UAE government guaranteed all deposits and interbank lending. Japan announces a plan that will help steady the Japanese market and avoid the worse of the credit crisis. Among the measures included are lifting restrictions on companies buying back their shares, strengthening disclosure on short selling, and the temporary suspension of the sale of government-owned stocks. The Australian government unveils a \$ 10.4 billion stimulus package. The Economic Security Strategy is designed to help pensioners, low and middle income families, and first time home buyers withstand the credit crisis and global economic slowdown. This followed the Australian government announcing that it would guarantee all bank deposits for three years, guarantee all term wholesaling funding by Australian banks in international markets and double its planned purchase of residential MBS. The Icelandic stock exchange begins trading again after a three day shutdown. The opening did not include Iceland's three largest banks which were nationalized last week.

Wednesday, 15 October 2008: European and Asian stock markets fall after initial upswing. Southeast Asian nations agree to start fund to provide financial support to countries in crisis; World Bank commits \$ 10 billion to the planned fund. Russian stock market posts losses as RTS Index falls below 800 points.

Thursday, 16 October 2008: Global markets fall on fears of global slowdown. Citigroup delays merger of its Japanese brokerage units due to costs involved. Swiss government bails out UBS with \$ 59.2 billion. Credit Suisse posts 1.3 billion-franc third quarter loss; raises \$ 8.7 billion from investors. Hungarian central bank gets cash injection from ECB to value of \$ 6.7 billion. EU leaders at Brussels summit call for complete overhaul of international financial system.

Saturday, 18 October and Sunday, 19 October 2008: Following a conference at Camp David over the weekend of 18 and 19 October, attended by President Nicolas Sarkozy of France and José Manuel Barroso, President of the European Commission, President George W. Bush announced on Wednesday, October 22 that he would host an international conference of financial leaders on November 15 in Washington, D.C. Participants would be drawn from both the developed world and the developing world, including participants from the G20 industrial nations such as India, Brazil and China.

Sunday, 19 October 2008 to Saturday, 25 October 2008: Despite some improvement in the availability of credit, stock markets and weak currencies such as the British Pound and the Euro continued to decline worldwide during the week of October 19. Markets across Asia suffered particularly heavy losses while European markets experienced substantial losses too, but to a lesser extent compared to those in Asia. The Dow Industrials Index, on the other hand, experienced a week of extreme volatility with violent swings both upwards and

downwards, eventually ending lower. The Yen and the Dollar showed particular strength with the Yen rising with respect to the Dollar. This “flight to quality” had baleful effects on the economies of all nations including the United States and Japan.

Sunday, 19 October 2008: The government of the Netherlands bailed out ING, the Dutch bank, with a €10 billion capital rescue plan.

Monday, 20 October 2008: On Monday the government of Belgium rescued the insurance company Ethias with a €1.5 billion capital injection. In Germany BayernLB has decided to apply for funds from the German €500 billion rescue program. Sweden announced formation of a 1.5 trillion kronor fund to support inter-bank lending and a 15 billion kronor capital injection plan. Swedish banks were reported to be increasingly affected by the financial crisis. An IMF rescue plan for Iceland was reported to be near finalization while Ukraine was reported to be in discussions with the IMF. Iceland was reported to have also received assistance from Denmark and Norway while Britain has offered a loan to support compensation of British depositors in failed Icelandic bank Landsbanki. On Monday France announced a €10.5 billion rescue plan for six of its largest banks, including

- 1) Crédit Agricole,
- 2) BNP and
- 3) Société Générale.

Wednesday, 22 October 2008: Pakistan joined Iceland, Hungary, Serbia and Ukraine and requested aid from the IMF in dealing with severe balance of payments difficulties. Hungary, Russia, Ukraine, Pakistan, Turkey, South Africa, Argentina, Iceland, Estonia, Latvia, Lithuania, Romania and Bulgaria are all experiencing financial difficulties with others threatened. These countries did not hold securities based on subprime mortgages, but are affected by inability to borrow money, the credit crisis. Plans are under discussion to increase credit available to the IMF, perhaps to a trillion dollars.

Friday, 24 October 2008: Stock markets plummeted worldwide amidst growing fears among investors that a deep global recession is imminent if not already settled in. The panic was partly fueled by remarks made by Alan Greenspan that the crisis is “a one in a century credit tsunami” and by comments made by Gordon Brown during a speech, admitting essentially that Great Britain is already in recession mode. Following the trend, the U.S. stock markets also fell sharply on opening and ended with the Dow Industrial Index down 312 points.

Friday, 24 October 2008 and Saturday, 25 October 2008: The 7th Asia-Europe Meeting was held in Beijing with the European Union meeting Asian states in an attempt to discuss a common approach ahead of the Emergency International Meeting that is scheduled

to take place in Washington on November 15. No specific recommendations to solve the crisis were developed.

Sunday, 26 October 2008: Hungary and Ukraine made tentative arrangements with the IMF for emergency aid packages. In Poland the value of stocks has fallen 50 % for the year and the zloty, the Polish currency, has fallen against both the dollar and the euro. The crisis has affected South Africa, Brazil and Turkey. South Africa was particularly affected by a dramatic drop in the price of platinum, a commodity used in automobile manufacturing. In addition to Iceland, Ukraine and Hungary, Belarus and Pakistan are also engaged in emergency discussions with the IMF. Pakistan has what is described as a “growing balance of payments crisis”. In the Gulf states, impacted by the falling price of oil and a drop in equities prices of 40 % for the year, the Gulf Cooperation Council met in Riyadh on Saturday to discuss a coordinated response to the crisis.

