Basel III And Asset Securitization

By

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EMERG History of Supervision

One of the contributions made by the NWU-MC to the activities of the stochastic analysis community has been the establishment of an active research group EMERG that has an interest in institutional finance. In particular, EMERG has made contributions about modeling, optimization, regulation and risk management in insurance and banking. Students who have participated in projects in this programme under Proffs. Petersen and Mukuddem-Petersen's supervision are listed in Table 1.

Level	Student	Graduation	Title
MSc	T Bosch	May 2003 Cum Laude	Controllability of HJMM Interest Rate Models
MSc	CH Fouche	May 2006 Cum Laude	Continuous-Time Stochastic Modelling of Capital Adequacy Ratios for Banks
MSc	MP Mulaudzi	May 2008 Cum Laude	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
MSc	MC Senosi	May 2009 NWU S2A3 Winner	Discrete Dynamics of Bank Credit and Capital and their Cyclicality
PhD	T Bosch	May 2009	Management and Auditing of Bank Assets and Capital
PhD	BA Tau	May 2009	Bank Loan Pricing and Profitability and Their Connections with Basel II and the Subprime Mortgage Crisis
PhD	MP Mulaudzi	May 2010	The SMC: Asset Securitization and Interbank Lending
MSc	B De Waal	May 2011 Cum Laude	Stochastic Optimization of Subprime Residential Mortgage Loan Funding and its Risks
PhD	MC Senosi	May 2011	Discrete-Time Modeling of Subprime Mortgage Credit
PhD	S Thomas	May 2011	Residential Mortgage Securitization and the Subprime Crisis
MComm	G Mah	May 2013 Cum Laude	Sovereign Debt
MComm	C Meniago	May 2013 Cum Laude	An Econometric Analysis of the Impact of the Financial Crisis on Household Indebtedness in South Africa
MComm	M Mpundu	May 2013 Cum Laude	Impact of Economic Shocks on Assets and Their Derivatives
MComm	C Scheepers	Sep 2013	The Impact of the Global Financial Crisis on the South African Steel Industry
PhD	IP Mongale	May 2013	An Analysis of the Impact of the Global Financial Crisis on Savings in South Africa
PhD	B De Waal	May 2013	Liquidity and Valuation in the Financial Crisis
PhD	N Moroke	May 2014	An Econometric Analysis of the Impact of the Financial Crisis on Household Indebtedness
MComm	JB Maruping	May 2014	Basel III and Leverage
PhD	H Kabir	2013 Onwards	Corporate Social Responsibility
PhD	M Mpundu	2013 Onwards	Basel III and Asset Securitization
PhD	G Mah	2013 Onwards	US and Greek Sovereign Debt
Postdoc	J Mukuddem-Petersen	2006-9	Financial Modeling and Optimization
Postdoc	T Bosch	2010	Finance, Risk and Banking
Postdoc	M Agaze Dessi	2011	Business Incubation
Postdoc	S Thomas	2011-2012	Collateralized Debt Obligations

Table 1: EMERG History of Supervision

Declaration

I declare that, apart from the assistance acknowledged, the research presented in this thesis is my own unaided work. It is being submitted in partial fulfilment of the requirements for the Degree Doctor of Philosophy in Economics in the Faculty of Commerce and Administration at the Mafikeng Campus of the North West University (NWU-MC) It has not been submitted before for any degree or examination to any other University.

Signature................................ Date...................................

Abstract

Asset securitization via special purpose entities involves the process of transforming receivable assets into sellable securities that are issued to investors. These investors hold the rights to payments supported by the cash flows from an asset pool held by the said entity. In this thesis, aspects of the mechanism by which entities securitize assets into derivatives were investigated. In this case, these assets were found to act as a source of collateral for inter-entity sponsoring as well as a means of generating derivatives. During the 2007-2009 financial crisis, the securitization of assets was seriously inhibited. In response to this, for instance, new Basel III capital and liquidity regulations were introduced to re-establish securitization in order to support credit provision to the real economy and improve banks' access to funding globally. In this thesis, an investigation on the impact of a change in profit subsequent to a rating downgrade with the influence of bank features such as asset and derivative rates as well as liquidity was undertaken. In addition, connections between the aformentioned results and Basel III were given throughout the thesis. A VECM approach was further applied to Balance sheet liability and liquidity data to ascertain the relationship of the dependent and independent variables in the data set, and their behaviour in a short run and long run setup where observed. It was discovered that there were cointegrating equations, hence a long run relationship among the variables existed. The impact of shocks on the variables in a 12 quarterly future forecast was also given with NSFR showing a more negative reaction to shocks in the LCR. This can be explained as being due to the fact that the BCBS introduced the LCR to be intended for 30 day stress scenario for banks to survive on, while the NSFR is meant for a longer period of 1 year. The failure of banks to survive on the LCR would mean tapping into the reserves of the NSFR. Hence a shock to the LCR would bring forth a negative reaction to the NSFR as was shown by the GIRFs.

KEY WORDS: Assets; Basel III; Prepayment; Refinancing; Derivatives; Entity; Credit Risk; Financial Crisis (FC).

CLASSIFICATION:
JEL: G13; G32

Glossary

Basel III A global regulatory standard on capital adequacy, stress testing and market liquidity risk.

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

Credit Risk the risk of loss of principle or loss of a financial reward stemming from a borrowers failure to repay a loan or otherwise meet a contractual obligation.

Lien this is when a creditor or bank has the right to sell the asset or collateral property of those who fail to meet the obligations of the loan contract.

Linearization refers to finding the linear approximation to a function at a given point.

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

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).

FICO is a public company that provides analysis and decision making services including credit scoring intended to help financial companies make complex, high volume decisions.

Low quality 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.

Abbreviations

ABS - Asset-Backed Security
ABX - Asset Backed Securities Index
ABX.HE - Asset Backed Security index-Home Equity
ADF - Augmented Dickey-Fuller
AH - Asset Holder
AFC - Available Funds Cap
AIG - American International Group
ARA - Adjustable-Rate Asset
ASF - Available Stable Funding
BCBS - Basel Committee on Banking Supervision
BIS - Bank for International Settlements
CCP - Central Counterparty
CDOs - Collateralized Debt Obligations
CDS - Credit Default Swap
CE - Credit Enhancement
CET1 - Common Equity Tier 1
CLO - Collateralized Loan Obligation
CRA - Credit Rating Agency
CRD - Capital Requirements Directive
CTD - Cheapest to Deliver
CVA - Credit Valuation Adjustment
EBA - European Banking Authority
EPE - Expected Positive Exposure
FC - Financial Crisis
FDIC - Federal Deposit Insurance Corporation
FSP - Financial Stability Board
GC - Granger-Causality
GIRFs - Generalized Impulse Response Functions

G-SIBs - Global Systematically Important Banks
HQA - High Quality Asset
HQLA - High Quality Liquid Asset
IO - Interest-Only
IR - Investor
IRB - Internal Ratings-Based (approach)
LCR - Liquidity Coverage Ratio
LIBOR - London Interbank Offered Rate
LTVR - Loan To Value Ratio
LQA - Low Quality Asset
NCO - Net Cash Outflow
NSFR - Net Stable Funding Ratio
OAD - Originate-and-Distribute
OC - Over collateralized
ODE - Ordinary Differential Equation
OR - Originator
PD - Probability of Default
PP - Phillips-Perron
RAL - Residential Asset Loan
RMBS - Residential Mortgage-Backed Security
RSF - Required Stable Funding
RW - Risk-Weight
SDE - Stochastic Differential Equation
SIB - Systemically Important Banks
SIFIs - Systemically Important Financial Institutions
SPE - Special Purpose Entity
VaR - Value-at-Risk
VECM - Vector Error Correction Model

Basic Notations

A - Quantity of assets
$\bar{A}$ - Total Asset Supply
A_m - Input Assets Securitized at date m
A_m - low quality entity's asset holdings in period m
A' - Asset Flow of Funds
B - Borrowing
β - Discount
c^p - Prepayment costs
$\hat{C}$ - Proportional Change in Derivative Output
E - Equilibrium
F_m - Simultaneous equation model of asset rate profit
G_m - Simultaneous equation model of loan-to-value-ratio
h - Default Intensity
H_m - Simultaneous equation model of prepayment cost;
K - Capital
M - Marketable Securities
$\bar{p}$ - Weighted Average Price Cap
p^{A*} - Steady-State Asset Price
p^0 - Asset Price
p^C - Cash flow constraint
x_m' - Budget Constraint
η - Elasticity
r^A - Asset Rate
r^f - Fraction of Assets that Refinance
r^R - Recovery Rate
r^B - Default Rate
r^S - Returns on Marketable Securities
r^B - Borrowing Rate in period m

u_m - Cost of Funds

Π - Profit

V - Volatility

Π_m^* - Profit when the asset value is in steady-state

$\hat{\Pi}_m$ - Proportional Change in Profit

σ - Continous-time Deviation of price changes

∞ - Infinity

Σ - Shock Parameter.

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Chapter 1

Introduction to Basel III and Asset Securitization

Asset securitization involves the process by which securities are created by a special purpose entity (SPE) – hereafter, simply known as an entity – and then issued to investors with a right to payments supported by the cash flows from a pool of financial assets held by the entity (see, for instance, [80]). There is broad-based usage of entities by financial institutions of many types, in various jurisdictions, and for many purposes (see, for instance, [24]).

Securitization has been popular as an alternative funding source for consumer and asset lending in market economies. Its main objective is to improve credit availability by converting hard-to-trade and non-tradable assets into securities that can be traded on capital markets. The categorization of the payment rights into "tranches" paid in a specific order and supported by credit enhancement mechanisms provides investors with diversified credit risk exposure to particular investor risk appetites (see, for instance, [22] and [53]).

Immediately prior to the securitization market collapse in 2007-2008, structured asset products (SAPs) such as asset-backed securities (ABSs) and collateralized debt obligations (CDOs) as well as covered bonds provided between 25 and 65 % of the funding for new residential assets originated in the US and Western Europe (see, for instance, [83]). In most developed economies, SAP growth peaked by 2007 before declining rapidly due to a lack of liquidity in secondary markets and decreases in primary issuance (see, for instance, [84] and [85] for more details). For example, SAP issuance in the US decreased from about US $ 2 trillion in 2007 to around US $ 400 billion in 2008. The impact of the financial crisis on securitization in emerging markets was more modest as initial growth had been more subdued. The contribution of securitization to the financial crisis necessitated changes to banking regulation. In this regard, the introduction of Basel III capital and liquidity regulation includes elements that will potentially affect the incentives for banks to securitize assets (see, for instance, the Basel documents [18], [21] and [22] as well as [85]).

There are several Basel III provisions that address areas of concern that were highlighted during the financial crisis and which supervisors determined were not adequately addressed under the previous framework (see, for instance, [18]). More specifically, in July 2009, the Basel Committee for Banking Supervision (BCBS) published enhancements to the Basel II framework that were intended to strengthen the framework and respond to lessons learned from the financial crisis (see [27] for more details). For instance, because of the higher degree of inherent risk in re-securitization exposures, the BCBS significantly increased the risk weights applicable to such exposures under both the standardized (SA) and internal ratings based (IRB) approaches relative to the risk weights for other securitization exposures (see, for example, [16], [20] and [53]). As a result, the capital requirements for re-securitizations have risen dramatically. In addition, to address the lack of appropriate due diligence on the part of investing institutions and deter them from relying solely on external credit ratings, the Basel framework now requires banks to meet specific operational criteria in order to use the risk weights specified in the Basel II securitization framework. During the financial crisis, credit rating agencies (CRAs) downgraded the ratings of many securitization tranches, including senior trances, highlighting deficiencies in credit rating agency models originally used to determine the ratings. Capital requirements assigned to highly rated (e.g., AAA) senior and mezzanine securitization exposures, were too low and this was illustrated by the poor performance of these securities (see, for instance, [16] and [20]).

The study investigated how entities securitize low-quality assets (LQAs) and high-quality assets (HQAs) – known as LQ-entities (LQEs) and HQ-entities (HQEs), respectively – into derivatives. In particular, the study looked at the securitization of such assets into derivatives by the aforementioned entities. It shall be seen that the reference asset portfolios are both a means of generating derivatives as well as collateral for interbank borrowing. The main result of the study quantifies the effects of shocks on asset price and input, derivative price and output as well as profit. For instance, the aforementioned result demonstrates how the proportional change in profit subsequent to a negative shock is influenced by LQA features such as asset, prepayment and refinancing rates as well as equity. Further examples that illustrate that asset price is most significantly affected by shocks from asset rates, while, for SAP price, shocks to speculative asset funding, investor risk characteristics and prepayment rate elicit statistically significant responses were presented. In short, the research focused on investigating the securitization of assets into derivatives and the extent to which economic shocks affect this process. Also, the study investigated how securitization impacts persistence and amplification in future with reference to the new proposed Basel III capital and liquidity regulation (see, for instance, [84]).

1.1 Preliminaries about Asset Securitization

In this subsection, preliminaries about high- and low-quality classification are provided.

1.1.1 Preliminaries about Low- and High-Quality Classification

HQAs are characterized by their long-term, usually 30-year period, fixed rates. An example of a HQA is a AAA or Aaa rated bond or security. These assets are sold to investors with a low default risk. Here, it is the investor's choice to refinance (call-option) or to default (put-option). In the case of refinancing, the prepayment cost $c_p = 0$. On the other hand, LQAs are short-term and are extended to riskier investors with a poor credit history. An example of a LQA is a B or CCC rated security. In this regard, the lender decides whether the investor will default or refinance and the prepayment cost c_p is non-zero. In general, the asset rate, r^A, for profit maximizing entities, may be represented as

$$r_m^A = r_m^L + \varrho_m, \tag{1.1}$$

where r^L is, for instance, the 6-month LIBOR rate and ϱ is the risk premium that is indicative of asset price. LQAs are usually adjustable rate assets (ARAs) where high step-up rates are charged in period $m+1$ after low teaser rates in period m. Secondly, this higher step-up rate causes an incentive to refinance in period $m+1$. Refinancing is subject to the fluctuation in asset prices. When asset prices rise, the dealer is more likely to refinance. This means that investors could receive further LQAs with lower interest rates as asset prices increase. Thirdly, a high prepayment penalty is charged to dissuade investors from refinancing.

In addition, as indicated in the BCBS documents, [21] and [22], the characterization of high-quality is based both, on available external information, such as external ratings, market data and analyst's reports; as well as the entity's own assessment of credit and liquidity risk, whereby the entity should demonstrate its understanding of the terms of the securitization exposure and the risks of the underlying collateral (see, for instance, [24], [84] and [85]). The entity would be required to demonstrate that the credit quality of the position is strong, with very low default risk, and is invulnerable to foreseeable events, implying that financial commitments would be met in a timely manner with a very high probability (see, [14] and [18] for further discussion). Where this determination could not be made, the position would be assumed to be "low-quality."

An example of a comparison between HQAs and LQAs as collateral for derivatives can be made. In this regard, Table 1.1 below illustrates that LQ- asset-backed securities (ABSs) dominated HQ- asset products as CDO collateral.

Vintage	LQ- Assets	HQ- Assets
2003	215	144
2004	371	188
2005	488	209
2006	522	142
2007	150	28

Table 1.1: Residential Asset Deals in 420 ABS CDOs; Source: [83]

The Basel III document [24], the Joint Forum Working Group on Risk Assessment and Capital (JFWGRAC) consisting of the BCBS, International Organization of Securities Commissions (IOSC) and the International Association of Insurance Supervisors (IAIS) under the support of the Bank for International Settlements (BIS), makes recommendations about such entities and can be shown in terms of defining features as follows.

Feature	LQAs	HQAs
External Information		
External Ratings	Low	High
Market Data	Poor	Rich
Analysts' Reports	Negative	Positive
Internal Information		
Credit Risk	High	Low
Liquidity Risk	High	Low
Securitization Exposure	Not Understood	Understood
Financial Obligations	Not Easily Met	Easily Met

Table 1.2: Defining Features of LQAs & HQAs; Source: [85]

We note from the last row and second colunm of Table 1.2 that LQ- assets do not easily meet financial obligations because of FICO scores, investor credit history and the lack of documentation.

1.1.2 Preliminaries about Structured Asset Products

LQAs were financed by securitizing assets into SAPs such as ABSs and CDOs. The lower-rated tranches of low quality ABSs formed 50% to 60% of the collateral for derivatives.

These were extremely sensitive to a deterioration in asset credit quality. For example, housing went through a classic inventory cycle with the worsening of the inventory-to-sales cycle being evident in the midst of the low quality asset crisis. When this inventory situation worsened, the risk that price would fall more rapidly deepened. The more substantial fall in prices accelerated the delinquency and foreclosure rater and spelt doom for the derivatives market. We briefly describe the aforementioned SAPs in turn.

Low quality ABSs are quite different from other securitizations because of the unique features that differentiate LQAs from other assets. Like other securitizations, low quality ABSs of a given transaction differ by seniority. But unlike other securitizations, the amount of *credit enhancement* for and the size of each tranche depend on the *cash flow* coming into the deal in a very significant way. The cash flow comes largely from prepayment of the reference asset portfolios through refinancing. What happens to the cash coming into the deal depends on *triggers* which measure (prepayment and default) performance of the reference asset portfolios. The triggers can potentially divert cash flows within the structure. In some case, this can lead to a leakage of protection for higher rated tranches. Time tranching in LQA transactions is contingent on these triggers. The structure makes the degree of credit enhancement dynamic and dependent on the cash flows coming into the deal.

1.1.3 Preliminaries About LQA- and HQA Securitization

In this study, the reference asset portfolios are both a means of generating CDOs as well as collateral for inter-entity sponsoring (see, for instance, [24]). The study quantifies the effects of unexpected negative shocks such as rating downgrades on asset price and input, CDO price and output as well as profit in a Basel III context (see, also, [79]). For instance, the aforementioned result demonstrates how the proportional change in profit subsequent to a rating downgrade is influenced by LQA features such as asset rates. Finally, examples that illustrate that asset price is most significantly affected by unexpected negative shocks from asset rates, while, for CDO price, shocks to speculative asset funding, investor risk characteristics and prepayment rate elicit statistically significant responses are provided (compare with [53]).

LQAs were financed by securitizing these assets into SAPs such as ABSs and CDOs. The lower-rated tranches of low quality ABSs formed 50 to 60% of the collateral for CDOs during 2007. These were extremely sensitive to a deterioration in asset credit quality. Housing went through a classic inventory cycle with a worsening of the inventory-to-sales cycle being evident in the midst of the 2007-2009 financial crisis. When this inventory situation worsened, the risk that price would fall more rapidly deepened. The more substantial fall in prices accelerated the delinquency and foreclosure rater and spelt doom for the CDO market which was further revised in Basel III (see, for instane, the BCBS paper [18] and [53]). The aforementioned SAPs are briefly described in turn.

LQ-ABSs are quite different from other securitizations because of the unique features that differentiate low quality assets from other assets. Like other securitizations, LQ-ABSs of a given transaction differ by seniority. But unlike other securitizations, the amount of *credit enhancement* for and the size of each tranche depend on the *cash flow* coming into the deal in a very significant way. The cash flow comes largely from prepayment of the reference asset portfolios through refinancing. What happens to the cash coming into the deal depends on *triggers* which measure (prepayment and default) performance of the reference asset portfolios. The triggers can potentially divert cash flows within the structure. In some cases, this can lead to a leakage of protection for higher rated tranches. Time tranching in low quality transactions is contingent on these triggers. The structure makes the degree of credit enhancement dynamic and dependent on the cash flows coming into the deal.

In this case, a CDO issues debt and equity and uses the income to invest in financial assets such as assets and ABSs. It distributes the cash flow from its asset portfolio to holders of various liabilities – usually a capital structure consisting of equity or preferred shares, subordinated debt, mezzanine debt and AAA rated senior debt as well as borrowings – in set ways taking into account the relative seniority of the aforementioned liabilities. A key feature of such CDOs is that they are mainly constituted by ABS portfolios that are rated according to their prevailing credit risk and put into tranches (compare with [53]). CDO tranches include LQ- and Alt-A deals and consist of three categories, namely, senior, mezzanine and equity or low tranches according to increasing credit risk. This risk is spread to investors who invest in these risky CDO tranches. It is difficult for investors to locate the risk exposure of these CDOs because of its complex design structure. Despite this, CDOs have additional structural credit protection which can be characterized as either cash flow or market value protection. Finally, all CDOs are created to fulfill a given purpose that can be classified as arbitrage, balance sheet or origination.

1.1.4 Preliminaries About Econometric Tests for Bank Liabilities and Liquidity

Liability and liquidity for Class I and II banks is applied for econometric testing in this study. The characteristics of the variables in these data sets are subject to tests conducted on them. Stationarity testing through the application of ADF and PP tests shows the non presence and or presence of unit root in the series for liability and liquidity with I(0) and I(1) representing the series at level and first difference respectively. A null hypothesis in this study represents the presence of a unit root and rejection of the results while the alternative hypothesis represents non presence of a unit root and acceptance of the results. Cointegration is applied through the use of Johansen tests comprising the trace and maximum-eigenvalue statistics (see for instance [66]) and chapter 6. The presence of cointegrating equations implies a long run relationship exists for the dependent and independent variables. This can for example point to a stable long run relationship between NSFR and LCR, GSR or BDR in this study. The VECM is further applied in the presence of cointegration and the error coefficient is expected to be negative in order for restoration of equilibrium and it confirms the unavailability of problems in the long run equilibrium relationship between the dependent and independent variables. To check the stability of the VECM, the inverse roots of AR characteristic polynomial is applied with a graph having all the roots inside the circle implying stability of the model. In addition, Girfs are used in this study to show the impact of shocks on variables. The reaction of IBD to a shock in NIBL and reaction of NSFR to a shock in LCR is shown by these functions.

1.2 Main Questions and Thesis Outline

In this subsection, the main problems addressed are identified and an outline of the thesis is further given.

1.2.1 Main Questions

The main questions that are solved in this paper may be formulated as follows.

Question 1.2.1 (HQ- and LQ-Entity Asset Securitization) *How do LQ- and HQ-entities securitize LQ- and HQ-assets into CDOs respectively?*

Question 1.2.2 (Shocks to Asset Securitization) *How do negative shocks affect asset price and input, CDO price and output as well as profit?*

Question 1.2.3 (Basel III and Asset Securitization) *How does proposed Basel III improve the flaws of the recent securitization framework?*

Question 1.2.4 (Illustrative Examples of Asset Securitization) *Can we provide examples to illustrate the main features of asset securitization by LQ- and HQ-entities?*

Question 1.2.5 (Cyclicality and Bank Securitization Incentives): *How does the revised capital framework in Basel III affect the incentives for banks to securitize assets into SAPs in a cyclical financial set up?*

Question 1.2.6 (Bank Liability) *How do liabilities impact on the stress level and performance of Class I and II banks?*

Question 1.2.7 (Bank Liquidity): *How does the level of Class I and II bank Liquidity affect the performance and securitization of assets into SAPs?*

1.2.2 Thesis Outline

Chapter 2 shows and explains the literature review behind asset securitization and Basel III. The backgrounds to these facets will be given and a base for further study in other chapters established. Chapter 3 provides an insight into the data and methods that will be used in this study to obtain results for analysis. Furthermore, Chapter 4 studies Basel III and one-step asset securitization. In this regard LQ- and HQ-entities at equilibrium in Subsections 4.3.1 and 4.3.2, will be considered respectively and also, market equilibrium for these entities will be considered. In addition, market equilibrium for these entities will be considered in section 4.1.7. Chapter 5 considers Basel III and two-step asset securitization and the effects of shocks to asset price and input, derivative price and output as well as profit. It also provides numerical quantitative results and discussion involving shocks to the aforementioned asset-related variables. Chapter 6 focuses on the econometric analysis of Basel III and modeling bank liability and liquidity data through the application of tests which include, unit root, cointegration, vecm, granger-causality and generalized impulse response functions. Chapter 7 identifies key conclusions and possible topics for future research while Chapter 8 shows the Bibliography. Chapter 9 shows the appendices. In addition to the issues highlighted above, throughout the thesis, the deleterious effects associated with derivative issuance by entities will be commented on. In particular, the reduction in incentives for banks to monitor entities, transaction fees, manipulation of price and structure, market opacity, self-regulation, systemic risks mispricing of debt, liquidity coverage ratio and net stable funding ratio introduction in Basel III will be focused on.

Chapter 2

Literature Review

Motivated by the 2007-2009 financial crisis, there is an ever-growing body of literature on LQ-asset related issues such as shocks to LQ-entities, investors and CDOs via, for instance, rating changes. The contribution [52] studies the pricing of LQ-assets and related SAPs on the basis of data for the ABX.HE family of indices (see [61] for further details). This, of course, is a recurring theme in the study where asset and CDO pricing during the financial crisis will be considered. Moreover, [83] addresses the impact of speculative asset funding on the pricing of LQ-assets (measured by risk premia) and securities backed by these assets (measured by ABX.HE indices). In addition, the paper [62] extends a Kiyotaki-Moore-type model that shows how relatively small shocks might suffice to explain business cycle fluctuations, if credit markets are imperfect. This study has a connection with this paper via the consideration of the effect of shocks on asset parameters although there will be no emphasis on the imperfection of credit markets (see [78] for additional analysis). The paper [45] studies the impact of penalties on LQ-asset loans (see, also, [72]). Here, asset prices and penalties are chosen simultaneously with the latter being associated with lower asset prices (see [78] for more details). The paper also contains discussions on prices and penalties and their relationship with loan-to-value ratios (see, also, [44] for more on house equity). In this study, the contribution made will come from the use of the framework introduced in [45] to show how a change in profit subsequent to a negative shock is influenced by LQ- asset features.

2.1 Literature Review of the Kiyotaki-Moore Model

The theory outlined is supported by various strands of existing literature. The model in [69] introduces a market equilibrium in which the marginal productivity of constrained firms are higher than that of the unconstrained firms. Consequently, any shift in usage from the constrained to the unconstrained firms leads to a first-order decline in aggregate output. Aggregate productivity, measured by average output per unit of land, also declines, not because there are variations in the underlying technologies (aside from the initial shock), but rather because the change in land use has a compositional effect. In their model economy, [69], Kiyotaki and Moore, assume patient and impatient decision makers, with different time preference rates. The patient agents are called gatherers but should be interpreted as households that wish to save. The impatient agents are called farmers but should be interpreted as entrepreneurs or firms that wish to borrow in order to finance their investment projects.

In the paper [69], gatherers can be partially associated with entity banks that are highly rated and hold HQAs and are called HQ-entities. Here, the role of Kiyotaki and Moore's farmers are partly taken by LQ-entities and hold LQAs. In the context of this paper, two key assumptions limit the effectiveness of the model credit market. Firstly, LQ-entities knowledge is an essential input to their asset securitization, that is, securitization becomes worthless if the LQ-entity who made the investment chooses to abandon it. Secondly, LQ-entities cannot be forced to securitize assets, and therefore they cannot sell off their future labor to guarantee their debts. Together, these assumptions imply that even though LQ-entitie's securitization projects are potentially very valuable, HQ-entities have no way to confiscate this value if LQ-entities choose not to pay back their debts. Therefore, inter-bank lending will not take place unless it is backed by some form of collateral. [69] considers land as an example of a collateralizable asset. Land is a productive input and also serves as collateral for debt. Hence, LQ-entities must provide land as collateral if they wish to borrow. If for any reason land value declines, so does the amount of debt they can acquire. This feeds back into the land market, driving the land price down further. In this case, the borrowing decisions of LQ-entities are strategic complements. This positive feedback is what amplifies economic fluctuations in the model. The paper also analyzes cases where debt contracts are set only in nominal terms or where contracts can be set in real terms, and considers the differences between the cases.

2.2 Literature Review of Asset Securitization

Securitization according to [83], is the process of taking an illiquid asset, or group of assets, and through financial engineering, transform them into a security. The process of securitization got its start in the 1970s, when home loans were pooled by the U.S. government-backed agencies. Beginning in the 1980s, other income-producing assets began to be securitized, and in recent years the market has grown dramatically. In some of these markets, such as those for securities backed by risky LQ- assets in the United States, the unexpected deterioration in the quality of some of the underlying assets undermined investor confidence as shown in, [78]. In this case, both the scale and persistence of the attendant credit crisis seem to suggest that securitization, together with poor credit origination, inadequate valuation methods, and insufficient regulatory oversight could severely hurt financial stability [84].

According to [65], increasing numbers of financial institutions employ securitization to transfer the credit risk of the assets they originate from their balance sheets to those of other financial institutions, such as banks, insurance companies, and hedge funds. This is done for a variety of reasons and is mostly cheaper to raise money through securitization, and securitized assets were then less costly for banks to hold because financial regulators had different standards for them than for the assets that underpinned them [89]. In principle, this originate and distribute approach brought broad economic benefits to spreading out credit exposures within the financial sector made up of all financial intermediaries, thereby diffusing risk concentrations and reducing systemic vulnerabilities [78].

The impact of securitization appeared to a great extent to be positive and unharmful until the unfolding of the 2007-2009 financial crisis. However this process has been indicted by some (see for instance [4]) for compromising the incentives for originators to ensure minimum standards of prudent lending, risk management, and investment, at a time when low returns on conventional debt products, default rates below the historical experience, and the wide availability of hedging tools were encouraging investors to take more risk to achieve a higher yield. The paper [4], points out that many of the loans were not kept on the balance sheets of those who securitized them as they where transferred to other participants, thereby encouraging originators to cut back on screening and monitoring borrowers. This was attributed to the systematic deterioration of lending and collateral standards[1].

A typical example of securitization according to [65] and [4], is an asset-backed security (ABS), which is a type of security that is secured by a collection of specific type of assets such as car loans, home loans or aircraft leases. This process works according to [4] by firstly having a regulated and authorized financial institution originate numerous assets, which are secured by claims against the various properties the borrower purchases. Next, the individual assets are bundled together into an asset pool, which is held in trust as the collateral for an ABS. The ABS can then in this case be issued by a third-party financial company, such as a large investment banking firm, or by the same bank that originated the assets in the beginning [4]. Asset-backed securities are also issued by government sponsored enterprises in the United States such as Fannie Mae or Freddie Mac

New securities are usually created irrespective of the result, supported by the claims against the borrowers' assets [4]. These securities can then be sold to participants in the secondary

[1]see for instance, BCBS189 Jun11

asset market which is extremely large, providing a significant amount of liquidity to the group of assets, which otherwise would have been quite illiquid on their own, (see for instance [4] and [84]).

Furthermore, according to [4], at the time the ABS is being created, the issuer often chooses to break the asset pool into a number of different parts, referred to as tranches. These tranches in turn can be structured in practically any way the issuer intends to put it which allows the issuer to modify a single ABS for a variety of risk broad-mindedness. Pension funds typically invest in high-credit rated asset-backed securities such the HQ-assets considered in this study, while hedge funds usually seek higher returns by investing in those with low credit ratings such as LQ- assets as seen in [80].

The process of asset securitization in the form of home loans and the payments involved is shown by figure 2.1.

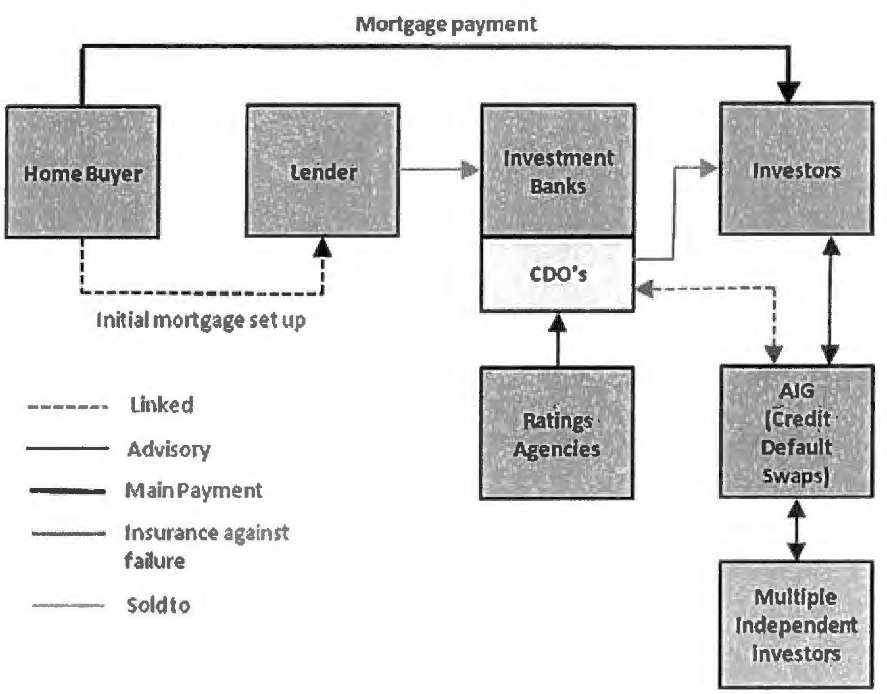

Figure 2.1: Illustration of Mortgage Securitization; Source[50]

The homeowners according to, [4], approach banks as borrowers for home loans which are issued to them based on their credit worthiness. The banks (originators) with loans or other income producing assets then identify the assets it wants to remove from its balance sheet for transfer to other financial participants thereby pooling them into the reference portfolio (see for instance, [104]). The bank then sells this asset pool to an issuer, such as a special purpose Entity (SPE) which is an entity set up, usually by a financial institution, specifically to purchase the assets and realize their off-balance-sheet treatment for legal and accounting purposes [89]. The SPE in turn sells loans to investment banks which finances the acquisition of the pooled assets by issuing tradable, interest-bearing securities that are sold to capital market in the form of CDOs for example. Rating agencies such as moody's, fitch or standard and poor's stamp the SAPs as good investments after they have been bundled up so that investors can buy them and expect good returns [4].

The investors as shown in the Basel document [20] receive fixed or floating rate payments from a trustee account funded by the cash flows generated by the reference portfolio. In many instances, the originator services the loans in the portfolio, collects payments from the original borrowers, and passes them on for a servicing fee paid directly to the SPE or the trustee [4]. In principle, the process of securitization represents a different and spread source of finance based on the transfer of credit risk[2] from issuers to investors.

2.2.1 Securitization Frictions

The process according to [4], starts with the borrower, applying for a home loan so as to purchase a property or to refinance an existing loan. The originator, possibly through a broker[3], underwrites and initially funds and services asset loans. The originator usually is rewarded through fees paid by the borrower[4], and by the proceeds of the sale of the asset loans. The originator might sell a portfolio of loans with an initial principal balance of \$100 million for \$102 million, corresponding to a gain on sale of \$2 million [4]. The buyer is usually willing to pay this premium because of anticipated interest payments on the principal.

Securitization frictions occur between the borrower and origination with LQ- borrowers being financially unsophisticated according to [4]. Borrowers might for example, be unaware of all the financial options available to them and even if these options are known, the borrower might be unable to make a choice between different financial options that are in there own best interest due to the similarities and sometime complex nature of these options (see for instance, [48]). This friction leads to the possibility of predatory lending, defined by [77] as the welfare-reducing provision of credit. The main protection against these practices are federal, state, and local laws disallowing some types of lending practices, as well as the recent regulatory guidance on LQ- lending as pointed out in [44] and [18]. The pool of asset loans is characteristically bought from the originator by an institution known as the arranger or issuer. The arranger according to [4], conducts due diligence

[2] possibly also interest rate and currency risk
[3] another intermediary in this process
[4] points and closing costs

on the originator which entails but is not restricted to, financial statements, underwriting guidelines, discussions with senior management, and background checks. The arranger is further accountable for ensuring that all the elements for the deal are brought together before closure (see for instance [44] and [4]). Specifically, the arranger creates a bankruptcy-remote trust[5] that buys the asset loans and consults with the credit rating agencies in order to finalize the details about deal structure, makes necessary filings with the securities and exchange commission, and underwrites the issuance of securities by the trust to investors [4].

