The Impact of Economic Shocks on Assets and Their Derivatives

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Dissertation submitted in partial fulfilment of the requirements for the Degree Masters of Commerce at the Mafikeng Campus of the North West University (NWU-MC)

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FMORG 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 FMORG that has an interest in institutional finance. In particular, FMORG has made contributions about modeling, optimization, regulation and risk management in insurance and banking. Students who have participated in projects in this programme under Proffs. Petersen and Mukuddem-Petersen's supervision are listed below.

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	C Scheepers	2011 Onwards	The Impact of the Global Financial Crisis on the South African Steel Industry
MComm	G Mah	2012 Onwards	Sovereign Debt
MComm	C Meniago	2012 Onwards	An Econometric Analysis of the Impact of the Financial Crisis on Household Indebtedness in South Africa
MComm	M Mubanga	2012 Onwards	Impact of Economic Shocks on Assets and Their Derivatives
PhD	I Mongale	2011 Onwards	An Analysis of the Impact of the Global Financial Crisis on Savings in South Africa
PhD	F Louw	2011 Onwards	Monetary Policy Transmission Mechanisms in South Africa
PhD	B De Waal	2011 Onwards	Liquidity and Valuation in the Financial Crisis
PhD	CO Miruka	2012 Onwards	Financial Guarantees and Other Fiscal Policies in South Africa
PhD	N Moroke	2012 Onwards	An Econometric Analysis of the Impact of the Financial Crisis on Household Indebtedness
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: FMORG History of Supervision

Declaration of Self-Endeavour

I declare that, apart from the assistance acknowledged, the research presented in this dissertation is my own unaided work. It is being submitted in partial fulfilment of the requirements for the Degree Master of Commerce 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

In this dissertation, we investigate dealers that securitize assets into derivatives. These assets are both a means of generating derivatives as well as a source of collateral for interbank borrowing. The main result quantifies the effects of temporary shocks on asset price and input, derivative price and output as well as profit. For instance, we show how a change in profit subsequent to a negative shock is influenced by bank features such as asset rates, derivatives rates and liquidity. We will further establish the probability of CDS defaults using Monte Carlo simulation. Finally, we present an example that characterizes amplification and persistence effects from shocks on asset and derivative prices.

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

CLASSIFICATION:

JEL: G13; G32

MSC2010: 91G10; 91G20; 91G40; 91G70; 91G80; 60G99; 62C20.

Glossary

Amortization the paying off of debt in regular installments over a period of time. Amortization refers to intangible assets such as a patent or copyright.

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;

AH - Asset Holder;

AFC - Available Funds Cap;

AIG - American International Group;

ARA - Adjustable-Rate Asset;

BVP - Boundary Value Problem;

CDO - Collateralized Debt Obligation;

CDOs - Collateralized Debt Obligations;

CDS - Credit Default Swap;

CE - Credit Enhancement;

CLO - Collateralized Loan Obligation;

CRA - Credit Rating Agency;

CTD - Cheapest to Deliver;

FDIC - Federal Deposit Insurance Corporation;

IO - Interest-Only;

IR - Investor;

FC - Financial Crisis;

GIRFs - Generalized Impulse Response Functions;

HQ - High Quality;

LIBOR - London Interbank Offered Rate;

LQ - Low Quality;

LQA - Low Quality Asset;

MCS - Monte Carlo Simulation;

OAD - Originate-and-Distribute;

OC - Over collateralized;

ODE - Ordinary Differential Equation;

OR - Originator;

PD - Probability of Default;

RMBS - Residential Mortgage-Backed Security;

RAL - Residential Asset Loan;

SDE - Stochastic Differential Equation;

SPV - Special Purpose Vehicle.

Basic Notations

A - Quantity of assets;

$\bar{A}$ - Total Asset Supply;

A_t - Input Assets Securitized at date t;

A_t - low quality dealer's asset holdings in period t;

A' - Asset Flow of Funds;

B - Borrowings;

β - Discount;

c^p - Prepayment costs;

$\hat{C}$ - Proportional Change in Derivative Output;

E - Equilibrium;

F_t - Simultaneous equation model of asset rate profit;

G_t - Simultaneous equation model of loan-to-value-ratio;

h - Default Intensity;

H_t - Simultaneous equation model of prepayment cost;

K - Capital;

k - Continous-time time speed of mean reversion;

M - Marketable Securities;

$\bar{p}$ - Weighted Average Price Cap;

p^{A*} - Steady-State Asset Price;

p^0 - Asset Price;

p^C - Cash flow constraint;

$x_t^{'}$ - 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 t;

u_t - Cost of Funds;

Π - Profit;

V - Volatility;

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

$\hat{\Pi}_t$ - Proportional Change in Profit;

θ - mean reversion level;

σ - Continous-time Deviation of price changes;

∞ - Infinity;

Σ - Shock Parameter.

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Chapter 1

Introduction and Background

The 2007-2009 financial crisis was characterized by an increase in turbulence from assets. This resulted in the decline in demand for structured asset products (SAPs) such as asset-backed securities (ABSs) and collateralized debt obligations (CDOs) that partly resulted from the securitization of the aforementioned assets. With the advent of securitization, the traditional asset model – involving originators extending loans to lenders and retaining the credit (default) risk – was replaced by the originate-to-distribute model in which originators sell assets and distribute credit risk to dealers. In our case, these dealers are essentially borrowing special purpose entities (SPEs) with price caps. In the case of derivatives, these dealers hold fixed income assets such as assets and bonds. In our study, we focus on the latter. Securitization meant that originators were no longer obligated to hold assets to maturity. By selling these assets to dealers, the originators replenished their funds enabling them to originate more assets and generate more income from transaction fees. As a result, moral hazard was created with an increase in incentives for processing asset transactions but with a decrease in credit quality.

In this dissertation, we investigate how dealers securitize low quality assets (LQAs) and high quality assets (HQAs) – known as LQ- and HQ- dealers, respectively – into derivatives. In particular, we study the securitization of such assets into derivatives by the aforementioned dealers. We shall see that the reference asset portfolios are both a means of generating derivatives as well as collateral for interbank borrowing. The main result of the dissertation 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. Finally, we present 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.

1.1 Preliminaries about HQAs, LQAs, SAPs and Transmission

In this section, we provide preliminaries about HQAs and LQAs, SAPs as well as the transmission mechanism. All events take place in period t, $t+1$, or a period thereafter.

1.1.1 Preliminaries about HQAs and LQAs

HQAs are characterized by their long-term, usually 30-year period, fixed rates. An example of an HQA is a prime mortgage. 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 subprime mortgage. 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 dealers, may be represented as

$$r_t^A = r_t^L + \varrho_t, \tag{1.1}$$

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 $t+1$ after low teaser rates in period t. Secondly, this higher step-up rate causes an incentive to refinance in period $t+1$. 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.