Monday, 27 October 2008: Hong Kong stocks crashed, losing more than 12 % of their value while in Japan, the Nikkei 225 Index plummeted by 6.4 % to its lowest level since 1982. European stock markets showed mixed results. After suffering an initial drop, the Dow Jones Industrial Average was in slightly positive territory for much of the trading day but eventually closed down 203 points. Oil futures continued to decline and the yen continued to rise against all other currencies. There was consideration given by both the G7 and the Japanese government to take measures to support other currencies as against the Yen. In a second round of recapitalization, the U.S. Treasury has funded 22 banks with 38 billion dollars. The list of banks aided was confidential, but some banks including

- 1) BB&T,
- 2) Capital One,
- 3) SunTrust Banks,
- 4) City National Bank,
- 5) Comerica,
- 6) First Niagara Bank,
- 7) Huntington Bancshares,
- 8) Northern Trust,
- 9) State Street Corporation,
- 10) UCBH Holdings,
- 11) First Horizon National Corporation,
- 12) PNC Financial Services (buyer of the National City Corporation),
- 13) Regions Financial Corporation,
- 14) Valley National Bancorp KeyBank,

15) Washington Federal Savings

said they would receive government money. Fifth Third Bank announced that they would apply. Criteria for funding was based on the strength of the bank with stronger banks with higher CAMELS ratings having a greater chance of being offered aid. The American Bankers Association stated that due to restrictions on salaries and payment of dividends that some U.S. banks may not participate. Another concern was that acceptance of the recapitalization plan might give a false signal that a bank was troubled.

Tuesday, 28 October 2008: Stocks rose dramatically worldwide in anticipation of rate cuts by central banks. In the U.S., the Dow Industrial Average rose 10.8 %, closing at over 9000.

Wednesday, 29 October 2008: Markets in the U.S. closed down slightly despite announcement by the Federal Open Market Committee of a reduction in the federal funds rate 50 points to 1 percent. In Russia the \$ 50 billion rescue program administered by the state development bank, Vnesheconombank (VEB), is assisting Russian firms controlled by Russian oligarchs who gave ownership of portions of their companies as security for loans from Western financial institutions. Recipients include Oleg Deripaska of Rusal owner of Norilsk Nickel and Mikhail Fridman of Alfa Group whose assets VimpelCom and TNK-BP were threatened. Stock markets in Russian have crashed, down 70 % and there is lack of faith in its currency the ruble. Despite significant foreign reserves from the sale of oil, Russia is now faced with sharply reduced commodities prices.

Thursday, 30 October 2008: In Asia, Japan announced its second economic stimulus plan of \$ 51 billion. Also on Thursday the Federal Reserve established a \$ 30 billion currency swap line with South Korea and Singapore as well as Brazil and Mexico.

Friday, 31 October 2008: Markets in the U.S. closed up for the week Monday, 27 October 2008 to Friday, 31 October 2008, cutting losses to the Dow Industrial Average during October to 17 %, down 30 % for the year. Hong Kong and Taiwan cut interest rates while an interest cut to 0.3 % was announced by the Bank of Japan on this day. JPMorgan Chase, the largest bank in the United States, announced that it would work with homeowners who demonstrate a willingness to pay their mortgages by reducing interest payments or principal. Counseling centers are planned for troubled areas. Washington Mutual, and EMC Mortgage Corporation, a loan servicing company, acquired by JPMorgan, will be included. Bank of America has announced a similar program, as has Countrywide Financial as the result of a court settlement. October sales of car and light trucks in the United States fell precipitously in October with General Motors falling 45 %, Ford falling 30 %, Chrysler falling 35 %, Toyota falling 23 %, Honda falling 25 % and Nissan falling 33 %. Much of the falloff in sales was attributable to customers being unable to arrange financing.

Saturday, 1 November 2008: Recovery package of \$ 51b for Japan. Recovery package of \$ 11b for South Korea.

Monday, 3 November 2008: Prognosis of the EU-commission of only 0.1 % increase of the BIP in 2009 for the countries of the European Union, and negative numbers for the UK (-1 %), Ireland and Spain. Iceland is granted €500 Million credit by Norway.

Tuesday, 4 November 2008: Ford and GM see October sales fall by almost 50 %.

Thursday, 6 November 2008: The Bank of England cuts its interest (base) rate drastically from 4.5 % down to 3.0 %, the lowest rate in 50 years. At the Central Bank for the European Union (France, Germany, Italy etc.) the cut-down amounted to only 0.5 %, down to 3.25 %. But another cut-down at the next opportunity was explicitly "not excluded." The U.S. Federal Reserve and Central Banks in China, Japan and Australia had already cut rates several days earlier. According to a prognosis of the IMF in Washington, D.C., a worldwide recession of the developed economies, -0.3 % on average, will happen in 2009. There has not been four consecutive negative growth quarters since WWII. U.S. futures, which offer an indication of how markets may open when trading begins in New York on Thursday, were higher, possibly signaling a rebounded after two days of selling. European markets are having a rough time as well. London, Paris and Frankfurt all lost 6 percent to 7 percent.

Friday, 7 November 2008: Asian and Pacific markets turned mixed on Friday, pulling back from selloffs that have plagued Wall Street and Europe the past two days.

Sunday, 9 November 2008: The People's Republic of China announced a \$ 586 billion domestic stimulus package for the remainder of 2008, 2009, and 2010. Economic growth has slowed in China with sharp drops in property and stock values. The money from the stimulus package will be spent on upgrading infrastructure, particularly roads, railways, airports and the power grids throughout the country and raise rural incomes via land reform. Also spending will be made on social welfare projects such as affordable housing and environmental protection.

Monday, 10 November 2008: The U.S. Treasury announced investment of \$ 40 billion in preferred stock of AIG, adjusting the terms of the existing credit line and its amount. Total exposure, including equity and debt, is now \$ 150 billion. Funds were drawn from the Troubled Asset Relief Program (TARP) which was not available at the time of the original bailout of AIG. The question of whether emergency funding would be made available to the troubled American auto industry remained under consideration. General Motors is the most threatened with a sharp drop in sales and diminishing cash reserves.

Wednesday, 12 November 2008: U.S. Treasury Secretary, Henry Paulson, scrapped the original Troubled Asset Relief Program (TARP) and announced shift in the focus to

consumer lending. The remaining portion of the TARP budget will be used to help relieve pressure on consumer credits such as car loans, student loans, credit cards etc.

Thursday, 13 November 2008: The Dow Jones Industrial Average (DJIA) marked another dramatic session, with the index (opening at 8 282.66) that after a mixed start tumbled again below the 8 000 mark (to a low of 7 965.42) but then reversed the trend and gained more than 900 points (fourth largest daily swing ever) in less than three hours closing at 8 835.25 with a net gain of more than 550 points (third largest ever).