The arranger according to [4] is usually paid through fees charged to investors and through any premium that investors pay on the issued securities over their par value. The originator in the securitization of assets usually has an information advantage over the arranger with regard to the quality of the borrower(see for instance,[4] and [45]). In the case of non presence of sufficient safeguards in place, an originator can have the motivation to collaborate with a borrower in order to make substantial misrepresentations on the loan application, which according to [4], depending on the situation, could be either interpreted as predatory lending[6] or predatory borrowing.[7]

The process of securitization initially began as a way for financial institutions and corporations to find new sources of funding either by moving assets off their balance sheets or by borrowing against them to refinance their origination at a fair market rate (see for instance, [4],[65] and [48]). This process of financial engineering reduced their borrowing costs and, in the case of banks, lowered regulatory minimum capital requirements[8]. If for instance a leasing company needed to raise cash, the standard procedure would require the company to take out a loan or sell bonds. The company's capability to make this happen, and the cost, would depend on the overall financial health and credit rating [4]. In instances where the company is able to find buyers, it could sell some of the leases directly, satisfactorily changing a future income stream to cash. The encountered setback is the unavailability of a secondary market for individual leases. However by the process of bundling the leases, the company can raise cash by selling the package to an issuer, which in turn changes the bundle of leases into a tradable security (seee for instance,[4] and [21]).

Assets, according to [65] and [4], are usually separated from the originators balance sheet[9], enabling issuers to raise funds to finance the buying of assets more cheaply than would be possible on the strength of the originators balance sheet alone. In other terms, according to [4], a company with an overall B rating with AAA-rated assets on its books might be

[5] usually referred to as a Special Purpose Entity(SPE)
[6] the lender convinces the borrower to borrow too much
[7] the borrower convinces the lender to lend too much
[8] BCBS189Jun11
[9] as well as its credit rating

able to raise funds at a AAA rather than B rating by securitizing those assets. It should be noted that, unlike predictable debt, securitization does not inflate a companys liabilities but instead produces funds for future investment without balance sheet growth according to [4]. Investors usually in most cases benefit from more than just a greater range of investible assets made available through securitization (see for instance, [18] and [20]).

The elasticity of securitization transactions according to [4], helps issuers to modify the risk-return properties of tranches to the risk tolerance of investors. In other terms, pension funds and some alternative combined investment schemes require an assorted range of highly rated long-term fixed-income investments beyond what the public debt issuance by governments can provide [4]. With the trading of securitized debt, investors can promply adjust their individual exposure to credit-sensitive assets in response to changes in personal risk sensitivity, market sentiment, and consumption preferences at low transaction cost(see for instance, [20] and [21]). The originators may at times not sell the securities outright to the issuer[10] but instead sell only the credit risk related to assets without the transfer of legal title.[11] Synthetic securitization enables issuers to take advantage of price differences between the acquired[12] assets and the price investors are willing to pay for them[13](see for instance, [4] and [31]).

2.2.2 Collateralized Debt Obligations (CDOs)

A CDO, according to [48], is fundamentally a securitization in which a special purpose Entity or SPE issues bonds or notes against an investment in an expanded pool of assets. These assets can be bonds, loans such as commercial bank loans or a mixture of both bonds and loans (see for instance,[89]). In cases where assets are bonds, they are usually high-yield bonds that provide a spread of interest over the interest liability of the issued notes and in other cases where the assets are loans, the CDO acts as a mechanism by which illiquid loans can be pooled into a marketable security or securities [89]. The third type of CDO is known as a synthetic CDO and refers to a structure in which credit derivatives are used to construct the underlying pool of assets (see for instance, [104] and [50]).

The investments, according to [89] are financially supported through the issue of the notes, and interest and principal payments on these notes are connected to the performance of the underlying assets. Furthermore, the underlying assets act as the collateral for the issued notes, as is given by the name (see for instance,[50]). The main difference between CDOs and ABS and multi-asset repackaged securities is the collateral pool being more actively

[10]called true sale securitization

[11]referred to as synthetic securitization

[12]often illiquid

[13]if diversified in a greater pool of assets

managed by a portfolio or collateral manager as explained by [50]. In most cases, CDOs feature a multi-tranche structure, comprising a number of issued securities, most or all of which are rated by a ratings agency such as moody's, fitch or standard and poor. The significance of the issued securities payment reflects the credit rating for each note, with the greatest senior note being the highest rated (see for instance,[89] and [104]). The term waterfall is used to refer to the order of payments; sufficient underlying cash flows must be generated by the issuing entity in order to meet the fees of third-party servicers and all the note issue liabilities [89]. In Europe issued securities may pay a fixed or floating coupon, usually on a semi-annual, quarterly or monthly basis, thereby proving once and for all that Euro-bonds, defined as international securities issued by a syndicate of banks and clearing in Euro-clear and Clear-stream, may pay coupon on frequencies other than an annual basis, with senior notes issues from AAA to A and junior and mezzanine notes rated BBB to B (see for instance,[48] and [55]). It should be noted that there may at times be unrated subordinated and equity pieces issues and investors in the subordinated notes in this case receive coupon after payment of servicing fees and the coupon on senior notes [89]. In addition, the equity and subordinated note are the first loss pieces and, as they are made up of the highest risk, have a higher expected return compared to that of the underlying collateral [89].

In a more current modification, the reference portfolio is seperated into several slices, called tranches, each of which has a different level of risk associated with it and is sold separately (see for instance, [83]). Both investment return[14] and losses are apportioned among the various tranches according to their seniority. See for instance the Figure 2.2.

[14]principal and interest repayment

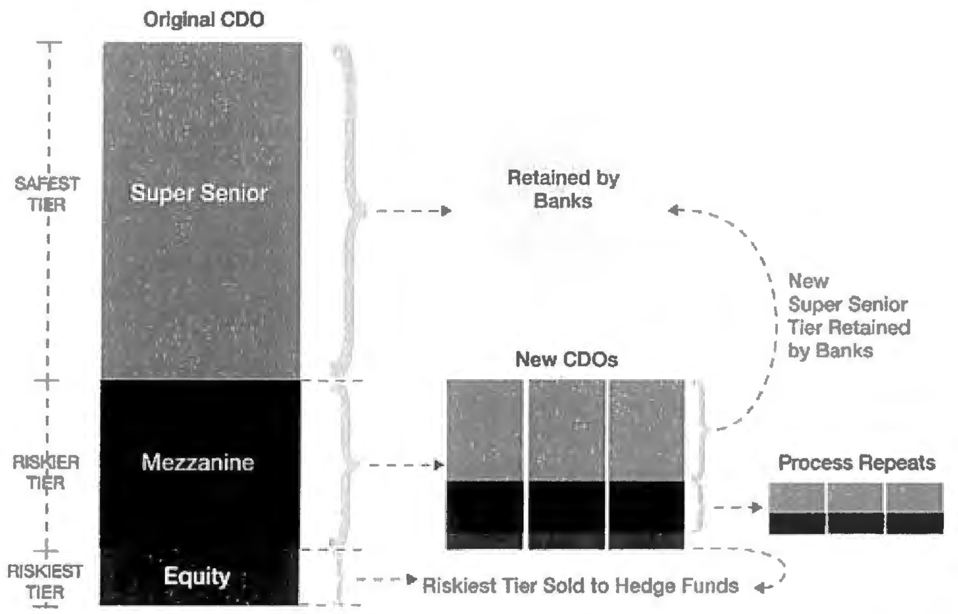

Figure 2.2: Colleteralized Debt Obligation (CDO) Structure; Source [50]

The least risky tranche according to [50], for example, has first call on the income generated by the underlying assets, while the riskiest has last claim on that income. The predictable securitization structure assumes a three tier security design made up of junior, mezzanine, and senior tranches (see for instance,[83]). This structure concentrates expected portfolio losses in the junior, or first loss position, which is usually the smallest of the tranches but should be noted is the one that bears most of the credit exposure and receives the highest return according to [83] and [89]. There is slight expectation of portfolio losses in senior tranches, which because of investors often financing their purchase by borrowing, are very sensitive to changes in underlying asset quality [50]. It was because of this sensitivity that was the initial source of the problems in the LQ- assets market in 2007-2009. When repayment issues surfaced in the riskiest tranches, lack of confidence spread to holders of more senior tranches causing panic among investors and a flight into safer assets, resulting in a panick sale of securitized debt (see for instance,[84] and [50]).

A more clear understanding of CDO tranches is shown by Figure 2.3 below

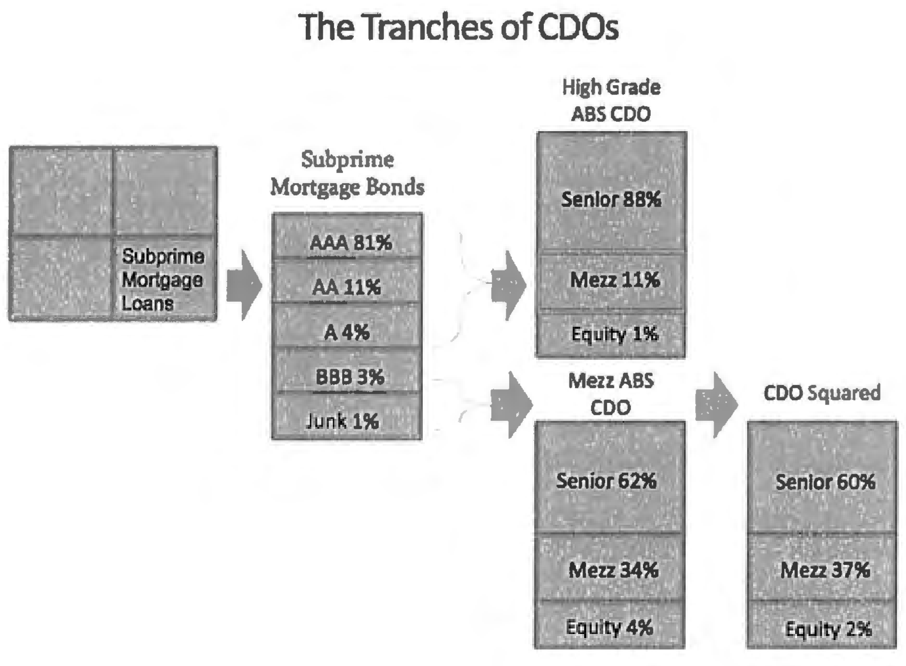

Figure 2.3: Tranches of CDOs; Source [89]

Securitization was initially used to finance simple, self- liquidating assets such as home loans. But any type of asset with a stable cash flow can in principle be structured into a reference portfolio that supports securitized debt [83]. Securities can be backed not only by assets but by corporate and sovereign loans, consumer credit, project finance, lease/trade receivables, and individualized lending agreements according to [48]. The generic name for such instruments is asset-backed securities (ABS), although securitization transactions backed by home loans[15] are called mortgage-backed securities. Another security that is of relevance is the collateralized debt obligation, which uses the same structuring technology as an ABS but includes wider and more diverse range of assets (see for instance,[89]). There are two types of CDOs according to [89] and [50], collateralized bond obligations (CBOs) and collateralized loan obligations (CLOs). From the suggestion of names, the primary difference between each type is the nature of the underlying assets; a CBO is usually collateralized by a portfolio of bonds while a CLO represents an underlying pool of bank loans [89]. CDOs have also been collateralized by credit derivatives and credit-linked notes. Following this

[15] ie residential or commercial

difference, CDOs can be broken into two main types, balance sheet CDOs and arbitrage CDOs according to [89]. In this case, balance sheet CDOs are most similar to a traditional securitization whereby they are created to remove assets from the balance sheet of the originating bank or financial institution, usually to reduce capital requirements, increase return on capital or free up lending lines (see for instance,[48] and [89]). In addition, an arbitrage CDO is created when the originator, who may be a bank or fund manager for instance, wishes to exploit the yield differential between the underlying assets and the overlying notes which may be achieved by active management of the underlying portfolio, consisting of high-yielding or emerging market bonds according to [89], [83] and [4].

2.2.3 CDO Cash Flow

According to [104] and [48], arbitrage CDOs are mostly the easiest to understand and are similar to other asset-backed securitization involving an SPE. In principle, assets such as bonds or loans are pooled together and the cash flows from these assets used to back the obligations of the issued notes (see for instance,[55]). As the underlying assets are sold to the SPE, they are removed from the originators balance sheet thereby transferring the credit risk associated with these assets to the holders of the issued notes while originator also obtains funding by issuing the notes [4]. The structure is illustrated in Figure 2.4 below.

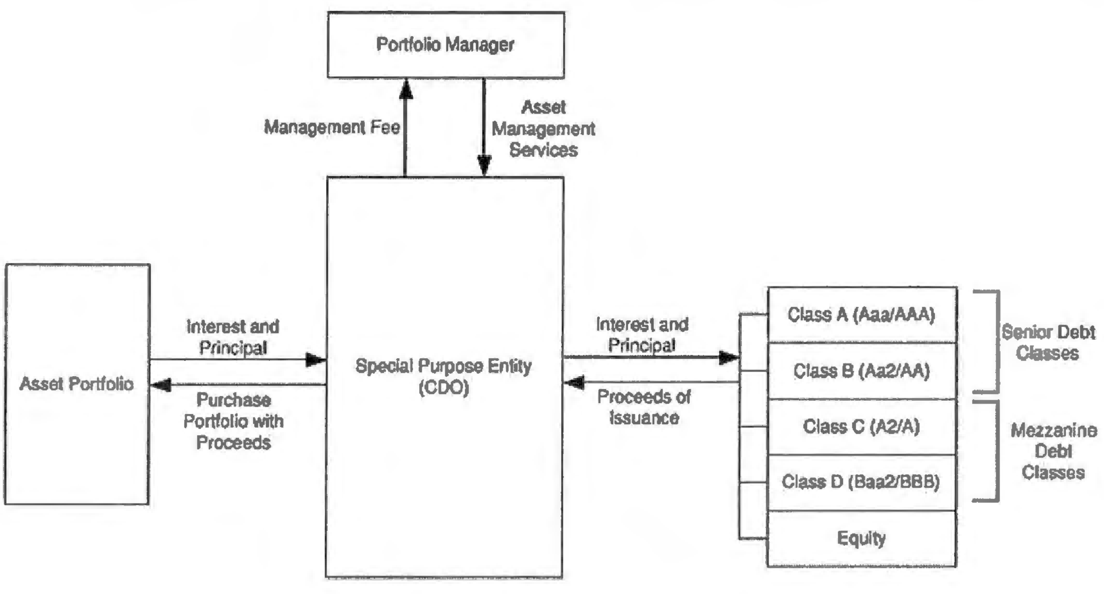

Figure 2.4: CDO Cash Flow Illustration; Source [89]

According to [89], the sponsor bank reduces exposure to selected clients and reduces concentration risks through the CDO. The overall exposure is reduced to the amount of the tranches[16] retained by the sponsor bank according to [4]. It should however be noted that, as the risk retained is subordinated element[17], the sponsor bank will endure substantial risk which may be similar to the actual economic risk on the underlying portfolio [4]. In practice however, this means that the risk reduction may not be important and the major benefit is the limitation on the maximum credit loss achieved [52]. In cases where the sponsor bank retains the equity component and all other parts of the capital structure are placed with investors, the maximum loss is limited to the amount of its investment [4].

2.2.4 High Quality Liquid-Assets

According to [14], items that qualify as liquid assets include cash and deposits held with central banks to the extent that these deposits can be withdrawn in times of stress; Transferable assets that are of extremely high liquidity and credit quality; Transferable assets representing claims on or guaranteed by the central government of a member state or a third country if the institution incurs a liquidity risk in that member state or third country that it covers by holding those liquid assets and transferable assets that are of high liquidity and credit quality (see for instance the BCBS documents, [14], [16] and [14]).

2.3 Literature Review of Basel III

Basel III[18] according to [21] is a global, voluntary regulatory standard on bank capital adequacy, stress testing and market liquidity risk. After the 2007-2009 financial crisis, the request for a more integrated capital accord with a feature that would help banks survive through the cycle was raised in both academia and the financial industry[19](see for instance,[10] and [13]). The Bank for International Settlements (BIS) introduced several drafts to analyze and respond to the LQ- asset crisis and in 2009 the New Capital Accord, referred to as Basel III, was proposed[20] and In November 2010, the G20 leaders officially endorsed the Basel III framework which was implemented in January 2013 and will eventually be fully implemented by 2019 through the BCBS[21] reviews and recommendations

[16] usually only the equity component of the transaction

[17] usually the first loss

[18] Also called the Third Basel Accord

[19] A new Capital Accord with counter-cycle effects was preferred and eminent after the 2007-2009 FC

[20] In July 2009, the revised securitization and trading book rules was issued, and in December 2009, Basel III consultative document was issued

[21] The Basel Committee on Banking Supervision consists of senior representatives of bank supervisory authorities and central banks from Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany,

from the financial sector and general public (see for instance, [15], [16] and [9]). According to [59], the aim of Basel III is to prepare the banking industry for future economic downturns by improving the banking sector's ability to absorb shocks arising from financial and economic stress, improving risk management and governance, and strengthening banks' transparency and disclosures. The framework also aims to enhance firm-specific measures, such as macro-prudential regulations to help create a more stable banking sector, by reducing the procyclical amplification risks across the banking sector over time [16]. Basel III can further be defined as a firm-specific, risk based framework and a system wide, systemic risk-based framework according to [31]

The public response to Basel III framework was different as is expected in every new regulatory reform. According to some, Basel III was unable to change the framework but instead only makes it more complex (see for instance,[26]). Therefore, it cannot solve the problem caused by Basel II, especially the procyclical effects while other people regarded Basel III as a great improvement in implementation [99].

2.3.1 Updated Features in Basel III

Basel III can be regarded as a complement to Basel II and it strengthens the financial stability in other ways out of the risk-based capital requirements, such as using leverage ratio and liquidity ratio according to [11] and [99]. This new third accord also updates the risk-based capital framework which includes strengthening the capital requirements and risk coverage, encourage using internal models rather than heavily relying on external rating agencies which were part of the 2007-2009 financial crisis due to the failure of their complex rating models [18].

It has been observed through past years that in terms of bank liabilities, capital is the most reliable source that can be used to absorb losses [99]. Therefore, there is international agreement that minimum capital requirements should be set for banks to protect against losses, help protect a bank from insolvency and prevent the negative effect caused by fierce rivalry (see for instance,[17]). These minimum standards for capital requirements were first introduced in 1988, which are now collectively known as Basel I [99]. After several banking crises, the BCBS found that Basel I does not cover all the risks a bank faces, and its lack of risk sensitivity does not give enough consideration to the different level of risk and ignores some products[22] (see for instance, [26] and [99]). Its capital requirements for

Hong Kong SAR, India, Indonesia, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. It usually meets at the Bank for International Settlements (BIS) in Basel, Switzerland, where its permanent Secretariat is located.

[22] less than one year and the off-balance sheet

credit risk exposures are set purely on the basis of the type of portfolio where a fixed risk-weight is applied to each type of exposure[23] and banks should maintain a ratio of capital, after deductions, to total RWA of 8% according to [92] and [22]. This framework has been concerned for increasing regulatory arbitrage and in June 1999, the first Consultative document in the New Capital Accord was published by the BCBS. In 2004, its revisions and a series of documents published from 1999 to 2006 were summarized in Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework by BCBS, which is herein referred to as Basel II (see for instance,[25]). Basel II allows banks the limited use of internal ratings for calculating regulatory capital requirements and the intention behind such amendments was to make regulatory capital match the economic capital requirements as close as possible [26].

A diagramatic overview of Basel III showing changes made from Basel II is shown in Figure 2.5.

[23]A portfolio of qualifying sovereign exposures attracts a risk-weight of 0%, a risk-weight of 20% for exposures to banks, and qualifying non-bank financial institutions, a weight of 50% for the retail mortgage portfolio, and a weight of 100% for corporate as well as unsecured retail portfolios

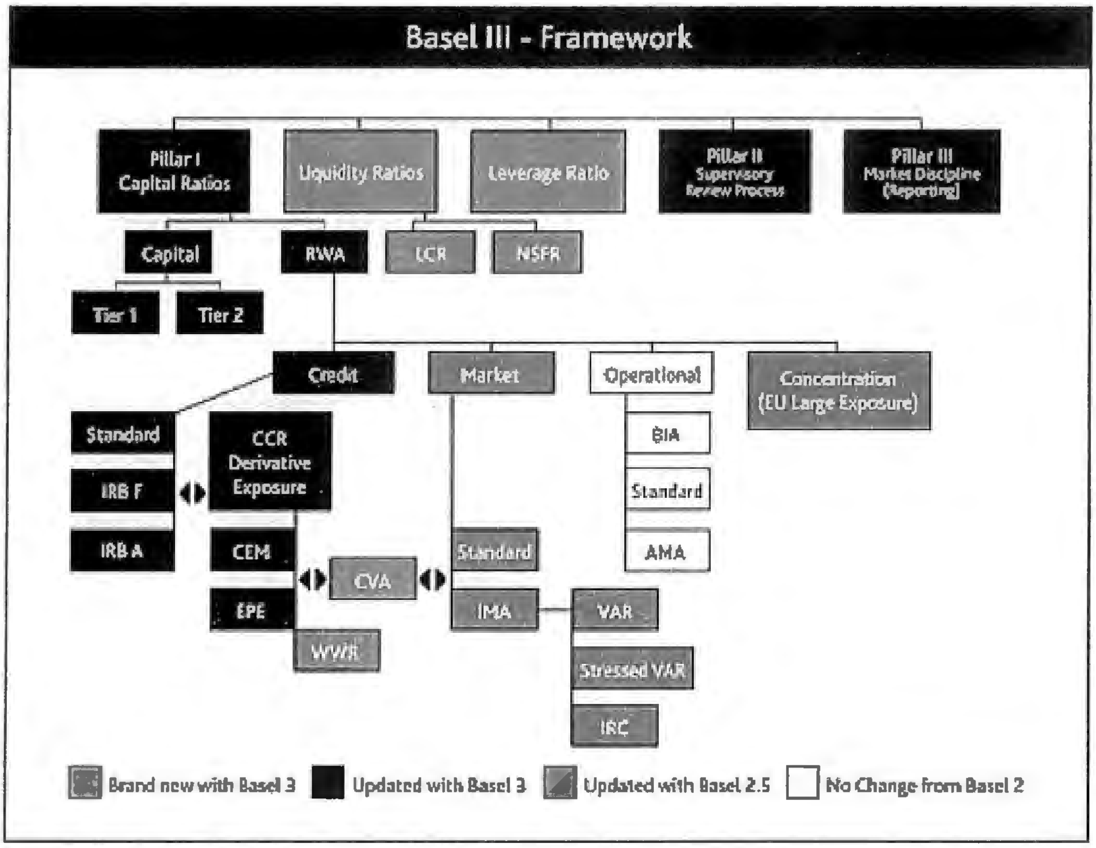

Figure 2.5: Basel III Framework; Source: [21]

Basel III according to [21], strengthens the Basel II capital requirements by adjusting Formula 3[24] in three ways:

1. increasing the quantity requirements for capital (increasing the capital ratio).
2. increasing the quality of the capital requirements (providing a stricter definition of capital numerator).
3. enhancing the risk coverage (denominator of Formula 3).

Figure 2.6 shows the three Basel III pillars that have been proposed to be applied to banks as part of the reforms to the framework.

[24]Credit Scoring models often become inputs into regulatory and economic capital calculations such as the Basel II RWA formula. Probability of Default (PD), Exposure at Default (EAD) and Loss given default (LGD) models are all used for this purpose

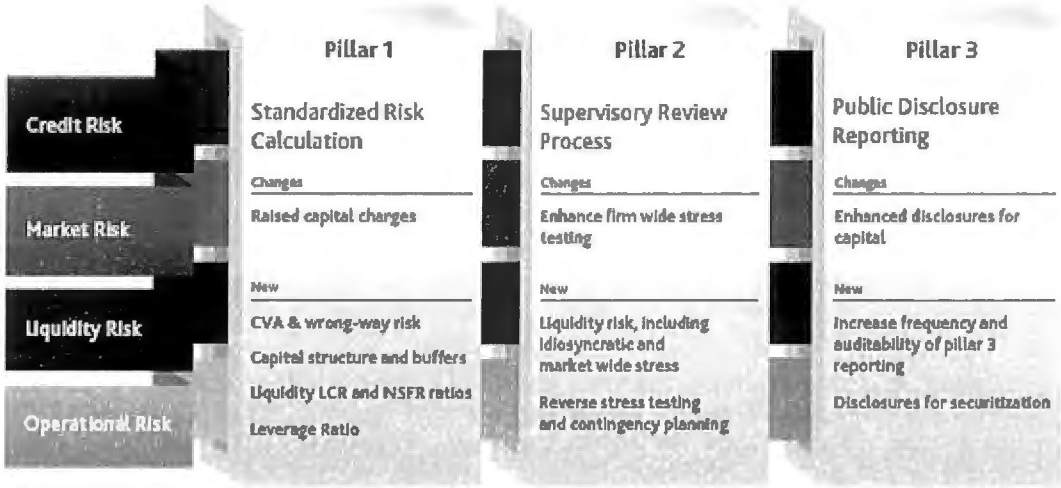

Figure 2.6: Basel III Pillars; Source: [21]

2.3.2 Changes in Quality and Quantity in Capital Requirements-Basel III

In percentage of risk-weighted assets	Capital requirements							Additional macroprudential overlay	
	Common equity			Tier 1 capital		Total capital		Counter-cyclical buffer	Additional loss-absorbing capacity for SIFIs*
	Minimum	Conservation buffer	Required	Minimum	Required	Minimum	Required	Range	
Basel II	2			4		8			
Memo:	*Equivalent to around 1% for an average international bank under the new definition*			*Equivalent to around 2% for an average international bank under the new definition*					
Basel III New definition and calibration	4.5	2.5	7.0	6	8.5	8	10.5	0–2.5	Capital surcharge for SIFIs?

Figure 2.7: Basel II to Basel III Capital Framework; Source: [59]

The Tier 1 capital ratio firstly increases from 4% to 6%. Basel III requires a 0% to 2,5% counter-cyclical capital buffer above the regulatory minimum capital requirements (see for instance,[12] and [16]). It is an extension of the capital conservation buffer for extremely large losses considering the country difference. Systemically important banks, according to [99] are recognized to have a loss-absorbing capacity beyond the normal Basel III standards (the exact number has not been defined yet in Fig 2.7) with the additional loss absorbing capacity for SIFIs[25]. The reason can be explained in terms of the correlations of financial institutions arising in recessions including the failure of SIFIs such as Lehman Brothers and AIG may have an infectivity to cause the downgrade of related companies, or general solvency problems among related financial intuitions, in turn adding to the cause of the recession (see for instance,[99] and [59]). The Basel Committee, in cooperation with the Financial Stability Board, is developing a methodology comprising both quantitative and qualitative indicators to assess the systemic importance of global financial institutions (see for instance [15]).

Although the minimum total capital requirements remain unchanged, the components of these requirements have changed. A higher-quality capital means that there will be more loss-absorbing capacity, which in turn indicates that banks will be stronger, allowing them to withstand periods of stress better [22]. It should be noted that common equity is the highest form of loss-absorbing capital. Thus, Basel III increases the minimum capital requirement for Tier 1 capital by largely increasing more than double the requirements for common equity and the proportion of common equity in Tier 1 capital increases from 50% to 75% (see for instance,[25] and [99]). The capital conservation buffer of 2.5% should be the common equity above the total minimum capital requirements and aims to build sufficient additional resources above regulatory minima to deal with business cycle fluctuations [99]. In addition, Basel III enhances the risk coverage in capital requirements. From 2004 to 2009, the total assets of the top 50 banks increased at a more rapid pace than their RWA according to [59] due to the trading book, securitization products, counter-party credit risk on OTC derivatives and repos. It should however be noted that these off-balance assets are not comprehensively covered by the RWA (see for instance,[99]). Trading book exposures are subject to a stressed value in the risk requirement and as a result, banks now hold capital for trading book assets which, on average, is about four times greater than that required by Basel II ([59]). Securitization pricing heavily relies on external rating by credit rating agencies such as Moody's or Fitch but after the 2007-2010 financial crisis, the external rating system was considered unreliable due to the fact that most of the models used by rating agencies were unstable and defaulted in turn (see for instance, [18]). This in turn means the increase of securitization exposure by Basel III. The re-securitization of the RW of AAA-rated tranches has for example increased from 7% to 20% according to [18].

[25]Stands for Systemically Important Financial Institutions

2.3.3 Risk Coverage Enhancement

According to [21], a lesson that was witnessed after the crisis has been the need to strengthen the risk coverage of the capital framework and the failure to capture major on and off-balance sheet risks, as well as derivative related exposures, was a key destabilizing factor during the crisis. In response to these shortcomings, the Basel Committee in July 2009 completed a number of critical reforms to the Basel II framework which are reforms that will raise capital requirements for the trading book and complex securitization exposures, which is a major source of losses for many internationally active banks (see for instance, [27] and [26]). The enhanced treatment introduces a stressed value-at-risk (VaR) capital requirement based on a continuous 12-month period of significant financial stress and in addition, the Basel Committee has also introduced higher capital requirements for re-securitizations in both the banking and the trading book according to [22] and [18]. The reforms also raise the standards of the Pillar 2 supervisory review process and strengthen Pillar 3 disclosures. The Pillar 1 and Pillar 3 enhancements must be implemented by the end of 2011; the Pillar 2 standards became effective when they were introduced in July 2009 [21]. The Committee is in addition conducting a fundamental review of the trading book where work on the fundamental review of the trading book was targeted for completion by the end of 2011 [21]. The Basel committee according to [26] and [21] has introduced measures to strengthen the capital requirements for counter-party credit exposures arising from banks derivatives, repo and securities financing activities. The aim of these reforms is to raise the capital buffers backing these exposures, reduce procyclicality and provide additional incentives to move OTC derivative contracts to central counter-parties, thus helping reduce systemic risk across the financial system and to provide incentives to strengthen the risk management of counter-party credit exposures (see for instance,[9]).

The BCBS, according to [12] and [11] assessed a number of measures to mitigate the reliance on external ratings of the Basel II framework. The measures include requirements for banks to perform their own internal assessments of externally rated securitization exposures, the elimination of certain cliff effects associated with credit risk mitigation practices, and the incorporation of key elements of the IOSCO Code of Conduct Fundamentals for Credit Rating Agencies into the Committees eligibility criteria for the use of external ratings in the capital framework [20].
The Committee is also conducting a more fundamental review of the securitization framework, including its reliance on external ratings which may have a negative impact on securitized products due to defaults in the models used by the external rating agents [18].

2.3.4 Reduction of Procyclicality and Promotion of Counter-cyclical Buffers

A destabilizing element of the crisis has been the procyclical amplification of financial shocks throughout the banking system, financial markets and the broader economy [99]. The tendency of market participants to behave in a procyclical manner has been amplified through a variety of channels, including through accounting standards for both mark-to-market assets and held-to-maturity loans, margining practices, and through the build up and release of leverage among financial institutions, firms, and consumers (see for instance,[17] and [15]). The Basel Committee is introducing a number of measures to make banks more resilient to such procyclical dynamics. These measures will in turn help ensure that the banking sector serves as a shock absorber, instead of a transmitter of risk to the financial system and broader economy according to [24]. In addition, the Committee is introducing a series of measures to address procyclicality and raise the resilience of the banking sector in good times [99]. These measures objectives such as; to dampen any excess cyclicality of the minimum capital requirement; to promote more forward looking provisions; to conserve capital to build buffers at individual banks and the banking sector that can be used in stress and achieve the broader macro-prudential goal of protecting the banking sector from periods of excess credit growth [26].

The Basel II framework increased the risk sensitivity and coverage of the regulatory capital requirement and one of the most procyclical dynamics has been the failure of risk management and capital frameworks to capture key exposures such as complex trading activities, re-securitizations and exposures to off-balance sheet vehicles in advance of the crisis (see for instance,[27] and [20]).

2.3.5 Global Liquidity Standard

According to [21] and [16], strong capital requirements are a necessary condition for banking sector stability but by themselves are not sufficient. A strong liquidity base reinforced through robust supervisory standards is of equal importance but there has however been no internationally harmonized standards in this area to date. The Basel Committee is therefore introducing internationally harmonized global liquidity standards [10]. As with the global capital standards, the liquidity standards will according to [11] establish minimum requirements and will promote an international level playing field to help prevent a competitive race to the bottom. The Committee was observed that during the early liquidity phase of the financial crisis, many banks despite adequate capital levels still experienced difficulties because they did not manage their liquidity in a prudent manner (see for instance,[15] and [10]) .

The crisis again drove home the importance of liquidity to the proper functioning of financial markets and the banking sector. Subsequent to the crisis, asset markets were resistant and funding was readily available at low cost and the rapid reversal in market conditions illustrated how quickly liquidity can evaporate and that illiquidity can last for an extended period of time (see for instance,[14]). The banking system came under severe stress, which necessitated central bank action to support both the functioning of money markets and, in some cases, individual institutions according to [16] and [21]. The difficulties experienced by some banks were due to lapses in basic principles of liquidity risk management. In response, as the foundation of its liquidity framework, the Basel Committee in 2008 published Principles for Sound Liquidity Risk Management and Supervision (see for instance,[23]).

2.3.6 Liquidity Coverage Ratio (LCR)

According to [16], the LCR standard aims to ensure that a bank maintains an adequate level of unencumbered, high-quality liquid assets that can be converted into cash to meet its liquidity needs for a 30 calendar day time horizon under a significantly severe liquidity stress scenario specified by supervisors. At a minimum, the stock of liquid assets should enable the bank to survive until day 30 of the stress scenario, by which time it is assumed that appropriate corrective actions can be taken by management and supervisors or the bank can on the other hand be resolved in an orderly way (see for instance,[10] and [11]). The LCR is given by the formulae;

$$\frac{\text{Stock of high-quality liquid assets}}{\text{Total net cash outflows over the next 30 calender days}} \geq 100\%$$

The LCR as pointed out by the BCBS in [16] and [17] builds on traditional liquidity coverage ratio methodologies used internally by banks to assess exposure to contingent liquidity events. In this case, the total net cash outflows for the scenario are to be calculated for 30 calendar days into the future and the standard requires that the value of the ratio be no lower than 100%.[26] Banks are expected to meet this requirement continuously and hold a stock of unencumbered, high-quality liquid assets as a defence against the potential onset of severe liquidity stress (see for instance.[13] and [10]). Given the uncertain timing of outflows and inflows, banks and supervisors are also expected to be aware of any potential mismatches within the 30-day period and ensure that sufficient liquid assets are available to meet any cash flow gaps throughout the period [16].
The stress scenario that has been specified incorporates many of the shocks that were experienced during the financial crisis that started in 2007 into one significant stress scenario

[26]ie the stock of high-quality liquid assets should at least equal total net cash outflows

for which a bank would need sufficient liquidity on hand to survive for up to 30 calendar days [16]. This stress test should be viewed as a minimum supervisory requirement for banks and they are expected to conduct their own stress tests to assess the level of liquidity they should hold beyond this minimum, and construct their own scenarios that could cause difficulties for their specific business activities (see for instance,[10] and [14]). Such internal stress tests should incorporate longer time horizons than the one mandated by this standard and banks are expected to share the results of these additional stress tests with supervisors (see for instance,[8]).