An example of a comparison between HQAs and LQAs as collateral for derivatives can be made for prime and subprime mortgages, respectively. In this regard, Table 1.1 below illustrates that subprime mortgage-backed securities (MBSs) dominated prime mortgage products as CDO collateral.

Vintage	Subprime Mortgages	Prime Mortgages
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: [15]

Also, we can distinguish between subprime and prime mortgages in terms of defining features as follows.

Feature	Subprime Mortgages	Prime Mortgages
Lien Position	$\geq$ 90 % First Lein	First Lein
Loan-to-Value Ratio (LTVR)	60–100 %	65–80 %
Weighted Average LTVR	low 80s	low 70s
Investor FICO	500-600	700+
Investor Credit History	Credit Derogatories	No Credit Derogatories
Agency Criteria Conforming	Non-Conforming	Conforming

Table 1.2: Subprime vs Prime Mortgage Features; Source: [15]

We note from the last row and second column of Table 1.2 that subprime mortgages were non-conforming 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 a 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 the Transmission Mechanism

The transmission mechanism associated with the subsequent analysis can be explained as follows. With the total asset supply to dealers for securitization being fixed, we consider an economy in which assets serve as collateral for securing interbank loans as well as a means of generating SAPs. Some dealers – such as those involved in LQA securitization and hereafter known as *LQ-dealers* – are credit constrained and highly leveraged. In this regard, they have borrowed heavily against asset value. Other dealers – such as those dealing with HQA securitization and subsequently called *HQ-dealers* – are not credit constrained. For sake of argument, we assume that in period t the dealers experience a temporary securitization shock that reduces their nett worth with period $t+1$ representing the ongoing crisis. Being unable to borrow more, the credit-constrained LQ-dealers are forced to reduce investment in assets. This has negative effects in the next period. Because LQ-dealers now earn less revenue, their nett worth decreases and due to credit constraints, they have to reduce investment. The knock-on effects continue, with the result that the temporary shock in period t reduces the constrained LQ-dealer's asset demand not only in period t but also in periods $t+1,\ t+2,\ldots$. For the market to clear in each of these periods, the asset demand by the unconstrained HQ-dealers has to increase, which requires that their asset transaction fees must fall. Given that HQ-dealers are unconstrained, such costs in each period is simply the difference between that period's asset price and the discounted value of the price in the following period. This anticipated decline in costs in periods $t,\ t+1,\ t+2,\ \ldots$ is reflected by a decrease in the asset price in period t. The fall in this price in period t has a significant impact on the behavior of the constrained HQ-dealers. They suffer a capital loss on their asset acquisitions, which, because of the high leverage, causes their nett worth to decrease dramatically. As a result, such dealers have to reduce asset investment more dramatically. Also, a multiplier process involving shocks to the constrained LQ-dealer's nett worth in period t causes a reduction in asset demand in period t and subsequent periods (refer to Section 2). For market equilibrium to be restored, the unconstrained HQ-dealers' asset costs is thus expected to fall in each of these periods. This results in a fall in the asset price in period t, which reduces the constrained LQ-dealers' nett worth in period t still further.

1.2 Literature Review

The theory outlined subsequently in Sections 1.2.1 and 1.2.2 is supported by various strands of existing literature. The model in [12] 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.

1.2.1 The Kiyotaki-Moore Model

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, [12], they 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 [12], gatherers can be partially associated with dealer banks that are highly rated and hold HQAs and are called HQ-dealers. Here, the role of Kiyotaki and Moore's farmers are partly taken by LQ-dealers and hold LQAs. In the context of this paper, two key assumptions limit the effectiveness of the model credit market. Firstly, LQ-dealers knowledge is an essential input to their asset securitization, that is, securitization becomes worthless if the LQ-dealer who made the investment chooses to abandon it. Secondly, LQ-dealers 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-dealers' securitization projects are potentially very valuable, HQ-dealers have no way to confiscate this value if LQ-dealers choose not to pay back their debts. Therefore, inter-bank lending will not take place unless it is backed by some form of collateral. [12] considers land as an example of a collateralizable asset. Land is a productive input and also serves as collateral for debt. Hence, LQ-dealers 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-dealers 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.

1.2.2 LQAs and HQAs

There is an ever growing body of literature on LQAs but we concentrate on the publications connecting financial shocks to LQ-dealers, assets and derivatives as well as their characteristic features. The study [8] studies the pricing of LQAs (in the form of low quality assets) and related structured asset products on the basis of data for the ABX.HE family of indices. This of course is a recurring theme in our contribution where we consider asset and derivative pricing during the financial crisis. We further address the impact of speculative asset funding on the pricing of LQAs (measured by risk premia) and securities backed by these assets (measured by ABX.HE indices). The paper makes use of multivariate vector autoregressive model estimates and generalized impulse response functions in order to study the shocks related to this type of funding. We follow a similar methodology in a current paper where the vector autoregressive model estimates individual regressions within a system while the response functions provide a means of determining the impact of shocks within a given horizon. In addition, the paper [9] extends a [12] type model that shows how relatively small shocks might suffice to explain business cycle fluctuations, if credit markets are imperfect. The basic model of section 3 has a number of limitations. The only investment occurs in assets themselves; and although assets change hands, between low and high quality dealers, aggregate investment is automatically zero because the total asset supply is fixed. Also, the impulse response of the economy is a shock arguably too dramatic and short lived (especially when the residual asset supply to low quality dealers is inelastic). The reason is that the leverage effect is so strong: in the steady state the LQ-dealers' debt-to-asset ratio is

$$1/(1+r^B)$$

that is unreasonably high if the length of the period is not long. Finally, the simplicity of the model hides certain important dynamics. Our work has a connection with this paper via the consideration of the effect of shocks on asset parameters although we do not emphasize the imperfection of credit markets. The paper [5] studies the impact of prepayment penalties on low quality assets. Here asset price and the prepayment penalty are chosen simultaneously with such penalties being associated with lower asset prices. The paper also contains discussions on prices and penalties and their relationship with loan-to-value ratios. In our contribution, we will use the framework introduced by [5] to show how a change in profit subsequent to a negative shock is influenced by low quality asset features such as asset, prepayment and refinancing rates as well as house equity.

1.3 Main Questions and Dissertation Outline

In this subsection, we identify the main problems addressed in and give an outline of the dissertation.