Friday, 14 November 2008: The prospect of a federal bailout of failing U.S. automakers appeared dim pending the inauguration of Barack Obama. There appeared to be opposition from both the Republican members of the Senate and the office of the incumbent president, George W. Bush, which expressed doubt that the companies could be salvaged.

Saturday, 15 November 2008: At the invitation of U.S. President, George W. Bush, the leaders of the G-20 held the initial session of the Summit on Financial Markets and the World Economy on Saturday, 15 November 2008 in Washington, D.C. They agreed to cooperate with respect to the global financial crisis and issued a statement regarding immediate and medium term goals and actions considered necessary to support and reform the international economy. The next session will be held April 30, probably in London, after Barack Obama takes office as President of the United States. The initial session, attended by the leaders of the G-20 set forth a road map of proposed reforms which will be followed up in coming months by the development of specific proposals, including a comprehensive reform of the Bretton Woods Institutions.

Sunday, 16 November 2008: It was widely anticipated that economic activity in the United States would be found to be at recession levels when relevant statistics are released.

Monday, 17 November 2008: Banking giant, Citigroup, has announced it is cutting a further 50 000 staff as the economic crisis worsens. Citigroup is rumored to be looking to cut staff in investment banking and wealth management divisions. It followed Japan's announcement that the world's second largest economy had slipped into recession. In the third quarter of 2008 the gross domestic product (GDP) of Japan fell 0.4 % following a 3.7 % drop in the second quarter. Similar reports of recession level economic activity had been released previously by Hong Kong, Germany and the European Union. Two separate studies put the U.S. economy firmly "in recession" after preliminary data shows GDP contracted 0.3 % in the third quarter. Three large U.S. life insurance companies seek TARP funding: Lincoln National, Hartford Financial Services Group, and Genworth Financial announce their intentions to purchase lenders/depositories and thus qualify as savings and loan companies to access TARP funding.

Tuesday, 18 November 2008: Executives of Ford, General Motors, and Chrysler testify before Congress, requesting access to the TARP for federal loans.

Wednesday, 19 November 2008: The Dow fell 427.47 points (equivalent to 5.07 %), and closed below 8 000 points for the first time since March 2003. In this regard, U.S. financial stocks led the way with Citigroup showing a 23 % drop. The U.K.'s FTSE 100 fell by about the same percentage, closing just above 4000. The BBC Global 30, combining Europe, Asia and North America in a single index, fell by 5.1 %.

Thursday, 20 November 2008: Asian and Pacific stocks tumbled sharply after Wall Street finished at its lowest point since Spring 2003 the previous day. The Dow plunged another 445 points in the last minutes of the trading session, closing at 7 552. This is its lowest point in six years. Shares in Citigroup plummeted another 26 % with drops of more than 10 % in the shares of other major U.S. financial institutions. The International Monetary Fund (IMF) approves a \$ 2.1 billion (1.4 billion Pound) loan for Iceland, after the country's banking system collapsed in October 2008. It is the first IMF loan for a Western European nation since 1976. Fannie Mae and Freddie Mac announce that they will suspend mortgage foreclosures until January 2009.

Friday, 21 November 2008: Asian and Pacific stocks turned mixed by midday after tumbling in early trading, struggling for direction after Wall Street slumped on fears of a prolonged recession. However, the Dow recovered about half of the loss for the week and closed above 8 000. Also, stocks of Citibank, Bank of America and J.P. Morgan Chase continued to decline. It was unclear whether the drop of the value of the Citigroup stock to under \$ 4 reflected financial weakness of the bank or what rescue plan could be crafted. One theory for the disappointment of investors was that the failure of the Treasury to purchase toxic mortgage-related securities held by the bank left billions of unrealized losses on the books. Citigroup continues to hold \$ 20 billion in mortgage-related securities, currently valued at a substantial discount. U.S. markets surged on the back of reports that New York Federal Reserve President, Timothy Geithner, was "on track" to become President-elect Barack Obama's pick for Treasury Secretary. Three more banks - two in California (Downey Savings and Loan Association of Newport Beach as well as PFF Bank & Trust of Downey) and one in Georgia (Loganville, Georgia- based Community Bank) - failed today bringing to 22 the number of institutions forced to close in the wake of the financial crisis.

The U.S. Treasury Department announces that it will help liquidate The Reserve Fund's U.S. Government Fund. The Treasury agrees to serve as a buyer of last resort for the fund's securities to ensure the orderly liquidation of the fund. The U.S. Treasury Department purchases a total of \$ 3 billion in preferred stock in 23 U.S. banks under the Capital Purchase Program.

Saturday, 22 November 2008: As of the week of Sunday, 16 November 2008, stock losses in United States markets during 2008, as measured by the SPX, were equivalent to those

suffered in 1931, over 50 %. Total losses during the Great Depression exceeded 80 % but that was over a three year period.

Sunday, 23 November 2008: A rescue plan for Citigroup was agreed with the U.S. government that involved a \$ 20 billion (13.4 billion Pound) rescue plan after Citigroup's shares plunge by more than 60 % in a week. In a joint statement by the U.S. Treasury Department, Federal Reserve and the FDIC it was announced that in exchange for preferred stock valued at \$ 27 billion paying 8 % interest a further \$ 20 billion would be invested into the company and that the government would limit loss on \$ 306 billion in risky loans and securities to \$ 29 billion plus 10 % of any remaining losses. According to the joint statement,

“With these transactions, the U.S. government is taking the actions necessary to strengthen the financial system and protect U.S. taxpayers and the U.S. economy.”

The U.S. Treasury Department, Federal Reserve Board, and FDIC jointly announce an agreement with Citigroup to provide a package of guarantees, liquidity access, and capital. Citigroup will issue preferred shares to the Treasury and FDIC in exchange for protection against losses on a \$ 306 billion pool of commercial and residential securities held by Citigroup. The Federal Reserve will backstop residual risk in the asset pool through a non-recourse loan. In addition, the Treasury will invest an additional \$ 20 billion in Citigroup from the TARP.