2.3.7 Net Stable Funding Ratio (NSFR)

For the promotion of more medium and long-term funding of the assets and activities of banking organizations, the Basel Committee has developed the Net Stable Funding Ratio (NSFR) (see for instance,[28]). This metric establishes a minimum acceptable amount of stable funding based on the liquidity characteristics of an institutions assets and activities over a one year horizon [16]. The NSFR is designed to act as a minimum enforcement mechanism to complement the LCR and reinforce other supervisory efforts by promoting structural changes in the liquidity risk profiles of institutions away from short-term funding mismatches and toward more stable, longer-term funding of assets and business activities (see for instance [21] and [16]). Furthermore, the NSFR standard is structured to ensure that long term assets are funded with at least a minimum amount of stable liabilities in relation to their liquidity risk profiles and it aims to limit over-reliance on short-term wholesale funding during times of resilient market liquidity and encourage better assessment of liquidity risk across all on and off-balance sheet items (see for instance,[16] and [28]). In addition, the NSFR approach offsets incentives for institutions to fund their stock of liquid assets with short-term funds that mature just outside the 30-day horizon for that standard [10]. The NSFR is given by the formulae;

$$\frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} \geq 100\%$$

The NSFR is formed on the basis of traditional net liquid asset and cash capital methodologies used widely by internationally active banking organizations, bank analysts and rating agencies [27] and [28]. In computing the amount of assets that should be backed by stable funding, the methodology includes required amounts of stable funding for all illiquid assets and securities held, regardless of accounting treatment[27] [16]. Additional funding

[27]such as trading versus available-for-sale or held-to-maturity designations

stable sources are also required to support at least a small portion of the potential calls on liquidity arising from off-balance sheet (OBS) commitments and contingencies [16].

The NSFR according to [10] is defined as the amount of available amount of stable funding to the amount of required stable funding and this ratio must be greater than 100%.[28] A definition of stable funding is given as the portion of those types and amounts of equity and liability financing expected to be reliable sources of funds over a one-year time horizon under conditions of extended stress (see for instance,[28] and [16]). The amount of such funding required of a specific institution is a function of the liquidity characteristics of various types of assets held, off-balance sheet contingent exposures incurred and the activities pursued by the institution [31].

2.3.7.1 Definition of Available Stable Funding

The amount of available stable funding (ASF) according to the BCBS document [28], is measured based on the broad characteristics of the relative stability of an institutions funding sources, including the prescribed maturity of its liabilities and the differences in the propensity of different types of funding providers to withdraw their funding. The amount of ASF is calculated by firstly assigning the carrying value of an institutions capital and liabilities (see for instance,[16] and [28]). The amount assigned to each category is then multiplied by an ASF factor, and the total ASF is the sum of the weighted amounts [28]. Carrying value represents the amount at which a liability or equity instrument is recorded before the application of any regulatory deductions, filters or other adjustments [28]. When determining the maturity of an equity or liability instrument, investors are assumed to redeem a call option at the earliest possible date (see for instance,[13] and [28]). For funding with options exercisable at the banks discretion, supervisors should take into account status factors that may limit a banks ability not to exercise the option [16]. In particular, where the market expects certain liabilities to be redeemed before their legal final maturity date, banks and supervisors should assume such behaviour for the purpose of the NSFR and include these liabilities in the corresponding ASF category [28]. For long dated liabilities, only the portion of cash flows falling at or beyond the six month and one year time horizons should be treated as having an effective residual maturity of six months or more and one year or more, respectively (see for instance,[16] and [28]).

Derivative liabilities are calculated first based on the replacement cost for derivative contracts[29] where the contract has a negative value [28]. When an eligible bilateral netting contract is in place that meets the conditions as specified in paragraphs 8 and 9 of the

[28]In addition, supervisors may use alternative levels of this NSFR as thresholds for potential supervisory action

[29]obtained by marking to market

BCBS document [29], the replacement cost for the set of derivative exposures covered by the contract will be the net replacement cost(see for instance,[16] and [28]). In addition, when calculating NSFR derivative liabilities, collateral posted in the form of variation margin in connection with derivative contracts, regardless of the asset type, must be deducted from the negative replacement cost amount [28].

2.4 Literature Review of the Econometric Analysis

During the 2007-2009 financial crisis outburst, the notion of funding liquidity frequently was pointed out in relation to asset prices [7]. The funding or balance sheet liquidity can be explained as the ability of a financial institution to settle obligations with as immediate as possible [42]. This notion fundamentally supposes that funding conditions should be an essential part of asset and financial stability valuation process [7]. In the core of rapidly evolving financial theory, it is inherently not unexpected that there are difficulties with the identification of liquidity and as a consequence with its measurement [7]. Discovering an appealing relationship between asset prices and monetary or credit aggregates seems interesting but only after the 2007-2009 financial crisis was a suitable answer arrived at (see for instance,[41]) According to [34], continuous rapid credit growth coupled with enormous increases in asset prices seems to increase the possibility of an occurrence of financial instability. On the other hand, rapid credit growth, on its own, creates uncertain risk to the stability of the financial system and the same can be said to be true for quick growths in asset prices or investments [7]. The combination of events, such as the coordinated occurrence of fast credit growth and rapid increases in asset prices that increases the likelihood of financial risk, rather than any one of these events alone [34]. The key feature of the development of financial systems since the 1970s has according to [35], been the rapid expansion of financial markets. The importance of liquidity has been acknowledged by central banks in respect to both monetary and financial stability(see for instance,[7] and [35]). An example can be given by yield curves that are commonly used to extract information about market participants expectations concerning inflation and process depending crucially on the liquidity of the underlying market, namely the treasury and bond market [35]. In the case of financial stability, central banks use asset prices in the monitoring of liabilities in the financial system, as they include information about market participants assessment and risk pricing [35].

Market-based institutions[30] overtook the dominant role in the supply of credit from commercial banks and these market-based financial institutions were deeply involved in securitization and actively used capital and financial markets to satisfy their funding needs (see for

[30] broker-dealers, investment banks

instance,[7] and [34]). In such a way, market-based liabilities such as repos and commercial paper are better indicators of credit conditions that influence the economy [7]. As a result, from the point of view of financial stability measures of collateralized borrowing, such as the weekly series of primary dealer repos can prove very useful [35]. In order to protect against losses in case of default of borrower, lenders apply haircut on pledged assets, which is the difference between the current market price of the security and the price at which it is sold (See for instance,[56]). The system of repurchase agreement is built on trust of the value of the underlying asset and in the case of questioning the value of collateralized assets, the trust fades from the markets resulting in higher haircuts [56]. In addition, haircuts addresses the risk that if the holder of the bond in repo, the depositor, has to sell a bond in the market to get the cash bank, he may face a better informed trader resulting in a loss[31]. The risk in this case is endogenous to the trading practice, which is not the danger of loss due to default [56]. One way to protect against this endogenous adverse selection risk is to require overcollateralization (see for instance,[7] and [56]). The association between global liquidity and asset prices has rarely been investigated using the CVAR framework. It appears that the potential relations between asset returns and liquidity have solely been studied by means of OLS regressions, SVAR models and in some cases panel cointegration tests [54]. This study proposes the use of a CVAR analysis as it allows for taking proper account of the non-stationarity of the data, i.e. look for cointegration properties in the data, and at the same time disentangle short- and long-run dynamics as was also proposed by [54].

[31]relative to the true value of the security

Chapter 3

Data and Methodology

3.1 Introduction

Over the past 25 years, the financial markets have gone through an enormous development. The introduction of new financial derivatives such as asset backed securities (ABS), mortgage backed securities (MBS) and collateralized debt obligations (CDOs) on underlyings (bonds, car loans, home loans, aircraft leases) has led to a new quality of the securitization of financial risk [89]. The models used for the securitization of these financial instruments according to [87] is based on advanced mathematical theory called, Itô stochastic calculus. The basic pricing of uncertain assets is described by Brownian Motion and related differential equations (see for instance,[71]). The pricing of a European call option by Black, Scholes and Merton in 1973 (the Nobel prize winning Black-Scholes formula) was a breakthrough in the understanding and valuing of financial derivatives [36]. Their approach has become the firm basis for modern financial mathematics which uses advanced tools such as martingale theory and stochastic control to find adequate solutions to the pricing and securitization of world-wide enormously increasing number of derivatives (see for instance,[83] and [71]).
The study approached the research from both a theoretical- and numerical-quantitative viewpoint. Where the need arise, these approaches were complemented by the use of stochastic analysis. Apart from obtaining results of interest for particular applications in Basel III, the study built a general econometric theory encompassing the shock models for LQ- and HQ assets (see for instance, chapters 4 and 6). The techniques that were employed to attain results in this research area mainly involve the use of existing knowledge about techniques in econometrics involving risk [50]. Specifically, aspects of Banking Risk and Financial Theory were considered. Further methods that were used to investigate such risks are related to techniques found in fields of research such as Probability Theory, Stochastic Processes, Optimal Stochastic Control, Stochastic Differential Equations and Numerical Analysis [71].

3.1.1 Data Specification

Bank data obtained from the sources shown in table 3.1 was used in the study. The LQ- and HQ-asset related data cover a quarterly period from 1999Q1 to 2013Q4 while the data comprising of liabilities and liquidity for Class I and II banks covers a period from 2002Q1 to 2012Q4.

Type of Data to be Analysed Class I & II Banks	**Source of Data** Class I & II Banks
LQ- and HQ-assets	Asset Banker Association Database
Balance Sheet Liabilities	Federal Reserve Bank of St. Louis
Balance Sheet Liquidity	Federal Reserve Bank of St. Louis

Table 3.1: Type of Data and Source

Dependent Variable Class I & II Banks	**Independent Variables** Class I & II Banks
Interest-Bearing Deposits	Interest-Bearing Liabilities, Non-Interest-Bearing Liabilities Borrowings
Net Stable Funding Ratio	Liquidity Coverage Ratio, Govt Securities Ratio, Brokered Deposits Ratio

Table 3.2: Classification of Dependent and Independent Variables

Table 3.2 shows the classification of the data into dependent and independent variables Balance sheet bank data was used for analysis in this study because it gives a better reflection of the financial position of banks. Their incentives to securitize assets depends on the number of non-performing assets and long term illiquid assets on their balance sheets. This helps banks to generate cash for the origination of other loans which are then offered to borrowers. Each data set was organized into subsets explaining how the independent variables affect dependent variables for both Class I and II bank liability and liquidity.[1] The regression model was given by;

$$Y_t = \alpha + \beta_1 X_t + \varepsilon_t$$

[1]i.e when analyzing liabilities of Class I banks, the dependent variable will be interest bearing deposits while independent variables considered will be given by non-interest bearing liabilities and borrowing

$$IBD_t = \alpha + \beta_1 NIBL_t + \beta_2 B_t + \varepsilon_t$$

Class II banks were also factored into this study so as to establish how their balance sheets were affected due to the increased manufacturing of financial products such as CDOs which eventually led to the financial market collapse of 2007-2009. A forecast for future recurrences was considered based on the availability of data.

3.1.2 Data Outliers

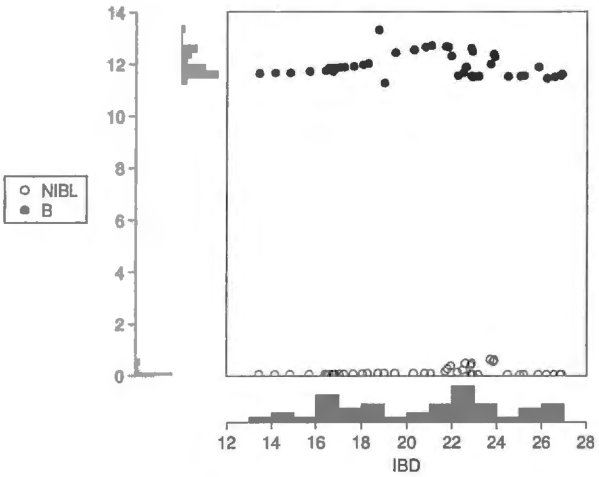

Figure 3.1: Scatter Plot; Class I Bank Liability

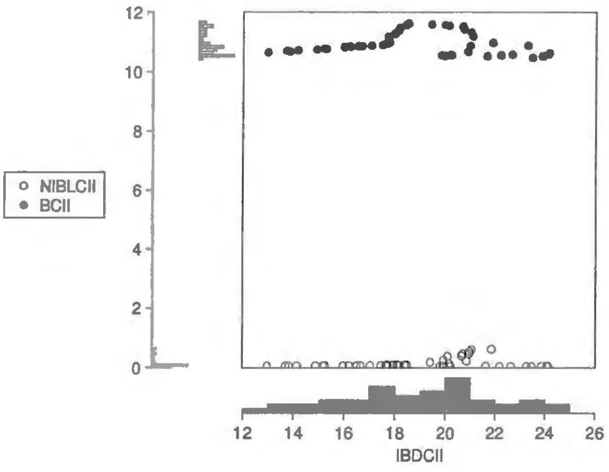

Figure 3.2: Scatter Plot; Class II Bank Liability

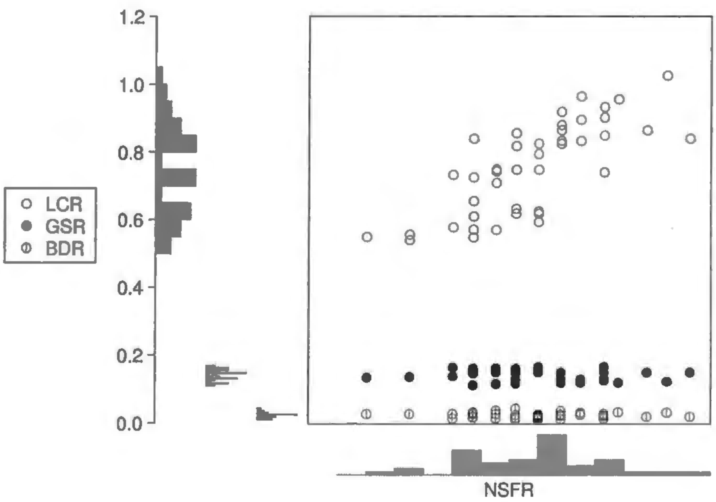

Figure 3.3: Scatter Plot; Class I Bank Liquidity

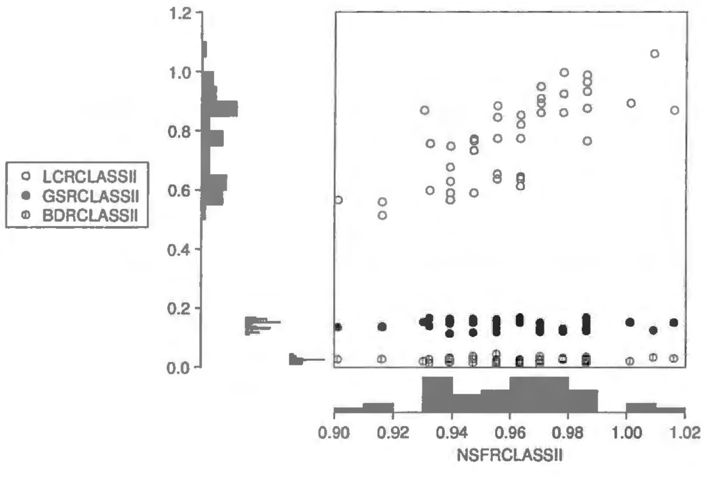

Figure 3.4: Scatter Plot; Class II Bank Liquidity

The outlier shows the nature of the data that was used in this study. Class I bank liabilities had a normally distributed Interest Bearing Deposits (IBD) ranging from $12 to $28 trillion dollars. Borrowing (B) were much higher than Non-Interest bearing Deposits (NIBL) with a positive skewness for all variables and high kurtosis was observed for the NIBL. IBD however exhibited a negative skewness which means it was mostly distributed towards the left side of the XY plane. Class II bank liabilities also seem to have a high kurtosis value for the NIBL and has positive skewness for the NIBL and Borrowing while the IBD showed negative skewness. Borrowing was also much higher than NIBL and IBL ranged from $12 to $26 trillion dollars which is slightly smaller than Class I bank liabilities. This can be due to the fact that Class I banks are internationally active banks with more minimum capital reserves than their counterparts.

Class I bank liquidity show normal distribution with the Net Stable Funding Ratio (NSFR) showing positive skewness and kurtosis. The NSFR seems to be distributed more on the right side of the XY plane while Government Security Ratio (GSR) seems to have a negative skewness. The Liquidity Coverage Ratio (LCR) and Brokered Deposits Ratio (BDR) also seem to have positive skewness and kurtosis values thereby rendering the distribution to be normally distributed. Class II bank liquidity on the other hand seem to have negatively skewed NSFR, LCR and GSR. This means that the distribution is mostly left sided on the XY plane. The values however seem to have positive kurtosis values with the NSFR being higher than the independent variables.

3.1.3 Comparison of Data With Other Studies

The data used in this study is similar to the EMERG data used for similar studies on Basel III. In particular, the paper [7] used similar data to model liquidity asset prices through the application of VECM. The paper showed that by the use of VECM model several effects can be examined such as the long run equilibrium relationships between levels of variables and the amount of changes in the variables that bring the system back to equilibrium (see for instance,[7]). In addition, coefficients can be imposed that show the short run changes occurring due to previous changes in the variables and coefficients that show the effect on the dynamics of external events [7].

Furthermore, the paper [54], used similar data to investigate global liquidity and asset prices in a cointegrated VAR. The paper focused on determining the importance of global liquidity, how interest rates are affected by the global monetary conditions and how it affects the ability of central banks to control inflation (see for instance,[54]). In addition, the study in [30] also used similar data to establish a global view of liquidity and the dynamic pattern of asset price adjustment. The focus in this case was on determining the dynamic expansion of liquidity since 2001. It also looked at the sharp increase in asset prices which seems to be outpacing the subdued development in consumer prices as well as the interactions between money and goods and asset prices at the global level (see for instance,[30]). These studies showed that it can for example be useful to start from a relatively small information set and observe whether the rank changes when additional variables are added. If the rank increases there exists some cointegrating relation including the new variables. On the other hand, if the rank is unchanged, adding the extra variables introduces additional common stochastic trends (see for instance,[7] and [30]).

3.1.4 Strengths and Weaknesses of the Data

The data gives quarterly observations of variables for Class I and II banks from the period 2002-2012. Some of the strengths of this data includes showing the movement of different balance sheet variables in trillions of dollars prior to the market collapse of 2007-2012 and giving the desired values of bank liability and liquidity, which was applied to model default risk of assets and for econometric analysis. In addition, the data has already been transformed into logs, making the variables independent of their units and comparable to each other. However, the data has shortcomings such as the time period for which the variables represent which is 10 years in this case. It might be difficult to forecast the behavior of banks with the proposed Basel III changes to liability and liquidity with minimal observations especially for the period after the financial crisis considering that most of the changes will fully be implemented in the year 2019. Econometric analysis enabled the study establish how these independent variables affected or impacted the respective dependent variables when regression and correlation tests were conducted.

3.1.5 Descriptive Statistics of the Data

	IBD	NIBL	B
Mean	20.76341	0.146318	11.95090
Median	21.73000	0.069500	11.85525
Maximum	26.89000	0.625000	13.32490
Minimum	13.43000	0.039000	11.28820
Std. Dev.	3.746837	0.167238	0.452516
Skewness	-0.145393	1.798782	0.996963
Kurtosis	1.915591	4.816600	3.323882
Jarque-Bera	2.310915	29.77792	7.481179
Probability	0.314913	0.000000	0.023740
Sum	913.5900	6.438000	525.8397
Sum Sq. Dev.	603.6678	1.202642	8.805133
Observations	44	44	44

Figure 3.5: Descriptive Statistics; Class I Bank Liability

	IBDCII	NIBLCII	BCII
Mean	18.97477	0.146318	10.94258
Median	19.57500	0.069500	10.86390
Maximum	24.12000	0.625000	11.64170
Minimum	12.95000	0.039000	10.48760
Std. Dev.	2.997705	0.167238	0.369383
Skewness	-0.149114	1.798782	0.655705
Kurtosis	2.212057	4.816600	2.050440
Jarque-Bera	1.301290	29.77792	4.806013
Probability	0.521709	0.000000	0.090446
Sum	834.8900	6.438000	481.4736
Sum Sq. Dev.	386.4081	1.202642	5.867097
Observations	44	44	44

Figure 3.6: Descriptive Statistics; Class II Bank Liability

The mean and median values for Class I bank liability were higher than those of Class

II banks. This can be attributed to the high maximum and minimum values as seen in the tables. Furthermore, the skewness of the data were both negative for Class I and II banks with values of -0.145393 and -0.149114 respectively. This means that IBD was mostly distributed on the left side of the XY plane. Kurtosis values are however positive for both banks meaning they were upward trending.

	NSFR	LCR	GSR	BDR
Mean	0.937568	0.748705	0.142136	0.023750
Median	0.940000	0.749000	0.148500	0.024000
Maximum	0.993000	1.027000	0.166000	0.044000
Minimum	0.880000	0.540000	0.112000	0.011000
Std. Dev.	0.023505	0.136022	0.016247	0.007644
Skewness	0.019594	0.027423	-0.248100	0.333869
Kurtosis	3.112716	1.825939	1.782049	2.846654
Jarque-Bera	0.026108	2.532615	3.170968	0.860545
Probability	0.987031	0.281870	0.204849	0.650332
Sum	41.25300	32.94300	6.254000	1.045000
Sum Sq. Dev.	0.023757	0.795581	0.011351	0.002512
Observations	44	44	44	44

Figure 3.7: Descriptive Statistics; Class I Bank Liquidity

	NSFRCLASSII	LCRCLASSII	GSRCLASSII	BDRCLASSII
Mean	0.959750	0.773500	0.144023	0.024136
Median	0.963000	0.774000	0.150500	0.025000
Maximum	1.016000	1.061000	0.168000	0.045000
Minimum	0.901000	0.515000	0.114000	0.011000
Std. Dev.	0.024096	0.143541	0.016286	0.007864
Skewness	-0.018271	-0.027088	-0.241821	0.304656
Kurtosis	3.091716	1.850555	1.782182	2.832527
Jarque-Bera	0.017870	2.427626	3.147815	0.732065
Probability	0.991105	0.297062	0.207234	0.693480
Sum	42.22900	34.03400	6.337000	1.062000
Sum Sq. Dev.	0.024966	0.885973	0.011405	0.002659
Observations	44	44	44	44

Figure 3.8: Descriptive Statistics; Class II Bank Liquidity

Class I bank liquidity has positive skewness values for NSFR, LCR and BDR meaning it was more distributed on the right side of the XY plane. GSR on the other hand exhibited a negative skewness value. All the variables had positive kurtosis with the NSFR being the highest. The data seem to be normally distributed with the maximum and minimum values ranging from 0.993000 and 0.880000 respectively. Class II bank liquidity on the other hand show negative skewness for the NSFR, LCR and GSR which means the variables were mostly distributed on the left side of the XY plane. BDR however was positively skewed. The NSFR also had the highest kurtosis value as was the case for Class I banks as well. This data set also seem to be normally distributed with maximum and minimum values ranging from 1.016000 and 0.901000 respectively. In this regard, both Class I and II bank variables had similar characteristics expect for the differences in skewness.

3.2 Stochastic Calculus

Stochastic calculus according to [87], is a branch of mathematics that operates on stochastic processes. It allows a consistent theory of integration to be defined for integrals of stochastic processes. It is used to model systems that behave randomly. A stochastic process, or sometimes random process is a collection of random variables; this is often used to represent the evolution of some random value, or system, over time (see for instance,[71]). This is the probabilistic counterpart to a deterministic process (or deterministic system). Instead of describing a process which can only evolve in one way[2], in a stochastic or random process there is some indeterminacy; even if the initial condition (or starting point) is known, there are several (often infinitely many) directions in which the process may evolve [87]. Stochastic Calculus deals with functions of time $t, 0 \leq, t \leq T$.
A function g is called continuous at the point $t = t_0$ if the increment of g over small intervals is small,

$$\Delta g(t) = g(t) - g(t_0) \to 0 \text{ as } \Delta t - t_0 \to 0$$

If g is continuous at every point of its domain of definition, it is simply called continuous. g is called differentiable at the point $t = t_0$ if at that point,

$$\Delta g \sim C\Delta t \text{ or } \lim_{\Delta t \to 0} \frac{\Delta g(t)}{\Delta t} = C$$

this constant C is denoted by $g'(t_0)$. If g is differentiable at every point of its domain, it is

[2]as in the case, for example, of solutions of an ordinary differential equation

called differentiable.

Observations of financial derivatives and securitization processes observed in time are often modeled by a stochastic process which is an umbrella term for any collection of random variables $\{X(t)\}$ depending on time t. This can be discrete, for example, $t = 1, 2, 3\ldots$ or continuous, $t \geq 0$. Calculus is suited more to continuous time processes. At any time t, the observation is described by a random variable denoted by $X(t)$. A stochastic process $\{X(t)\}$, can be denoted by X or $X(t)$. Where $X(t)$ is a non random simple process and the function of t does not depend on $B(t)$ which is a Brownian motion.

3.2.1 Brownian Motion

Botanist R. Brown described the motion of a pollen particle suspended in fluid in 1828. It was observed that a particle moved in an irregular, random fashion. A. Einstein, in 1905, argued that the movement is due to bombardment of the particle by the molecules of the fluid, he obtained the equations for Brownian motion [71]. In 1900, L. Bachelier used the Brownian motion as a model for movement of stock prices in his mathematical theory of speculation. The mathematical foundation for Brownian motion as a stochastic process was done by N. Wiener in 1931, and this process is also called the Wiener process. The Brownian motion process $B(t)$ serves as a basic model for the cumulative effect of pure noise. If $B(t)$ denotes the position of a particle at time t, then the displacement $B(t) - B(0)$ is the effect of the purely random bombardment by the molecules of the fluid, or the effect of noise over time t (see for instance,[87] and [71]).

Brownian motion $B(t)$ is a stochastic process with the following properties;

1. (Independence of increments) $B(t) - B(s)$, for $t > s$, is independent of the past that is, of $B_u, 0 \leq u \leq s$, or of $\mathcal{F}_s$, the σ field generated by $B(u), u \leq s$.

2. (Normal increments) $B(t) - B(s)$ has a normal distribution with mean 0 and variance $t - s$. This implies (taking $s = 0$) that $B(t) - B(0)$ has $N(0, t)$ distribution.

3. (Continuity of paths) $B(t), t \geq 0$ are continuous functions of date t.

3.2.2 Itō Calculus

According to [70], the stochastic integral $\int_0^t X(t)dB(t)$, also denoted $\int xdB$ or $X.B$ can be defined. This integral should have the property that if $X(t) = 1$ then $\int_0^T dBt = B(T) - B(0)$. Similarly, if $X(t)$ is a constant c, then the integral should be $c(B(T) - B(0))$. In this way, we can integrate constant processes with respect to B. The integrals over two subintervals,

$(0, a)$ and (a, T). Thus if $X(t)$ takes two values c_1 on $(0, a)$, and c_2 on (a, T), then the integral of X with respect to B is easily defined. In this way the integral is defined for simple processes, that is, processes which are constant on finitely many intervals. By the limiting procedure the integral is defined for more general processes.

3.2.3 Financial Derivatives Pricing by Mathematical Means

Approach taken by Black, Scholes and Merton. The price P_t of a risky asset, the share price of a particular stock is for example described by a geometric Brownian motion

$$P_t = P_0 \exp\{\sigma B_t + \mu t - 0.5\sigma^2 t\}$$

where $(B_t, t \geq 0)$ stands for Brownian motion (a stochastic process with independent stationary increments, continuous sample paths and such that B_t has a normal distribution with mean zero, variance t), μ is the mean rate of return and $\sigma > 0$ is the volatility. In particular, for fixed t, P_t has a lognormal distribution. The larger σ, the stronger the oscillations of P_t around its mean value. Hence σ describes the variability of the price. Alternatively, P_t satisfies the Itô stochastic differential equation (SDE)

$$dP_t = P_t[\mu d_t + \sigma dB_t]$$

The above SDE has to be interpreted as Itô integral equation:

$$P_t = P_0 + \mu \int_0^t P_s ds + \sigma \int_0^t P_s dB_s$$

where the first integral is an ordinary Riemann integral, the second an Itô integral. This means that it stands for the limit of sums

$$\int_0^t P_s dB_s \approx \sum_i P_{t_{i-1}} \left[B_{t_i} - B_{t_{i-1}}\right]$$

along any partitions $0 = t_0 < t_1 < \cdots < t_{n-1} < t_n = t$ of the interval $[0, t]$ with $\max_i(t_i - t_{i-1}) \to 0$ as $n \to \infty$. Since the paths of Brownian motion are not of bounded variation unlike the Riemann-Stieltjes integral as shown by [87], the limit cannot be taken along a fixed Brownian path, but in the mean square sense. For the definition of the Itô integral it is crucial that the values on the right hand side of the above equation be constituted in a non-anticipating way. For example by taking the integrand at the beginning of the time intervals and assuming that it does not depend on future values of geometric Brownian motion such as future values of the price. These type of models will be applied in this study when ascertaining the riskness of LQ- and HQ assets as well as their securitization tranches and exposures.

3.2.4 Financial Time Series Model

For the pricing and analysis of derivatives, it is useful to consider continuous time models. Moreover, according to [46] theoretical arguments show that a portfolio cannot be hedged if only the prices at discrete instants of time are known. However there are various other reasons to consider financial time series models $X_0, X_1, X_2...$ One of them is that real-life data are not gathered continuously but rather at discrete time points and fitting a statistical model to them contributes to the understanding of the mechanism that have generated the data (see for instance,[71] and [87]). A good fit of theoretical model to real-life data would also allow for the fitting and prediction (in some sense) future values of the series. In financial time series analysis the price series $P_t, t = 0, 1, ...$ are transformed to log-returns

$$X_t = \log(P_t/P_{t-1}) = \log\left(1 + \frac{P_t - P_{t-1}}{P_{t-1}}\right), \; t = 1, 2, ...$$

The main goal of this transformation is to make prices independent of their unit and comparable to each other. It is believed that in contrast to the prices P_t, the log returns X_t can be modeled by a stationary process such as a process whose characteristics do not change when time goes by [71]. The latter is a basic assumption in classical time series analysis. This method will be used in the study because empirical research according to [46] and [97] shows that log-return series of foreign exchange rates, share prices, stock indices, securities and other financial instruments have various properties in common. Among them are the following stylized facts:

- Very large and very small values of X_t occur more often than in the Gaussian white noise sequence. This means that the distribution of log-returns is heavily tailed. For example the tails $P(X_t \leq -x)$ and $P(X_t > x)$ when compared to the tails of the normal distribution are much larger for x. This property indicates that losses as well as gains can be much more severe than anticipated by the normal distribution.

- The sample autocorrelations of the $X_t s$ are negligible at almost all lags, even for the time series worth several years of data whereas for longer time series the sample autocorrelations of the absolute values $|X_t|$ and squares X_t^2 decay rather slowly to zero. This indicates that the sequence X_t is uncorrelated (white noise) whereas $(|X_t|)$ and (X_t^2) seem to be heavily dependant, even over longer periods of time. In the latter case, it can be said that there is a long range dependence or long memory in the time series. A probable alternative explanation of the latter sample autocorrelation behavior is non-stationarity of the time series.

- Large and small values of X_t occur not separated in time, as one would expect for a sequence of indent random variables, but in clusters for example if one unusually large/small value of X_t occurs, various other values of a comparable size appear shortly afterwards.

It is the aim of financial time series to explain these and other features of log-returns by a physical model. It should be noted that none of the standard models described below captures all the stylized facts.
Standard models for log-returns are given by equations of the form

$$X_t = \mu + \sigma_t Z_t, \ t = 0, 1, 2, ...$$

where μ is a constant, σ_t is a function of past log-returns X_s, the past noise variables $Z_s s$ and past volatilities σ_s. Focus will be made on one-dimensional series; vector-valued $X_t s$ can be defined in a similar way as shown by [33]. For ease of notation, assume $\mu = 0$. The volatility σ_t is supposed to be independent of Z_t and the noise (Z_t) is often a sequence of independent, identically distributed symmetric random variables with variance 1. The symmetry expresses the belief that one cannot predict whether future price changes are positive or negative. This is in agreement with empirical research.

3.2.5 Adaptation of Stochastic and Econometric Methods

This study used the concept of Brownian motion and stochastic differential equations to model LQ- and HQ-asset shocks and securitization incentives. These type of formulas have been used before by [87] to model variables that occur follow a random pattern and cannot easily be predicted. In 1828, botanist R. Brown observed the random bahaviour or movement of a pollen particle suspended in liquid. He concluded that the random behaviour was due to bombardments of particles within the liquid. This same concept has been adapted and applied in this to the random behaviour of stock prices and securities. In addition, Black, Scholes and Merton in 1973 came up with a formula for pricing European call options which became known as the Black-Scholes formula[3] and it has become a widely used method in understanding the valuing of financial derivatives such as ABSs and CDOs. Furthermore, the paper [36] studies time-changed Lévy processes and option pricing with an application of the Black-Scholes option pricing and Brownian motion. The emphasis was on understanding the reason why asset prices jump, leading to non-normal return innovations, why return volatilities vary stochastically over time and how returns and their volatilities are correlated, mostly negatively for equities (see for instance,[36]).

Studies [7], [54] and [30] applied econometric tests such as VECM and VAR to determine the behaviour and importance of liquidity levels in domestic and global set ups. Their results mostly showed that liquidity variables were cointegrated thereby entailing that long run relationships existed amongst the data sets. The same reasoning was applied to Class I and II bank liability and liquidity data in this study and the results showed similar characteristics as those from other studies. The stochastic differential equations used in this study allowed for the understanding of LQ- and HQ- assets both as individually and at market equilibrium. In addition, the equations assisted to a great deal in determining the behaviour of such financial assets to different temporary economic shocks.

3.3 Econometric Techniques

In relation to factors influencing capital and liquidity conditions, different asset prices like stock, bonds can be investigated. Research direction is not straightforward. Money according to [7] originating from a repo transaction can be used to buy different type of assets like bonds, stock, treasuries or asset-backed securities and CDOs as well. The source of liquidity does not tell anything about the destination of the fund received. Secondly, money obtained in one country can be invested in a different country exploiting the potential in carry trade[4] taking note that there may be other patterns as well.

3.3.1 Stationarity Test

Stationarity of a series according to [49] is an important phenomenon because it can influence behaviour of the series. If for example x and y series are non-stationary random processes (integrated), then modeling the x and y relationship as a simple OLS relationship as in equation 3.1 below will generate a spurious regression.

[3]The 1997 Nobel prize winning Black-Scholes formula

[4]Liquidity spill-over effect

$$Y_t = \alpha + \beta X_t + \varepsilon_t \tag{3.1}$$

Time series stationarity is the statistical characteristics of the series such as its mean and variance over time. If both are constant over time, then the series is said to be a stationary process meaning it has no random walk and no unit root. Whereas the series is described as being a non-stationary process when it is a random walk and has unit root. According to [49], differencing a series using differencing operations produces other sets of observations such as the first-differenced values, the second differenced values and so on.

$$\begin{aligned} &\text{x level} && \mathrm{x}_t \\ &\text{x } 1^{\text{st}} - \text{differenced value} && \mathrm{x}_t - \mathrm{x}_{t-1} \\ &\text{x } 2^{\text{nd}} - \text{differenced value} && \mathrm{x}_t - \mathrm{x}_{t-2} \end{aligned} \tag{3.2}$$

A stationary series without any differencing is designated as I(0), or integrated of order (0). And a series that has stationary at first difference is designated I(1) or integrated of order (1). In stationarity testing, the Augmented Dickey-Fuller test suggested by [40] and the Phillips-Perron test advocated by [86] will be used on the variables.