1.3.1 Main Questions

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

Question 1.3.1 (Downside of Assets and Derivatives): *How does our models for assets and derivatives relate to problems experienced in the financial crisis such as the reduction in incentives for banks to monitor dealers, transaction fees, manipulation of price and structure, market opacity, self-regulation, systemic risks and mispricing of debt ? (see Chapters 1 and Chapter 2).*

Question 1.3.2 (Shocks to Asset Price and Input, Derivative Price and Output and Profit): *In the presence of a dynamic multiplier, how can we quantify changes to asset price and input, derivative price and output as well as profit subsequent to negative shocks ? (see Theorem 4.1.1 in Chapter 4).*

Question 1.3.3 (Low Quality Assets and Prepayment Rates, Equity and Profit Shocks): *In the presence of a dynamic multiplier, how can we quantify changes to profit in terms of asset and prepayment rates as well as equity subsequent to negative shocks ? (see Corollary 4.1.1 in Chapter 4).*

Question 1.3.4 (Examples of the Effect of Shocks on Asset and Derivative Prices): *How can we effectively illustrate the amplification and persistence of the impact of asset-related shocks on asset and derivative prices by means of a real-world example ? (see Chapter 5).*

1.3.2 Dissertation Outline

Chapter 2 studies dealer equilibrium. In this regard, we consider LQ- and HQ-dealers at equilibrium in Subsections 2.3.1 and 2.3.2, respectively. Furthermore, in section 2.4 we consider market equilibrium for these dealers. Chapter 3 provides an insight into the data and methodology used in the dissertation. Furthermore, in Chapter 4, we discuss the effects of shocks to asset price and input, derivative price and output as well as profit. Chapter 5 provides numerical quantitative results and discussion involving shocks to the aforementioned asset-related variables while Chapter 6 identifies key conclusions and possible topics for future research. In addition to the issues highlighted above, throughout the dissertation, we comment on the deleterious effects associated with derivative issuance by dealers. In particular, we focus on the reduction in incentives for banks to monitor dealers, transaction fees, manipulation of price and structure, market opacity, self-regulation, systemic risks and mispricing of debt.

Chapter 2

Dealer Equilibrium

In this chapter, we consider LQ- and HQ-dealers and their equilibrium features. We study an economy consisting of LQAs with a fixed total supply of $\overline{A}$ and derivatives that are constantly being traded. In the sequel, for sake of argument, we assume that the derivatives correspond to the senior tranches of OTC derivatives – simply referred to as derivatives hereafter. In this model, derivatives are taken as the numeraire. There is a continuum of infinitely lived LQ- and HQ-dealers, with population sizes 1 and n, respectively. Both these dealers take one period to securitize assets into derivatives – LQ- and HQ-dealers produce derivatives from LQAs and HQAs, respectively – but they differ in their securitization technologies. At each date, t, there is a competitive spot market in which assets for derivatives are purchased by dealers at a price of p_t^A. The only other market is a one-period credit market in which one derivative unit at date t is exchanged for a claim to $1 + r_t^{\mathrm{B}}$ units of derivatives at date $t + 1$. These markets are opaque and are dominated by a handful of interests. During the financial crisis, because derivatives, like collateralized debt obligations (CDOs), were lightly regulated their details often went undisclosed. This created major problems in the monitoring of these products.

2.1 LQ-Dealers

Figure 2.1 below illustrates the LQ-dealer's securitization of LQAs into ABSs and ABS Derivatives.

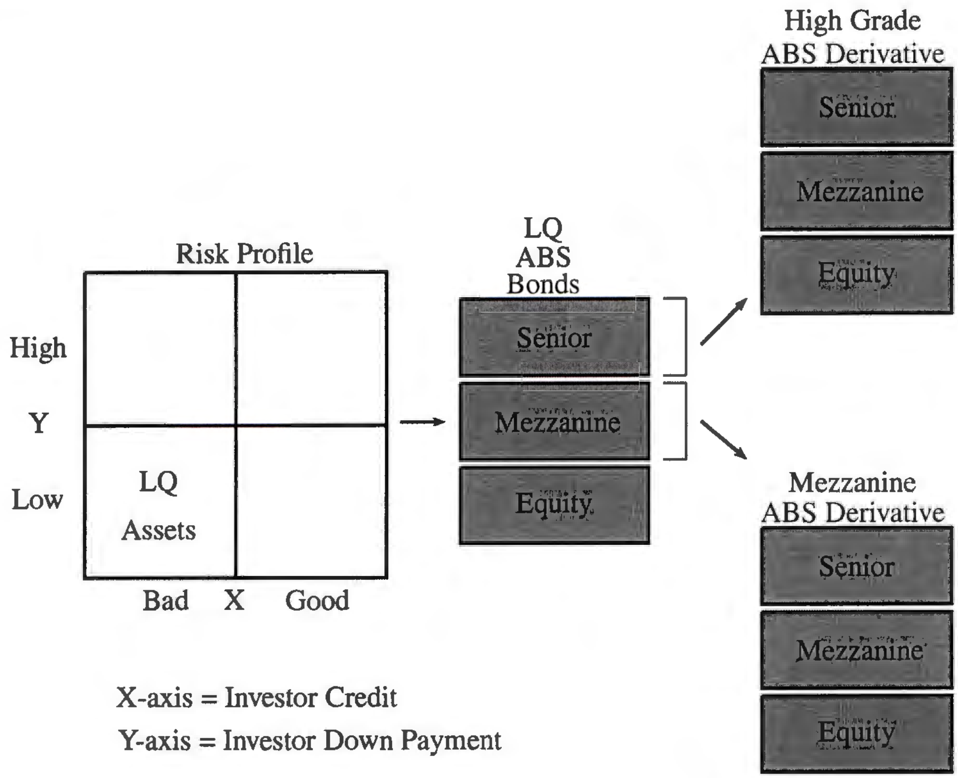

Figure 2.1: Chain of LQAs and Their Structured Products; Source: [15]

We notice from Figure 2.1 that LQAs are securitized into ABSs that, in turn, get securitized into ABS derivatives. 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 derivative portfolio. On the other hand, the mezzanine rated ABS bonds are securitized into *mezzanine ABS derivatives*, since its portfolio is based on BBB rated ABSs and their tranches which expose the portfolio to an increase in credit risk. From Figure 2.1, it is clear that LQ-dealers (and any other dealers) rather than banks, hold assets and ABSs. As a result there are reductions in the incentives of banks to play their traditional monitoring function. During the financial crisis, systemic risk from derivatives was problematic. In this case, the default of one or more collateral asset classes generated a ripple effect on the defaults of derivatives. Figure 2.1 suggest how this may have happened.