Monday, 24 November 2008: Friday, November 21 and Monday, November 24 marked the Dow's largest two-session gain since October 1987. The Dow gained 891.10 points, 11.8 %, bringing it to a close at 8 443.39 points. The U.K. government announces a temporary cut in the level of VAT - to 15 % from 17.5 % - in its pre-Budget report. Chancellor Alistair Darling also says government borrowing will rise to record levels, but defends the move as essential to save the U.K. from a deep and long-lasting recession.

Tuesday, 25 November 2008: The International Monetary Fund (IMF) approves a \$ 7.6 billion (5.1 billion Pound) loan for Pakistan to shore up the country's economy. Pakistan needs the money in order to avoid defaulting on international debt. The U.S. Federal Reserve announces it will inject another \$ 800 billion into the economy in a further effort to stabilize the financial system and encourage lending. About \$ 600 billion will be used to buy up MBSs while \$ 200 billion is being targeted at unfreezing the consumer credit market.

The Federal Reserve Board announces the creation of the Term Asset-Backed Securities Lending Facility (TALF), under which the Federal Reserve Bank of New York will lend up to \$ 200 billion on a non-recourse basis to holders of AAA-rated asset-backed securities and

recently originated consumer and small business loans. The U.S. Treasury will provide \$ 20 billion of TARP money for credit protection. The Federal Reserve Board announces a new program to purchase direct obligations of housing related government[sponsored enterprises (GSEs).Fannie Mae, Freddie Mac and Federal Home Loan Banks and MBSs backed by the GSEs. Purchases of up to \$ 100 billion in GSE direct obligations will be conducted as auctions among Federal Reserve primary dealers. Purchases of up to \$ 500 billion in MBS will be conducted by asset managers.

Wednesday, 26 November 2008: The European Commission unveils an economic recovery plan worth €200 billion which it hopes will save millions of European jobs. The scheme aims to stimulate spending and boost consumer confidence. The Federal Reserve Board announces approval of the notice of Bank of America Corporation to acquire Merrill Lynch and Company.

Monday, 1 December 2008: The National Bureau of Economic Research (NBER) officially declared that the U.S. economy had started to contract (i.e., entered recession) in December 2007. The NBER consists of a leading panel including economists from Stanford, Harvard and MIT. After 5 positive days the previous week, the S&P 500 fell 80 points to 816, down 9 %. Financial stocks in the S&P 500 fell 17 %. The Dow Jones Industrial Average closed at 8149 with a drop of 679 points, 7.7 % down. Oil fell below \$ 50 a barrel in New York trading.

Tuesday, 2 December 2008: The General Accounting Office released a report that claims that the oversight of the Troubled Assets Relief Program (TARP) requires additional actions to ensure

“integrity, accountability, and transparency”. (Washington Post) (bloomberg.com)
(Wall Street Journal) (CNN Money)

The Federal Reserve Board announces that it will extend three liquidity facilities, the

- 1) Primary Dealer Credit Facility (PDCF),
- 2) Asset-Backed Commercial Paper Money Market Fund Liquidity Facility (AMLF), and
- 3) Term Securities Lending Facility (TSLF) through 30 April 2009.

Wednesday, 3 December 2008: The SEC approves measures to increase transparency and accountability at credit rating agencies and thereby ensure that firms provide more meaningful ratings and greater disclosure to investors.

Thursday, 4 December 2008: French President, Nicholas Sarkozy, unveils a plan to help France fend off a looming financial crisis. The funds from this plan will be spent on public sector investments and loans for the country’s troubled automobile industry.

Friday, 5 December 2008: The U.S. Treasury Department purchases a total of \$ 4 billion in preferred stock in 35 U.S. banks under the Capital Purchase Program.

Tuesday, 9 December 2008: The Bank of Canada lowered its key interest rate by 0.75 % to 1.5 %, the lowest it's been since 1958. This move comes after the news that Canada lost 70 600 jobs during November 2008, the most since 1982. The official Bank of Canada press release states that the

“...outlook for the world economy has deteriorated significantly and the global recession will be broader and deeper than previously anticipated.”

Wednesday, 10 December 2008: The FDIC reiterates the guarantee of federal deposit insurance in the event of a bank failure.

Thursday, 11 December 2008: Bank of America announces up to 35 000 job losses over three years following its takeover of Merrill Lynch at the beginning of 2008. It said that the cuts will be spread across both businesses. The Bank of England as well as central banks in Germany and Denmark, slash interest rates again in an effort to prevent a looming recession. The Business Cycle Dating Committee of the National Bureau of Economic Research (NBER) announces that a peak in U.S. economic activity occurred in December 2007 and that the economy has since been in a recession.

Friday, 12 December 2008: The U.S. Treasury Department purchases a total of \$ 6.25 billion in preferred stock in 28 U.S. banks under the Capital Purchase Program.

Monday, 15 December 2008: The Federal Reserve Board announces that it has approved the application of PNC Financial Services to acquire National City Corporation.

Tuesday, 16 December 2008: The U.S. Federal Reserve cuts interest rates from 1 % to a range between 0 % and 0.25 %. This represents the lowest rate since records began. In particular, the Federal Open Market Committee FOMC votes to establish a target range for the effective federal funds rate of 0 to 0.25 %. The Federal Reserve Board votes to reduce the primary credit rate 75 basis points to 0.50 %. The Federal Reserve Board also establishes the interest rates on required reserve balances and excess balances at 0.25 % for reserve maintenance periods beginning Thursday, 18 December 2008.

Friday, 19 December 2008: Japan's central bank follows suit and cuts rates from 0.3 % to 0.1 %. The Japanese government says the world's second largest economy is in recession. The U.S. government announced that it will give \$ 17.4 billion in loans from TARP to help three of the nation's automobile makers - Chrysler, General Motors and Ford - avoid bankruptcy. The money will be taken from the \$ 700 billion bailout package originally

intended to rescue U.S. banks. General Motors will get \$ 9.4 billion and Chrysler \$ 4 billion before next year. Ford stated that it wants to get by without government aid. President George Bush said that it would not be

“a responsible course of action”

to allow the motor companies to collapse. The Federal Reserve Board announces revised terms and conditions of the Term Asset-Backed Securities Loan Facility (TALF). Among the revisions are an extension of TALF loans from maturities of one year to three years and an expansion of eligible ABS collateral. The U.S. Treasury Department purchases a total of \$ 27.9 billion in preferred stock in 49 U.S. banks under the Capital Purchase Program (CPP).