3.3.1.1 Augmented Dickey-Fuller Test (ADF)

According to [4], as the error term is unlikely to be a white noise, the test procedure suggesting an augmented version of the test which includes extra lagged terms of the dependent variable in order to eliminate autocorrelation was extended by Dickey and Fuller. The lag length on these extra terms is either determined by the Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC) or Hannan-Quin Criterion (HQC). The three possible forms of the ADF test are given by the following eqautions:

Specification at none is given by

$$\Delta y_t = \gamma_t y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + u_t$$

Specification at intercept

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + u_t$$

Specification at intercept and trend

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + u_t$$

The null hypothesis of the Augmented Dickey-Fuller t-test is

$$H_0 : \theta = 0 \qquad \text{(i.e the data needs to be differenced to make it stationary)} \tag{3.3}$$

versus the alternative hypothesis of

$$H_1 : \theta < 0 \qquad \text{(i.e the data is stationary and does not need to be differenced)} \tag{3.4}$$

3.3.1.2 Phillips-Perron Test (PP)

Phillips and Perron [86] developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP tests ignores any serial correlation in the test regression. The test regression for the PP tests is

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \tag{3.5}$$

where D_t is the vector deterministic terms (constant, trend etc), u_t is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the errors u_t of the test regression by directly modifying the test statistics $t_{\pi=0}$ and $T_{\hat{\pi}}$. The modified statistics denoted by Z_t and Z_π are given by;

$$Z_t = \left(\frac{\hat{\sigma}^2}{\hat{\lambda}^2}\right)^{\frac{1}{2}} .t_\pi = 0 - \frac{1}{2}\left(\frac{\hat{\lambda}^2 - \hat{\sigma}^2}{\hat{\lambda}^2}\right).\left(\frac{T.SE(\hat{\pi})}{\hat{\sigma}^2}\right) \tag{3.6}$$

$$Z_\pi = T\hat{\pi} - \frac{1}{2}\frac{T^2.SE(\hat{\pi})}{\hat{\sigma}^2}(\hat{\lambda}^2 - \hat{\sigma}^2) \tag{3.7}$$

The terms $\hat{\sigma}^2$ and $\hat{\lambda}^2$ are consistent estimates of the variance parameters

$$\sigma^2 = \lim_{T\to\infty} = T^{-1}\sum_{t=1}^{T} E[\mu_t^2]$$

$$\lambda^2 = \lim_{T\to\infty}\sum_{t=1}^{T} E[T^{-1}S_T^2]$$

where $S_T = \Sigma_{t=1}^{T} u_t$. The sample variance of the least squares residual $\hat{u}_t$ is a consistent estimate of σ^2 and the Newey-West long-run variance estimate of u_t using $\hat{t}_t$ is a consistent estimate of λ^2.

Under the null hypothesis that $\pi = 0$, the PP Z_t and Z_π statistics have the same asymptotic distributions as the ADF t-statistic and normalized bias statistics. One advantage of the PP tests over the ADF tests is that the PP tests are robust to general forms of heteroskedasticity in the error term u_t. Another advantage is that the user does not have to specify a lag length for the test regression.

3.3.2 Johansen and Juselius Cointegration Test

This procedure according to [66] uses two tests to determine the number of cointegration vectors which consists of the Maximum Eigenvalue test and the Trace test. For testing the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations for $r = 0, 1, 2...n-1$, the Maximum Eigenvalue statistic is used and it is computed as:

$$LR_{\max}(r/n+1) = -T^{*}\log(1-\hat{\lambda}) \tag{3.8}$$

where λ is the Maximum Eigenvalue and T is the sample size. Trace statistics on the other hand investigate the null hypothesis of r cointegrating relations against the alternative of n cointegrating relations, where n is the number of variables in the system for $r = 0, 1, 2...n-1$ and its equation is given by the formula below:

$$LR_{tr}(r/n) = -T^* \sum_{i=r+1}^{n} \log(1 - \hat{\lambda}_i) \tag{3.9}$$

Trace and Maximum Eigenvalue statistics may in some cases yield different results and in such a case, the results of the Trace test should be preferred as indicated by [3].

3.3.3 Vector Error Correction Model (VECM)

According to [49] and [66], if cointegration has been discovered between the series, it means that there exists a long run relationship between them and hence the VECM is applied in order to evaluate the short run properties of the cointegrated series. However in the case of no cointegration, the VECM is not used but instead the analysis proceeds straight to the Granger causality tests to establish causal links between variables. The regression equation of the VECM is given as follows:

$$\Delta Y_t = \alpha_1 + p_1 e_1 + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i}$$

$$\Delta X_t = \alpha_2 + p_2 e_{i-1} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i} \tag{3.10}$$

The cointegration rank in the VECM shows the number of cointegrating vectors. For example, a rank of two signifies that two linearly independent combinations of the non-stationary variables will be stationary. A negative and significant coefficient of the error correction model (such as the $et - 1$ in the equations above) indicates that any short-term fluctuations between the independent variables and the dependent variable will give rise to a stable long run relationship between the variables.

Chapter 4

Basel III and One-Step Asset Securitization

4.1 Background to Basel III and One-Step Asset Securitization

In this section, HQ- and LQ-entities and their equilibrium features are considered. Emphasis will be on studying an economy consisting of LQ-assets with a fixed total supply of $\overline{A}$ and CDOs that cannot be retained by the entity. In the sequel, for sake of argument, an assumption that the CDOs correspond to senior CDO tranches is made. In this model, CDOs are taken as the numeraire. There is a continuum of infinitely lived HQ- and LQ-entities, with population sizes n and 1, respectively. Both these entities take one period to securitize assets into CDOs . HQ- and LQ-entities produce CDOs from HQ- and LQ-assets, respectively, but they differ in their securitization technologies. At each date, m, there is a competitive spot market in which assets for CDOs are purchased by entities at a price of p^A_m. The only other market is a one-period credit market in which one CDO unit at date m is exchanged for a claim to $1 + r^B_m$ units of CDOs at date $m + 1$. These markets are opaque and are dominated by a handful of interests. During the 2007-2009 financial crisis, because CDOs were lightly regulated their details often went undisclosed. This created major problems in the monitoring of these credit derivatives and the new regulatory framework in Basel III focuses on correcting such problems (see, [18]) for further explanation.

4.1.1 Aims and Section Outline

The following aims are the core basis on which this section is built and analyzed;

- To assess the securitization process in an economy consisting of LQ-assets with a fixed total supply and CDOs that cannot be retained by the entity. In doing so, it is assumed that each LQ-entity's CDO technology is different in the logic that when securitization has began, only the LQ-entity has the skill required to securitize assets into CDOs subject to the availability of appropriate technology and labor with an option of the LQ- entity to withdraw its labor. Furthermore, the LQ-entity is assumed to be credit limited and can therefore borrow in total with the repayment not exceeding the market value of assets. Marketable CDOs are assumed to be enough to compensate for any depreciated RABs and new investment opportunities to securitize assets arise with high probability. In addition, an assumption that the arrival of securitization is independent both across LQ-entity and through time is made.
- To ascertain the LQ-entity behavior at steady-state assuming that the asset bubble does not burst during the securitization process.
- To assess the securitization of HQ-assets by HQ-entities in an economy assuming that assets held by the mentioned entities do not default or refinance.
- To examine HQ-entities behavior at equilibrium taking into account the fact that such entities are not credit constrained with their asset demand being determined at the point where the present value of marginal product of assets equals the transaction fee associated with assets.
- To show the main features of LQ- and HQ- entity market equilibrium.
- To illustrate a numerical example of asset securitization and give recommendations for LQ- and HQ-entities.

Section 4.2.1 focuses on LQ-entities and their securitization incentives of LQ- assets while section 4.2.2 concentrates on the HQ- entities and subsequent HQ- asset securitization. Furthermore, section 4.3 considers market equilibrium of LQ- and HQ- entities while section 4.3.1 and section 4.3.2 shows the behaviour of LQ- and HQ- assets entities respectively when in equilibrium. In addition section 4.3.3 considers LQ- and HQ- market clearing which refers to either a simplifying assumption made that markets always go to where the assets supplied equals the assets demanded or the process of getting there via price adjustment. Section 4.4 gives a summary of LQ- and HQ- entity equilibrium while section presents a numerical

4.2 LQ- and HQ-Entities

In this section, the study discusses low quality- and high quality-entities.

4.2.1 LQ-Entities

Figure 4.1 below illustrates the securitization of assets into ABSs and ABS CDOs by LQ-entities.

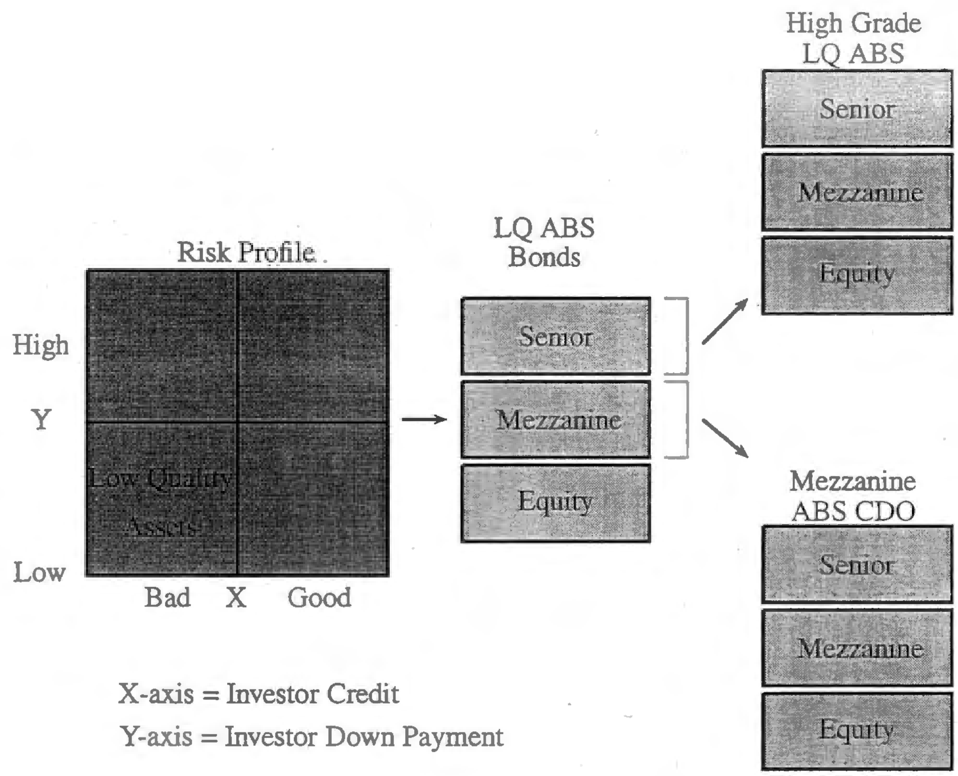

Figure 4.1: Chain of LQ-Assets and Their SAPs; Source: [83]

It can be noticed from Figure 4.1 that LQ-assets are securitized into ABSs that, in turn, get securitized into ABS CDOs. As far as the latter is concerned, it is clearly shown that senior ABS bonds rated AAA, AA, and A constitute the *high grade* ABS CDO portfolio. On the other hand, the mezzanine rated ABS bonds are securitized into *mezzanine ABS CDOs*, since its portfolio is based on BBB rated ABSs and their tranches which expose the portfolio to an increase in credit risk. From Figure 4.1, it is clear that LQ-entities (and any other entities) rather than banks, hold assets and ABSs. As a result there are reductions in the incentives of banks to play their traditional monitoring function. The fundamental role of banks in financial intermediation according to Basel III in the document [10], makes portfolio to an increase in credit risk. From Figure 4.1, it is clear that LQ-entities (and any other entities) rather than banks, hold assets and ABSs. As a result there are reductions in the incentives of banks to play their traditional monitoring function. The fundamental role of banks in financial intermediation according to Basel III in the document [10], makes them inherently vulnerable to liquidity risk, of both an institution-specific and market nature. Financial market developments have increased the complexity of liquidity risk and its management. During the early liquidity phase of the financial crisis that began in 2007, many banks - despite adequate capital levels still experienced difficulties because they did not manage their liquidity in a prudent manner. The difficulties experienced by some banks, which, in some cases, created significant contagion effects to the broader financial system, were due to lapses in basic principles of liquidity risk measurement and management. During the 2007-2009 financial crisis, systemic risk from CDOs was problematic. In this case, the default of one or more collateral asset or bond classes generated a ripple effect on the defaults of CDOs. Figure 4.1 suggest how this may have happened. LQ-entities are risk neutral, with their expected utilities being

$$\mathbf{E}_m\left(\sum_{d=0}^{\infty}\beta^d x_{m+d}\right) \text{ and } \mathbf{E}_m\left(\sum_{m=0}^{\infty}\beta^m x_m\right), \tag{4.1}$$

where x_{m+d} and x_m are their respective LQ-entity CDO consumption at dates $m+d$ and m, with $\mathbf{E}_m$ denoting the expectation formed at date m. These entities have a constant returns to scale securitization function of

$$C_{m+1} = S(A_m) \equiv (\mu+\nu)A_m, \quad \nu = c + r^f, \quad \left(\frac{\mu}{\mu+\nu}\right) < \beta \tag{4.2}$$

where A_m are the input assets securitized at date m and C_{m+1} is the CDO output at date $m+1$. Also, r^f is the fraction of assets that have refinanced and c the fraction of CDOs consumed. However, only μA_m of the CDO output is marketable. Here, νA_m, is non-marketable, and can be consumed by the LQ-entity. There is an introduction of νA_m so as to avoid the situation in which the LQ-entity keeps postponing consumption. The ratio $\mu(\mu+\nu)^{-1}$ may be thought of as a technological upper bound on the LQ-entity's retention rate. Since β is near 1, the inequality in (4.2) amounts to a weak assumption. It shall be seen later that this inequality makes certain that in equilibrium the LQ-entity will not want to consume more than illiquid CDOs as observed in Basel III (see for instance, [14]). The overall return from investment, $\mu+\nu$, is high enough that all its marketable CDO output is used for investment. There is a further critical assumption that is made about investing.

Assumption 4.2.1 (CDO Technology and Labor): *An assumption is made that each LQ-entity's CDO technology is distinct whereby, when securitization has started at date m with assets, A_m, the LQ-entity has the only expertise for securitizing assets into CDOs at date $m+1$, subject to the availability of appropriate technology and labor. Secondly, the study assumes that an LQ-entity always has the option to withdraw its labor.*

In other words, if the LQ-entity were to withdraw its labor between dates m and $m+1$, there would be no CDO output at $m+1$. Assumption 4.2.1 leads to the fact that if an LQ-entity is highly leveraged, it could be more forceful to pressurize the HQ-entities into pulling back its labor and renouncing the debt contract. HQ-entities as inter-entity lenders shield themselves from the pulling back action of LQ-entities through the collateralization of the LQ-entity's assets. On the other hand, assets do not yield SAPs when not taking into consideration the LQ-entity's labor, asset liquidation value is usually less than what the assets would earn under its control [69]. This in turn would mean that, after renounciation, it would be more effective for the LQ-entity to persuade the sponsoring HQ-entity into letting it keep the assets. Additionally, the LQ-entity may consider renegotiating a smaller loan. HQ-entities have insight of this possibility, they in turn ensure that they do not allow the size of the debt to be more than the value of the collateral as in the following assumption.

Assumption 4.2.2 (Credit Limit): *Assuming that at date m, the LQ-entity is in possesion of assets, A_m, it may consider acquiring T_m in total, taking into account that repayment does not exceed the market value of assets at date $m+1$ given by*

$$(1+r^{\mathrm{T}})\mathrm{T}_m \leq p^A_{m+1}A_m, \tag{4.3}$$

where p^A_{m+1} represents the asset price in period $m+1$ while A_m represents the LQ-entity's asset holdings in period m. In this case, when rational expectations are provided, agents usually have foresight of future asset prices.

As noted in Basel III[1], the objective of the LCR is to promote the short-term resilience of the liquidity risk profile of banks. It does this by ensuring that banks have an adequate stock of unencumbered high-quality liquid assets (HQLA) that can be converted easily and immediately in private markets into cash to meet their liquidity needs for a 30 calendar day liquidity stress scenario. Of course, during the 2007-2009 financial crisis, when monitoring incentives were reduced, it is unlikely that the HQ-entity monitored the LQ-entity closely.

[1]The Liquidity Coverage Ratio and liquidity risk monitoring tools

The LQ-entity's balance sheet consists of assets and marketable securities (assets) as well as borrowings and capital (liabilities). Therefore, an LQ-entity's balance sheet constraint can be represented at time m as

$$p^A_m A_{m-1} + B_m = \mathrm{T}_m + K_m, \tag{4.4}$$

where p^A, A, B, T and K represent the LQ-entity's asset price, asset holdings, marketable securities, borrowings and capital, respectively. As was mentioned before, the entities' capital structure consists of equity or preferred shares, subordinated debt, mezzanine debt and AAA rated senior debt. For this study's purpose, B includes risky marketable securities such as ABSs, B^R, and CDOs, C. In this study, the LQ-entity enforces a price cap (PC), with the weighted average PC being denoted by $\overline{p}$ (see, for instance, [83] for more details). In this case, the CDO price is given by

$$p^C_m = \min[p^A_m, \overline{p}_m], \tag{4.5}$$

where P^C denotes the price of CDOs in period m. Hedge funds and other sophisticated investors have incentives to manipulate the pricing and structuring of CDOs. Some studies suggest that CDO managers manipulate collateral in order to shift risks among various tranches. The potential for this can be clearly seen in (4.5) where the PC offers a means of changing collateral features that are important in determining the CDO price, p^C_m. During the 2007-2009 financial crisis, collateral according to Basel III was also manipulated via the violation of restrictions on asset portfolio composition, rating category, weighted average life, weighted average weighting factor, correlation factors and the number of obligors (see, [22]). Nevertheless, in this case, the value of assets in period m can be represented as

$$p^A_m A_{m-1} = \mathrm{T}_m + K_m - B_m. \tag{4.6}$$

Next, the LQ-entity's profit may be expressed as

$$\Pi_m = \left(r^A_m + c^p_m r^f_m - (1 - r^R_m) r^S_m\right) p^A_m A_{m-1} + r^B B_m - r^{\mathrm{T}} \mathrm{T}_m, \tag{4.7}$$

where r^A, c^p, r^f, r^R, r^S, r^B and r^{T} represents the asset rate, prepayment costs, fraction of assets that refinance, recovery rate, default rate, returns on marketable securities and borrowing rate in period m, respectively. In this case, asset value can be represented by

$$p^A_m A_{m-1} = \frac{\Pi_m - r^B B_m + r^{\mathrm{T}} \mathrm{T}_m}{r^A_m + c^p_m r^f_m - (1 - r^R_m) r^S_m} \tag{4.8}$$

From (4.8) it is clear that even a relatively small default rate can trigger a crisis. The unwinding of contracts involving the securitization of such assets such as CDO contracts created serious liquidity problems during the 2007-2009 financial crisis as detailed in Basel III (see [10]). Since the CDO market was quite large, the crisis caused convulsions throughout global financial markets. By considering the above, it can be deduced to an appropriate LQ-entity cash flow constraint in the following result.

Assumption 4.2.3 (Marketable CDOs and Depreciating RABSs): *A supposition is made that*

$$\mu > (1 - \lambda)\rho.$$

In Assumption 4.2.3, the marketable CDOs are at least enough to compensate for the depreciated RABSs. It should be noted on the other hand when an assumption is made that new investment opportunity to securitize assets comes from probability π.

Assumption 4.2.4 (Arrival Time of Investment Opportunities): *Suppose that*

$$\pi > 1 - \left(\frac{1}{1 + r^{\mathrm{B}}}\right). \tag{4.9}$$

With probability $1 - \pi$ the LQ-entity is unable to invest, so the scale of its operations is limited to λA_{m-1} and (in equilibrium) it sells off the $(1 - \lambda)A_{m-1}$ non-reference assets.

Lemma 4.2.5 (LQ-Entity Cash Flow Constraint): *Suppose that the credit constraint (4.3) as well as (4.6) to (4.8) hold. In this case, the LQ-entity's cash flow is subject to the constraint*

$$\Pi_m \geq \left(r^A_m + c^p_m r^f_m - (1 - r^R_m) r^S_m\right) p^A_m A_{m-1} + r^B B_m - p^A_{m+1} A_m + \mathrm{T}_m. \tag{4.10}$$

Proof. The proof follows from taking constraint (4.3) from Assumption 4.2.2 and (4.10) into consideration. □

The LQ-entity can expand its scale of securitization by investing in more assets. Consider an LQ-entity that holds A_{m-1} assets at the end of date $m-1$, and incurs a total debt of T_{m-1}. At date m, the LQ-entity harvests μA_{m-1} marketable CDOs, which, together with a new loan T_m, is available to cover the cost of purchasing new assets, to repay the accumulated debt $(1+r^{\mathrm{T}})\mathrm{T}_{m-1}$ (which includes interest), and to meet any additional consumption $x_m - \nu A_{m-1}$ that exceeds the normal consumption of non-marketable output νA_{m-1}. The LQ-entity's flow-of-funds constraint is thus

$$p_m^A(A_m - A_{m-1}) + (1 + r^{\mathrm{T}})\mathrm{T}_{m-1} + x_m - \nu A_{m-1} = \mu A_{m-1} + \mathrm{T}_m. \tag{4.11}$$

The discussion on LQ-entities has relationships with Basel III capital and liquidity regulation. It is clear from the above, that investors may be motivated to purchase securities issued by entities to avert Basel III regulatory limits, such as those relating to LQ-assets. In the case of synthetic transactions, investors may find it beneficial that they would not have to fund credit exposures at the outset (see, for instance, [24]). In cases where parties to entities possessed a comprehensive understanding of the associated risks and possible structural behaviors of these entities under various scenarios, they have effectively engaged in and reaped benefits from their entity activities (see, [18] and [24] for more details). However, it is unclear that LQ-assets sold into LQ-entities can be attributed to the existence of these structures, which were simply the legal form in which such assets were held to issue bonds backed by them. Nonetheless, it is important to address why some of the recent failures of entity usage occurred (see, for instance, [18] and [24]).

4.2.2 HQ-Entities

For HQ-entities, Figure 4.2 below shows the chain formed by HQ-assets, ABSs and ABS CDOs.

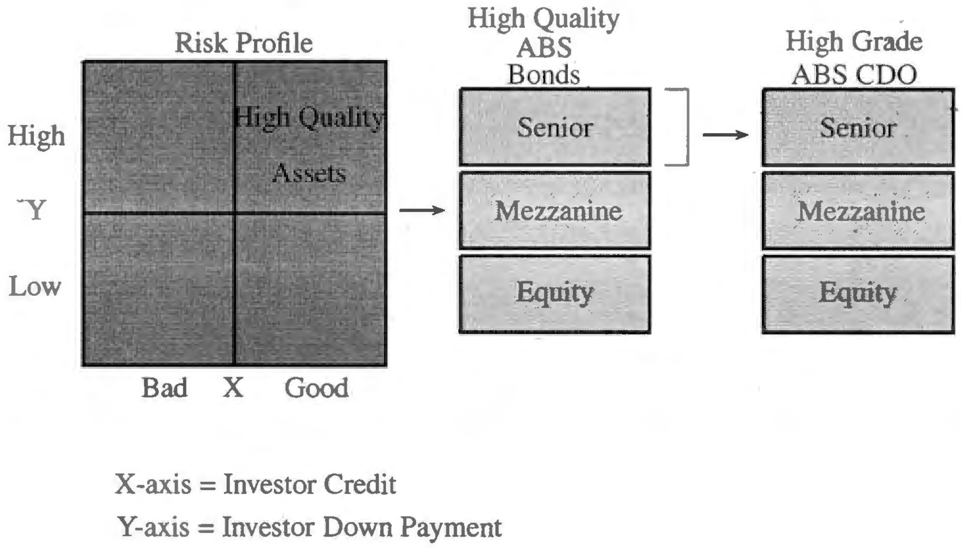

Figure 4.2: Chain of HQ-Assets and Their SAPs; Source: [83]

Proceeding from left to right 4.2, HQ-assets are securitized into ABSs that, in turn, get securitized into ABS CDOs. Only the higher grade ABS bonds rated AAA, AA, and A are securitized that make out the high grade ABS CDO portfolio. Figure 4.2 also suggests that HQ-entity ABSs and CDOs are not as risky as that of the LQ-entity since the reference asset portfolios have higher credit quality. HQ-entity capital levels will also be greater than that of the LQ-entity, in the sense that LQ-entities used their capital to provision for low quality default. In this regard, we have the secondary effect of securitization where credit risk is transferred to investors. The Basel Committee in Basel III identified a number of shortcomings within the current securitization framework some of which were categorized broadly as too low risk weights for highly rated securitizations and too high risk weights for low rated senior securitization exposures (see, [16]) for detailed explanation. Furthermore, it is assumed that HQ-entities are risk neutral, with expected utilities

$$\mathbf{E}_m\Big(\sum_{d=0}^{\infty}\beta'^{d}x'_{m+d}\Big) \quad \text{and} \quad \mathbf{E}_m\Big(\sum_{m=0}^{\infty}\beta'^{m}x'_{m}\Big),$$

where x'_{m+d} and x'_m are their respective consumptions of CDOs at dates $m+d$ and m. For the discount factors β^d and β'^d, it is given that $0 < \beta^d,\ \beta'^d < 1$ and suppose that $\beta < \beta'$. This inequality ensures that, in equilibrium, the LQ-entity will not want to postpone securitization, because they are relatively impatient (compare with [62] and the references contained therein). The following assumption is made for ease of computation.

Assumption 4.2.6 (Price, Asset, Default and Borrowing Rate): *For HQ-entities, suppose that $p^{A'}$, $r^{A'}$ and $r^{T'}$ are the asset price, asset rate and borrowing rate, respectively. For all m, it is assumed that*

$$p^{A'}_m = p^A_m,\ r^{A'}_m = r^A_m \text{ and } r^{T'}_m = r^T_m,$$

where p^A, r^A and r^T are as before for HQ-entities. Also, an assumption is made that the assets held by HQ-entities do not default or refinance.

In reality, this assumption may be violated since LQ-assets are more expensive than HQ-assets. However, this adjustment can be catered for in the sequel.

HQ-entity securitization does not require any specific skill nor do they produce any non-marketable CDOs [69]. As a result, no HQ-entity is credit constrained as noted in Basel III (see, [18]). At date m, such entities' budget constraint can be expressed as

$$p^A_m(A'_m - A'_{m-1}) + (1 + r^T)T'_{m-1} + x'_m = P(A'_{m-1})_{m-1} + T'_m, \tag{4.12}$$

where x'_m is secondary securitization at date m, $(1 + r^T)T'_{m-1}$ is debt repayment, and T'_m is new interbank sponsoring. The HQ-entities' balance sheet constraint

$$p^A_m A'_{m-1} + B'_m = T'_m + K'_m,$$

is the same as in the case for an LQ-entity, but the ratios of these variables will differ from that of the LQ-entity's with much lower risk (compare with (4.4)). In this regard, assets held by HQ-entities are less risky, long-term loans with fixed rates. Next, the HQ-entities' profit may be expressed as

$$\Pi'_m = r^A_m p^A_m A'_{m-1} + r^B B'_m - r^T T'_m, \tag{4.13}$$

where r^A, r^B and r^{T} represents the asset rate, returns on marketable securities and borrowing rate in period m, respectively. Notice that the prepayment cost is zero in the case for HQ-entities (see, equation 4.10). Thus, the value of HQ-entity assets is represented by

$$p^A_m A'_{m-1} = \frac{\Pi'_m - r^B B'_m + r^{\mathrm{T}} \mathrm{T}'_t}{r^A}. \tag{4.14}$$

An appropriate HQ-entity cash flow constraint is provided in the following result.

Lemma 4.2.7 (HQ-Entity Cash Flow Constraint): *Suppose that the credit constraint (4.3) as well as (4.12) to (4.14) hold. In this case, the HQ-entities' cash flow constraint is given by*

$$\Pi'_m \geq r^A p^A_m A'_{m-1} + r^B B'_m - p^A_{m+1} A'_m + \mathrm{T}'_m. \tag{4.15}$$

The above discussion on HQ-entities has relationships with Basel III capital and liquidity regulation. For example, a bank might view the Basel III risk-based capital charge applied to HQ-assets as being excessive, and therefore might engage in securitization activities of these receivables to benefit from a slightly lower capital charge resulting from other aspects of the risk-based capital rules (see, for instance, [24]). In the bank's view, this slightly lower charge might be more rational in terms of the true risks and capital needed for corporate lending activities (see, for instance, [18] and [24]).

4.3 Market Equilibrium

In equilibrium, T'_{m-1} and T'_m are negative, reflecting the fact that HQ-entities lend to the LQ-entities. For this study's purposes, market equilibrium is defined as follows.

Definition 4.3.1 (Market Equilibrium): ***Market equilibrium*** *is a sequence of asset prices and allocations, debt and securitization by LQ- and HQ-entities, given by*

$$\left\{p^A_m,\ A_m,\ A'_m,\ \mathrm{T}_m, \mathrm{T}'_m,\ x_m,\ x'_m\right\},$$

such that each LQ-entity chooses $(A_m,\ \mathrm{T}_m,\ x_m)$ to maximize the expected discounted utilities of LQ- and HQ-entities subject to the securitization function, sponsoring constraint and flow-of-funds constraint given by (4.2), (4.3) and (4.11), respectively. On the other hand, *each HQ-entity chooses* $(A_m^{'}, \mathrm{T}_m^{'}, x_m^{'})$ *to maximize the above expected discounted utilities subject to the securitization function (4.11) and budget constraint (4.12). Also, in the case of the HQ-entity, it is given that the markets for assets, CDOs and debt clear.*

4.3.1 LQ-Entity at Equilibrium

It is assumed that the asset price bubble does not burst during securitization.

As a result, entities neither expand nor shrink. To further characterize entity equilibrium, the following Kiyotaki-Moore-type result is provided.

Theorem 4.3.2 (LQ-Entity Behavior at Steady-State): *Assume that the asset bubble does not burst during the securitization process. In the neighborhood of the steady-state, the LQ-entity prefers to borrow up to the maximum and invest in assets, consuming no more than their current output of non-marketable CDOs. In this case, there is a unique steady-state* $(p^{A^*}, A^*, \mathrm{T}^*)$*, with the associated transaction fee,* u^**, being given by*

$$u^* = \frac{r^{\mathrm{T}}}{1+r^{\mathrm{T}}}p^{A^*} = \frac{1}{1+r^{\mathrm{T}}}P'\left[\frac{1}{n}(\overline{A} - A^*)\right] = \mu, \tag{4.16}$$

$$\mathrm{T}^* = \frac{\mu}{r^{\mathrm{T}}}A^*. \tag{4.17}$$

Proof. The result follows by considering the LQ-entity's additional level of marketable CDOs at date m. This entity may ultimately put more money in $1/u_m$ assets, which in turn gives c/u_m non-marketable CDOs and a/u_t marketable CDOs at date $m+1$. The former are consumed while the later are re-invested. This, in turn, yields

$$\frac{a}{u_m}\frac{c}{u_{m+1}}$$

non-marketable CDOs and

$$\frac{a}{u_m}\frac{a}{u_{m+1}}$$

marketable CDOs at date $m+2$, $m+3$, $m+4$ ...

The LQ-entity can either save the additional level or use it. The following routes of decision making can be considered.

$$\text{Future use: } 0,\ \frac{c}{u_m},\ \frac{a}{u_m}\frac{c}{u_{m+1}},\ \frac{a}{u_m}\frac{a}{u_{m+1}}\frac{c}{u_{m+2}},\ \ldots \tag{4.18}$$

$$\text{Save: } 0,\ 0,\ r^{\mathrm{T}}\frac{c}{u_m},\ r^{\mathrm{T}}\frac{a}{u_m}\frac{c}{u_{m+2}},\ \ldots \tag{4.19}$$

$$\text{Consumption: } 1,\ 0,\ 0,\ 0,\ \ldots \tag{4.20}$$

at dates $m,\ m+1,\ m+2,\ m+3,\ldots$, respectively.

The asset holding of entities as well as borrowing A_m and T_m may be given respectively by

$$A_m = \frac{1}{u_m}\left[(\mu + p_m^A)A_{m-1} - (1+r^{\mathrm{T}})\mathrm{T}_{m-1}\right], \tag{4.21}$$

$$\mathrm{T}_m = \frac{1}{1+r^{\mathrm{T}}}p_{m+1}^A A_m. \tag{4.22}$$

LQ- and HQ-entities' total demand for assets is equal to supply given by

$$\overline{A} = A_m + nA_m^{'}. \tag{4.23}$$

In this case, from (4.27), the asset market (clearing) equilibrium condition is obtained by

$$u_m = p_m^A - \frac{p_{m+1}^A}{1+r^{\mathrm{T}}} = u(A_m), \quad \text{where } u(A) \equiv \frac{1}{1+r^{\mathrm{T}}}P'\left[\frac{1}{n}(\overline{A} - A)\right]. \tag{4.24}$$

Entities have at least two obligations in terms of transaction fees. The first is towards the originator for acquiring the assets while the second is for using the assets for securitization into CDOs a type of user cost. The latter fee involves, for instance, an external credit rating agency (see subsection 4.3.4 for more details). Also, because of information asymmetry and regulatory dysfunction, CDOs open up opportunities for arbitrage, a point that has been considered in Basel III for balanced information distribution (see for instance, [18]). In this regard, sophisticated CDO entities, often circumvent regulatory constraints. This type of arbitrage is accompanied by high costs with originators and other financial intermediaries earning huge transaction fees and eroding value for entities and investors.

Theorem 4.3.2 postulates that at each date m, the LQ-entity's optimal choice of $(A_m,\ \mathrm{T}_t,\ x_m)$ satisfies $x_m = \nu A_{m-1}$ in (4.11), and the borrowing constraint (4.3) is binding so that

$$\mathrm{T}_m = \frac{p^A_{m+1}}{1+r^{\mathrm{T}}} A_m \text{ and } A_m = \frac{1}{p^A_m - \dfrac{1}{1+r^{\mathrm{T}}} p^A_{m+1}} \Big[(\mu + p^A_m) A_{m-1} - (1+r^{\mathrm{T}}) \mathrm{T}_{m-1} \Big]. \quad (4.25)$$

Here, the term $(\mu + p^A_m)A_{m-1} - (1+r^{\mathrm{T}})\mathrm{T}_{m-1}$ is the LQ-entity's nett value at date m.

(4.25) emphasizes that LQ-entity utilizes its nett value to sponsor the difference between the asset price, p^A_m, and value the entity can get against each asset level, $\frac{p^A_{m+1}}{1+r^{\mathrm{T}}}$. This difference is given by

$$u_m = p^A_m - \frac{p^A_{m+1}}{1+r^{\mathrm{T}}} \quad (4.26)$$

and is the screening costs required to buy an asset unit.

The usual notion that a higher asset price p^A_m reduces the LQ-entity's demand is more than offset by the facts that they can borrow more when p^A_{m+1} is higher and their nett worth increases as p^A_m rises.

4.3.2 HQ-Entity at Equilibrium

Next,the HQ-entities' behavior at equilibrium is examined. Such entities are not credit constrained, and so their asset demand is determined at the point at which the present value of the marginal product of assets is equal to the transaction fee associated with assets (refer to Basel III in, [24]). In this case, it is given that

$$u_m = p^A_m - \frac{p^A_{m+1}}{1+r^{\mathrm{T}}} = \frac{1}{1+r^{\mathrm{T}}} P'(A'_m). \quad (4.27)$$

In the model, u_m is both the HQ-entities' opportunity cost of holding an asset unit and the required screening costs per unit of assets held by the LQ-entities.