LQ-dealers are risk neutral, with their expected utilities being

$$\mathbf{E}_t\left(\sum_{s=0}^{\infty}\beta^s x_{t+s}\right) \text{ and } \mathbf{E}_t\left(\sum_{s=0}^{\infty}\beta^t x_t\right), \tag{2.1}$$

where x_{t+s} and x_t are their respective LQ-dealer derivative consumptions at dates $t+s$ and t, with $\mathbf{E}_t$ denoting the expectation formed at date t. These dealers have a constant returns to scale securitization function of

$$C_{t+1} = S(A_t) \equiv (\mu+\nu)A_t, \quad \nu = c + r^f, \quad \left(\frac{\mu}{\mu+\nu}\right) < \beta \tag{2.2}$$

where A_t are the input assets securitized at date t and C_{t+1} is the derivative output at date $t+1$. Also, r^f is the fraction of assets that have refinanced and c the fraction of derivatives consumed. However, only μA_t of the derivative output is marketable. Here, νA_t, is non-marketable, and can be consumed by the LQ-dealer. We introduce νA_t in order to avoid the situation in which the LQ-dealer continually postpones consumption. The ratio $\mu(\mu+\nu)^{-1}$ may be thought of as a technological upper bound on the LQ-dealer's retention rate. Since β is near 1, the inequality in (2.2) amounts to a weak assumption. We shall see later that this inequality ensures that in equilibrium the LQ-dealer will not want to consume more than illiquid derivatives. The overall return from investment, $\mu+\nu$, is high enough that all its marketable derivative output is used for investment. There are further critical assumptions we make about investing.

Assumption 2.1.1 (Derivative Technology and Labor): *We assume that each LQ-dealer's derivative technology is idiosyncratic in the sense that, once securitization has started at date t with assets, A_t, only the LQ-dealer has the skill necessary for securitizing assets into derivatives at date $t+1$. Secondly, we assume that LQ-dealer always have the option to withdraw their labor.*

In other words, if the LQ-dealer were to withdraw its labor between dates t and $t+1$, there would be no derivative output at $t+1$. Assumption 2.1.1 leads to the fact that if a LQ-dealer is highly leveraged, it may find it advantageous to threaten the HQ-dealers by withdrawing its labor and repudiating its debt contract. HQ-dealers as interbank lenders protect themselves from the threat of repudiation by collateralizing the LQ-dealer's assets. However, because assets yield no SAPs without the LQ-dealer's labor, the asset liquidation value (outside value) are less than what the assets would earn under its control (inside value). Thus, following a repudiation, it is efficient for the LQ-dealer to persuade the borrowing HQ-dealer into letting it keep the assets. In effect, the LQ-dealer can renegotiate a smaller loan. HQ-dealers know of this possibility in advance, and so take care never to allow the size of the debt (gross of interest) to exceed the value of the collateral as in the following assumption.

Assumption 2.1.2 (Credit Limit): *If at date t, the LQ-dealer has assets, A_t, then it can borrow $\mathtt{B}_t$ in total, as long as the repayment does not exceed the market value of assets at date $t+1$ given by*

$$(1 + r^{\mathtt{B}})\mathtt{B}_t \leq p_{t+1}^A A_t, \tag{2.3}$$

where p_{t+1}^A represents the asset price in period $t+1$ while A_t represents the LQ-dealer's asset holdings in period t.

Under this assumption, given rational expectations, agents have perfect foresight of future asset prices. Of course, during the financial crisis when monitoring incentives were reduced, it is unlikely that the HQ-dealer monitored the LQ-dealer closely. The LQ-dealer's balance sheet consists of illiquid assets and marketable securities (assets) as well as borrowings and capital (liabilities). Therefore, a LQ-dealer's balance sheet constraint can be represented at time t as

$$p_t^A A_{t-1} + B_t = \mathtt{B}_t + K_t, \tag{2.4}$$

where p^A, B, $\mathtt{B}$ and K represent the LQ-dealer's asset price, asset holdings, marketable securities, borrowings and capital, respectively. As we have mentioned before, the dealers' capital structure consists of equity or preferred shares, subordinated debt, mezzanine debt and AAA rated senior debt. For our purposes, B includes risky marketable securities such as ABSs, B^R, and derivatives, C. In our study, the LQ-dealer enforces a price cap (PC), with the weighted average PC being denoted by $\overline{\mathrm{p}}$ (see, for instance, [15] for more details). In this case, we have that the derivative price is given by

$$p_t^C = \min[p_t^A, \overline{\mathrm{p}}_t], \tag{2.5}$$

where C_{t-1} denotes the quantity of derivatives in period $t-1$. Hedge funds and other sophisticated investors have incentives to manipulate the pricing and structuring of derivatives. Some studies suggest that derivative managers manipulate collateral in order to shift risks among various tranches. The potential for this can be clearly seen in (2.5) where the PC offers a means of changing collateral features that are important in determining the derivative price, p_t^C. During the financial crisis, collateral 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. Nevertheless, in our case, the value of assets in period t can be represented as

$$p_t^A A_{t-1} = \mathrm{B}_t + K_t - B_t. \tag{2.6}$$

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

$$\Pi_t = \left(r_t^A + c_t^p r_t^f - (1 - r_t^R) r_t^S \right) p_t^A A_{t-1} + r^B B_t - r^{\mathrm{B}} \mathrm{B}_t, \tag{2.7}$$

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

$$p_t^A A_{t-1} = \frac{\Pi_t - r^B B_t + r^{\mathrm{B}} \mathrm{B}_t}{r_t^A + c_t^p r_t^f - (1 - r_t^R) r_t^S} \tag{2.8}$$

From (2.8) 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 derivative contracts – created serious liquidity problems during the financial crisis. Since the derivative market was quite large, the crisis caused convulsions throughout global financial markets. By considering the above, we can deduce an appropriate LQ-dealer cash flow constraint in the following result.

Lemma 2.1.3 (LQ-dealer Cash Flow Constraint): *Suppose that the credit constraint (2.3) as well as (2.6) to (2.8) hold. In this case, the LQ-dealer's cash flow is subject to the constraint*

$$\Pi_t \geq \left(r_t^A + c_t^p r_t^f - (1 - r_t^R) r_t^S \right) p_t^A A_{t-1} + r^B B_t - p_{t+1}^A A_t + \mathrm{B}_t. \tag{2.9}$$

Proof. The proof follows from taking constraint (2.3) from Assumption 2.1.2 and (2.9) into consideration. □

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

$$p_t^A(A_t - A_{t-1}) + (1+r^{\mathrm{B}})\mathrm{B}_{t-1} + x_t - \nu A_{t-1} = \mu A_{t-1} + \mathrm{B}_t. \tag{2.10}$$

2.2 HQ-Dealers

For HQ-dealers, Figure 2.2 below shows the chain formed by HQAs, ABSs and ABS derivatives.