Monday, 22 December 2008: The Federal Reserve Board approves the application of CIT Group Inc., an \$ 81 billion financing company, to become a bank holding company. The Board cites unusual and exigent circumstances affecting the financial markets' for expeditious action on CIT Group's application.

Tuesday, 23 December 2008: The U.S. Treasury Department purchases a total of \$ 15.1 billion in preferred stock from 43 U.S. banks under the Capital Purchase Program.

Wednesday, 24 December 2008: The Federal Reserve Board approves the applications of GMAC LLC and IB Finance Holding Company, LLC (IBFHC) to become bank holding companies, on conversion of GMAC Bank, a \$ 33 billion Utah industrial loan company, to a commercial bank. GMAC Bank is a direct subsidiary of IBFHC and an indirect subsidiary of GMAC LLC, a \$ 211 billion company. The Board cites unusual and exigent circumstances affecting the financial markets' for expeditious action on these applications. As part of the agreement, General Motors will reduce its ownership interest in GMAC to less than 10 percent.

Monday, 29 December 2008: The U.S. Treasury unveils a \$ 6 billion bail-out for GMAC, the car-loan arm of General Motors. The U.S. Treasury Department announces that it will purchase \$ 5 billion in equity from GMAC as part of its program to assist the domestic automotive industry. The Treasury also agrees to lend up to \$ 1 billion to General Motors “so that GM can participate in a rights offering at GMAC in support of GMAC's reorganization as a bank holding company.” This commitment is in addition to the support announced on Friday, 19 December 2008.

Tuesday, 30 December 2008: The Federal Reserve Board announces that it expects to begin to purchase MBSs backed by Fannie Mae, Freddie Mac and Ginnie Mae under a previously announced program in early January 2009 (see November 25, 2008). The U.S.

Securities and Exchange Commission (SEC) releases a report that recommends against the suspension of fair value accounting standards. The report was mandated by the Emergency Economic Stabilization Act of 2008 (EESA).

Wednesday, 31 December 2008: The FTSE 100 ends closes down by 31.3 % since the beginning of 2008, which is the biggest annual fall in the 24 years since the index was started. The Dax in Frankfurt lost 40.4 % while the Cac 40 in Paris dropped 42.7 %.

The U.S. Treasury Department purchases a total of \$ 1.91 billion in preferred stock from seven U.S. banks under the Capital Purchase Program.

8.4.11.1 2009 Timeline of the Subprime Mortgage Crisis Events

This subsection chronicles the events related to the SMC that took place in 2009.

Monday, 5 January 2009: The Federal Reserve Bank of New York begins purchasing fixed rate MBSs guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae under a program first announced on Tuesday, 25 November 2008. US President-elect Barack Obama describes America's economy as

“very sick”

and says that the situation is worsening.

Tuesday, 6 January 2009: German billionaire, Adolf Merckle, commits suicide after his business empire ran into trouble in the global economic slowdown.

Wednesday, 7 January 2009: The Federal Reserve Board announces two changes to the Money Market Investor Funding Facility (MMIFF) that

- 1) expand the set of institutions eligible to participate in the MMIFF and
- 2) reduce the minimum yield on assets eligible to be sold to the MMIFF.

Thursday, 8 January 2009: Moody's Investor Services issues a report suggesting that the Federal Home Loan Banks are currently facing the potential for significant accounting writedowns on their \$ 76.2 billion private label MBSs portfolio. According to Moody's, only four of 12 banks' capital ratios would remain above regulatory minimums under a worst case scenario. The Bank of England cuts interest rates to 1.5 %, the lowest level in its 315-year history, as it continues efforts to aid an economic recovery in the UK.

Friday, 9 January 2009: The Congressional Oversight Panel issues its second monthly report on the expenditure of the Troubled Asset Relief Program (TARP). Official figures show the US jobless rate rose to 7.2 % in December 2008, the highest in 16 years. The

figures also indicate that more US workers lost jobs in 2008 than in any year since World War II.

Monday, 12 January 2009: The FDIC issues a letter to FDIC-supervised institutions calling on them to implement a process to monitor their use of

- 1) capital injections,
- 2) liquidity support and/or
- 3) financing guarantees obtained through

Treasury, FDIC, and Federal Reserve financial stability programs. At the request of President-elect Obama, President Bush submits a request to Congress for the remaining \$ 350 billion in TARP funding for use by the incoming administration.

Tuesday, 13 January 2009: The Federal Home Loan Bank of Seattle reports that it will likely report a risk-based capital deficiency and suspend its dividend because of a decline in the market value of its MBSs portfolio. The move follows a similar announcement on Thursday, 8 January 2009 by the Federal Home Loan Bank of San Francisco. A survey by the British Chambers of Commerce suggests the end of 2008 saw a

“frightening deterioration”

in the UK economy. China’s exports register their biggest decline in a decade. German Chancellor, Angela Merkel, unveils an economic stimulus package worth about €50 billion (\$ 67 billion; GBP 45 billion) to kick-start Europe’s largest economy.

Wednesday, 14 January 2009:

The U.K. government unveils a plan to guarantee up to GBP 20 billion of loans to small and medium-sized firms, to help them survive the downturn. U.S. Commerce Department figures show retail sales fell by more than expected in December, as shoppers cut back on spending over the Christmas period. The news prompts big falls in share prices in the US and Europe.

Thursday, 15 January 2009: Democratic leaders in the U.S. House of Representatives unveil a \$ 825 billion recovery package aimed at turning around the US economy. The mix of tax cuts and spending – developed with President-elect Barack Obama – aims to create millions of jobs as it attempts to halt the recession. House speaker, Nancy Pelosi, acknowledges that this is the

“first step”

in trying to push a plan through Congress, and that the numbers may change. The European Central Bank (ECB) cuts Eurozone interest rates by half a percentage point to 2 % the

lowest level since the common currency was launched 10 years ago. The ECB has now reduced rates four times from 4.25 % in September 2008 as it continues efforts to bolster the Eurozone economy. The Irish government says it is to nationalize the Anglo Irish Bank after deciding pumping money into the lender was not enough to secure its future.