4.3.3 LQ- and HQ-Entity Market Clearing

In this subsection, the study considers market clearing that refers to either a simplifying assumption made that markets always go to where the assets supplied equals the assets demanded or the process of getting there via price adjustment. A market clearing price is the price of goods or a service at which assets supplied is equal to assets demanded, also called the equilibrium price. Another market clearing price may be a price below equilibrium price to stimulate demand.

Since all HQ-entities have identical securitization functions (See Basel III and revision to Securitization in [18]), their aggregate asset demand equals $A_m^{'}$ times their population n. The sum of the aggregate demand for assets by the LQ- and HQ-entities is equal to the total supply given by (4.23). In this case, from (4.27), the study obtains the asset market (clearing) equilibrium condition (4.24). The function $u(\cdot)$ is increasing.

This arises from the fact that if the LQ-entity's asset demand, A_m, goes up, then in order for the asset market to clear, the HQ-entities' demand has to be stymied by a rise in the transaction fee, u_m.

4.3.4 Entity Equilibrium Summary

Figure 4.3 displays the main features of market equilibrium for LQ- and HQ-entities.

The horizontal axis represents LQ- and HQ-entity asset demand from the left-hand side and right-hand-side, respectively. It is noted that the total asset supply is denoted by $\overline{A}$. The vertical axis represents the marginal products of assets for LQ- and HQ-entities given by $\mu + \nu$ and $P^{'}(A^{'}/n)$, respectively. The HQ-entities' marginal product decreases with asset use. If there are no credit limits, then E^0 would be the best allocation for where the LQ- and HQ-entity marginal products are in equilibrium. The asset price would then be $p^0 = (\mu+\nu)(r^{\mathrm{T}})^{-1}$. On the other hand, when credit limits exist, then the equilibrium is E^*, where the additional product of the LQ-entity is greater than that of the HQ-entity. In this case, it can be shown that

$$\mu + \nu > P^{'}[(\overline{A} - A^*)/n] = \mu(1 + r^{\mathrm{T}}).$$

This means that the LQ-entity's asset use is not enough. The output of CDOs per period in equilibrium is represented by the light gray area under the thick line, whereas the gray triangle represents the CDO loss per period. In this case, CDO output increases relative to the LQ-entity's asset holding. If A_m increases, then the CDO output will also increase in

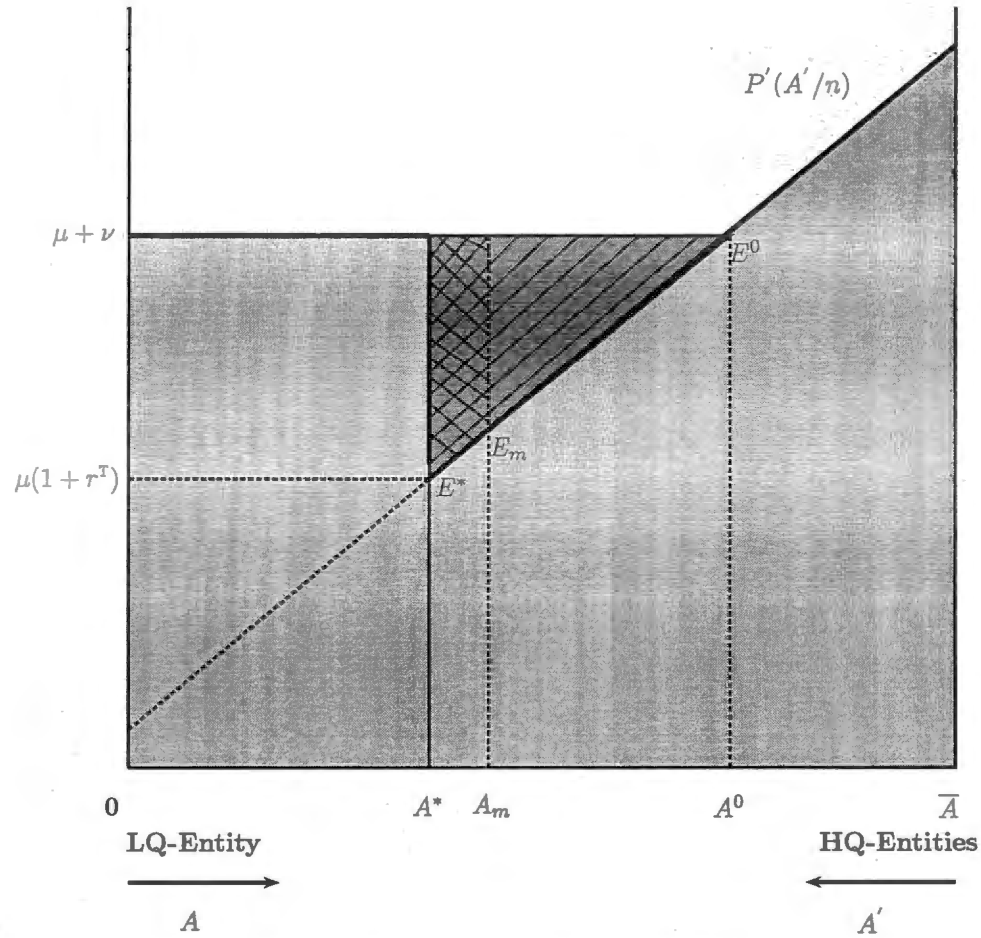

Figure 4.3: LQ- and HQ-Entity Market Equilibrium

period $m + 1$.

4.4 Illustrative Example of Asset Securitization

In this section a numerical example with a shock of 0.01 and a simulation to illustrate the effects of shocks to asset and CDO prices is given.

4.4 Illustrative Example of Asset Securitization

In this section a numerical example with a shock of 0.01 and a simulation to illustrate the effects of shocks to asset and CDO prices is given.

Parameter	Value	Parameter	Value	Parameter	Value
μ	1	ν	0.8	α	0.5
p^A_{m+1}	0.013	c^p	0.05	r^f	0.01
$\overline{A}_m$	680 000	$\overline{A}_{m-1}$	420 000	r^A	0.051
r^R	0.5	r^S	0.15	T_m	\$ 4 000
n	1	r^{m}	0.1	B_m	\$ 3 500
r^B	0.105	K_m	\$ 3 000	$P(A'_{m-1})$	\$ 240 000
Σ	0.01	C^*	\$ 200 000	λ	0.95
π	0.1	ρ	10		

Table 4.1: Asset Parameter Choices

4.4.1 Numerical Example: Entity Equilibrium

The coverage offered by the example in this subsection includes the securitization function, balance sheet as well as the cash flow, LQ-entity cash flow, LQ-entity flow of funds, HQ-entity budget and HQ-entity cash flow constraints, given by (4.2), (4.6), (4.8), (4.10), (4.11), (4.12), (4.15), respectively. Also, the variables p^C, Π', A', p^{A*}, T^*, u_m, A, T and $\overline{A}$ presented in (4.5), (4.13), (4.14), (4.15), (4.16), (4.26), (4.21), (4.22) and (4.23), respectively, are incorporated in the numerical example. Suppose that the LQ- and HQ-entity borrowings, marketable securities and capital are equal at the outset. In this case, notice that the LQ- and HQ-entity asset holdings, A and A' are a proportion, α and $1-\alpha$ of the aggregate assets, $\overline{A}$, respectively. Thus $A = \alpha\overline{A} = 0.5 \times 680000 = 340000$ and $A' = (1-\alpha)\overline{A} = (1-0.5) \times 680000 = 340000$.

The LQ-entitie's CDO output in period $m+1$ is computed by considering the securitization function (4.2). Therefore, the CDO output can be computed by

$$C_{m+1} = (\mu+\nu)A_m = (\mu+\nu)\alpha\overline{A_m} = (1+0.8) \times 0.5 \times 680000 = 612000.$$

Next, the upper bound of the LQ-entitie's retention rate is less than the discount factor β in (4.1) so that

$$\beta > \left(\frac{1}{1+0.8}\right) = 0.56.$$

The value of LQ-entity assets in period m is computed by using (4.6). Thus,

$$p_m^A A_{m-1} = \text{T}_m + K_m - B_m = 4000 + 3000 - 3500 = 3500.$$

The asset price in period m is therefore

$$p_m^A = 3500/A_{m-1} = 3500/\alpha\overline{A}_{m-1} = 3500/.5 \times 420000 = 0.016666666 \approx 0.017.$$

The LQ-entitie's profit is computed by considering the cash flow constraint (4.9) so that

$$\Pi_m = (0.051 + 0.05 \times 0.01 - (1 - 0.5) \times 0.15)3500 + 0.105 \times 3500 - 0.1 \times 4000 = -114.75.$$

Furthermore, the LQ-entitie's profit is subject to the constraint (4.10), thus

$$\begin{aligned} \Pi_m &\geq (0.051 + 0.05 \times 0.01 - (1 - 0.5) \times 0.15)3500 + 0.105 \times 3500 - 0.013 \times 0.5 \times 680000 + 4000 \\ &= -134.75. \end{aligned}$$

The LQ-entitie's additional consumption, $x_m - \nu A_{m-1}$, is computed by considering the flow-of-funds constraint (4.11) given by

$$\begin{aligned} &1 \times 0.5 \times 420000 + 4000 - (1 + 0.1) \times 2100 - 0.017(0.5 \times 680000 - 0.5 \times 420000) \\ &\qquad -10(0.5 \times 680000 - 0.95 \times 0.5 \times 420000) = -1195520. \end{aligned}$$

Thus, $x_m = -1027520$.

Next, the study concentrates on the HQ-entity constraints. Such an entities' securitization at date m is computed by using the budget constraint (4.12), so that

$$\begin{aligned} x_m' &= 240000 + 4000 - 0.017((1 - 0.5)680000 - (1 - 0.5)420000) - (1 + 0.1) \times 2100 \\ &= 239480. \end{aligned}$$

Next,the HQ-entities' profit, (4.13), is computed at face value at date m as

$$\Pi_m^{'} = 0.051 \times 0.017 \times 210000 + 0.105 \times 3500 - 0.1 \times 4000 = 149.57.$$

Also, the value of assets (4.14) can be computed as

$$p_m^A A_{m-1}^{'} = \frac{149.57 - 0.105 \times 3500 + 0.1 \times 4000}{0.051} = 3570.$$

The HQ-entities' cash flow constraint (4.15), given by

$$\Pi_m^{'} \geq 0.051 \times 3570 + 0.105 \times 3500 - 0.013 \times (1 - 0.5)680000 + 4000 = 129.57.$$

Next, the steady-state asset price and borrowings for the LQ-entity, represented by (4.16) and (4.17) are

$$p^{A^*} = 1\frac{1+0.1}{0.1} = 11 \text{ and } \mathrm{T}^* = \frac{1}{0.1}(1 - 10 + 0.95 \times 10)210000 = 1050000.$$

Notice that the required screening costs per asset unit equals the LQ-entitie's securitization of marketable output, $u^* = \mu = 1$, also $A_{m-1} = A^*$ and $\mathrm{T}_{m-1} = \mathrm{T}^*$.

Aggregate asset holding and borrowing, A_m and T_m of the LQ-entity represented by (4.20) and (4.21) may be computed as

$$\begin{aligned} A_m &= (1 - 0.1)0.95 \times 210000 + \frac{0.1}{10 + 0.017 - \frac{1}{1+0.1} \times 0.013}[(1 + 0.017 \\ &\quad +0.95 \times 10)210000 - (1 + 0.1)1050000] = 190080.22, \end{aligned}$$

and

$$\begin{aligned} \mathrm{T}_m &= (1 + 0.1)1050000 + 0.017(340000 - 210000) + 10(340000 - 0.95 \times 210000) \\ &\quad -1 \times 210000 = 2352210. \end{aligned}$$

The screening cost incurred by an LQ-entity to purchase an asset unit is financed by the LQ-entitie's nett worth. This cost is represented by (4.26) and may be computed as

$$u_m = 0.017 - \frac{0.013}{1+0.1} = 0.005181818.$$

The sum of the aggregate asset demand by LQ- and HQ-entities represented by (4.23) is computed by

$$\overline{A} = 0.5 \times 680000 + 1(1-0.5)680000 = 680000.$$

4.4.2 Numerical Example: Shocks to Low Quality Assets and Their Structured Products

The variables $u(A)$, B, presented in (5.-25), (5.3), (5.4), (5.5), (5.6), (5.7), (5.8), (5.9), (5.11), (5.12) and (5.13), respectively, are covered by the example in this subsection. At date m, the LQ-entity's asset demand and borrowings under a temporary shock given by (4.21) and (4.22), respectively, are computed as

$$\begin{aligned} A_m &= \frac{1}{0.005181818}\Big[(1+0.017)\times 0.5\times 420000-(1+0.1)\times 2100\Big] \\ &= 40769475.1147. \end{aligned}$$

and

$$\mathrm{T}_m = \frac{1}{1+0.1}0.013 \times 0.5 \times 680000 = 4018.181818,$$

respectively. In this regard, the cost of funds (5.-26) in period m, is computed as

$$\begin{aligned} u(A_m)A_m &= (1 - 1\times 0.01 + 0.017 - 11)0.5 \times 420000 \\ &= -2098530. \end{aligned}$$

Also, it can be seen that the LQ-entitie's nett worth at date m is more than their current output immediately after the shock given by (5.3), so that

$$(1-\Sigma)\mu A^* = (1-0.01)1 \times 0.5 \times 420000 = 207900.$$

Here unexpected capital gains (5.4) are given by

$$(p_m^A - p^{A*})A^* = (0.017 - 11)0.5 \times 420000 = -2306430$$

while the debt repayment (5.5) is

$$(1 + r^{\mathrm{T}})\mathrm{T}^* = (1 + 0.1)1050000 = 1155000.$$

The proportional changes in A_m and p_m^A in (5.6) can be computed by

$$\widehat{A}_m = \frac{0.5(680000 - 420000)}{0.52 \times 420000} = 0.619047619 \text{ and}$$
$$\widehat{p}_m^A = \frac{0.017 - 11}{11} = -0.998455,$$

respectively. The steady-state profit for LQ- and HQ-entities given by (5.7) and (5.8), respectively, are

$$\begin{aligned} \Pi_m^* &= (0.051 + 0.05 \times 0.01 - (1 - 0.5) \times 0.15)11 \times 0.5 \times 420000 + 0.105 \times 3500 - 0.1 \times 1050000 \\ &= -158917.5 \end{aligned}$$

and

$$\begin{aligned} \Pi_m'^* &= 0.051 \times 11 \times (1 - 0.5) \times 420000 + 0.105 \times 3500 - 0.1 \times 1050000 \\ &= 13177.5 \end{aligned}$$

respectively. Thus, the proportional changes in Π_m and Π_m' are

$$\widehat{\Pi}_m = \frac{-114.75 - -158917.5}{-158917.5} = -0.999278 \text{ and } \widehat{\Pi}_m' = \frac{149.57 - 13177.5}{13177.5} = -0.988650,$$

respectively. At date m, the elasticity of the residual asset supply to the LQ-entities with respect to the transaction fee at the steady-state in (5.9) is

$$\eta = \left[\frac{\frac{1+0.1}{0.1} \times -0.998455 - 0.01}{0.619047619} - 1 \right]^{-1} = -0.05331078.$$

The ratio of the steady state user cost of assets to the LQ-entities' required down payment per unit of investment is given by

$$\theta = \frac{1}{(10+1)} = 0.090909,$$

Furthermore, the proportional changes in p_m^A, A_m and C_m subject to negative shock Σ in (5.11), (5.12) and (5.13) may be computed as

$$\begin{aligned}
\widehat{p_m^A} &= -\frac{1}{-0.05331078} \frac{0.95 \times 0.1 + (1-0.95)(0.1(1+0.1) - 0.1)}{1 - 0.95 + 0.95 \times 0.1} \frac{1}{1 + 0.95 \times 10} \times 0.01 \\
&= 0.0117661,
\end{aligned}$$

$$\begin{aligned}
\widehat{A}_m &= -\frac{1}{1 + \frac{0.090909}{-0.05331078}(1 - 0.95 + 0.95 \times 0.1)} \left[1 + \frac{1+0.1}{0.1} \frac{0.1}{1 - 0.95 + 0.95 \times 0.1} \frac{0.090909}{-0.05331078}\right] \\
&\quad \times [0.95 \times 0.1 + (1-0.95)(0.1(1+0.1) - 0.1)] \frac{1}{1 + 0.95 \times 10} 0.01 \\
&= -0.0014423.
\end{aligned}$$

and

$$\begin{aligned}
\widehat{C}_m &= -\frac{1}{0.5} \frac{1}{1 + 0.95 \times 10} \Big\{ 0.1(1+0.1) - 0.1 - \frac{0.95(1-0.1)0.1 \times 10}{1 + 0.95 \times 10 - 10} + (1-0.95) \\
&\quad (0.1(1+0.1) - 0.1) \\
&\quad \frac{0.090909}{-0.05331078} \left[\frac{1 + 0.95 \times 10}{1 + 0.95 \times 10 - 10} + \frac{1+0.1}{0.1} \frac{0.1}{1 - 0.95 + 0.95 \times 0.1} \right] \Big\} 0.01 \\
&= 0.0032845.
\end{aligned}$$

respectively.

4.4.3 Numerical Example: Summary and Analysis

A summary of computed shock parameters is provided in Table 4.2 below.

Parameter	Value	Parameter	Value
C_{m+1}	\$ 612 000	$\beta >$	0.56
$p_m^A A_{m-1}$	\$3 500	Π_m	-114.75
$\Pi_m \geq$	-134.75	x_m	-1 027 520
$x_m^{'}$	\$ 239 480	$\Pi_m^{'}$	\$ 149.57
$p_m^A A_{m-1}^{'}$	\$ 3 570	$\Pi_m^{'} \geq$	\$ 129.57
p^{A^*}	11	T^*	\$ 105 0000
Aggregate A_m	\$ 190 080.22	Aggregate T_m	\$ 2 352 210
u_m	0.005181818	$\overline{A}$	\$ 680 000
A_m under shock	\$ 40 769 475.1147	T_m under shock	\$ 4 018.181818
$u(A_m)A_m$	-2 098 530	Current Output	207 900
Unexpected Capital Gains	\$ -2 306 430	Debt Repayment	\$ 1 155 000
$\widehat{A}_m$	0.619 047 619	$\widehat{p}_m^A = \widehat{p}_m^C$	-0.998 455
Π_m^*	\$ -158 917.5	$\Pi_m^{*'}$	\$ 13 177.5
$\widehat{\Pi}_m$	-0.999278	$\widehat{\Pi}_m^{'}$	-0.988650
η	-0.05331078	u^*	1
θ	0.090909	$\widehat{p}_m^A$ in terms of shock	0.0117661
$\widehat{A}_m$ in terms of shock	-0.0014423	$\widehat{C}_m$ in terms of shock	0.0032845

Table 4.2: Computed Asset Parameters

Table 4.2 shows parameters computed of asset securitization after the economy was hit with a shock of 0.01. The aggregate output increased to \$ 612,000 as compared to the previous example. The value of LQ-assets reduces to \$3,500 from \$ 5,000 due to the fact that most investors found themselves with risky assets which defaulted and could not be sold to other people. There were many LQ-assets on the market and the demand for these assets declined which in turn reduced their value. Aggregate borrowing also increased to \$ 2, 352 210 as most borrowers were trying to get money from banks and other financial intermediaries in order to payoff their debts. In addition banks that were at the brink of collapse had to borrow money as well or be bailed out by their governments. The steady-state asset price of LQ-assets increased to \$11 mostly because of the high demand for these type of financially engineered products by investors which can also be explained by the increase in LQ-entity asset demand to \$ 40, 769 475. The increase in demand for these products necessitated an increase in borrowing which went up to \$ 105,000. This is in line with economic theory which postulates that an increase in demand is most likely to be accompanied by an increase in the price of the product. The transaction fee associated with CDO price, p^C, are extremely high which erodes CDO benefits such as using financial engineering to complete markets, advantages of mathematical finance and new diversification opportunities and the value created by CDOs violates economic theory that postulates that similar reference assets and bonds should have similar values. The methods used to rate CDOs are complicated, arbitrary and opaque and they created opportunities for entities to create a ratings arbitrage opportunity without enhancing value during the FC.

4.5 Basel III Recommendations for LQ- and HQ-Entities

In the Basel III document [24], the Joint Forum makes the following recommendations about the supervision of the LQ- and HQ-entities discussed previously.

- Firstly, supervisors should make sure that market participants assess all economic risks and business purposes of LQ- and HQ-entities during the lifespan of a transaction distinguishing between risk transfer and transformation. We note that, over time, the nature of these risks can change. Supervisors should ensure that such assessment is ongoing and that management has sufficient understanding of the risks (see [24] for more details). These risks are usually excarbated by new investment opportunities to securitize assets arising from high probability of non defualt and the arrival of securitization being independent both across LQ-entity and through time (see for instance, assumption 4.2.4).

- Secondly, market participants should be able to assess and risk manage factors that increase transaction complexity, such as structural features of LQ- and HQ-entities including triggers and the roles of parties involved (see, for instance, [18] and [24]). Participants should be able to access features such those given in section 4.3 about LQ- and HQ- market equilibrium to help them make more informed decisions before they get into any securitization transaction.

- In the third place, firms and supervisors should ensure the governance process of LQ- and HQ-entities commensurate with the degree of active intervention and discretion of the parties participating in these entities (see [24] for more discussions). Taking into account the fact that LQ- entities are assumed to be credit limited and can therefore borrow in total with requirements not exceeding the market value of assets (see for instance, assumption 4.2.2, in section 4.2.1).

- The fourth recommendation is that firms should continually monitor the quality of transferred exposures in relation to the risk profile of the firm's remaining portfolios and the impact on its balance sheet components, and supervisors should where appropriate assess systemic implications of risk dispersion to transferees (see [18] and [24] for more details). For example, HQ-assets held by HQ-entities are assumed to be non defaulting (see for instance, section 4.2.2).

- Fifthly, firms should have the capability to aggregate, assess and report all their LQ- and HQ-entity exposure risks in conjunction with all other firm-wide risks (see, for instance, [24]). Emphasis can be made for this recommendation on the assumption that each LQ-entity's CDO technology is for example different and when securitization has began, only the LQ-entity has the required skill to securitize assets into CDOs as was shown by assumption 4.2.1 in section 4.2.1.

- In the sixth place, if at inception or at any point during the lives of LQ- and HQ-entities there is a likelihood or evidence of support by the financial firm, including non-contractual support, then the activities and risks of those entities should be aggregated with those of the institution for both supervisory assessment and internal risk management purposes (see [18] and [24] for more discussions). For instance, at a point in time, the behavior of an LQ-entity at steady-state assuming the asset bubble does not burst during the securitization process can provide valuable information for risk management purposes (see for instance, theorem 4.3.2) in section 4.3.2.

- The seventh recommendation is that supervisors should support market participants' efforts towards greater standardization of definitions, documentation, and disclosure requirements of LQ- and HQ-entity transactions and provide for the communication of any material divergence from these standards to investors in individual transactions (see [24] for more details). Such disclosure requirements include the behavior of HQ-entity at equilibrium taking into consideration that these entities are not credit constrained and their asset demand is determined at the point where marginal product of assets equals the transaction fee associated with assets as shown in section 4.3.2.

- Finally, supervisors should regularly oversee and monitor the use of all LQ- and HQ-entity activity and assess the implications for regulated firms of the activities of such entities, in order to identify developments that can lead to systemic weakness and contagion or that can exacerbate procyclicality (see, for instance, [18] and [24]). This can be attributed to the securitization of LQ- and HQ-assets in an economy presented in this section with a fixed total supply where CDOs cannot be retained by the LQ- or HQ-entity.

Chapter 5

Basel III and Two-Step Asset Securitization

5.1 Background to Basel III and Two-Step Asset Securitization

In this section, a description of the effect of unexpected negative shocks on LQ-asset price and input, CDO price in a Basel III context and output as well as profit is given. In this regard, two kinds of multiplier processes are considered. The first is the within-period or static multiplier process. Here, the shock such as a ratings downgrade reduces the nett worth of the constrained LQ-entity and compels it to reduce its asset demand. In this case, by keeping the future constant, the transaction fees decrease to clear the market and the asset price falls by the same amount. In turn, this lowers the value of the LQ-entity's existing assets and reduces their nett worth even more. Since the future is not constant, this multiplier misses the intuition offered by the more realistic inter-temporal or dynamic multiplier. In this case, the decrease in asset prices results from the cumulative decrease in present and future opportunity costs, stemming from the persistent reductions in the constrained LQ-entity's nett worth and asset demand, which are in turn exacerbated by a decrease in asset price and nett worth in period m [69].

5.1.1 Aims and Section Outline

This section aims to describe the effects of the unexpected negative shocks on LQ-asset price and input, CDO price and output in an economy. The specific aims are formulated as follows:

- To understand the effect of unexpected inter-temporal shocks to the economy in a dynamic multiplier with emphasis on the shock equilibrium path for LQ- and HQ-entities.

- To examine the dynamics of asset price and input, CDO and output, as well as profit, in a dynamic multiplier by linearizing around the steady-state and ruling out bursting bubbles in the asset price.

- To introduce uncollateralized RABs into the securitization model and examine its impact on LQ- entities and the economy.

- To determine the impact of shocks to asset price and input in a static multiplier, supposing that the asset bubble does not burst during the securitization process.

- To present an example of asset securitization and give recommendations in relation to Basel III for the section as a whole.

Section 5.2 focuses on the response of temporary shocks to LQ- and HQ- assets in a dynamic multiplier set up, with reference on the shock equilibrium path, asset price and input, CDO price and output as well as profit and shocks to low quality asset profit. Furthermore, section 5.3 introduces uncolletaralized residential asset backed securities (RABs) which increases the degree of persistence, shifts the focus from quantities to asset prices and assists in reducing the LQ-entities' debt-to-asset ratio to reasonable levels. In addition, section 5.3 considers the response of LQ- and HQ- assets to temporary shocks in a static multiplier setting while 5.4.2 presents a numerical example of asset securitization.

5.2 Dynamic Multiplier: Response to Temporary Shock

In order to understand the effect of unexpected inter-temporal shocks to the economy, suppose at date $m-1$, the economy is in steady-state with

$$A^* = A_{m-1} \text{ and } \mathtt{T}^* = \mathtt{T}_{m-1}.$$

5.2.1 Dynamic Multiplier: Shock Equilibrium Path

Unexpected inter-temporal shock where the CDO output of LQ- and HQ-entities at date m are $1-\Sigma$ times their expected levels are introduced. In order for this model to resonate with the 2007-2009 financial crisis, Σ is taken to be positive.

Combining the market-clearing condition (4.24) with the LQ-entity's asset demand under a temporary shock and borrowing constraint given by (4.21) and (4.22), respectively, the study obtains

$$u(A_m)A_m = (\mu - \mu\Sigma + p^A_m - p^{A^*})A^*, \text{ (date } m) \quad (5.1)$$

$$u(A_{m+s})A_{m+s} = \mu A_{m+s-1}, \text{ (dates } m+1,\ m+2,\ \ldots) \quad (5.2)$$

The formulae (5.1) and (5.2) imply that at each date the LQ-entity can hold assets up to the level A at which the required cost of funds, $u(A)A$, is covered by its nett value.

From (5.1), subsequent to the shock, it can be seen that the LQ-entity's nett worth at date m is more than only their current output given by

$$(1-\Sigma)\mu A^*, \quad (5.3)$$

because p^A_m changes due to shocks and

$$(p^A_m + p^{A^*})A^*, \quad (5.4)$$

result on their asset holdings.

Debt repayment is given by

$$(1+r^{\mathrm{T}})\mathrm{T}^* = p^{A^*}A^*. \quad (5.5)$$

In the sequel, proportional changes in A_m, p^A_m and Π_m relative to their steady-state values, A^*, p^{A^*} and Π^* respectively, are given by

$$\widehat{A}_m = \frac{A_m - A^*}{A^*},\ \widehat{p}^A_m = \frac{p^A_m - p^{A^*}}{p^{A^*}} \text{ and } \widehat{\Pi}_m = \frac{\Pi_m - \Pi^*}{\Pi^*} \quad (5.6)$$

respectively. For the purpose of this study, it is assumed that steady-state profit, Π^*_m, represents profit when the asset value and borrowings are in steady-state. Thus steady-state profit for LQ- and HQ-entities are represented by

$$\Pi^*_m = \left(r^A_m + c^p_m r^f_m - (1 - r^R_m) r^S_m\right) p^{A^*}{}_m A^*_{m-1} + r^B B_m - r^{\mathrm{T}} \mathrm{T}^*_m \tag{5.7}$$

and

$$\Pi'^*_m = r^A p^{A^*}{}_m A'^*_{m-1} + r^B B'_m - r^{\mathrm{T}} \mathrm{T}'^*_m, \tag{5.8}$$

respectively. Then, by using the steady-state, transaction fee, (4.16), it can be given from equations (5.1) and (5.2) that

$$\left(1 + \frac{1}{\eta}\right) \widehat{A}_m = \frac{1 + r^{\mathrm{T}}}{r^{\mathrm{T}}} \widehat{p}^A_m - \Sigma, \text{ (date } m) \tag{5.9}$$

$$\left(1 + \frac{1}{\eta}\right) \widehat{A}_{m+s} = \widehat{A}_{m+s-1}, \text{ for } s \geq 1, \text{ (dates } m+1,\ m+2,\ \ldots) \tag{5.10}$$

where $\eta > 0$, denotes the elasticity of the residual asset supply to the LQ-entity with respect to the transaction fee at the steady-state.

Theorem 5.2.1 (Dynamic Multiplier: Shocks to Asset Price and Input, CDO Price and Output and Profit): *Assume that the asset bubble does not burst during the securitization process and that $p^A_m \leq \overline{p}_m$, for all m in (4.5). In this case, it can be said that the proportional change in asset price and input, CDO price and output as well as profit subject to a negative shock is given by*

$$\widehat{p}^A_m = -\frac{1}{\eta} \frac{\lambda\pi + (1-\lambda)(\pi(1 + r^{\mathrm{T}}) - r^{\mathrm{T}})}{1 - \lambda + \lambda\pi} \frac{\mu}{\mu + \lambda\rho} \Sigma, \tag{5.11}$$

$$\begin{aligned} \widehat{A}_m &= -\frac{1}{1 + \frac{\theta}{\eta}(1 - \lambda + \lambda\pi)} \left[1 + \frac{1 + r^{\mathrm{T}}}{r^{\mathrm{T}}} \frac{\pi}{1 - \lambda + \lambda\pi} \frac{\theta}{\eta}\right] \\ &\quad \times [\lambda\pi + (1-\lambda)(\pi(1 + r^{\mathrm{T}}) - r^{\mathrm{T}})] \frac{\mu}{\mu + \lambda\rho} \Sigma \end{aligned} \tag{5.12}$$

$$\widehat{C}_m = -\frac{1}{\alpha}\frac{\mu}{\mu+\lambda\rho}\Big\{\pi(1+r^{\mathrm{T}}) - r^{\mathrm{T}} - \frac{\lambda(1-\pi)r^{\mathrm{T}}\rho}{\mu+\lambda\rho-\rho} + (1-\lambda)(\pi(1+r^{\mathrm{T}})-r^{\mathrm{T}})\frac{\theta}{\eta}\Big[\frac{\mu+\lambda\rho}{\mu+\lambda\rho-\rho} + \frac{1+r^{\mathrm{T}}}{r^{\mathrm{T}}}\frac{\pi}{1-\lambda+\lambda\pi}\Big]\Big\}\Sigma \tag{5.13}$$

and

$$\widehat{\Pi}_m = \frac{\Big(r^A_m + c^p_m r^f_m - (1-r^R_m)r^S_m\Big)p^A_m A_{m-1} + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m}{\Big(r^A_m + c^p_m r^f_m - (1-r^R_m)r^S_m\Big)p^{A*}_m A^*_{m-1} + r^B B_m - r^{\mathrm{T}}\mathrm{T}^*_m} - 1 \tag{5.14}$$

respectively.

In percentage terms, the impact on the asset price, given by (5.11) is of the same magnitude as the temporary shock Σ.

A 1% rise in asset price increases the LQ-entities' aggregate net value by $[(1+r^B)/r^B - 1][\pi/(1-\lambda)(\pi(1+\lambda))]\theta$ percent.

Proof.

By considering the roles of π and ρ in turn, from (5.11) and (5.12), the responses of that period are dampened by π understandably, given that not all the LQ-entities can immediately adjust their investment at date t to respond to the shock.

This is in contrast to Section 2 where the default starts immediately. Moreover, the effects last longer; the default rate is smaller when π is smaller, as long as HQ-assets are not too costly. From (5.11) and (5.12), the contemporaneous responses are dampened also by ρ because the LQ-entities' net worth at date m includes the value of the HQ-assets inherited from date $m-1$ and so there is less leverage. However, the effects are more persistent. From (5.10), the default rate is a decreasing function of ρ. The reason is that ρ reduces the chocking-off effect at all dates $m+d$, $d \geq 0$: the required down payment per unit of asset comprises the user cost u_{m+d} and the cost of HQ-assets and so the LQ-entities' asset demand is less sensitive to a rise in u_{m+d}, (it is equivalent to an increase in the elasticity of the residual supply of assets to the LQ-entities from η to η/θ). Greater persistence in turn means that a given shock to asset usage at date m has a bigger impact on asset price. From (5.11) and (5.12), the ratio $\widehat{p}^A_m/\widehat{A}_m$ increases with ρ. In other words, ρ shifts the action from quantities to prices.

By considering (5.10) with $d = 0$, the study solves simultaneously for $\widehat{p}^A_m$, $\widehat{A}_m$ and $\widehat{C}_m$.

Since there are no bursting bubbles, the asset price p_m^A, is intimated to be the discounted sum of future opportunity costs given by

$$u_{m+d} = u(A_{m+d}),\ d \geq 0.$$

Replacing from (5.10) given by

$$\left(1+\frac{1}{\eta}\right)\widehat{A}_{m+d} = \widehat{A}_{m+d-1},\ \text{for } d \geq 1,\ (\text{dates } m+1,\ m+2,\ \ldots),$$

the study obtains

$$\widehat{p}_m^A = \frac{1}{\eta}\frac{r^{\mathrm{T}}}{1+r^{\mathrm{T}}}\sum_{d=0}^{\infty}(1+r^{\mathrm{T}})^{-d}\widehat{A}_{m+d} = \frac{1}{\eta}\frac{r^{\mathrm{T}}}{1+r^{\mathrm{T}}}\frac{1}{1-\dfrac{\eta}{(1+r^{\mathrm{T}})(1+\eta)}}\widehat{A}_m. \tag{5.15}$$

It has to be verified that

$$\sum_{d=0}^{\infty}(1+r^{\mathrm{T}})^{-d}\widehat{A}_{m+d} = \frac{1}{1-\dfrac{\eta}{(1+r^{\mathrm{T}})(1+\eta)}}\widehat{A}_m = \frac{(1+r^{\mathrm{T}})(1+\eta)}{(1+r^{\mathrm{T}})(1+\eta)-\eta}\widehat{A}_m.$$

is standard for infinite series. The dynamic multiplier

$$\left[1-\frac{\eta}{(1+r^{\mathrm{T}})(1+\eta)}\right]^{-1} = \frac{(1+r^{\mathrm{T}})(1+\eta)}{(1+r^{\mathrm{T}})(1+\eta)-\eta} \tag{5.16}$$

in (5.15) captures the effects of persistence in entities' reference asset portfolio holdings. In order to find $\widehat{p}_t^A$ and $\widehat{A}_t$ in terms of the size of the shock Σ, a utilization of (5.9) and (5.15) is made. The calculations above verify that (5.11) and (5.12) hold.