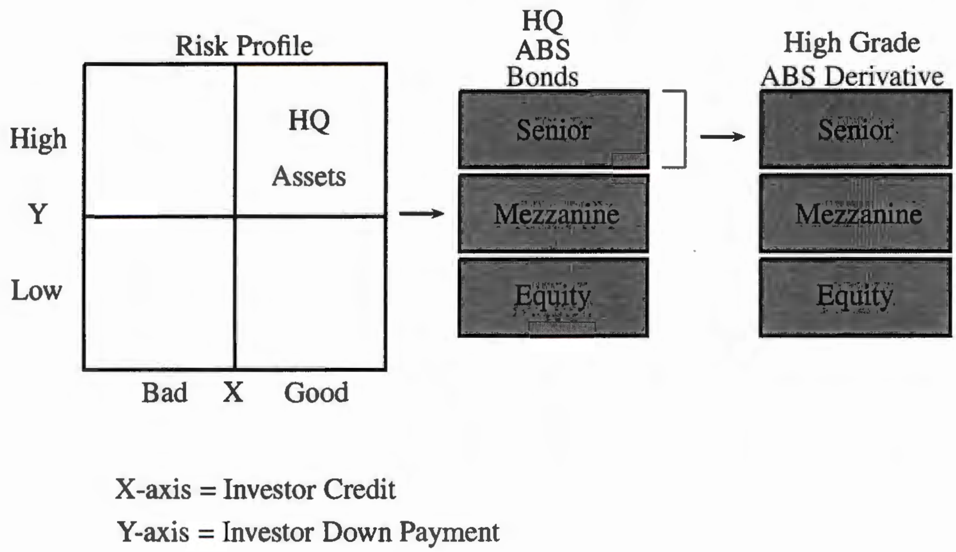

Figure 2.2: Chain of HQAs and Their Structured Products; Source: [15]

As we proceed from left to right in Figure 2.2, assets are securitized into ABSs that, in turn, get securitized into ABS derivatives. Only the higher grade ABS bonds rated AAA, AA, and A are securitized that make out the high grade ABS derivative portfolio. Figure 2.2 also suggests that HQ-dealer ABSs and derivatives are not as risky as that of the LQ-dealer since the reference asset portfolios have higher credit quality. HQ-dealer capital levels will also be greater than that of the LQ-dealer, in the sense that LQ-dealers used their capital to provision for LQA default. In this regard, we have the secondary effect of securitization where credit risk is transferred to investors. Furthermore, we assume that HQ-dealers are risk neutral, with expected utilities

$$\mathbf{E}_t\Big(\sum_{s=0}^{\infty}\beta'^s x'_{t+s}\Big) \text{ and } \mathbf{E}_t\Big(\sum_{s=0}^{\infty}\beta'^t x'_t\Big),$$

where x'_{t+s} and x'_t are their respective consumptions of derivatives at dates $t+s$ and t. For the discount factors β^s and β'^s, we have that $0 < \beta^s,\ \beta'^s < 1$ and suppose that $\beta < \beta'$. This inequality ensures that, in equilibrium, the LQ-dealer will not want to postpone securitization, because they are relatively impatient (compare with [9] and the references contained therein). The following assumption is made for ease of computation.

Assumption 2.2.1 (Price, Asset, Default and Borrowing Rate): *For HQ-dealers, suppose that $p^{A'}$, $r^{A'}$ and $r^{\mathrm{B}'}$ are the asset price, asset rate and borrowing rate, respectively. For all t, we assume that*

$$p_t^{A'} = p_t^A,\ r_t^{A'} = r_t^A \text{ and } r_t^{\mathrm{B}'} = r_t^{\mathrm{B}},$$

where p^A, r^A and r^{B} are as before for HQ-dealers. Also, we assume that the assets held by HQ-dealers do not default or refinance.

In reality, this assumption may be violated since LQAs are more expensive than HQAs. However, this adjustment can be catered for in the sequel. We shall see that in equilibrium the LQ-dealer borrows from HQ-dealers, and that the rate of interest always equals the HQ-dealers' constant rate of time preference so that

$$r^{\mathrm{B}} = r_t^{\mathrm{B}} \equiv 1/\beta' - 1.$$

All HQ-dealers have an identical securitization function that exhibits decreasing returns to scale. In this case, per unit of population, an asset input of A'_t at date t yields an output of $\widetilde{C}_{t+1}$ marketable derivatives at date $t+1$, according to

$$\widetilde{C}_{t+1} = P(A'_t), \quad \text{where } P' > 0,\ P'' < 0,\ P'\left(\frac{\overline{A}}{n}\right) < \mu(1+r^{\mathrm{B}}) < P'(0). \tag{2.11}$$

The last two inequalities in (2.11) are included to ensure that both LQ- and HQ-dealers are producing in the neighborhood of the steady-state equilibrium. HQ-dealer securitization does not require any specific skill nor do they produce any non-marketable derivatives. As a result, no HQ-dealer is credit constrained. At date t, such dealers' budget constraint can be expressed as

$$p_t^A(A'_t - A'_{t-1}) + (1+r^{\mathrm{B}})\mathrm{B}'_{t-1} + x'_t = P(A'_{t-1})_{t-1} + \mathrm{B}'_t, \tag{2.12}$$

where x'_t is secondary securitization at date t, $(1+r^{\mathrm{B}})\mathrm{B}'_{t-1}$ is debt repayment, and B'_t is new interbank borrowing. The HQ-dealers' balance sheet constraint

$$p_t^A A_{t-1}^{'} + B_t^{'} = \mathrm{B}_t^{'} + K_t^{'},$$

is the same as in the case for a LQ-dealer, but the ratios of these variables will differ from that of the LQ-dealer's with much lower risk (compare with (2.4)). In this regard, assets held by HQ-dealers are less risky, long-term loans with fixed rates. Next, the HQ-dealers' profit may be expressed as

$$\Pi_t^{'} = r_t^A p_t^A A_{t-1}^{'} + r^B B_t^{'} - r^{\mathrm{B}} \mathrm{B}_t^{'}, \tag{2.13}$$

where r^A, r^B and r^{B} represents the asset rate, returns on marketable securities and borrowing rate in period t, respectively. Notice that the prepayment cost is zero in the case for HQ-dealers (see, equation 2.9). Thus, the value of HQ-dealer assets is represented by

$$p_t^A A_{t-1}^{'} = \frac{\Pi_t^{'} - r^B B_t^{'} + r^{\mathrm{B}} \mathrm{B}_t^{'}}{r^A}. \tag{2.14}$$

From the above analysis, we conclude that an appropriate HQ-dealer cash flow constraint in the following result.