Nortel Networks Corp (NT.TO)NT.N, North America's biggest telephone equipment maker, files for bankruptcy. JPMorgan Chase & Co's (JPM.N) fourth-quarter profit plunges 76 % as it writes down bad loans.

Friday, 16 January 2009: The Treasury Department announces that it will lend \$ 1.5 billion from the TARP to a special purpose entity created by Chrysler Financial to finance the extension of new consumer auto loans. Sony posted \$ 1.1 billion operating loss. The US government reaches an agreement to provide Bank of America with another \$ 20 billion in fresh aid from its \$ 700 billion financial rescue fund. The emergency funding will help the troubled bank absorb the losses it incurred when it bought Merrill Lynch. Struggling US banking giant Citigroup announces plans to split the firm in two, as it reports a quarterly loss of \$ 8.29 billion (GBP 5.6 billion).

Sunday, 18 January 2009: On the evening of 18 January, the Danish Parliament, agreed to a financial package worth 100.000.000.000 Danish krone (\$ 17.596.339.961).

Monday, 19 January 2009: The Royal Bank of Scotland (RBS) has lost around 70 % of its share price in a matter of hours, after news reports indicated a GBP 28 billion loss for 2008, and the UK government pledged to increase its stake in the company to 70 %. The RBS shares in London opened today at 34.50, and apart from a small increase to 34.90, the shares have been below that rate throughout the day. The shares fell to just over 10, although they have since recovered very slightly to 11.60 as of 16:05 UTC. These low share prices are only a fraction of the 52 week high of 427.50 pence, and the all time high of 607 pence. The all time high was reached approximately two years ago, in February 2007. In addition to the falls in London, RBS shares in New York also fell dramatically on their most recent trading day. The shares fell by 10.33 %. The bank's chief executive, Stephen Hester, spoke to The Times regarding the poor performance of his company.

"The world remains an uncertain place. We can all be sure there will be future significant credit losses but we cant be sure of what amount and what timingall banks are facing uncertainties,"

he said.

Britain launches a second bank rescue plan, under which the BoE will set up an asset purchase program to buy private sector assets with an initial fund of GBP 50 billion.

Tuesday, 20 January 2009: Barack Obama takes office as president of the United States. Wall Street greets the new president with its worst inauguration day ever. Stock prices

extend losses as the Dow closes down 4 percent, extending its 2009 slump to more than 9 percent, as Obama says that the economy was

“badly weakened” by “greed and irresponsibility.”

Wednesday, 21 January 2009: Britain says its bank bailouts have dealt a major blow to Britain’s public finances as the recapitalization of ailing Royal Bank of Scotland (RBS) blows out the deficit to GBP 44.2 billion (\$ 62 billion) last month, its highest on record.

Thursday, 22 January 2009: Philippines fears 60 000 IT job losses after Intel shutdown. Also, the editorial board of The Christian Science Monitor wrote that the four largest U.S. banks

“have lost half of their value since 2 January 2009.”

Friday, 23 January 2009: The UK has officially entered a recession as fourth quarter GDP falls by 1.5 % compared to the previous three months. The U.S. Treasury Department purchases a total of \$ 326 million in preferred stock from 23 U.S. banks under the Capital Purchase Program.

Saturday, 24 January 2009: President Obama pledges that his economic recovery package will be at the centrepiece of his administration and says that the \$ 825 billion plan will pass Congress by mid-February. The House of Representative has already begun deliberations on the plan, which includes tax cuts, aid to states, and a boost to spending on infrastructure. Mr Obama says that 80 % of the spending will take place within 18 months.

Monday, 26 January 2009: New U.S. Treasury Secretary, Timothy Geithner, sworn in.

Wednesday, 28 January 2009: The National Credit Union Administration (NCUA) Board announces that the NCUA will guarantee uninsured shares at all corporate credit unions through February 2009 and establish a voluntary guarantee program for uninsured shares of credit unions through December 2010. The Board also approves a \$ 1 billion capital purchase in U.S. Central Corporate Federal Credit Union. Corporate credit unions provide financing, check clearing, and other services to retail credit unions.

World economic growth is set to fall to just 0.5 % this year, its lowest rate since World War II, warns the International Monetary Fund (IMF). It now projects the UK will see its economy shrink by 2.8 % next year, the worst contraction among advanced nations. The International Labour Organization said that as many as 51 million jobs worldwide could be lost this year because of the global economic crisis. The U.S. House of Representatives passed President

Barack Obama's \$ 819 billion (GBP 572 billion) economic stimulus package. Passed by 244 votes to 188, no Republicans backed the plan, saying it was too expensive and would not work.

Thursday, 29 January 2009:

Friday, 30 January 2009: The Board of Governors announces a policy to avoid preventable foreclosures on certain residential mortgage assets held, controlled or owned by a Federal Reserve Bank. The policy was developed pursuant to section 110 of the Emergency Economic Stabilization Act. The U.S. Treasury Department purchases a total of \$ 1.15 billion in preferred stock from 42 U.S. banks under the Capital Purchase Program.

Tuesday, 3 February 2009: The Federal Reserve announces the extension through Friday, 30 October 2009, of the existing liquidity programs scheduled to expire on Thursday, 30 April 2009. The Board of Governors and the FOMC note

“continuing substantial strains in many financial markets.”

In addition, the swap lines between the Federal Reserve and other central banks are also extended to Friday, 30 October 2009. The expiration date for the TALF remains Thursday, 31 December 2009, and the TAF does not have an expiration date.

Friday, 6 February 2009: The Federal Reserve Board releases additional terms and conditions of the Term Asset-Backed Securities Loan Facility (TALF). Under the TALF, the Federal Reserve Bank of New York will lend up to \$ 200 billion to eligible owners of certain AAA-rated asset-backed securities backed by newly and recently originated auto loans, credit card loans, student loans and SBA-guaranteed small business loans.