Next, it is proved that (5.13) holds.

Suppose that the proportional change in aggregate output, $\widehat{C}_{m+d}$, is given (compare with $\widehat{p}_m^A$ and $\widehat{A}_m$ above) by

$$\widehat{C}_m = \frac{C_m - C^*}{C^*},\ C_m = (\widehat{C}_m + 1)C^* \text{ and } C^* = \frac{C_m}{\widehat{C}_m + 1},$$

In this case, it can be verified that at date $m+d$ the change in output, $\widehat{C}_{m+d}$, may be shown by

$$\widehat{C}_{m+d} = \frac{\mu+\nu-(1+r^{\mathrm{T}})\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\widehat{A}_{m+d-1}, \text{ for } d \geq 1. \tag{5.17}$$

The RHS of (5.17) yields

$$\frac{\mu+\nu-(1+r^{\mathrm{T}})\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\widehat{A}_{m+d-1} = \frac{C_{m+s}-[(1+r^{\mathrm{T}})\mu A_{m+d-1}+(\mu+\nu-(1+r^{\mathrm{T}})\mu)A^*]}{C^*}.$$

In order to verify (5.17) the study shows that

$$C^* = (1+r^{\mathrm{T}})\mu A_{m+d-1} + (\mu+\nu-(1+r^{\mathrm{T}})\mu)A^* = [(1+r^{\mathrm{T}})\mu\widehat{A}_{m+d-1}+\mu+\nu]A^*.$$

This, of course, is true since

$$C^* = (\mu+\nu)A^* \text{ and } (1+r^{\mathrm{T}})\mu A_{m+d-1} = (1+r^{\mathrm{T}})\mu A^* \text{ or } A_{m+d-1} = A^*.$$

The proportional change in profit, $\widehat{\Pi}_m$, given by (5.14) is a direct consequence of its definition. □

The proportional changes in CDO output, $\widehat{C}$, and profit, $\widehat{\Pi}$, given by (5.13) and (5.14), respectively, have important connections with the financial crisis. This relationship stems from the terms involving the asset and prepayment rates, refinancing as well as house equity.

The multiplier in (5.12) can be significant because of the leverage effect and a 1% rise in asset price increases the LQ-entities' aggregate nett worth by

$$\frac{1+r^{\mathrm{T}}}{r^{\mathrm{T}}}\frac{\pi}{1-\lambda+\lambda\pi}\theta$$

percent. This is not as large as in Section 4, but still can be considerably larger than unity. The study considers the roles of π and ρ in turn. From (5.11) and (5.12), the contemporaneous responses are dampened by π understandably, given that not all the LQ-entities can immediately adjust their investment at date m to respond to the shock.

However, after date m, when other LQ-entities have investment opportunities, the effects of the shock can continue to build up. See the simulations below. This is in contrast to Section 4, where depreciation starts immediately. Moreover, the effects last longer. In this regard, the decay rate is smaller when π is smaller, as long as RABSs are not too costly.

From (5.11) and (5.12), the contemporaneous responses are dampened also by ρ, because the LQ-entities' nett worth at date m includes the value of RABSs inherited from date $m-1$, and so there is less leverage. However, the effects are more persistent. In this regard, the depreciation rate is a decreasing function of ρ. The reason is that ρ reduces the choking-off effect at all dates $m+d$, $d \geq 0$. In this case, the required down payment per unit of assets comprises the user cost u_{m+d} and the cost of RABSs, and so the LQ-entities' asset demand is less sensitive to a rise in u_{m+d}. It is tantamount to an increase in the elasticity of the residual asset supply to the LQ-entities from η to η/θ. Greater persistence in turn means that a given shock to asset securitization at date m has a bigger impact on the asset price.

5.2.2 Dynamic Multiplier: Shocks to Low Quality Asset Profit

In the low quality asset context, the paper [45] provides a relationship between the asset rate, r^A, LTVR, L, and prepayment cost, c^p, by means of the simultaneous equations model

$$\begin{aligned} r^A_m &= \alpha^0 L_m + \alpha^1 c^p_m + \alpha^2 X_m + \alpha^3 Z^{r^A}_m + u_m \\ L_m &= \psi^1 r^A_m + \psi^2 X_m + \psi^3 Z^L_m + v_m \\ c^p_m &= \gamma^1 r^A_m + \gamma^2 X_m + \gamma^3 Z^{c^p}_m + w_m. \end{aligned} \tag{5.18}$$

Investors typically have a choice of r^A and L, while the choice of c^p triggers an adjustment to r^A. Thus, L and c^p are endogenous variables in the r^A-equation. There is no reason to believe that L and c^p are simultaneously determined. Therefore, c^p does not appear in the L-equation and L does not make an appearance in the c^p-equation. From [45], X comprises explanatory variables such as asset characteristics (owner occupied, asset purpose, documentation requirements); investor characteristics (income and Fair Isaac Corporation (FICO) score) and distribution channel (broker origination). The last term in each equation Z^{r^A}, Z^L or Z^{c^p} comprises the instruments excluded from either of the other equations. [45] points out that the model is a simplification with other terms such as type of interest rate, the term to maturity and distribution channel possibly also being endogenous.

Corollary 5.2.2 (Dynamic Multiplier: Shocks to LQ-Asset Profit): *Suppose that the hypothesis of Theorem 5.2.1 holds. Then the relative change in profit may be expressed* *in terms of r^A, c^p and L as*

$$\widehat{\Pi}_m(r^A) = \frac{F_m p_m^A A_{m-1} + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m}{F_m p_m^{A*} A_{m-1}^* + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m^*} - 1; \tag{5.19}$$

$$\widehat{\Pi}_m(c^p) = \frac{G_m p_m^A A_{m-1} + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m}{G_m p_m^{A*} A_{m-1}^* + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m^*} - 1; \tag{5.20}$$

$$\widehat{\Pi}_m(L) = \frac{H_m p_m^A A_{m-1} + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m}{H_m p_m^{A*} A_{m-1}^* + r^B B_m - r^{\mathrm{T}}\mathrm{T}_m^*} - 1, \tag{5.21}$$

respectively. Here, it is given in (5.19), (5.20) and (5.21) that

$$\begin{aligned} F_m &= r_m^A(1 + \gamma^1 r_m^f) + (\gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m)r_m^f - (1 - r_m^R)r_m^S, \\ G_m &= c_m^p(1/\gamma^1 + r_m^f) - 1/\gamma^1(\gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m) - (1 - r_m^R)r_m^S \end{aligned}$$

and

$$\begin{aligned} H_m = &\left[\gamma^1\left\{\frac{1}{\psi^1}L_m - \frac{\psi^2}{\psi^1}X_m - \frac{\psi^3}{\psi^1}Z_m^L - \frac{1}{\psi^1}v_m\right\} + \gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m\right][\gamma^1 + r_m^f] \\ &+\alpha^0 L_m + \alpha^2 X_m + \alpha^3 Z_m^{r^A} + u_m - (1 - r_t^R)r_m^S, \end{aligned}$$

respectively.

The most important contribution of the aforementioned result is that it demonstrates how the proportional change in profit subsequent to a negative shock is influenced by quintessential LQ asset features such as asset and prepayment rates, refinancing and house equity given by r^A, c^p, r^f and L, respectively. The default rate is also implicitly embedded in formulas (5.19) to (5.21) in Corollary 5.2.2. In this regard, by consideration of simultaneity in the choice of r^A and c^p, it is possible to address the issue of possible bias in estimates of the effect of c^p on r^A.

5.2.3 The Role of Uncollateralized RABSs

There are several significant consequences of introducing uncollateralized RABSs into the model. Firstly, it increases the degree of persistence. Secondly, it shifts the focus from quantities to asset prices. Finally, it assists in reducing the LQ-entities' debt-to-asset ratio to reasonable levels. ρ has more significant effects on the dynamics of the economy, as will be seen. It is clearest to look at the special case where there is no heterogeneity among the LQ-entities: $\pi = 1$.

The argument of section 2 carries over to the case $\rho > 0$. Of the three key equations, (4.22) and (4.26) are unchanged and (4.27) becomes

$$A_m = \frac{1}{\rho + p_m^A - \frac{1}{1+r^{\mathrm{T}}} p_{m+1}^A} \left[(\mu + p_m^A + \lambda\rho) A_{m-1} - (1 + r^{\mathrm{T}}) \mathrm{T}_{m-1} \right] \tag{5.22}$$

which is the special case of (4.20) with $\pi = 1$. Notice that ρ appears twice in (5.22). The $\lambda\rho A_{m-1}$ term in the numerator is the depreciated value of LQ assets inherited from date $m-1$, which is part of the LQ entities' net value at date m. The ρ in the denominator reflects the fact that the sort after payment per unit of asset includes the cost of LQ assets (Since LQ assets cannot be collateralized), in addition to the user cost, $p_m^A - \frac{1}{1+r^{\mathrm{T}}} p_{m+1}^A$. Consider the counterpart to (5.9) and (5.10).

Following the unexpected temporary shock Σ at date m, the proportional changes in asset price, p_m^A and the LQ entities' future path asset holdings, $\hat{A}_m$, $\hat{A}_{m+1}$..., satisfy

$$\left[1 + \frac{\rho}{\eta}\right] \hat{A}_m = \frac{\mu}{\mu + \lambda\rho} \Sigma + \frac{1 + r^{\mathrm{T}}}{r^{\mathrm{T}}} \rho \hat{p}_m^A \text{ (dates } m) \tag{5.23}$$

$$\left[1 + \frac{\rho}{\eta}\right] \hat{A}_{m+d} = \hat{A}_{m+d-1} \text{ for } m \geq 1 \text{ (dates } m+1,\ m+2,\ \ldots) \tag{5.24}$$

where the parameter $\theta = \frac{\mu - (1-\lambda)\rho}{\mu + \lambda\rho}$ which lies between 0 and 1. There are two kinds of differences between (5.23), (5.24) and (5.9), (5.10). First, the coefficients of Σ and p_m^A in (5.23) are both smaller than in (5.9), ρ reduces the impact of both Σ and $\hat{p}_m^A$ on the LQ entities' net value which is because ρ reduces leverage.

Secondly, the bracketed coefficients on the left hand sides of (5.23) are smaller than in (5.9) which increases the impact of the shock on LQ entities asset holdings at all dates $m + d$, $d \geq 0$.

It can be learnt from (5.24) that ρ makes the changes in the LQ entitie's future asset holdings and hence the future user costs are more persistent; the depreciation factor is $\eta/(\theta + \eta)$, compared to only $\eta/(1 + \eta)$, without LQ assets.This additional persistence is reflected in

asset price.
To see this, consider the counterpart to (5.18) for $\rho > 0$.

$$\hat{p}_m^A = \frac{1}{\eta}\frac{r^{\mathrm{T}}}{1+r^{\mathrm{T}}}\sum_{d=0}^{\infty}(1+r^{\mathrm{T}})^{-d}\hat{A}_{m+d} = \frac{1}{\eta}\frac{r^{\mathrm{T}}}{1+r^{\mathrm{T}}}\frac{1}{1-\frac{1}{1+r^{\mathrm{T}}}\frac{\eta}{\theta+\eta}}\hat{A}_m \tag{5.25}$$

(5.25) tells us that ρ causes the asset price to change more relative to the LQ entities' asset holdings; without LQ assets, the factor $\eta/\theta+\eta$ in the denominator reduces to $\eta/(1+\eta)$. Altogether then, there are a number of competing effects, to find out which one dominates, the study solves (5.23) and (5.25) for $\hat{p}_m^A$ and $\hat{A}_m$;

$$\hat{p}_m^A = \frac{\mu}{\mu+\lambda\rho}\frac{1}{\eta}\Sigma \tag{5.26}$$

$$\hat{A}_m = \frac{1}{1+\frac{\theta}{\eta}}\left[1+\frac{1+r^{\mathrm{T}}}{r^{\mathrm{T}}}\frac{\theta}{\eta}\right]\frac{\mu}{\mu+\lambda\rho}\Sigma \tag{5.27}$$

(5.26) and (5.27) are the counterparts to $\hat{p}_m^A = \frac{1}{\eta}\Sigma$ and $\hat{A}_m = \frac{1}{1+\frac{1}{\eta}}\left[1+\frac{1+r^{\mathrm{T}}}{r^{\mathrm{T}}}\frac{1}{\eta}\right]\Sigma$ for $\rho > 0$
Overall, it can be seen that ρ reduces the input of the shock on asset price and LQ entities' asset holdings. Put differently, the reduction in leverage is the dominant impact effect. From the discussion of (5.25), it is known that although ρ may reduce the impact of a shock on both the price (p_m^A) and quantity (A_m), it reduces the impact on quantity by more, the ratio $\hat{p}_m^A/\hat{A}_m$ is greater than the equivalent ratio. ρ therefore helps explain greater movements in asset prices, relative to quantities.
The introduction of uncollateralized assets into the model increases the degree of persistence. The only drawback is that impulse responses are reduced. However, the impulse responses in section 2 are too strong anyway. All the conclusions that have been reached at in this section hold for the full model of section 3 where the LQ entities are heterogeneous. In (5.11) and (5.12), $\hat{p}_m^A/\hat{A}_m$ increases with ρ. Also there is greater persistence; the deterioration rate $1-\sqrt{\Upsilon/\alpha}$ is a decreasing function of ρ in the characteristic equation for the eigenvalues x of the jacobian;

$$(\alpha-(1+r^{\mathrm{T}})(\alpha x^2-\beta x+\gamma))=0$$

where;

$$\alpha = 1 + \frac{\theta}{\eta}(1 - \lambda + \lambda\pi)$$

$$\beta = 1 + \lambda(1 + r^{\mathrm{T}})(1 - \pi) + \frac{\theta}{\eta}(1 + r^{\mathrm{T}})(1 - \pi)(1 - \lambda)$$

$$\gamma = \lambda(1 + r^{\mathrm{T}})(1 - \pi)$$

5.3 Static Multiplier: Response to Temporary Shocks

This section considers the response of asset price to a temporary shock in a static multiplier set up.

Corollary 5.3.1 (Static Multiplier: Shocks to Asset Price and Input): *For the static multiplier, suppose that the hypothesis of Theorem 5.2.1 holds. Then it is given that*

$$\widehat{p}_m^A|_{p_{m+1}^A = p^{A*}} = -\frac{r^{\mathrm{T}}}{\eta(1 + r^{\mathrm{T}})}\Sigma, \tag{5.28}$$

$$\widehat{A}_m|_{p_{m+1}^A = p^{A*}} = -\Sigma. \tag{5.29}$$

Proof. The result can be proved by considering (5.9) and (5.15) where the changes in the asset price and the LQ-entity's asset holdings can be connected to the static multiplier. □

The term

$$\frac{\mu + \nu - (1 + r^{\mathrm{T}})\mu}{\mu + \nu}$$

reflects the difference between the LQ-entity's securitization (equal to $\mu + \nu$) and the HQ-entities securitization (equal to $(1 + r^{\mathrm{T}})\mu$ in the steady-state).

5.4 Illustrative Examples of Asset Securitization

In this section, an example of LQ- Asset securitization is presented. For LQ- Asset securitization, the main results contained in [45] are brought into play.

5.4.1 Example of LQ- Asset Securitization

LQ- Assets are usually adjustable rate assets (ARAs) where high step-up rates are charged in period $m+1$ after low teaser rates in period m. Secondly, this higher step-up rate causes an incentive to refinance in period $m+1$. Refinancing is subject to the fluctuation in house prices. When house prices rise, the entity is more likely to refinance. This means that investors could receive further assets with lower interest rates as house prices increase. Thirdly, a high prepayment penalty is charged to dissuade investors from refinancing.

5.4.2 Numerical Example: Asset Securitization $\Sigma = 0.002$

In this section, numerical examples to illustrate the effects of shocks to asset and CDO prices are provided. Asset securitization parameter choices are given in the Table below.

Parameter	Value	Parameter	Value	Parameter	Value
μ	0.002	ν	0.2	α	0.3
p_{m+1}	0.113	c^p	0.03	r^f	0.2
$\overline{A}_m$	720 000	$\overline{A}_{m-1}$	460 000	r^A	0.061
r^R	0.5	r^S	0.15	T_m	\$ 4 800
T_{m-1}	\$ 2 600	r^{T}	0.2	B_m	\$ 5 000
r^B	0.205	K_m	\$ 3 000	n	1
Σ	0.002	C^*	240 000	$P(A'_{m-1})$	240 000

Table 5.1: Asset Securitization Parameter Choices

The 2007-2009 financial crisis exposed the limits of liability management and the proposed regulation will make the retreat from liability management permanent. To a much greater extent than at any time since the 1970s, banks will be forced back towards asset management, in other words towards a business model in which balance sheet size is determined from the liabilities side of the balance sheet, by the amount of funding which the bank can raise, and in which asset totals have to be adjusted to meet the available liabilities. This amounts to a macroprudential policy that is, a policy designed to prevent credit creation from getting out of hand as it did in the run-up to the recent crisis as expressed in Basel III on the macroprudential overlay (see for instance, [10]).

5.4.3 Numerical Example: Entity Equilibrium

Suppose that the LQ- and HQ-entities' deposits, borrowings, marketable securities and capital are equal. In this case, notice that the LQ- and HQ-entities' asset holdings, A and A' are a proportion, α and $1-\alpha$ of the aggregate assets, $\bar{A}$, respectively. Thus, it is given that

$$A = \alpha\bar{A} = 0.3720000 = 216000; \quad A' = (1-\alpha)\bar{A} = (0.6-0.3)720000 = 216000.$$

The LQ-entity's derivative output in period $m+1$ is computed by considering the securitization function (4.2). Therefore, the derivative output can be computed by

$$C_{m+1} = (\mu+\nu)A_m = (\mu+\nu)\alpha\bar{A}_m = (0.002+0.2)\times 0.3\times 720000 = 43632.$$

Next, the upper bound of the LQ-entity's retention rate should be less that the discount factor β, thus

$$\beta\left(\frac{0.002}{0.002+0.2}\right) = 0.0099099.$$

The value of the LQ-entity assets in period m is computed by using (4.6). Thus, it is given that

$$p_m^A A_{m-1} = D_m + B_m + K_m - B_m = 1200 + 4800 + 3000 - 5000 = 4000.$$

The asset price in period m is therefore

$$p_m^A = 4000/(A_{m-1} = 4000/(\alpha\bar{A}_{m-1} = 4000/(0.3\times 460000) = 0.0289855072$$

The LQ-entity's profit is computed by considering the cash flow constraint (4.10)

$$\Pi_m = (r^A + c_m^p r_m^f)p_m^A A_{m-1} + r^B B_m - r^D D_m - r^B B_m$$

$$\Pi_m = (0.061 + 0.03 \times 0.2) \times 4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.2 \times 4800 = 87$$

Furthermore, the LQ-entity's profit is subject to the constraint (2.9), thus

$$\Pi_m = (0.061 + 0.03 \times 0.2)4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.113 \times 0.3 \times 720000 + 4800$$
$$= -18561$$

The study computes the LQ-entity's additional consumption, $x_m - \nu A_{m-1}$ by considering the flow of funds constraint given by

$$0.002 \times 0.3 \times 460000 + 8000 - (1 + 0.2) \times 2600 - 0.011904761(0.3 \times 720000 - 0.3 \times 460000)$$
$$= 4227.4286$$

Next, the study concentrates on HQ-entity constraints. HQ-entities' secondary securitization at date m is computed by using the budget constraint (4.12), thus

$$x'_m = 280000 + 4800 - 0.011904761(1 - 0.3)720000 - (1 - 0.3) \times 460000 - (1 + 0.2) \times 2600 =$$
$$-46319.99954.$$

Thus $x_m = 54103.64210$. Next, the HQ-entity's profit (4.13) at face value is considered to compute profit at date m, thus

$$\Pi'_m = 0.061 \times 4000 + 0.205 \times 5000 - 0.205 \times 1500 - 0.2 \times 4800 = 123.5$$

In this regard, the value of assets can be computed as

$$p^A_m A'_{m-1} = \frac{123.5 - 0.205 \times 5000 + 0.205 \times 1200 + 0.2 \times 4800}{0.061} = 4991.8$$

The HQ-entity's cash flow constraint (4.15), is given by

$$\Pi'_m \geq 0.061 \times 4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.113(1-0.3) \times 720000 + 4800 = -51007.$$

The screening cost an LQ-entity has to pay to purchase an asset unit is financed by the HQ-entity's nett worth. This screening cost is represented by

$$u_m = p^A_m - \frac{p^A_{m+1}}{1+r^B} = 0.011904761 - \frac{0.113}{1+0.2} = -0.082261905$$

The asset holding and borrowing, A_m and B_m of the entity may be computed as

$$A_m = \frac{1}{0.082261905}\left[(0.002 + 0.011904761) \times 0.3 \times 460000 - (1+0.2) \times 2600 = 14601.44865\right]$$

and

$$B_m = \frac{1}{1+0.2} 0.113 \times 0.3 \times 720000 = 20340.$$

The sum of the aggregate asset demand from asset originators by LQ- and HQ-entities' is computed by

$$\bar{A} = A_m + nA'_m = 0.3 \times 720000 + 1(1-0.3)720000 = 720000$$

The steady-state asset price and borrowings for the LQ-entity

$$p^{A^*} = 0.002\frac{1+0.2}{0.2} = 0.012 \text{ and } B^* = \frac{0.002}{0.2}260000 = 2600$$

Notice that the required screening costs per asset unit equals the LQ-entity's securitization of marketable output, $u^* = \mu = 0.001$. Also, it is given that $A_{m-1} = A^*$ and $B_{m-1} = B^*$.

5.4.4 Numerical Example: Shocks to LQ-Assets and Their SAPs

LQ-entity's asset demand and borrowings under a temporary shock at date m are computed by

$$\begin{aligned} A_m &= \frac{1}{-0.082261905}[(0.002 - 0.002 \times 0.002 + 0.011904761) \times 0.3 \times 460000 - (1+0.2) \times 2600] \\ &= 14608.15893 \end{aligned}$$

and

$$B_m = \frac{1}{1+0.2}0.113 \times 0.3 \times 720000 = 20340,$$

respectively. In this regard, the cost of funds in period m, is computed as

$$u(A_m)A_m = (0.002 - 0.002 \times 0.002 + 0.011904761 - 0.022) \times 0.3 \times 460000 = -1117.69.$$

Also, LQ-entity's net value at date m is more than their current output just after the shock, thus

$$(1-\Sigma)uA^* = (1-0.002)0.002 \times 0.3 \times 460000 = 275.448.$$

With unexpected capital gains

$$(p_m^A + p^{A*})A^* = (0.011904761 + 0.022) \times 0.3 \times 460000 = 4679.$$

While the debt repayment is given by

$$(1+r^B)B^* = p^{A*}A^* = (1+0.2)2600 = 3120.$$

Proportional change in A_m and p_m^A can be computed as

$$\widehat{A}_m = \frac{0.3(720000-460000)}{0.3 \times 460000} = 0.565217391$$

and

$$\widehat{p}_m^A = \frac{0.011904761 - 0.022}{0.022} = -0.4588745$$

The steady-state profit for LQ-entity is

$$\begin{aligned}\Pi_m^* &= (0.061 + 0.03 \times 0.2)0.022 \times 0.3 \times 460000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.2 \times 2600 \\ &= 462.412\end{aligned}$$

and steady-state profit for HQ-entities are

$$\begin{aligned}\Pi_m^{'*} &= 0.061 \times 0.022(1 - 0.3) \times 460000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.2 \times 2600 \\ &= 691.124\end{aligned}$$

Thus, the proportional changes in Π_m and $\Pi_m^{'}$ are

$$\widehat{\Pi}_m = \frac{87 - 462.412}{462.412} = -0.81186$$

and

$$\widehat{\Pi}_m^{'} = \frac{123.5 - 691.124}{691.124} = -0.82131.$$

Residual for elasticity of LQ-entity at date t is given by

$$\eta = \left[\frac{\frac{2+0.2}{0.2}0.4588745 - 0.002}{0.565217391} - 1\right]^{-1} = 0.126718931$$

The proportional changes for $\widehat{p}_m^A$ and $\widehat{A}_m$ are computed by

$$\widehat{p}_m^A = -\frac{1}{0.126718931}0.002 = -0.015782961$$

and

$$\widehat{A}_m = -\frac{1}{1+\frac{1}{0.126718931}}\left(1+\frac{1+0.2}{0.126718931\times 0.2}\right)0.002 = -0.010875327,$$

respectively. By considering (5.9), it can be observed from (5.17) and (5.18) that $\widehat{p}^A_m$ and $\widehat{A}_m$ become

$$\widehat{p}^A_m\bigg|_{p^A_{m+1}=p^{A*}} = -\frac{0.2}{0.126718931(2+0.2)}0.002 = -0.001434814$$

and

$$\widehat{A}_m\bigg|_{p^A_m+1=p^{A*}} = -0.002$$

respectively. The proportional change in aggregate output,C_{m+1},represented by (4.13) is given by

$$\widehat{C}_{m+1} = \frac{0.002+0.2-(1+0.2)0.002}{0.002+0.2}\frac{0.002+0.2)0.3\times 460000}{240000}0.565217391 = 0.064869$$

A summary of computed asset securitization parameters in Table 5.2 is provided below.

Parameter	Value	Parameter	Value
C_{m+1}	43 632	$\beta >$	0.0099099
$p^A_m A_{m-1}$	\$ 4 000	Π_m	\$ 87
$\Pi_m \geq$	\$ -18 561	x_m	\$ 54 103.6421
x'_m	\$ -46 319.9995	Π'_m	\$ 123.5
$p^A_m A'_{m-1}$	\$ 4 991.8	$\Pi'_m \geq$	\$ -51 007
u_m	-0.082261905	Aggregate A_m	14 601.44865
Aggregate T_m	\$ 20 340	$\overline{A}$	720 000
p^{A^*}	0.012	T^*	\$ 2 600
A_m under shock	\$ 14 608.15893	T_m under shock	\$ 20 340
$u(A_m)A_m$	-1 117.69	$(1-\Sigma)\mu A^*$	275.448
$(p^A_m + p^{A^*})A^*$	\$ 4 679	$(1+r^{\mathrm{T}})\mathrm{T}^*$	\$ 3 120
$\widehat{A}_m$	0.565217391	$\widehat{p}^A_m = \widehat{p}^C_m$	-0.4588745
Π^*_m	\$ 462.412	$\Pi^{*'}$	\$ 275.31
$\widehat{\Pi}_m$	\$ -2.1118	$\widehat{\Pi}'_m$	\$ 691.124
η	0.126718931	$\widehat{p}^A_m$ in terms of shock	-0.015782961
$\widehat{A}_m$ in terms of shock	0.01	$\widehat{p}^A_m$ where $p^A_{m+1} = p^{A*}$	-0.001434814
$\widehat{A}_m$ where $p^A_{m+1} = p^{A*}$	-0.002	$\widehat{C}_{m+1}$	0.064869

Table 5.2: Computed Asset Securitization Parameters

The computed shock parameters show that the aggregate asset output, $\widehat{C}_{m+1}$, with an economic shock of 0.002 is found to be \$ 43 632 and the value of LQ-entity assets $p^A_m A_{m-1}$ comes to \$ 5 000. LQ-entity asset demand, A_m, declines to \$ 14 608.15893 while the borrowings B_m is maintained at \$ 20 340 respectively in comparison with the values obtained in the second example where the economy is hit with a bigger shock of 0.01. This implies that HQ-assets were more sensitive to changes in market conditions and that asset transformation may have been a greater priority. The proportional negative change in profit for the LQ-entity subsequent to a temporary shock is higher than that of the HQ-entities. In addition, the steady-state asset price p^{A^*} and the borrowings B^* for the LQ-entity increased to \$ 0.012 and \$2 600, respectively. In summary, this example shows that when the shock is minimal the LQ-entity suffers less losses on their asset holdings and the rate of borrowing to refinance increases as compared to having been hit by a bigger shock. This explains why most people could not pay back their loans during the 2007-2009 financial crisis.

5.4.5 Simulation

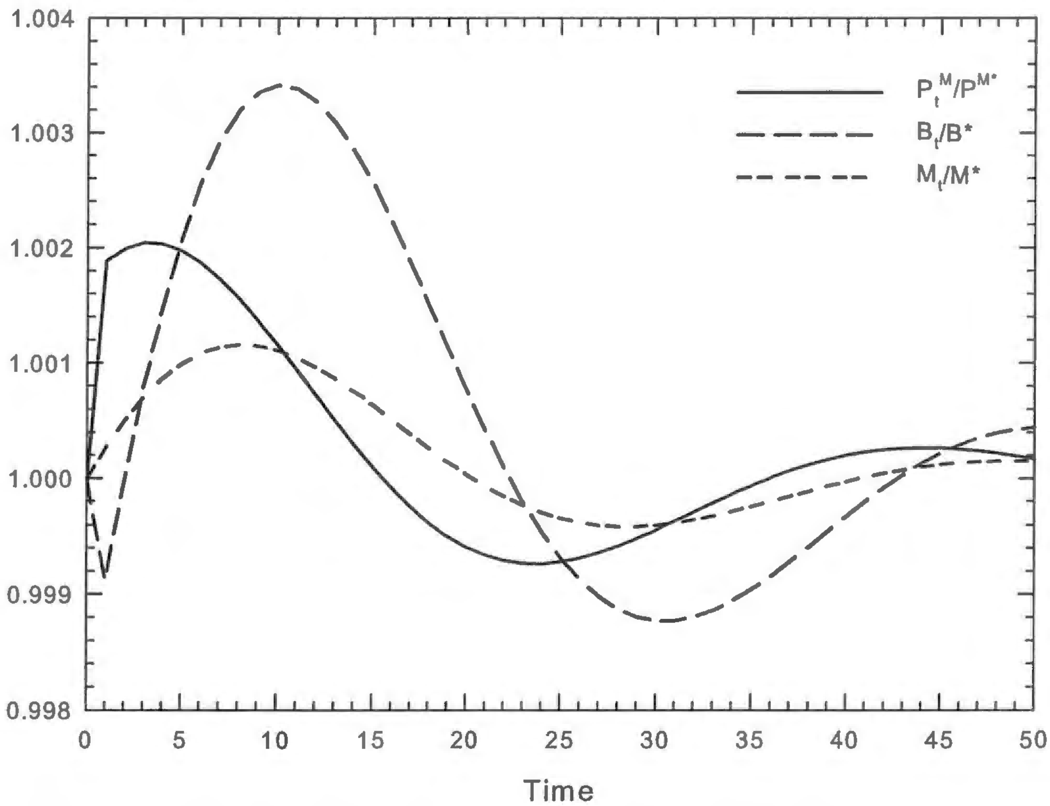

Figure 5.1: The ratios of p_m^A/p^{A^*}, A_m/A^* and $\mathrm{T}_t/\mathrm{T}^*$ for $\pi = 10\%$ and $\rho = 10$.

Figure 5.1 displays the simulation results for the full nonlinear model, using parameters π, arrival rate of investment opportunities, ρ, the cost of investing in RABS, temporary shock Σ, $1 + r^{\mathrm{T}}$ and $U(A)$. Where $U(A) = A - v$, with v which is used to compute LQ-entity supply. The values used are $\pi = 0.1$, $\rho = 10$, $\Sigma = 0.95$, $1 + r^{\mathrm{T}} = 1.1$ and $v = 2.0$.

Aggregate debt-asset ratio (adebt) for assets is defined as $\mathrm{T}_t/[(p_m^A+\rho)A_m]$ while the marginal debt-asset ratio (mdebt) is defined as $p_{m+1}^A/[(1+r^B)(p_m^A+\rho)]$, for an LQ-entity who is investing at time m. These ratios are given by 24% and 48%. The asset price increased by 0.20% and the LQ-entity's asset holding and debt increased by 0.12% and 0.34% respectively.

5.4.6 GIRFs of Asset Price and ABX Price

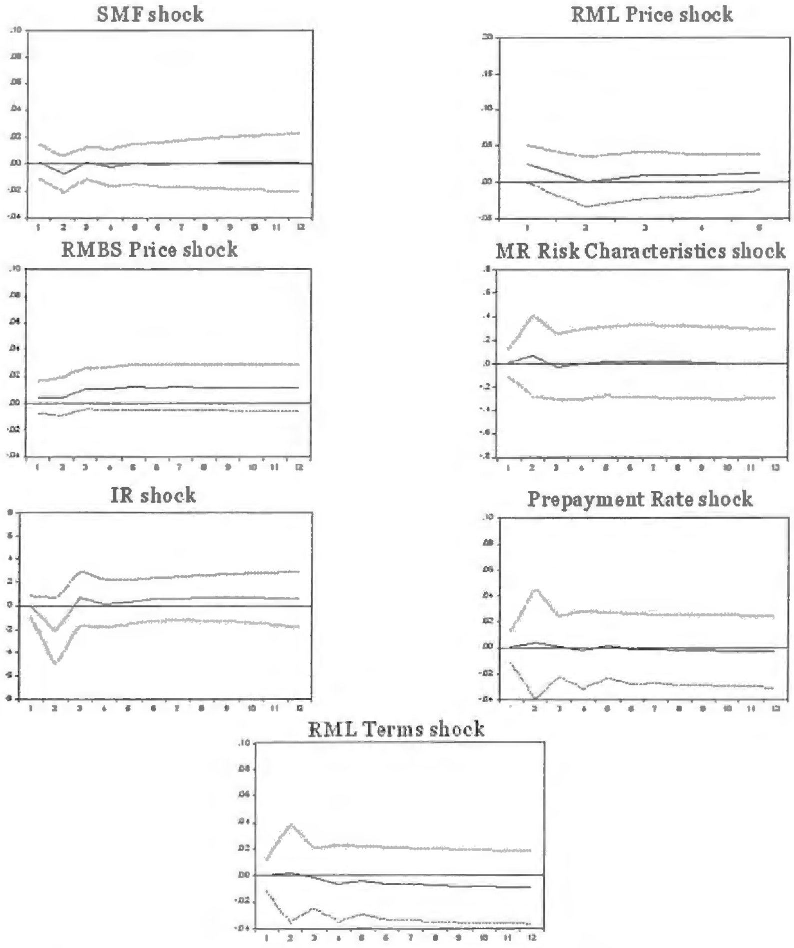

Figure 5.2: GIRFs of Asset Price Under Various Shocks

Figure 5.2 reveals that asset price exhibits mild amplification and weak persistence subsequent to a shock to speculative asset funding. In particular, a shock from an increase in such funding elicits an immediate positive impact on the asset market and in turn results in an increase in asset price. It is clear that the effect of this shock is weakly persistent (see, for instance, [83] for more discussion). The impulse response of the asset price to a positive price shock results in an increase in price corresponding to strong amplification. However, this impact is mildly persistent and from 2 months onwards small fluctuations in asset price occur (see, [44] and [72] for further details)

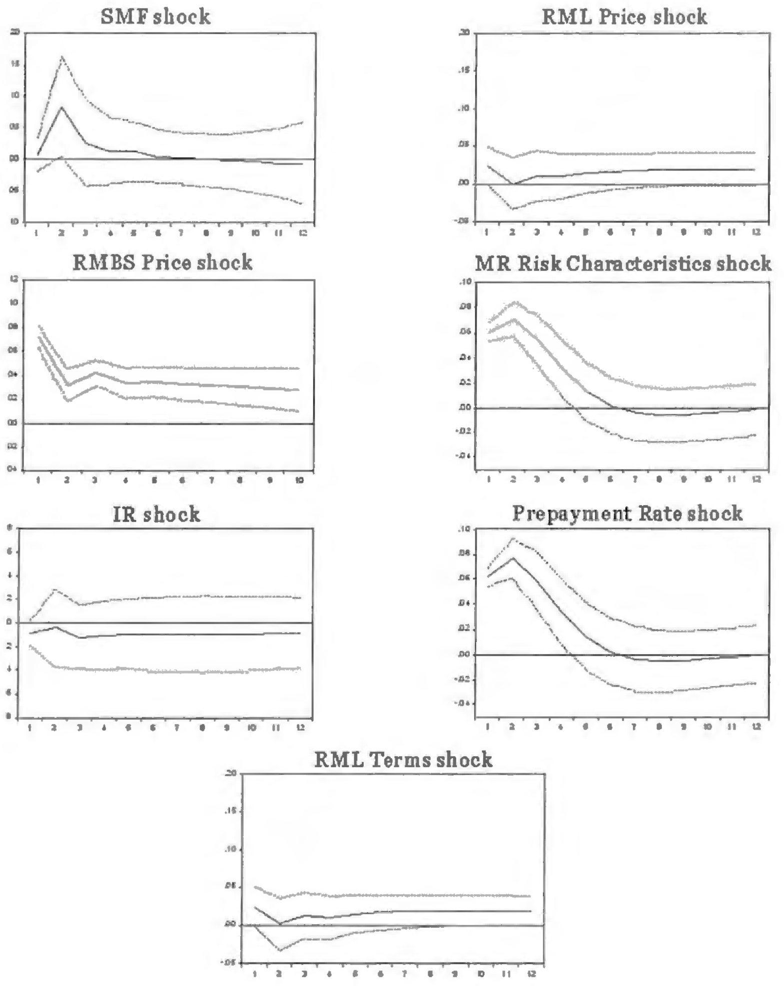

Figure 5.3: GIRFs of ABX Price Under Various Shocks

The impulse response of asset price to a positive ABX price shock exhibits weak amplification. Also, it is clear that the positive impact of the ABX price on the asset price is mildly persistent and procyclical with the ABX market. Asset price, however, responds to ABX price shocks in a weak amplified manner. This contrasts with the findings in [52] where ABX price shocks affect asset price in a strongly amplified and persistent manner. Investor risk characteristics appear to have mildly amplified and weakly persistent impact on asset price. Particularly, in the initial few months, a positive change in risk characteristics elicits an upward trend in the asset price.