Lemma 2.2.2 (HQ-Dealer Cash Flow Constraint): *Suppose that the credit constraint (2.3) as well as (2.12) to (2.14) hold. In this case, the HQ-dealers' cash flow constraint is given by*

$$\Pi_t^{'} \geq r^A p_t^A A_{t-1}^{'} + r^B B_t^{'} - p_{t+1}^A A_t^{'} + \mathrm{B}_t^{'}. \tag{2.15}$$

2.3 Market Equilibrium

In equilibrium, $\mathrm{B}_{t-1}^{'}$ and $\mathrm{B}_t^{'}$ are negative, reflecting the fact that HQ-dealers lend to the LQ-dealers. For our purposes, market equilibrium is defined as follows.

Definition 2.3.1 (Market Equilibrium)*: **Market equilibrium** is a sequence of asset prices and allocations, debt and securitization by LQ- and HQ-dealers, given by*

$$\left\{ p_t^A,\ A_t,\ A_t^{'},\ \mathrm{B}_t, \mathrm{B}_t^{'},\ x_t,\ x_t^{'} \right\},$$

such that each LQ-dealer chooses $(A_t,\ \mathtt{B}_t,\ x_t)$ to maximize the expected discounted utilities of LQ- and HQ-dealers subject to the securitization function, borrowing constraint and flow-of-funds constraint given by (2.2), (2.3) and (2.10), respectively. On the other hand, each HQ-dealer chooses $(A_t^{'},\ \mathtt{B}_t^{'},\ x_t^{'})$ to maximize the above expected discounted utilities subject to the securitization function (2.11) and budget constraint (2.12). Also, in the case of the HQ-dealer, we have that the markets for assets, derivatives and debt clear.

2.3.1 LQ-Dealers at Equilibrium

In the sequel, we assume that the asset price bubble does not burst during securitization. In this case, it turns out that there is a locally unique perfect-foresight equilibrium path starting from initial values A_{t-1} and $\mathtt{B}_{t-1}$ in the neighborhood of the steady-state. In this state, the LQ-dealer's marketable output, μA^*, is just enough to cover the interest on their debt, $r^{\mathtt{B}}\mathtt{B}^*$. Equivalently, the required screening costs per asset unit, u^*, equals the LQ-dealer's securitization of marketable output, μ. As a result, dealers neither expand nor shrink. To further characterize dealer equilibrium, we provide the following Kiyotaki-Moore-type result.

Theorem 2.3.2 (LQ-dealer Behavior at Steady State): *Assume that the asset bubble does not burst during the securitization process. In the neighborhood of the steady-state, LQ-dealers prefer to borrow up to the maximum and invest in assets, consuming no more than their current output of non-marketable derivatives. In this case, there is a unique steady-state $(p^{A^*},\ A^*,\ \mathtt{B}^*)$, with the associated transaction fee, u^*, being given by*

$$u^* = \frac{r^{\mathtt{B}}}{1+r^{\mathtt{B}}}p^{A^*} = \frac{1}{1+r^{\mathtt{B}}}P'\left[\frac{1}{n}(\overline{A} - A^*)\right] = \mu, \tag{2.16}$$

$$\mathtt{B}^* = \frac{\mu}{r^{\mathtt{B}}}A^*. \tag{2.17}$$

Proof. The proof is analogous to that for the Kiyotaki-Moore model. □

The dealer has 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 derivatives – a type of user cost. The latter fee involves, for instance, a credit rating agency (see Section 5 for more details). Also, because of information asymmetry and regulatory dysfunction, derivatives open up opportunities for arbitrage. In this regard, sophisticated derivative dealers, often circumvent regulatory constraints. This type of arbitrage is accompanied by astronomical costs with originators and other financial intermediaries earning huge transaction fees and eroding value for dealers and investors.

Theorem 2.3.2 postulates that at each date t, the LQ-dealer's optimal choice of $(A_t,\ \mathtt{B}_t,\ x_t)$ satisfies $x_t = \nu A_{t-1}$ in (2.10), and the borrowing constraint (2.3) is binding so that

$$\mathrm{B}_t = \frac{p^A_{t+1}}{1+r^{\mathrm{B}}} A_t \text{ and } A_t = \frac{1}{p^A_t - \dfrac{1}{1+r^{\mathrm{B}}} p^A_{t+1}} \left[(\mu + p^A_t) A_{t-1} - (1+r^{\mathrm{B}}) \mathrm{B}_{t-1} \right]. \tag{2.18}$$

Here, the term $(\mu + p^A_t)A_{t-1} - (1+r^{\mathrm{B}})\mathrm{B}_{t-1}$ is the LQ-dealer's nett worth at the beginning of date t. This corresponds to the value of its marketable derivatives and assets held from the previous period nett of debt repayment. In effect, (2.18) says that the LQ-dealer uses all its nett worth to finance the difference between the asset price, p^A_t, and the amount the dealer can borrow against each asset unit, $\frac{p^A_{t+1}}{1+r^{\mathrm{B}}}$. This difference is given by

$$u_t = p^A_t - \frac{p^A_{t+1}}{1+r^{\mathrm{B}}} \tag{2.19}$$

and can be thought of as the screening costs required to purchase an asset unit. The equations of motion of the aggregate asset holding and borrowing, A_t and B_t, respectively, of dealers may be given by

$$A_t = \frac{1}{u_t} \left[(\mu + p^A_t) A_{t-1} - (1+r^{\mathrm{B}}) \mathrm{B}_{t-1} \right], \tag{2.20}$$

$$\mathrm{B}_t = \frac{1}{1+r^{\mathrm{B}}} p^A_{t+1} A_t. \tag{2.21}$$

Notice from (2.20) that if, for example, present and future asset prices, p^A_t and p^A_{t+1}, were to rise, then the LQ-dealer's asset demand at date t would also rise - provided that leverage is sufficient that debt repayments $(1+r^{\mathrm{B}})\mathrm{B}_{t-1}$ exceed current output μA_{t-1}, which holds in equilibrium. The usual notion that a higher asset price, p^A_t, reduces the LQ-dealer's demand is more than offset by the facts that they can borrow more when p^A_{t+1} is higher and their nett worth increases as p^A_t rises. Even though the required screening costs, u_t, per asset unit rises proportionately with p^A_t and p^A_{t+1}, the LQ-dealer's nett worth is increasing more than proportionately with p^A_t because of the leverage effect of the outstanding debt.