Tuesday, 10 February 2009: U.S. Treasury Secretary, Timothy Geithner, announces a Financial Stability Plan involving

- Treasury purchases of convertible preferred stock in eligible banks;
- the creation of a Public-Private Investment Fund to acquire troubled loans and other assets from financial institutions;
- expansion of the Federal Reserve's Term Asset-Backed Securities Loan Facility (TALF);
- new initiatives to stem residential mortgage foreclosures and to support small business lending.

The Federal Reserve Board announces that is prepared to expand the Term Asset-Backed Securities Loan Facility (TALF) to as much as \$ 1 trillion and broaden the eligible collateral to include AAA-rated commercial mortgage-backed securities, private-label residential MBSs and other asset-backed securities. An expansion of the TALF would be supported by

\$ 100 billion from the Troubled Asset Relief Program (TARP). The Federal Reserve Board will announce the date that the TALF will commence operations later this month.

Timothy Geithner, the US Treasury Secretary, introduces the Financial Stability Plan in an attempt to clean up the US financial system. The \$2 trillion plan includes a financial stability trust to manage the US government's investments, a public-private investment fund to clean up the banks' balance sheets, a consumer and business lending initiative, a small business and community lending initiative, and housing support and foreclosure prevention plan. Commentators have suggested that the Financial Stability Plan is not detailed enough to restore confidence in the financial system. UBS announces that it lost \$17 billion in 2008, the largest corporate loss in Swiss history. UBS intends to keep its investment banking division despite cutting 1500-2000 more investment banking jobs.

Friday, 13 February 2009: Fannie Mae and Freddie Mac will suspend mortgage foreclosures until March 6th. The announcement came before President Obama was scheduled to announce a detailed plan to help prevent more foreclosures.

The U.S. Treasury Department purchases a total of \$429 million in preferred stock from 29 U.S. banks under the Capital Purchase Program.

Tuesday, 17 February 2009: The Treasury Department releases its first monthly survey of bank lending by the top 20 recipients of government investment through the Capital Purchase Program. The survey found that banks continued to originate, refinance and renew loans from the beginning of the program in October through December 2008.

President Obama signs into law the "American Recovery and Reinvestment Act of 2009", which includes a variety of spending measures and tax cuts intended to promote economic recovery.

Wednesday, 18 February 2009: President Obama announces The Homeowner Affordability and Stability Plan. The plan includes a program to permit the refinancing of conforming home mortgages owned or guaranteed by Fannie Mae or Freddie Mac that currently exceed 80 percent of the value of the underlying home. The plan also creates a \$75 billion Homeowner Stability Initiative to modify the terms of eligible home loans to reduce monthly loan payments. In addition, the Treasury Department will increase its preferred stock purchase agreements with Fannie Mae and Freddie Mac to \$200 billion, and increase the limits on the size of Fannie Mae and Freddie Mac's portfolios to \$900 billion.

Monday, 23 February 2009: The Treasury Department, Federal Deposit Insurance Corporation, Office of the Comptroller of the Currency, Office of Thrift Supervision, and the Federal Reserve Board issue a joint statement that the U.S. government stands firmly behind the banking system, and that the government will ensure that banks have the capital and liquidity they need to provide the credit necessary to restore economic growth. Further,

the agencies reiterate their determination to preserve the stability of systemically important financial institutions.

Tuesday, 24 February 2009: The U.S. Treasury Department purchases a total of \$365.4 million in preferred stock from 23 U.S. banks under the Capital Purchase Program.

Wednesday, 25 February 2009: The Federal Reserve Board, Federal Deposit Insurance Corporation, Office of the Comptroller of the Currency and Office of Thrift Supervision announce that they will conduct forward-looking economic assessments or "stress tests" of eligible U.S. bank holding companies with assets exceeding \$100 billion. Supervisors will work with the firms to estimate the range of possible future losses and the resources to absorb such losses over a two-year period. The assessment process is expected to be completed by the end of April 2009.

Thursday, 26 February 2009: The FDIC announces that the number of "problem banks" increased from 171 institutions with \$116 billion of assets at the end of the third quarter of 2008, to 252 insured institutions with \$159 billion in assets at the end of fourth quarter of 2008. The FDIC also announces that there were 25 bank failures and five assistance transactions in 2008, which was the largest annual number since 1993.

Fannie Mae reports a loss of \$25.2 billion in the fourth quarter of 2008, and a full year 2008 loss of \$58.7 billion. Fannie Mae also reports that on February 25, 2009, the Federal Housing Finance Agency submitted a request for \$15.2 billion from the Treasury Department under the terms of the Senior Preferred Stock Purchase Agreement in order to eliminate Fannie Mae's net worth deficit as of December 31, 2008.

Friday, 27 February 2009: The Treasury Department announces its willingness to convert up to \$25 billion of Citigroup preferred stock issued under the Capital Purchase Program into common equity. The conversion is contingent on the willingness of private investors to convert a similar amount of preferred shares into common equity. Remaining Treasury and FDIC preferred shares issued under the Targeted Investment Program and Asset Guarantee Program would be converted into a trust preferred security of greater structural seniority that would carry the same 8% cash dividend rate as the existing issue.

The Federal Deposit Insurance Corporation (FDIC) announces changes in its risk-based assessment system and a 20 basis point emergency special assessment on insured depository institutions to be collected on September 30, 2009.

The U.S. Treasury Department purchases a total of \$394.9 million in preferred stock from 28 U.S. banks under the Capital Purchase Program.

Monday, 2 March 2009: The Treasury Department and Federal Reserve Board announce a restructuring of the government's assistance to American International Group (AIG).

Under the restructuring, AIG will receive as much as \$30 billion of additional capital from the Troubled Asset Relief Program (TARP). In addition, the Treasury Department will exchange its existing \$40 billion cumulative preferred shares in AIG for new preferred shares with revised terms that more closely resemble common equity. Finally, AIG's revolving credit facility with the Federal Reserve Bank of New York will be reduced from \$60 billion to no less than \$25 billion and the terms will be modified. In exchange, the Federal Reserve will receive preferred interests in two special purpose vehicles created to hold the outstanding common stock of two subsidiaries of AIG: American Life Insurance Company and American International Assurance Company Ltd. Separately, AIG reports a fourth quarter 2008 loss of \$61.7 billion, and a loss of \$99.3 billion for all of 2008.