5.5 Recommendations for Two-Step Asset Securitization

According to [19], in the current standardized securitization framework, originating banks are required to assign a 1,250 % risk weight to a below investment grade securitization exposure retained by the bank[1]. The BCBS proposed to remove this requirement and this should reduce cliff effects and improve consistency of implementation among originators that use different approaches for the underlying pool.

[1]paragraphs 569 and 570 of the current framework

Chapter 6

Basel III and Securitization: Econometric Analysis

6.1 Background to Econometric Analysis

The purpose of this chapter is to conduct an econometric analysis of Basel III securitization and complement the previous analysis of LQ- and HQ- asset undertaken in chapters 4 and 5 by focusing on liability and liquidity as some of the key variable drivers that influence the incentives of banks to securitize assets into ABSs and CDOs. A Cointegrated Vector Autorgressive (CVAR) approach is applied to balance sheet liability and liquidity data to ascertain the relationship of the dependent and independent variables in the data set for Class I and II banks. Furthermore, the analysis will help the study to demonstrate the nature of each of the variables and also determine cointegration relationship amongst the variables in both the long run and short run. The advantage of using the CVAR for this analysis is it models time series and helps in arriving at the desired results in terms of the variables behaviour. In addition such relationships amongst variables could not be done through stochastic calculus in the previous chapters as SC focuses more on modeling data that occur randomly.

6.2 Econometric Methodology

To empirically analyze the long-run relationship and dynamic interactions among the variables of interest, the model was estimated by using the Cointegrated Vector Autorgressive (CVAR) procedure, developed by Johansen and Juselius [66]. According to [60], the CVAR approach insists on careful stochastic specification as a necessary groundwork for econometric inference and the testing of economic theories. In the time series data, the probability approach requires careful specification of the integration and cointegration properties of variables in the system of equations. The CVAR approach includes stationarity testing, cointegration analysis and the Vector Error Correction Model (VECM). The VECM was used to test for the long run relationship should cointegration be present in the variables. In addition, generalized impulse response functions (GIRFs) showed the impact of shock on the variables.

6.3 Data and Model Specification

The data used in this study is similar to the EMERG data used for similar studies on Basel III such as the study by Petersen and Mukuddem-Petersen [85], on Basel III liquidity and its regulations as well as Roman et al. [88], on Bank's Capital and Liquidity Creation. It gives the desired values of bank liability and liquidity; hence it was applied to model default risk of assets and for econometric analysis. The data gives quarterly observations of variables for Class I and II banks from the period 2002-2012. Therefore the thesis adopts the following econometric models for bank liability and liquidity respectively:

$$IBD_t = \alpha + \beta_1 NIBL_t + \beta_2 B_t + \varepsilon_t \tag{6.1}$$

where:
IBD = Interest Bearing Deposits
NIBL = Non-Interest Bearing Loans
B = Borrowing
β = Intercept parameters
ε = A normally distributed error term

$$NSFR_t = \alpha + \beta_1 LCR_t + \beta_2 GSR_t + \beta_3 BDR_t + \varepsilon_t \tag{6.2}$$

where:
NSFR = Net Stable Funding Ration
LCR = Liquidity Coverage Ratio
GSR = Government Security Ratio
BDR = Brokered Deposit Ratio

β = Intercept parameters
ε = A normally distributed error term

6.4 Results and Discussion

6.4.1 Stationarity Test

Before proceeding with the CVAR analysis the study tests for the stationarity status of all the variables in the model. To determine their order of integration before the necessary econometric tests are performed. Gujarati and Porter [58], argues that before one pursues formal tests, it is always advisable to plot the time series under investigation graphically. Furthermore, [58] maintain that such plots provide an initial hint about the likely nature of the time series. The advantage is that a visual display helps to present information of a data set in a summarized and informative way. The results of both Class I and Class II banks are presented in the Figures and Tables respectively as follows:

6.4.1.1 Bank Liability

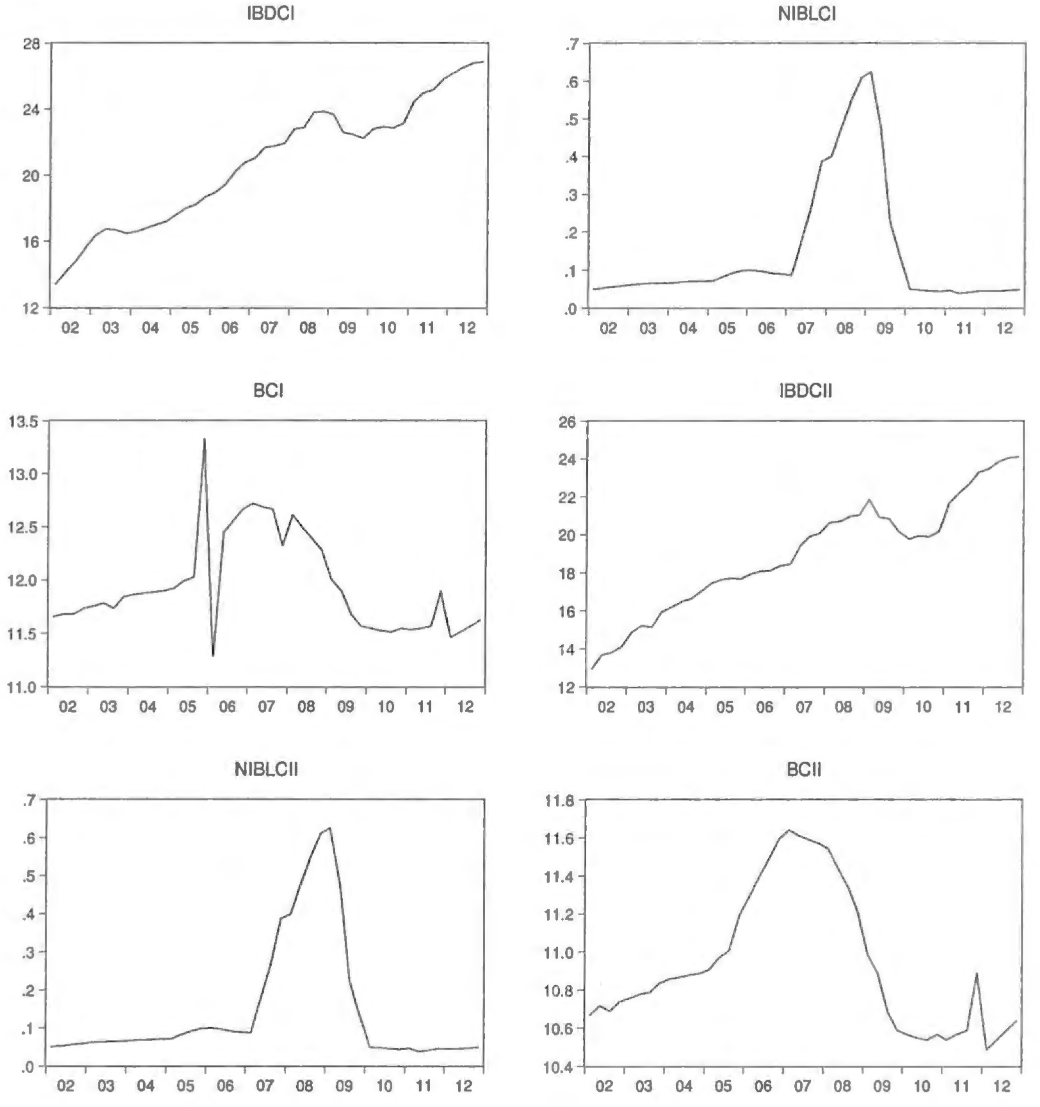

Figure 6.1: Class I & II Bank Liabilities at Level

Based on Figure 6.1, both Class I and II bank liabilities appear to be non stationary at level. All the series display upwards, downwards or up and down trends over the period of study.

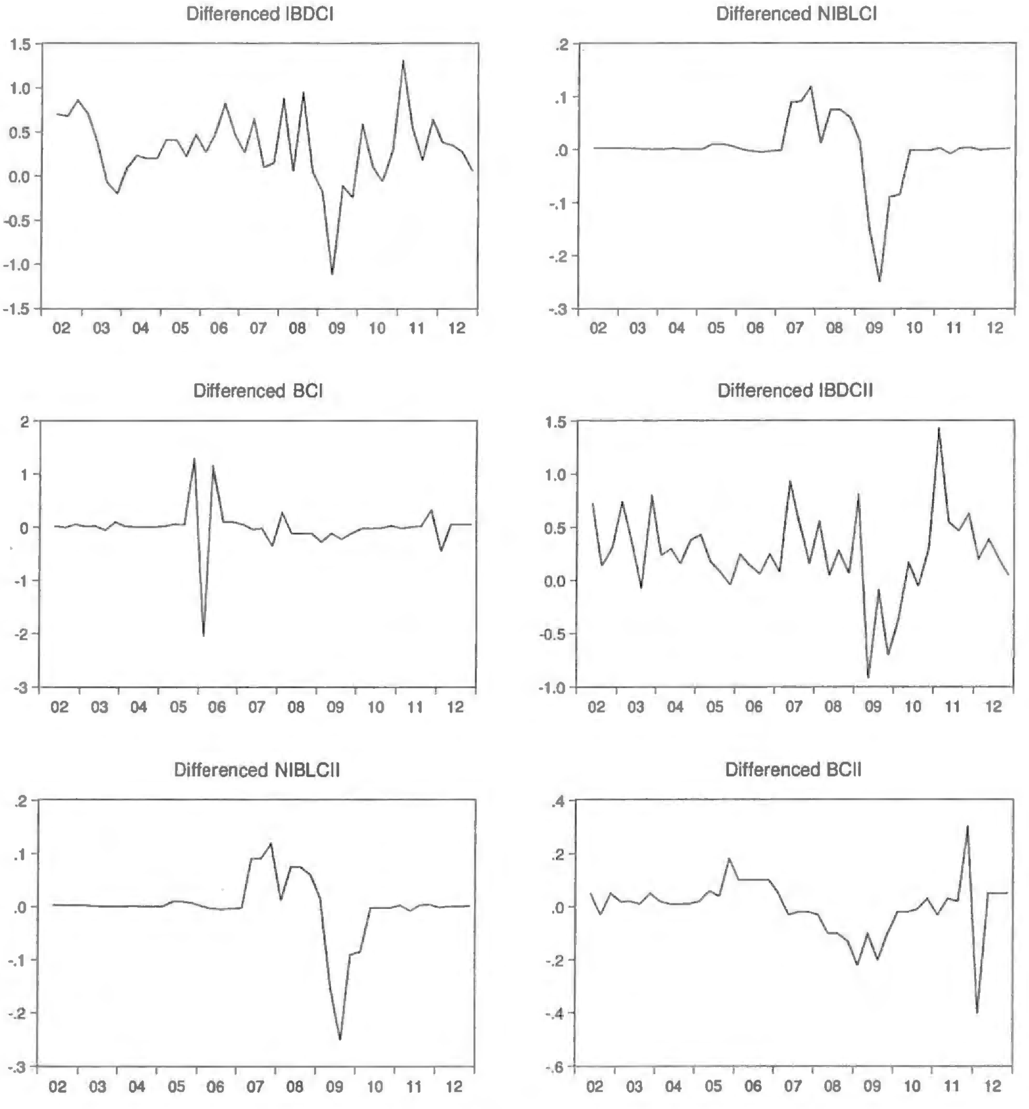

Figure 6.2: Class I & II Bank Liabilities at Difference

The variables for Class I and II banks in Figure 6.2 appear to be stationary at first difference when the time component is removed from the series. The mean and variance of all the series portray constant values as the mean seems to revert and fluctuate around zero. The study now proceeds with a formal analysis by applying ADF and PP tests to check for stationarity. Asteriou and Hall [75], refer to the use of two or more tests as a confirmatory analysis. Both the ADF and the PP tests are based on the following hypothesis: Null (Unit root exists) and Alternative (Unit root does not exist). The two tests use the same critical value.

Variable		ADF test statistic at level	ADF test statistic at 1st difference	Result
IBD Class I	Intercept	-1.227712 (-2.931404)	-4.620676* (-2.933158)	I(1)
NIBL Class I	Intercept	-2.737862 (-2.933158)	-2.812215 (-2.933158)	
B Class I	Intercept	-1.152482 (-2.935001)	-7.715713* (-2.935001)	I(1)
		PP test statistic at level	**PP test statistic at 1st difference**	
IBD Class I	Intercept	-1.144797 (-2.931404)	-4.593665* (-2.933158)	I(1)
NIBL Class I	Intercept	-1.754248 (-2.931404)	-2.949549* (-2.933158)	I(1)
B Class I	Intercept	-3.598761 (-2.603944)	-14.10725* (-2.933158)	I(1)

Note: I(1) indicates unit root and stationarity after first differencing
* Denotes significance at 5% level and the rejection of the null hypothesis of non-stationarity.

Table 6.1: ADF and PP Test Results for Class I Bank Liabilities

The results in Table 6.1, show that only interest bearing deposits (IBD) and borrowing (B) become stationary at I(1). To countercheck these results, the PP test was also performed and it shows that all the variables are stationary at I(1). A great advantage of the PP test is that it is non-parametric which means that it does not require to select the level of serial correlation as is the case in the ADF test. It instead takes the same estimation scheme as in Dickey-Fuller test, but eventually corrects the statistic to conduct for autocorrelations and heteroscedasticity.

Variable		ADF test statistic at level	ADF test statistic at 1st difference	Result
IBD Class II	Intercept	-0.968592 (-2.935001)	-3.164886* (-2.935001)	I(1)
NIBL Class II	Intercept	-2.737862 (-2.933158)	-2.812215 (-2.933158)	
B Class II	Intercept	-2.500453 (-2.938987)	-2.844085 (-2.935001)	
		PP test statistic at level	**PP test statistic at 1st difference**	
IBD Class II	Intercept	-1.086972 (-2.931404)	-5.643447* (-2.933158)	I(1)
NIBL Class II	Intercept	-1.754248 (-2.931404)	-2.949549* (-2.933158)	I(1)
B Class II	Intercept	-1.311148 (-2.931404)	-5.987773* (-2.933158)	I(1)

Note: I(1) indicates unit root and stationarity after first differencing
* Denotes significance at 5% level and the rejection of the null hypothesis of non-stationarity.

Table 6.2: ADF and PP Test Results for Class II Bank Liabilities

The series does not show stationarity at level as evidenced in the visual inspection graphs. However it seems to show stationarity at first difference as the mean seems to revert and fluctuate around 0. The mean and variance portray constant values. The Adf is further performed to check stationarity and it shows that only interest bearing deposits (IBD) and borrowings (B) become stationary at I(1). To countercheck these results, the PP test was also performed and it shows that all the variables are stationary at I(1). A great advantage of the PP test is that it is non-parametric which means that it does not require to select the level of serial correlation as is the case in the ADF. It instead takes the same estimation scheme as in DF test, but eventually corrects the statistic to conduct for autocorrelations and heteroscedasticity. The variables for Class II banks seem non stationary at level through visual inspection. When they are differenced with the time component removed from the series, the appear stationary. A formal analysis is done to check for stationarity through application of the ADF and PP tests.

6.4.1.2 Bank Liquidity

Since similar patterns to Figures 6.1 and 6.2 where observed during the visual inspection of bank liquidity, only formal tests are presented in section 6.4.1.2 to avoid repetition. The ADF and PP test results of Class I and II bank liquidity are presented in Tables 6.3 and 6.4 respectively.

Variable		**ADF test statistic at level**	**ADF test statistic at 1st difference**	**Result**
LCR	Intercept	-1.115959 (-2.931404)	-5.382705* (-2.933158)	I(1)
NSFR	Intercept	-2.879233 (-2.931404)	-7.512755* (-2.933158)	I(1)
GSR	Intercept	-1.127572 (-2.931404)	-6.629503* (-2.933158)	I(1)
BDR	Intercept	-1.880787 (-2.933158)	-5.300611* (-2.933158)	I(1)
		PP test statistic at level	**PP test statistic at 1st difference**	
LCR	Intercept	-1.115959 (-2.931404)	-5.377240* (-2.933158)	I(1)
NSFR	Intercept	-2.883220 (-2.931404)	-8.592902* (-2.933158)	I(1)
GSR	Intercept	-1.138511 (-2.931404)	-6.628121* (-2.933158)	I(1)
BDR	Intercept	-1.590563 (-2.931404)	-5.341996* (-2.933158)	I(1)

Note: I(1) indicates unit root and stationarity after first differencing
* Denotes significance at 5% level and the rejection of the null hypothesis of non-stationarity.

Table 6.3: ADF and PP Test Results for Class I Bank Liquidity

Variable		ADF test statistic at level	ADF test statistic at 1st difference	Result
LCR Class II	Intercept	-1.196122 (-2.931404)	-5.483439* (-2.933158)	I(1)
NSFR Class II	Intercept	-2.912241 (-2.931404)	-7.392878* (-2.933158)	I(1)
GSR Class II	Intercept	-1.138699 (-2.931404)	-6.685446* (-2.933158)	I(1)
BDR Class II	Intercept	-1.717819 (-2.931404)	-6.174256* (-2.933158)	I(1)
		PP test statistic at level	PP test statistic at 1st difference	
LCR Class II	Intercept	-1.196122 (-2.931404)	-5.460584* (-2.933158)	I(1)
NSFR Class II	Intercept	-2.875632 (-2.931404)	-8.118934* (-2.933158)	I(1)
GSR Class II	Intercept	-1.151767 (-2.931404)	-6.685045* (-2.933158)	I(1)
BDR Class II	Intercept	-1.717819 (-2.931404)	-6.174430* (-2.933158)	I(1)

Note: I(1) indicates unit root and stationarity after first differencing
* Denotes significance at 5% level and the rejection of the null hypothesis of non-stationarity.

Table 6.4: ADF and PP Test Results for Class II Bank Liquidity

The ADF results in Tables 6.3 and 6.4 indicate the non-stationarity of the series when the variables are defined at levels. However, first differencing the series removes the non-stationarity components in all cases and the null hypothesis of non-stationarity is rejected at the 5% significance level which implies that all the variables are integrated of order one, I(1). At the same time, PP tests are also reported in both tables and they are not essentially different from the ADF results. The Bartlett Kernel according to [81] were chosen for the lag truncations. The results after first-differencing the series strongly reject the null hypothesis of the presence of a unit root implying that the series are integrated of order one.

6.4.2 Cointegration Test

Since stationarity has been established in all the variables of the study, the next step is to perform the cointegration analysis of both bank liability and liquidity. The purpose is to determine if there is a long run economic relationship among the variables. The study follows the Johansen Cointegration approach which consents the testing of hypotheses about the equilibrium relationships among the variables. This approach is based on the Trace and Maximum eigenvalue test statistics. According to Verbeek [102], the trace test checks whether the smallest $k - r_0$ are significantly different from zero. It is based on the following hypothesis; $H_0 : r \leq r_0$ against $H_1 : r_0 \leq k$ and can be tested using the following equation

$$\lambda_{\text{trace}} = -T \sum_{j=r_0+1}^{k} \log(1 - \hat{\lambda}_j) \tag{6.3}$$

The maximum eigenvalue test on the other hand is based on the estimated (r_0+1)th largest eigenvalue. It tests the $H_0 : r \leq r_0$ versus $H_1 : r = r_0 + 1$ by using the following expression:

$$\lambda_{\max}(r_0) = -T\text{Log}(1 - \hat{\lambda}_j) \tag{6.4}$$

The results of bank liability and liquidity cointegration tests are presented in Tables 6.5 up to 6.12.

6.4.2.1 Bank Liability

Hypothesized no. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob****
None	0.290306	19.87877	29.79707	0.4311
At Most 1	0.130410	5.818996	15.49471	0.7168
At Most 2	0.002191	0.089936	3.841466	0.7642

Trace test indicates no cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.5: Unrestricted Cointegration Rank Test (Trace)

Hypothesized no. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob**
None	0.290306	14.05977	21.13162	0.3601
At Most 1	0.130410	5.729060	14.26460	0.6482
At Most 2	0.002191	0.089936	3.841466	0.7642

Trace test indicates no cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.6: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Tables 6.7 and 6.8 present the cointegration test results of Class II banks.

Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.565230	43.23033	29.79707	0.0008
At Most 1	0.172223	8.246975	15.49471	0.4394
At Most 2	0.007318	0.308493	3.841466	0.5786

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.7: Unrestricted Cointegration Rank Test (Trace)

Hypothesized no. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob**
None*	0.565230	34.98336	21.13162	0.0003
At Most 1	0.172223	7.938482	14.26460	0.3850
At Most 2	0.007318	0.308493	3.841466	0.5786

Maximum Eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.8: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

The trace and maximum eigenvalue statistics in Table 6.5 and 6.6 show that there are no cointegrating equations. The probabilities given in the tests are all larger than the 5% significance level. In table 6.5 the trace statistic at None is 19.87877 which is smaller than the critical value given by 29.79707. The same applies for At most 1 and At most 2. A long run relationship does not exist in this case for the variables and any random behavior of non interest bearing deposits or borrowing will not have any impact on interest bearing deposits in the long run. The maximum eigenvalue test portrays the same senario as trace results owing to its high probability values of more than 5% and high critical values. Class II bank liabilities in Tables 6.7 and 6.8 show that there is one cointegrating equation in both the trace and maximum eigenvalue statistics. They show cointegration At none meaning there is a long run relationship of the variables in the long run. Trace and maximum eigenvalue statistics values given by 43.23033 and 34.98336 respectively are larger than the critical values and the probabilities are smaller than 5%.

6.4.2.2 Bank Liquidity

The cointegration analysis results of Class I bank liquidity are presented in Tables 6.9 and 6.10 respectively.

Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.465873	54.95981	47.85613	0.0093
At Most 1	0.262374	28.62072	29.79707	0.0679
At Most 2*	0.207397	15.83936	15.49471	0.0444
At Most 3*	0.134713	6.077166	3.841466	0.0136

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.9: Unrestricted Cointegration Rank Test (Trace)

Hypothesized no. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob**
None	0.465873	26.33909	27.58434	0.0715
At Most 1	0.262374	12.78136	21.13162	0.4725
At Most 2	0.207397	9.762196	14.26460	0.2280
At Most 3*	0.134713	6.077166	3.841466	0.0136

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.10: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Tables 6.11 and 6.12 present cointegration results for Class II banks.

Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.483266	56.90476	47.85613	0.0056
At Most 1	0.248656	29.17520	29.79707	0.0589
At Most 2*	0.222961	17.16776	15.49471	0.0277
At Most 3*	0.144861	6.572646	3.841466	0.0104

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.11: Unrestricted Cointegration Rank Test (Trace)

Hypothesized no. of CE(s)	Eigenvalue	Max-Eign Value	0.05 Critical Value	Prob**
None*	0.483266	27.72955	27.58434	0.0479
At Most 1	0.248656	12.00744	21.13162	0.5469
At Most 2	0.222961	10.59511	14.26460	0.1757
At Most 3*	0.144861	6.572646	3.841466	0.0104

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6.12: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

In Table 6.9, the trace statistic shows 3 cointegrating equations at 5% significance level while the maximum eigenvalue test in Table 6.10 shows 1 cointegrating equation at all levels in Class I bank liquidity. The trace test are advantageous if there are atleast two more cointegrating relations in the process than specified under the null hypothesis. Based on the two tests undertaken, the trace test is preferred because it has more cointegrating ranks. The hypothesis of no cointegration in the trace test at none is rejected because the probability 0.0093 is less than 5% and the trace statistic 54.95981 is greater than the critical value 47.85613 at 5% significance level. The same can be said for At most 2 and At most 3 in the trace test. For the maximum eigenvalue, only At most 3 has a probability 0.0136 which is less than 5% and a trace statistic 6.077166 which is greater than the critical value 3.841466 at 5% significance hence showing the presence of cointegration in the series. For Class II banks, the trace test in Table 6.11 shows the presence of 3 cointegrating equations and the maximum eigenvalue in Table 6.12 shows 2 cointegrating equations. This points to the existence of a long run relationship between the dependent and independent variables in both Class I and II bank liquidity. A change in the independent variables given by LCR, GSR and BDR will have an effect or impact on the NSFR.

6.4.3 Vector Error Correction

Based on the fact that cointegration has been established, the next step is to estimate both the short and long run effects of the explanatory variables. According to [76], VECM connects long run disequilibrium through short run adjustments, leading the system to short run equilibrium.

6.4.3.1 Bank Liability

Variable	Coefficient	Standard Error	t-statistic
EC	-0.001810	0.00089	-2.04042
D(IBDCII)	-0.169517	0.17374	-0.97570
D(NIBLCII)	2.389778	1.39282	1.71578
D(BCII)	-0.491593	0.76125	-0.64577
C	0.287993		

Note: D; Denotes the first difference of the variables
C; Stands for the Constant
EC; Represents the error correction

Table 6.13: Vector Error Correction Estimates

Cointegrating Eqn	CointEq1	NIBLCII(-1)	BCII(-1)
IBDCII	1.000000	-0.111524	-0.917697
C	-0.666971		

Note: (-1); Denotes the first difference of the variables
C; Stands for the Constant

Table 6.14: Vector Error Correction Estimates in Short Run

There exists a relationship in the log run among the variables. A negative change in one of the independent variables will have a positive effect on the dependent variable. The negative signs of the independent variables will change to positive when they are presented in an equation through the application of the findings in table 6.14. According to [76], the error correction term (EC) indicates the speed of adjustment of any disequilibrium towards a long run equilibrium state.

6.4.3.2 Bank Liquidity

Variable	Coefficient	Standard Error	t-statistic
EC	-0.393100	0.22477	-1.74890
D(NSFR)	-0.088516	0.25923	-0.34146
D(LCR)	0.001220	0.09337	0.01306
D(GSR)	0.021906	0.68427	0.03201
D(BDR)	-1.433363	1.37810	-1.04010
C	-1.94625		

Note: D; Denotes the first difference of the variables
C; Stands for the Constant
EC; Represents the error correction

Table 6.15: Vector Error Correction Estimates; Class I Banks

Variable	Coefficient	Standard Error	t-statistic
EC	-0.328604	0.23539	-1.39599
D(NSFR)	-0.219409	0.27319	-0.80315
D(LCR)	0.051634	0.08147	0.63377
D(GSR)	0.408163	0.65570	0.62249
D(BDR)	-0.904992	1.27751	-0.70840
C	-0.000632		

Note: D; Denotes the first difference of the variables
C; Stands for the Constant
EC; Represents the error correction

Table 6.16: Vector Error Correction Estimates; Class II Banks

The error correction coefficient of -0.3931 for Class I bank liquidity estimated in Table 6.15 above is significant given by the theoretical negative sign and a high absolute t-statistic given by -1.7489. The expectation is for the value to be negative for restoration of equilibrium and

Cointegrating Eqn	**CointEq1**	**LCRCII(-1)**	**GSRCII(-1)**	**BDRCII(-1)**
NSFRCII	1.000000	-0.111524	-0.917697	-3.066468
C	-0.666971			

Note: (-1); Denotes the first difference of the variables
C; Stands for the Constant

Table 6.17: Vector Error Correction Estimates in Short Run

it confirms the unavailability of problems in the long run equilibrium relationship between the dependent and the independent variables. This gives a suggestion that any short term fluctuations between the independent and the dependent variables gives rise to a stable long run relationship between the variables. The error correction model is thus well specified and confirms the findings on the cointegration of the variables. The -0.3931 estimated coefficient indicates that approximately 39% of the disequilibrium of the previous quarter comes back to long run equilibrium in the next quarter. The significance of the EC term and its negative value serves as evidence for the existence of cointegration relationship amongst the variables of NSFR function. In addition, it also suggests the presence of long term causal relations between the dependent variable and the independent variables.
The negative EC (-0.327) estimated for Class II bank liquidity is significant and the t-statistic (-1.396) is within the desired level. The negative value shows that equilibrium can be restored and confirms the non existence of a problem between the dependent and independent variables in the long run. The presence of any short term fluctuations between the independent variables and the dependent variable will enable a long run relationship between the variables. Therefore a change in the government securities ratio (GSR) given by -0.918 will have positive impact on the change in NSFR as shown in Table 6.17.

6.4.4 VECM Stability Check

In order to obtain additional results of the VECM, Agung [1], suggests that the VEC stability condition check of the VECM should be performed. The results are presented by means of the graphical representation of the inverse roots of the AR characteristic polynomial shown by Figures 6.3, 6.4 and 6.5 respectively.

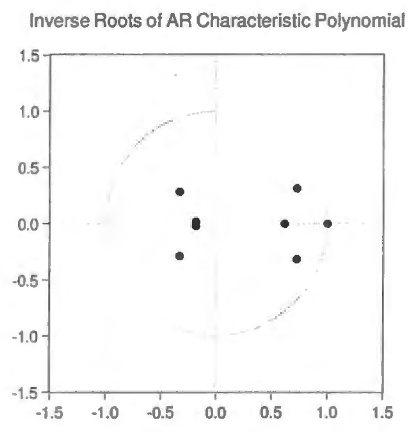

Figure 6.3: Class II Bank Liability Inverse Roots

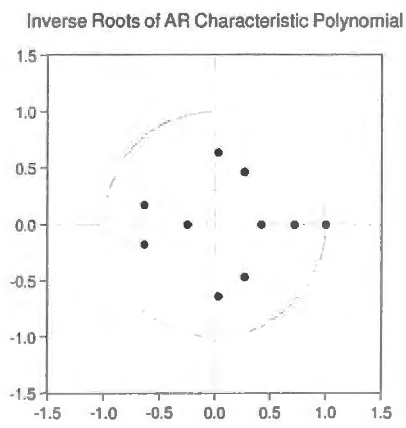

Figure 6.4: Class I Bank Liquidity Inverse Roots

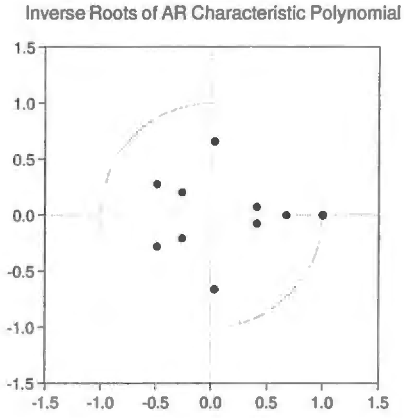

Figure 6.5: Class II Bank Liquidity Inverse Roots

The insinuation is that the models satisfies the stability condition since there are no single roots outside the unit circles. Therefore, VECMs under this study can be considered as acceptable in statistical sense and further analysis can be done.

6.4.5 Generalized Impulse Response Functions

Finally, the study performs the generalized impulse response function (GIRF) developed by Koop et al.[73]. It is employed to examine the dynamic relationship among the variables and to give overview of the whole system. The results are presented in Figures 6.6, 6.7 and 6.8 respectively.

6.4.5.1 Bank Liability

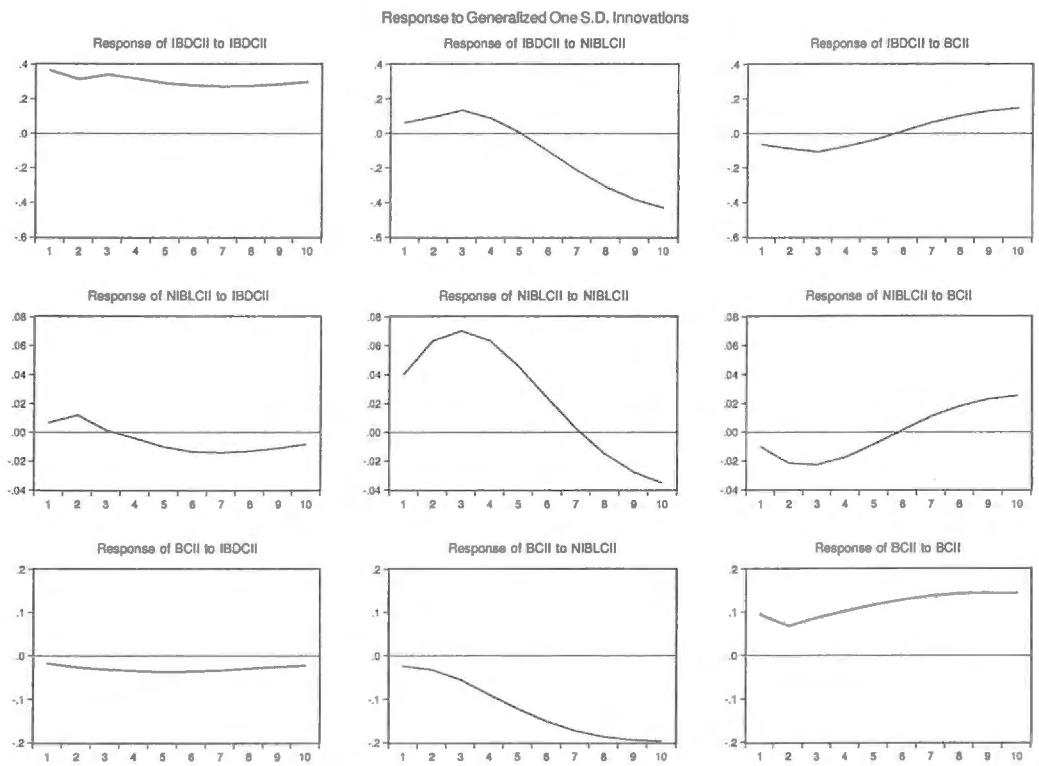

Figure 6.6: GIRFs for Class II Bank Liability

GIRFs for Class II bank liabilities in Figure 6.6 show that there is a positive response of IBD in the first three quarters to a shock in NIBL. However this response is short lived by a downward or negative response in the preceding quarters. The same reaction is observed for the response of NIBL to a shock in IBD but this is short lived as it gradually starts to pick up and become positive again around the 7th and 8th quarters. The relationship of borrowings to interest bearing deposits is negative which shows that when a their has been a shock to IBD, most consumers or investors will not have access to loans due to bank's strict reform policies aimed at non replenishing of capital reserves to meet the standards of Basel III.