2.3.2 HQ-Dealers at Equilibrium

Next, we examine the HQ-dealers' behavior at equilibrium. Such dealers 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. In this case, we have that

$$u_t = p_t^A - \frac{p_{t+1}^A}{1+r^{\mathrm{B}}} = \frac{1}{1+r^{\mathrm{B}}} P'(A_t'). \tag{2.22}$$

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

Finally, we consider market clearing. Since all the highly rated banks have identical securitization functions, their aggregate asset demand equals A_t' times their population n. The sum of the aggregate demand for assets by the LQ- and HQ-dealers is equal to the total supply given by

$$\overline{A} = A_t + nA_t'. \tag{2.23}$$

In this case, from (2.22), we obtain the asset market (clearing) equilibrium condition

$$u_t = p_t^A - \frac{p_{t+1}^A}{1+r^{\mathrm{B}}} = u(A_t), \quad \text{where } u(A) \equiv \frac{1}{1+r^{\mathrm{B}}} P'\left[\frac{1}{n}(\overline{A} - A)\right]. \tag{2.24}$$

The function $u(\cdot)$ is increasing. This arises from the fact that if the LQ-dealer's asset demand, A_t, goes up, then in order for the asset market to clear, the HQ-dealers' demand has to be stymied by a rise in the transaction fee, u_t. Given that the HQ-dealers have linear preferences and are not credit constrained, in equilibrium they must be indifferent about any path of consumption and debt (or credit). In this case, the interest rate equals their rate of time preference so that

$$r^{\mathrm{B}} = \frac{1}{\beta'} - 1.$$

Moreover, given (2.24), the derivative markets and credit are in equilibrium.

We restrict attention to perfect-foresight equilibria in which, without unanticipated shocks, the expectations of future variables realize themselves. For a given level of the LQ-dealer's asset holding and debt at the previous date, A_{t-1} and B_{t-1}, an equilibrium from date t onward is characterized by the path of asset price, LQ-dealer asset holding and interbank borrowings given by

$$\left\{(p_{t+s}^A,\ A_{t+s},\ \mathrm{B}_{t+s}) | s \geq 0\right\},$$

satisfying equations (2.20), (2.21) and (2.24) at dates $t,\ t+1,\ t+2, \ldots.$

2.4 Dealer Equilibrium Summary

Figure 2.3 displays the main features of market equilibrium for LQ- and HQ-dealers.

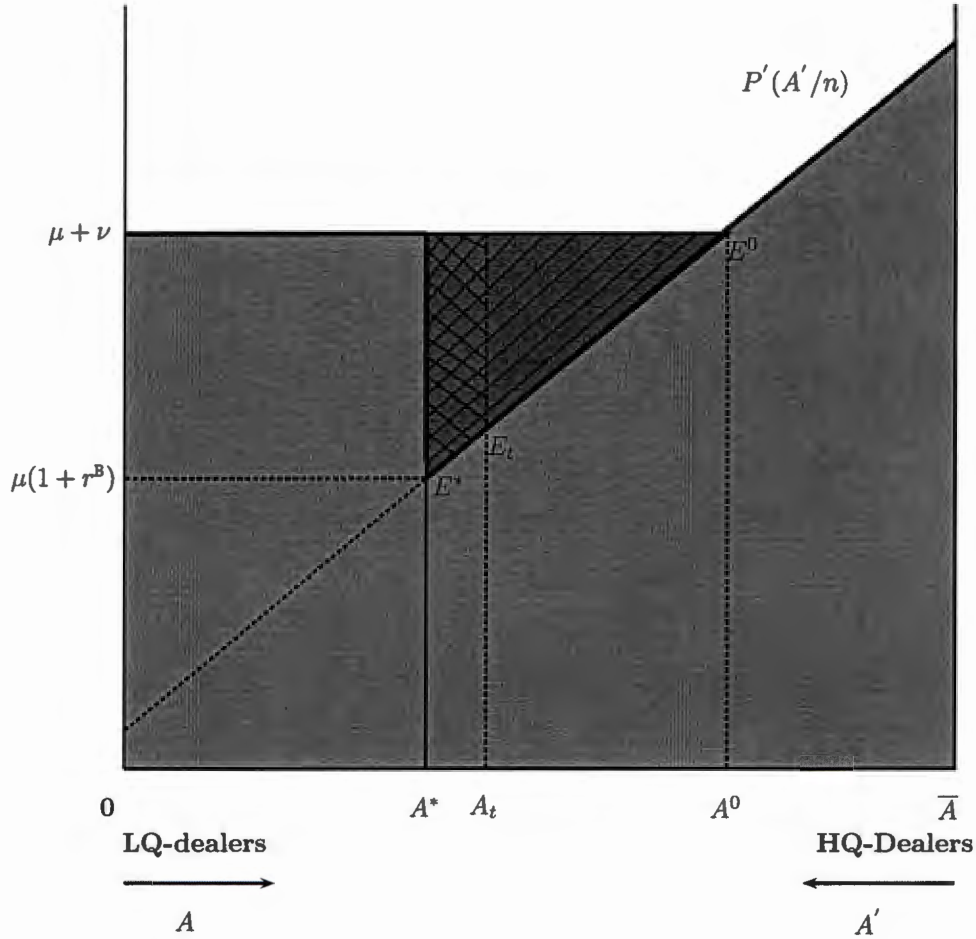

Figure 2.3: LQ- and HQ-Dealer Market Equilibrium

The horizontal axis represents LQ- and HQ-dealer asset demand from the left-hand side and right-hand-side, respectively. We note that the total asset supply is denoted by $\overline{A}$. The vertical axis represents the marginal products of assets for LQ- and HQ-dealers given by $\mu+\nu$ and $P'(A'/n)$, respectively. The HQ-dealers' 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-dealer marginal products are in equilibrium. The asset price would then be $p^0 = (\mu+\nu)(r^B)^{-1}$. On the other hand, when credit limits exist, then the equilibrium is at point E^*, where the marginal product of the LQ-dealer is greater than that of the HQ-dealer. In this case, we have that

$$\mu+\nu > P'[(\overline{A}-A^*)/n] = \mu(1+r^B).$$

This means that the LQ-dealer's asset use is not enough. The output of derivatives per period in equilibrium is represented by the green area under the thick line, whereas the red triangle represents the derivative loss per period. In this case, derivative output increases relative to the LQ-dealer's asset holding. If A_t increases, then the derivative output will also increase in period $t + 1$.

Chapter 3

Data and Methodology

3.1 Data Description

Appropriate shock parameters are given in the numerical examples and stochastic processes will be used to calculate the impact of these shocks on assets. Furthermore, for CDS pricing models and low as well as high quality asset simulations, the data used was found at the Asset Banker Association Database with both series covering the first quarter in 2002 to the second quarter in 2009. In addition, the real-world examples involve the parameters r^A and ρ, and X, p^C, Σ discussed previously. Furthermore, we will follow the amplification and persistence of shocks to asset and derivatives prices.

In particular, we addressed the impact of a temporary shock to speculative asset funding on the pricing of low quality assets (measured by risk premia) and derivatives (measured by ABX.HE indices). In this regard, we used techniques involving multivariate vector autoregressive models and generalized impulse response functions. The asset-related data was retrieved from the Federal Reserve Bank of St Louis Database and Financial Service Research Program's (FSRP) low quality asset database. These variables were analyzed using the Eviews 7 Quantitative Micro Software statistical package.