Insurance giant AIG reports the largest quarterly loss in US corporate history of \$ 61.7 billion (£43 billion) in the final three months of 2008. The firm is also to receive an extra \$ 30 billion from the U.S. government as part of a revamped rescue package. Meanwhile, HSBC confirms it is seeking to raise £12.5bn (\$ 17.7 billion) from shareholders through a UK rights issue. The news came as HSBC revealed pre-tax profits for 2008 of \$ 9.3 billion (£6.5 billion), down 62 % on the previous year.

Tuesday, 3 March 2009: The Treasury Department and the Federal Reserve Board announce the launch of the Term Asset-Backed Securities Loan Facility (TALF). Under the program, the Federal Reserve Bank of New York will lend up to \$200 billion to eligible owners of certain AAA-rated asset-backed securities backed by newly and recently originated auto loans, credit card loans, student loans and small business loans that are guaranteed by the Small Business Administration. The Federal Reserve and Treasury expect to include asset-backed securities backed by other types of loans in future monthly fundings. Subscriptions for funding in March will be accepted on Tuesday, 17 March 2009. Securitizations will be funded by the program on Wednesday, 25 March 2009. The program will hold monthly fundings through December 2009 or longer if extended by the Federal Reserve Board.

Wednesday, 4 March 2009: The Treasury Department announces guidelines to enable servicers to begin modifications of eligible mortgages under the Homeowner Affordability and Stability Plan.

Wednesday, 4 March 2009: The Treasury Department announces guidelines to enable servicers to begin modifications of eligible mortgages under the Homeowner Affordability and Stability Plan.

Wednesday, 11 March 2009: The Federal Reserve Board releases the minutes of its meetings from Sunday, 13 July 2008 through Tuesday, 16 December 2008 concerning Federal Reserve liquidity facilities and other issues related to the financial turmoil.

Freddie Mac announces that it had a net loss of \$23.9 billion in the fourth quarter of 2008, and a net loss of \$50.1 billion for 2008 as a whole. Further, Freddie Mac announces that its

conservator has submitted a request to the U.S. Treasury Department for an additional \$30.8 billion in funding for the company under the Senior Preferred Stock Purchase Agreement with the Treasury.

Saturday, 14 March 2009: Finance ministers from the G20 group of rich and emerging nations have pledged to make a "sustained effort" to pull the world economy out of recession. The main summit takes place in London in April.

Tuesday, 17 March 2009: The Federal Deposit Insurance Corporation (FDIC) decides to extend the debt guarantee portion of the Temporary Liquidity Guarantee Program (TLGP) from Tuesday, 30 June 2009 through Saturday, 31 October 2009, and to impose a surcharge on debt issued with a maturity of one-year or more beginning in the second quarter of 2009 to gradually phase-out the program.

Wednesday, 18 March 2009: The FOMC votes to maintain the target range for the effective federal funds at 0 to 0.25 percent. In addition, the FOMC decides to increase the size of the Federal Reserve's balance sheet by purchasing up to an additional \$750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to \$1.25 trillion this year, and to increase its purchases of agency debt this year by up to \$100 billion to a total of up to \$200 billion. The FOMC also decides to purchase up to \$300 billion of longer-term Treasury securities over the next six months to help improve conditions in private credit markets. Finally, the FOMC announces that it anticipates expanding the range of eligible collateral for the TALF (Term Asset-Backed Securities Loan Facility). The US Federal Reserve says it will buy almost \$ 1.2 trillion (£843bn) worth of debt to help boost lending and promote economic recovery.

The Federal Reserve Bank of New York releases more information on the Federal Reserve's plan to purchase Treasury securities. The Desk will concentrate its purchases in nominal maturities ranging from 2 to 10 years. The purchases will be conducted with the Federal Reserve's primary dealers through a series of competitive auctions and will occur two to three times a week. The Desk plans to hold the first purchase operation late next week.

Thursday, 19 March 2009: The U.S. Department of the Treasury announces an Auto Supplier Support Program that will provide up to \$5 billion in financing to the automotive industry. The Supplier Support Program will provide selected suppliers with financial protection on monies ("receivables") they are owed by domestic auto companies and the opportunity to access immediate liquidity against those obligations. Receivables created with respect to goods shipped after Thursday, 19 March 2009, will be eligible for the program. Any domestic auto company is eligible to participate in the program. Any U.S.-based supplier that ships to a participating auto manufacturer on qualifying commercial terms may be eligible to participate in the program.

The Federal Reserve Board announces an expansion of the eligible collateral for loans extended by the Term Asset-Backed Securities Loan Facility (TALF) to include asset-backed securities backed by mortgage servicing advances, loans or leases related to business equipment, leases of vehicle fleets, and floorplan loans. The new categories of collateral will be eligible for the April TALF funding.

The Federal Reserve Bank of New York releases the initial results of the first round of loan requests for funding from the Term Asset-Backed Securities Loan Facility (TALF). The amount of TALF loans requested at the Tuesday, 17 March to Thursday, 19 March operation was \$4.7 billion.

The FDIC completes the sale of IndyMac Federal Bank to OneWest Bank. OneWest will assume all deposits of IndyMac, and the 33 branches of IndyMac will reopen as branches of OneWest on Friday, 20 March. As of Saturday, 31 January 2009, IndyMac had total assests of \$23.5 billion and total deposits of \$6.4 billion. IndyMac reported fourth quarter 2008 losses of \$2.6 billion, and the total estimated loss to the Deposit Insurance Fund of the FDIC is \$10.7 billion. The FDIC had been named conservator of IndyMac FSB on Friday, 11 July 2008.

Thursday, 2 April 2009:

Leaders of the world's largest economies reach an agreement at the G20 summit in London to tackle the global financial crisis with measures worth \$ 1.1 trillion (£681 billion).