6.4.5.2 Bank Liquidity

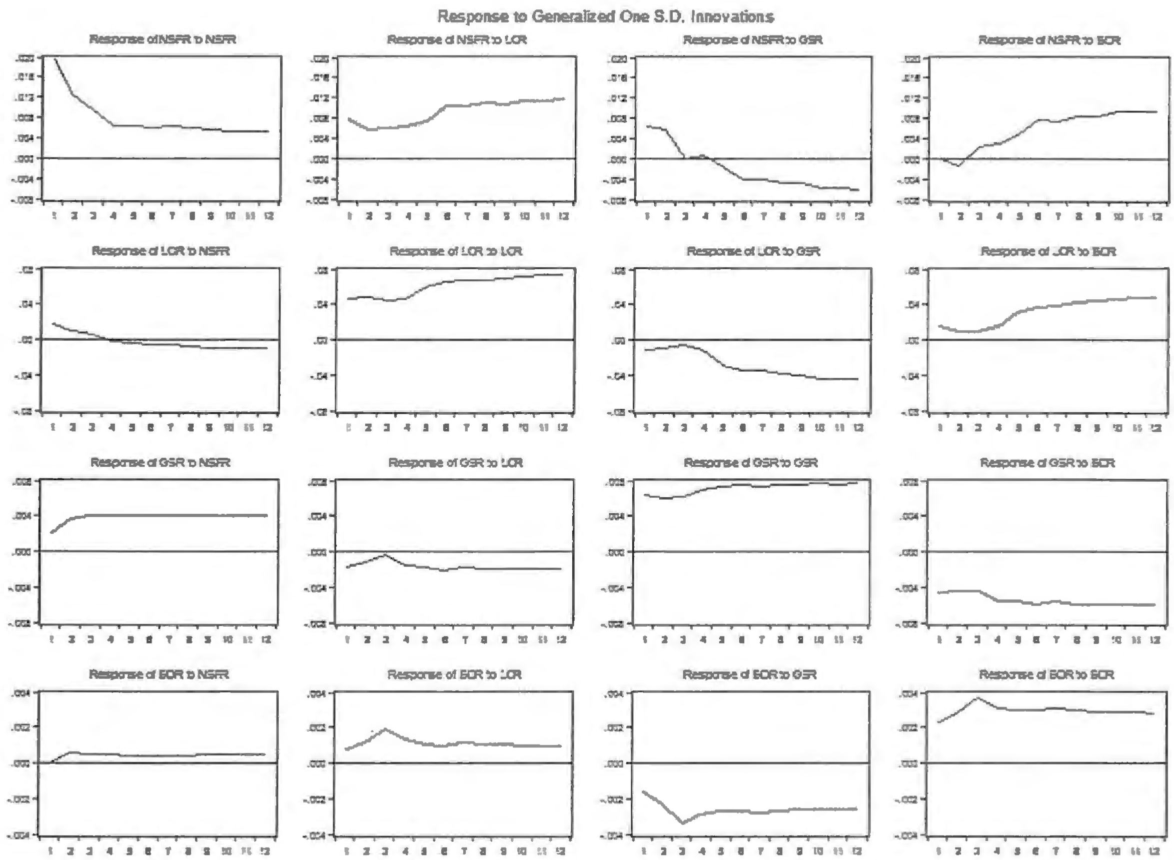

Figure 6.7: GIRFs for Class I Bank Liquidity

In Figure 6.7, the GIRF for a response NSFR to NSFR of a shock shows a negative reaction from the 1st quarter to the 5th quarter and then maintains a constant value in the next quarters. On the other hand the response of NSFR to a shock in LCR shows a decrease in the first quarter and a steady continuous increase in the next quarters. A shock on LCR would therefore cause banks to increase their level of NSFR. This explains why the LCR is considered for a short term stress period of 30 calender days while the NSFR will be considered for a longer stress period of 1 year when fully implemented. In addition, a shock to NSFR will cause the LCR to decrease in future quarters to negative value due to the fact that all the capital and liquidity held by banks to satisfy the BCBS standards will be used and deplete faster than anticipated with no back up money to buffer the balance sheet of banks as the next best alternative to cushion this shortfall is the NSFR.

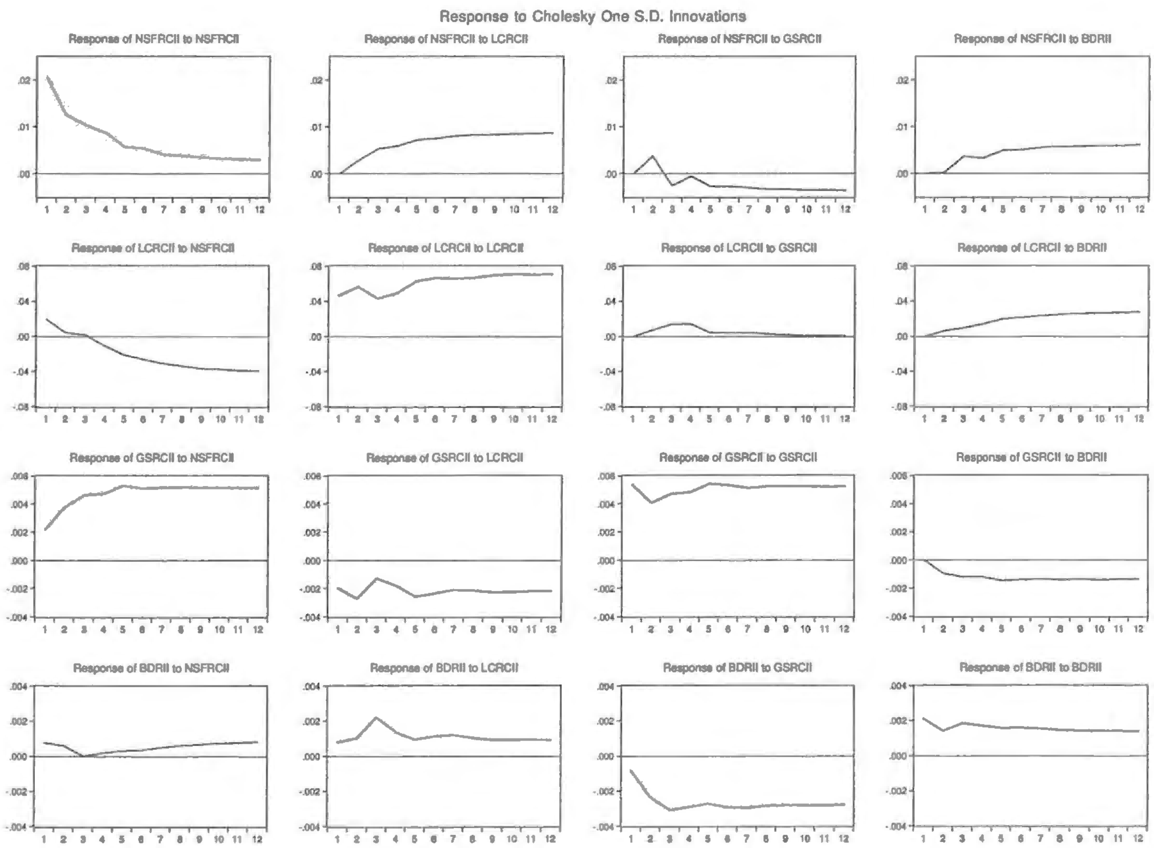

Figure 6.8: GIRFs for Class II Bank Liquidity

The GIRF in Figure 6.8 shows the reaction of NSFR to a shock to NSFR has a negative trending reaction in the 1st quarters and then begins to stabilizes in the 10th quarter onwards. The reaction of the NSFR to a shock in LCR is different from what was observed in the GIRFs for Class I banks. In this case the NSFR increases at a diminishing rate in the 1st quarter to about the 6th quarter. NSFR for Class II banks therefore react positively to a shock in LCR as compared to Class I banks. A reason that can be given for this observation is that most Class II banks are not considered to be internationally active banks and are not usually involved in the chain of securitization that spreads risk world wide through bundling and selling of high risk securities to investors. Hence the first banks to be hit by any default or shock are Class I banks which then resort to borrowing from Class II banks.

Chapter 7

Conclusions and Future Directions

This section will focus on the results that were obtained in Chapters 4, 5 and 6. Asset securitization results are contained in chapters 4 and 5 while chapter 6 considers an econometric analysis of Basel III.

7.1 Securitization and Basel III

In this thesis, the main accomplishments can be summarized as follows. Problems from the financial crisis relate to the models for assets and derivatives with respect to the reduction in incentives for banks to monitor entities, transaction costs, manipulation of derivatives price and structure, derivative market opacity, self-regulation, systemic risks associated with derivatives and the mispricing of debt (see Question 1.2.1).

In the presence of a multiplier, the changes to asset price and holdings, derivative output as well as profit subsequent to negative shocks where quantified (compare with Question 1.2.2). Also, the changes to profit in terms of asset and prepayment rates as well as house equity subsequent to negative shocks where quantified. In terms of the impact Basel III has on the reforms in banking industry, literature on this subject matter was considered. A lot of progress has been made by the BCBS in reforming the banking sector as a whole and implementation of these reforms has already began. Capital requirements are already taking shape and liquidity requirements such as the LCR has began while the NSFR is still being worked on and will only fully be implemented in 2019 (compare with Question 1.2.3).

Numerical examples and GIRFs that illustrate the amplification and persistence of the impact of asset-related shocks on asset and ABX prices by means of a real-world examples where given in Chapter 5 (compare with Question 1.3.4)

The effects of the Basel III proposals in connection with the numerical examples in chapter

5 can be looked at from two perspectives which are[1]:

- The quantitative perspective - the amount of liquid assets that the banks will have to amass in the next few years, both to meet the new requirements and to repay special facilities provided by governments and central banks, which it is assumed will not be renewed. There is clearly a potential transition problem which needs to be considered in determining the timing of implementation of new regulations.
- The structural perspective - This refers to the ways in which the funding and liquidity management, not only of banks but also of their customers, will be permanently affected by the proposed regulations. What may appear to be rather detailed aspects of the proposed regulations may in fact have very serious implications for financial stability in the future.

The revised capital framework in Basel III was considered as it was envisaged that this will have an impact on the incentives of banks to securitize assets. Banks mostly use their capital base to gauge their financial position and strength. More capital means they can make loans readily available to consumers or borrowers and investors. To clear their balance sheet from these loans and make them more liquid, the pool them together according to their classifications and pass them over to SPEs who in turn have them graded by rating agencies. These loans now in form of securities are then sold to investors worldwide spreading the risk (compare with Question 1.3.5).

Approximate Base III liquidity and traditional risk measure was also analyzed in this study for Class I and II banks. Class I banks are internationally active and have capital reserves of $4 billion dollars above. The interconnectedness of these banks established a link in which default risk was spread easily and the failure of one entity mearnt more harm to the financial sector than was anticipated. Class II banks were also actively involved in inside trading of risky securities and there involvement in the financial collapse cannot be shadowed. Further securitization of assets after the financial crisis was inhibited and the BCBS had to make revisions to the practice. Therefore reforms are expected to have a major impact on the incentives of banks to securitize these financial products (compare with Question 1.3.6).

The proportional negative change in profit for the LQ-entity subsequent to a temporary shock is higher in the first numerical example than that of the HQ-entities. In addition, the steady-state asset price p^{A^*} and the borrowings B^* for the LQ-entity increased to $ 0.012 and $2 600, respectively. In summary, this example shows that when parameter choices are altered and the size of shock increased, the LQ-entity suffers bigger losses on their asset

[1]See BCBS(2009c) pages 9-11

holdings and the rate of borrowing to refinance increases. This explains why most people could not pay back their loans during the 2007-2009 financial crisis.

A positive shock to asset rates results in a decrease in asset price. In addition, from Figure 5.3, it is clear that the reaction of asset price is more amplified and persistent for shocks from asset rates than other asset-related variables. This is to be expected and is confirmed by many studies like [83] that shows how asset rate volatility has a major impact on asset price in a low quality context (see. also, [72]). The shocks originating from prepayment rates and asset terms appear to have responses that are weakly amplified and persistent (see, for instance, [62] for more evidence).

Investors could avoid exceeding concentration limits, both regulatory restrictions and internal limits on exposures to a single name, by purchasing securitized products. Further, investors could manage risk in the entire portfolio by holding securitized assets that had a low correlation with other components of the investors portfolios, such as equities and corporate bonds. Also, investors could meet their internal portfolio diversification requirements by increasing the types of assets as well as the geographical location of the assets origination.

The BCBS documents [17] and [18] show that problems in securitization markets were not limited to CRAs. Some banks' internal assessments performed equally poor or even worse. In some cases banks impudently managed the risk of securitized exposures. The capital framework did not help to provide prudent incentives to banks. During the crisis, following small changes in the quality of the underlying pool of securitized exposures, banks experienced severe cliff effects for unrated exposures under the Supervisory Formula Approach (SFA), similar to those experienced under RBA. These cliff effects were particularly pronounced for the thin mezzanine tranches. The cliff effects in capital requirements increased the incentives for banks to sell certain securitization positions, which further exacerbated mark-to-market losses for banks.

7.2 Econometric Conclusions

Liabilities and Liquidity data was analyzed comprising of 157 Class I banks and 234 Class II banks. Class I banks are categorized as those with tier 1 capital in excess of $4 billion and internationally active while Class II banks are the rest. Liabilities data was not stationary at level when it was visually inspected but showed stationarity trends at I(1) in Figures 6.1 and 6.2 respectively. The ADF and PP tests were further performed at intercept as formal methods of checking for the presence of stationarity in Table 6.1. The ADF showed two variables being stationary at I(1) which were the interest bearing deposits and borrowings respectively while the PP test showed that all variables where stationary at I(1). There was no unit root existing in the variables and the next step was to check for cointegration using the Johansen method which comprised of the trace and maximum-eigenvalue statistic. There was no cointegration present in both tests for Class I banks as shown by Tables 6.5 and 6.6 which means that there is no long run relationship between the dependent variable; Interest Bearing Deposits and independent variables; Non Interest Bearing Liabilities and Borrowings. Class II bank liabilities on the other hand showed the existence of 1 cointegrating equation at 0.05% significance for in both the trace and maximum eigenvalue statistics (see for instance Tables 6.7 and 6.8). This showed that there is long run relationship amongst the variables in the long run and the independent variables have an impact on the behaviour of the dependent variable. The VECM in Table 6.13 showed the short run characteristics of the series, where a positive or negative change in non-interest bearing liabilities or deposits will have a corresponding impact on interest bearing deposits. The stability test given by the inverse roots of AR characteristic polynomial graph, Figure 6.6 showed that the model for Class II banks is stable and henceforth, could be worked with while the GIRFs in Figure 6.6 showed that there is a positive response of IBD in the first three quarters to a shock in NIBL. The relationship of borrowings to interest bearing deposits is negative which shows that when their has been a shock to IBD, most consumers or investors will not have access to loans due to bank's strict reform policies aimed at non replenishing of capital reserves to meet the standards of Basel III.

The ADF and PP test results in Table 6.3 showed that the null hypothesis of non-stationarity at 5% significance is rejected due to the non presence of a unit root for Class I bank liquidity. Lag truncations were chosen using the Bartlett Kernel. The Johansen cointegration showed 3 cointegrating equations with the trace test in table 6.9 while the maximum-eigenvalue showed in Table 6.10 showed 1 cointegrating equation. long run relationship was found to exist between the dependent variable which in this case was the net stable funding ratio and the independent variables. The NSFR is yet to be implemented by the Basel committee and one of the aims of this study was to find out how the liquidity coverage ratio which has already started being implemented and other traditional liquidity measures (Government Security Ratio and Brokered Deposit Ratio) would affect or impact implementation progress. Changes to any of the independent variables will definitely affect the NSFR as evidenced by the existence of cointegration. The Error correction term size in the Vecm indicates the speed of adjustment of any disequilibrium towards a long run equilibrium and it was found to be negative which is economically significant for the restoration of equilibrium and confirms the unavailability of problems in the long run equilibrium relationship between the dependent and independent variables. This in turn suggests that any short term fluctuations between the independent and the dependent variables gives rise to a stable long run relationship between the variables. The inverse roots of the AR characteristic polynomial and all the roots are inside the unit circle in Figure 6.4 affirming the stableness of the vecm model. In addition Figure 6.7 shows the GIRFs for Class I banks. Response of NSFR to a shock in LCR shows a decrease in the first quarter and a steady continuous increase in the next quarters. A shock on LCR would therefore cause banks to increase their level of NSFR. This explains why the LCR is considered for a short term stress period of 30 calender days while the NSFR will be considered for a longer stress period of 1 year when fully implemented.

Class II bank liquidity was non stationary at level but became stationary at I(1) as shown by the ADF and PP tests in Table 6.4 and the null hypothesis of non-stationarity was rejected at 5% significance. The Johansen test shows 3 cointegrating equations for the trace and 2 cointegrating eqautions for the maximum-eigenvalue statistics according to Tables 6.11 and 6.12 respectively. This points to the existence of a long run relationship between the dependent and independent variables in Class II bank liquidity. A change in the independent variables given by LCR, GSR and BDR will have an effect or impact on the NSFR. The estimated Vecm in Table 6.16 is significant and The presence of any short term fluctuations between the independent variables and the dependent variable will enable a long run relationship between the variables. Therefore a change in the government securities ratio (GSR) given by -0.918 will have positive impact on the change in NSFR as shown in Table 6.17. The Vecm model is stable as shown by the inverse roots in Figure 6.5 which are all within the circle. Furthermore, Class II bank liquidity GIRFs in Figure 6.8 show the reaction of the NSFR to a shock in LCR is different from what was observed in the GIRFs for Class I banks. In this case the NSFR increases at a diminishing rate in the 1st quarter to about the 6th quarter. NSFR for Class II banks therefore react positively to a shock in LCR as compared to Class I banks. A reason that can be given for this observation is that most Class II banks are not considered to be internationally active banks and are not usually involved in the chain of securitization that spreads risk world wide through bundling and selling of high risk securities to investors. Hence the first banks to be hit by any default or shock are Class I banks which then resort to borrowing from Class II banks.

The BCBS should insure that it imposes high penalty charges for banks that do not have sufficient capital and liquidity but are in the business of securitizing assets. Their should be a minimum capital and liquidity level set up for each bank to adhere to before they indulge in securitization practices. Governments of each respective country should insure that they set up regulatory boards that will insure sound banking principles are followed by each bank operating in the country. In addition, governments should have strict guidelines for non bailing of defaulting banks, a process which will encourage banks hold enough capital and increase their liquidity to safe levels. The complexity of securitized assets and the process of securitization itself should be explained to investors or buyers of these products to help them understand the risks that comes with investing in such products. It is certain that the disclosure of information on these products will dissuade some investors from buying them. Securitization is a worldwide connected process and any default in major players causes global financial problems due to the interconnectedness of banks. In addition Class II banks have to be regulated with the same measures taken on Class I banks. Some of the Class II banks qualify to trade internationally and have capital reserves similar to those of Class I banks. These Class II banks can therefore securitize and trade assets without notice from regulators which in turn contributes to the risk of defualt for these structured asset products. The BCBS should consider increasing the NSFR stress scenario period from one year to one year six months considering it shall be the last line of defence for banks after using the LCR. This will help banks keep enough reserves and avoid a situation of government bailouts.

Chapter 8

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Chapter 9

Appendices

In this chapter, the appendices about economic conditions and econometric tests are provided.

9.1 Appendix A: Economic Conditions Before and During the Financial Crisis

Table 9.1 below compares economic conditions before and during the FC.

Before FC (Year $<$ 2007)	**During FC (Year $\geq$ 2007)**
High Level of Macroeconomic Activity	Lower Level of Macroeconomic Activity
Boom Conditions	Recession Conditions
Low Perceived Credit Risk	Higher Perceived Credit Risk
Low Delinquency Rate	Higher Delinquency Rate
Low Foreclosure Rate	Higher Foreclosure Rate
Regret-Averse Agents	Risk-Averse Agents
House Prices Increase	House Prices Decline
Low Counterparty Risk	Higher Counterparty Risk
High Rate of Securitization of Low Quality RALs	Lower Rate of Securitization of Low Quality RALs
Low Investment in Safe Assets such as Treasuries	Higher Investment in Safe Assets such as Treasuries
High Spreads	Low Spreads
High Market Liquidity	Low Market Liquidity
Few Credit Crunches	Many Credit Crunches
Highly Leveraged Financial Institutions	Less Highly Leveraged Financial Institutions

Table 9.1: Differences in Economic Conditions Before and During the FC

9.2 Appendix B: Stationarity Tests; Bank Liability

Appendix B_1

Null Hypothesis: IBD has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.227712	0.6538
Test critical values:	1% level	-3.592462	
	5% level	-2.931404	
	10% level	-2.603944	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IBD)
Method: Least Squares
Date: 11/04/14 Time: 10:57
Sample (adjusted): 2002Q2 2012Q4
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IBD(-1)	-0.020807	0.016948	-1.227712	0.2266
C	0.742092	0.354848	2.091298	0.0427

R-squared	0.035459	Mean dependent var	0.313023
Adjusted R-squared	0.011934	S.D. dependent var	0.405372
S.E. of regression	0.402946	Akaike info criterion	1.065366
Sum squared resid	6.656977	Schwarz criterion	1.147282
Log likelihood	-20.90536	Hannan-Quinn criter.	1.095574
F-statistic	1.507277	Durbin-Watson stat	1.374460
Prob(F-statistic)	0.226557		

Null Hypothesis: D(IBD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.620676	0.0006
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IBD,2)
Method: Least Squares
Date: 11/04/14 Time: 11:34
Sample (adjusted): 2002Q3 2012Q4
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IBD(-1))	-0.689540	0.149229	-4.620676	0.0000
C	0.204758	0.076756	2.667640	0.0110

R-squared	0.348010	Mean dependent var	-0.015238
Adjusted R-squared	0.331710	S.D. dependent var	0.477285
S.E. of regression	0.390176	Akaike info criterion	1.002009
Sum squared resid	6.089486	Schwarz criterion	1.084755
Log likelihood	-19.04219	Hannan-Quinn criter.	1.032339
F-statistic	21.35065	Durbin-Watson stat	2.073568
Prob(F-statistic)	0.000039		

Null Hypothesis: IBDCII has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.968592	0.7555
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IBDCII)
Method: Least Squares
Date: 11/04/14 Time: 12:10
Sample (adjusted): 2002Q4 2012Q4
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IBDCII(-1)	-0.022567	0.023299	-0.968592	0.3390
D(IBDCII(-1))	0.131601	0.158165	0.832051	0.4107
D(IBDCII(-2))	0.228781	0.155560	1.470691	0.1498
C	0.588806	0.451034	1.305457	0.1998

R-squared	0.100016	Mean dependent var	0.251463
Adjusted R-squared	0.027044	S.D. dependent var	0.404979
S.E. of regression	0.399465	Akaike info criterion	1.095087
Sum squared resid	5.904178	Schwarz criterion	1.262265
Log likelihood	-18.44929	Hannan-Quinn criter.	1.155964
F-statistic	1.370610	Durbin-Watson stat	2.062032
Prob(F-statistic)	0.266845		

Null Hypothesis: D(IBDCII) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.164886	0.0295
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IBDCII,2)
Method: Least Squares
Date: 11/04/14 Time: 12:16
Sample (adjusted): 2002Q4 2012Q4
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IBDCII(-1))	-0.647487	0.204585	-3.164886	0.0031
D(IBDCII(-1),2)	-0.227354	0.155427	-1.462769	0.1518
C	0.159218	0.081927	1.943399	0.0594

R-squared	0.450272	Mean dependent var	-0.002195
Adjusted R-squared	0.421339	S.D. dependent var	0.524702
S.E. of regression	0.399140	Akaike info criterion	1.071346
Sum squared resid	6.053884	Schwarz criterion	1.196730
Log likelihood	-18.96260	Hannan-Quinn criter.	1.117004
F-statistic	15.56253	Durbin-Watson stat	2.042522
Prob(F-statistic)	0.000012		

Appendix B_2

Null Hypothesis: IBD has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.144797	0.6893
Test critical values:	1% level	-3.592462	
	5% level	-2.931404	
	10% level	-2.603944	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.154813
HAC corrected variance (Bartlett kernel)	0.237235

Phillips-Perron Test Equation
Dependent Variable: D(IBD)
Method: Least Squares
Date: 11/04/14 Time: 11:45
Sample (adjusted): 2002Q2 2012Q4
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IBD(-1)	-0.020807	0.016948	-1.227712	0.2266
C	0.742092	0.354848	2.091298	0.0427

R-squared	0.035459	Mean dependent var	0.313023
Adjusted R-squared	0.011934	S.D. dependent var	0.405372
S.E. of regression	0.402946	Akaike info criterion	1.065366
Sum squared resid	6.656977	Schwarz criterion	1.147282
Log likelihood	-20.90536	Hannan-Quinn criter.	1.095574
F-statistic	1.507277	Durbin-Watson stat	1.374460
Prob(F-statistic)	0.226557		

Null Hypothesis: D(IBD) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.593665	0.0006
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.144988
HAC corrected variance (Bartlett kernel)	0.139696

Phillips-Perron Test Equation
Dependent Variable: D(IBD,2)
Method: Least Squares
Date: 11/04/14 Time: 11:46
Sample (adjusted): 2002Q3 2012Q4
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IBD(-1))	-0.689540	0.149229	-4.620676	0.0000
C	0.204758	0.076756	2.667640	0.0110

R-squared	0.348010	Mean dependent var	-0.015238
Adjusted R-squared	0.331710	S.D. dependent var	0.477285
S.E. of regression	0.390176	Akaike info criterion	1.002009
Sum squared resid	6.089486	Schwarz criterion	1.084755
Log likelihood	-19.04219	Hannan-Quinn criter.	1.032339
F-statistic	21.35065	Durbin-Watson stat	2.073568
Prob(F-statistic)	0.000039		

Null Hypothesis: IBDCII has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.086972	0.7125
Test critical values:	1% level	-3.592462	
	5% level	-2.931404	
	10% level	-2.603944	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.153301
HAC corrected variance (Bartlett kernel)	0.250175

Phillips-Perron Test Equation
Dependent Variable: D(IBDCII)
Method: Least Squares
Date: 11/04/14 Time: 12:31
Sample (adjusted): 2002Q2 2012Q4
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IBDCII(-1)	-0.023436	0.021153	-1.107941	0.2743
C	0.701664	0.403505	1.738923	0.0896

R-squared	0.029070	Mean dependent var	0.259767
Adjusted R-squared	0.005388	S.D. dependent var	0.402057
S.E. of regression	0.400972	Akaike info criterion	1.055547
Sum squared resid	6.591936	Schwarz criterion	1.137464
Log likelihood	-20.69427	Hannan-Quinn criter.	1.085756
F-statistic	1.227533	Durbin-Watson stat	1.680288
Prob(F-statistic)	0.274345		

Null Hypothesis: D(IBDCII) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.643447	0.0000
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.153033
HAC corrected variance (Bartlett kernel)	0.188947

Phillips-Perron Test Equation
Dependent Variable: D(IBDCII,2)
Method: Least Squares
Date: 11/04/14 Time: 12:34
Sample (adjusted): 2002Q3 2012Q4
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IBDCII(-1))	-0.853336	0.154355	-5.528409	0.0000
C	0.209978	0.074135	2.832393	0.0072

R-squared	0.433133	Mean dependent var	-0.015952
Adjusted R-squared	0.418962	S.D. dependent var	0.525877
S.E. of regression	0.400854	Akaike info criterion	1.056011
Sum squared resid	6.427370	Schwarz criterion	1.138757
Log likelihood	-20.17623	Hannan-Quinn criter.	1.086341
F-statistic	30.56331	Durbin-Watson stat	2.032794
Prob(F-statistic)	0.000002		

9.3 Appendix C: Cointegration Test

Appendix C_1

Date: 11/04/14 Time: 13:00
Sample (adjusted): 2002Q3 2012Q4
Included observations: 42 after adjustments
Trend assumption: Linear deterministic trend
Series: IBD NIBL B
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.276537	21.26549	29.79707	0.3413
At most 1	0.166867	7.669830	15.49471	0.5014
At most 2	5.36E-05	0.002250	3.841466	0.9602

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.276537	13.59566	21.13162	0.3991
At most 1	0.166867	7.667580	14.26460	0.4135
At most 2	5.36E-05	0.002250	3.841466	0.9602

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

IBD	NIBL	B
0.065629	-7.784342	2.365768
-0.110618	-1.250142	-2.252745
0.280502	-1.909710	-0.610566

Unrestricted Adjustment Coefficients (alpha):

D(IBD)	0.114639	0.089627	0.001596
D(NIBL)	0.018608	-0.003528	-9.41E-05
D(B)	0.015417	0.119094	-0.001226

1 Cointegrating Equation(s): Log likelihood 53.55377

Normalized cointegrating coefficients (standard error in parentheses)

IBD	NIBL	B
1.000000	-118.6108	36.04743
	(30.6276)	(13.1123)

Adjustment coefficients (standard error in parentheses)

D(IBD)	0.007524
	(0.00389)
D(NIBL)	0.001221
	(0.00037)
D(B)	0.001012
	(0.00364)

2 Cointegrating Equation(s): Log likelihood 57.38756

Normalized cointegrating coefficients (standard error in parentheses)

IBD	NIBL	B
1.000000	0.000000	21.72940
		(8.56007)
0.000000	1.000000	-0.120714
		(0.11309)

Adjustment coefficients (standard error in parentheses)

D(IBD)	-0.002391	-1.004434
	(0.00739)	(0.45276)
D(NIBL)	0.001611	-0.140438
	(0.00071)	(0.04363)
D(B)	-0.012162	-0.268895
	(0.00667)	(0.40882)

Date: 11/04/14 Time: 13:22
Sample (adjusted): 2002Q3 2012Q4
Included observations: 42 after adjustments
Trend assumption: Linear deterministic trend
Series: IBDCII NIBLCII BCII
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.565230	43.23033	29.79707	0.0008
At most 1	0.172223	8.246975	15.49471	0.4394
At most 2	0.007318	0.308493	3.841466	0.5786

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.565230	34.98336	21.13162	0.0003
At most 1	0.172223	7.938482	14.26460	0.3850
At most 2	0.007318	0.308493	3.841466	0.5786

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

IBDCII	NIBLCII	BCII
-0.004973	-8.571707	1.594002
-0.102999	1.909955	-3.491397
0.378233	-2.266277	-0.201711

Unrestricted Adjustment Coefficients (alpha):

D(IBDCII)	0.110422	0.067415	0.023738
D(NIBLCII)	0.021332	-0.011371	0.001416
D(BCII)	0.065999	0.014237	-0.004573

1 Cointegrating Equation(s):	Log likelihood	110.3784

Normalized cointegrating coefficients (standard error in parentheses)

IBDCII	NIBLCII	BCII
1.000000	1723.588	-320.5198
	(252.090)	(109.551)

Adjustment coefficients (standard error in parentheses)

D(IBDCII)	-0.000549
	(0.00027)
D(NIBLCII)	-0.000106
	(3.0E-05)
D(BCII)	-0.000328
	(7.0E-05)

2 Cointegrating Equation(s):	Log likelihood	114.3476

Normalized cointegrating coefficients (standard error in parentheses)

IBDCII	NIBLCII	BCII
1.000000	0.000000	30.12506
		(10.9708)
0.000000	1.000000	-0.203439
		(0.05291)

Adjustment coefficients (standard error in parentheses)

D(IBDCII)	-0.007493	-0.817746
	(0.00558)	(0.47495)
D(NIBLCII)	0.001065	-0.204572
	(0.00060)	(0.05095)
D(BCII)	-0.001795	-0.538533
	(0.00144)	(0.12235)

9.4 Appendix D: Vector Error Correction Test

Appendix D_1

Vector Error Correction Estimates
Date: 11/04/14 Time: 13:37
Sample (adjusted): 2002Q4 2012Q4
Included observations: 41 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
IBDCII(-1)	1.000000		
NIBLCII(-1)	809.6614 (152.122) [5.32246]		
BCII(-1)	-122.6661 (52.9559) [-2.31638]		
C	1201.430		
Error Correction:	**D(IBDCII)**	**D(NIBLCII)**	**D(BCII)**
CointEq1	-0.001810 (0.00089) [-2.04042]	-0.000255 (9.8E-05) [-2.60800]	-0.000810 (0.00023) [-3.52557]
D(IBDCII(-1))	-0.169517 (0.17374) [-0.97570]	0.000638 (0.01912) [0.03334]	-0.031418 (0.04503) [-0.69778]
D(IBDCII(-2))	0.016233 (0.16667) [0.09740]	-0.033959 (0.01834) [-1.85123]	-0.014141 (0.04319) [-0.32740]
D(NIBLCII(-1))	2.389778 (1.39282) [1.71578]	0.736746 (0.15330) [4.80591]	0.311588 (0.36096) [0.86323]
D(NIBLCII(-2))	1.902154 (1.66559) [1.14203]	0.120840 (0.18332) [0.65917]	0.279250 (0.43164) [0.64694]

D(BCII(-1))	-0.491593	-0.095331	-0.432979
	(0.76125)	(0.08379)	(0.19728)
	[-0.64577]	[-1.13778]	[-2.19472]
D(BCII(-2))	-0.357772	-0.026329	-0.092694
	(0.72525)	(0.07982)	(0.18795)
	[-0.49331]	[-0.32984]	[-0.49318]
C	0.287993	0.008440	0.008923
	(0.08814)	(0.00970)	(0.02284)
	[3.26750]	[0.86998]	[0.39063]
R-squared	0.321817	0.632243	0.402408
Adj. R-squared	0.177961	0.554234	0.275645
Sum sq. resids	4.449089	0.053897	0.298807
S.E. equation	0.367180	0.040413	0.095156
F-statistic	2.237066	8.104742	3.174511
Log likelihood	-12.64859	77.82573	42.71490
Akaike AIC	1.007248	-3.406133	-1.693410
Schwarz SC	1.341604	-3.071778	-1.359054
Mean dependent	0.251463	-0.000171	-0.001224
S.D. dependent	0.404979	0.060530	0.111805

Determinant resid covariance (dof adj.)	1.78E-06
Determinant resid covariance	9.27E-07
Log likelihood	110.2368
Akaike information criterion	-4.060332
Schwarz criterion	-2.931882

9.5 Appendix E: VEC Stability Condition Check

Appendix E_1

Roots of Characteristic Polynomial
Endogenous variables: IBDCII NIBLCII BCII
Exogenous variables:
Lag specification: 1 2
Date: 11/04/14 Time: 15:13

Root	Modulus
1.000000 - 2.94e-16i	1.000000
1.000000 + 2.94e-16i	1.000000
0.724153 - 0.315044i	0.789715
0.724153 + 0.315044i	0.789715
0.614629	0.614629
-0.333103 - 0.284571i	0.438108
-0.333103 + 0.284571i	0.438108
-0.185514 - 0.019647i	0.186551
-0.185514 + 0.019647i	0.186551

VEC specification imposes 2 unit root(s).