3.2 Methodology

We approach the research from both a theoretical- and numerical-quantitative view point. Where the need arised, these approaches were complemented by the use of stochastic analysis. We attempt to build a general econometric theory encompassing the shock models mentioned in previous sections as special cases.

The techniques that we employ to attain results in this research area mainly involve the innovative use of existing knowledge about cutting edge techniques in econometrics involving risk. Specifically, we were required to consider aspects of Banking Risk and Financial Theory. Further methods that we use 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. These methods were used in this paper because of their powerful applicability when working with finite time mathematics and probability theory.

Furthermore, these methods have been used before by researchers in financial economics, banking, statistics, risk management as well as academics in similar commerce and management fields to answer questions related to the work in this dissertation and they have proved to be helpful. For instance, [3] uses such methods to answer similar questions. Some of the features of this contribution is listed below.

1. Data on 30-year first assets originated by several large national L:Q-lenders during 2004.

2. Prepayment penalty was associated with lower annual percentage rate.

3. Other explanatory variables were the FICO risk score, the borrower's income, the loan to value, and whether or not reduced documentation requirements.

In [6], the following is considered.

1. Data on securitized 30-year assets originated during 2000-2002.

2. Prepayment penalty was not associated with lower interest rate.

3. Other explanatory variables were loan to value, FICO risk score, the borrower's debt-to-income ratio, whether or not income was fully documented, property type, whether or not a jumbo loan, the proportion of the population in the ZIP code area that is minority (non-whites), dummy variables for month of origination.

In this study, we use the Financial Services Research Program's Subprime Mortgage Origination Database in part to conduct the research.

1. The database contains information on all originations since Q3 1995 of eight low quality asset subsidiaries of large financial institutions.

2. The data allows us to replicate previous studies.

Chapter 4

Theoretical Quantitative Results and Analysis

In this section, we describe the effect of negative shocks on asset price and input, derivative price and output as well as profit. In this regard, two kinds of multiplier processes are considered. The first is the within-period or static multiplier process. Here, the shock reduces the nett worth of the constrained LQ-dealers and compels them to reduce their asset demand. In this case, by keeping the future constant, the transaction fees decrease to clear the market and the asset price drops by the same amount. In turn, this lowers the value of the LQ-dealer'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-dealer's nett worth and asset demand, which are in turn exacerbated by a decrease in asset price and nett worth in period t.

4.1 Dynamic Multiplier: Response to Temporary Shock

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

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

4.1.1 Dynamic Multiplier: Shock Equilibrium Path

We introduce an unexpected inter-temporal shock where the derivative output of LQ- and HQ-dealer at date t are $1-\Sigma$ times their expected levels. In order for our model to resonate with the LQ asset crisis, we take Σ to be positive. Eventually, the LQ- and HQ-dealers' securitization technologies between dates t and $t+1$ (and thereafter) return to (2.2) and (2.11), respectively. Combining the market-clearing condition (2.24) with the LQ-dealer's asset demand under a temporary shock and borrowing constraint given by (2.20) and (2.21), respectively, we obtain

$$u(A_t)A_t = (\mu - \mu\Sigma + p_t^A - p^{A^*})A^*, \text{ (date } t) \tag{4.1}$$

$$u(A_{t+s})A_{t+s} = \mu A_{t+s-1}, \text{ (dates } t+1,\ t+2,\ \ldots). \tag{4.2}$$

The formulae (4.1) and (4.2) imply that at each date the LQ-dealer can hold assets up to the level A at which the required cost of funds, $u(A)A$, is covered by its nett worth. Notice that in (4.2), at each date $t+s$, $s \geq 1$, the LQ-dealer's nett worth is just its ambient output of marketable derivatives, μA_{t+s-1}. In this case, from the borrowing constraint at date $t+s-1$, the value of the LQ-dealer's assets at date $t+s$ is exactly offset by the amount of debt outstanding. From (4.1), subsequent to the shock, we see that the LQ-dealer's nett worth at date t is more than only their current output given by

$$(1-\Sigma)\mu A^*, \tag{4.3}$$

because p_t^A changes in response to the shock and unexpected capital gains of

$$(p_t^A + p^{A^*})A^*, \tag{4.4}$$

result on their asset holdings. In this case, the asset value held from date $t-1$ is now $p_t^A A^*$, while the debt repayment is

$$(1+r^{\mathtt{B}})\mathtt{B}^* = p^{A^*}A^*. \tag{4.5}$$

To find closed-form expressions for the new equilibrium path, we take Σ to be small and linearize around the steady-state. In the sequel, we let the proportional changes in A_t, p_t^A and Π_t relative to their steady-state values, A^*, p^{A^*} and Π^* respectively, be given by

$$\widehat{A}_t = \frac{A_t - A^*}{A^*}, \ \widehat{p}_t^A = \frac{p_t^A - p^{A^*}}{p^{A^*}} \text{ and } \widehat{\Pi}_t = \frac{\Pi_t - \Pi^*}{\Pi^*} \tag{4.6}$$

respectively. For our purpose, assume that steady-state profit, Π_t^*, represents profit when the asset value and borrowings are in steady-state. Thus steady-state profit for LQ- and HQ-dealers are represented by

$$\Pi_t^* = \left(r_t^A + c_t^p r_t^f - (1 - r_t^R) r_t^S\right) p^{A^*}_t A_{t-1}^* + r^B B_t - r^{\mathrm{B}} \mathrm{B}_t^* \tag{4.7}$$

and

$$\Pi'^*_t = r^A p^{A^*}_t A'^*_{t-1} + r^B B'_t - r^{\mathrm{B}} \mathrm{B}'^*_t, \tag{4.8}$$

respectively. Then, by using the steady-state, transaction fee; (2.16), we have from equations (4.1) and (4.2) that

$$\left(1 + \frac{1}{\eta}\right)\widehat{A}_t = \frac{1 + r^{\mathrm{B}}}{r^{\mathrm{B}}}\widehat{p}_t^A - \Sigma, \ (\text{date } t) \tag{4.9}$$

$$\left(1 + \frac{1}{\eta}\right)\widehat{A}_{t+s} = \widehat{A}_{t+s-1}, \ \text{for } s \geq 1, \ (\text{dates } t+1, \ t+2, \ \ldots) \tag{4.10}$$

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

$$\frac{1}{\eta} = \left.\frac{d \log u(A)}{d \log A}\right|_{A=A^*} = -\left.\frac{d \log P'(A')}{d \log A'}\right|_{A'=1/n(\overline{A}-A^*)} \times \frac{A^*}{\overline{A} - A^*}.$$

The right-hand side of (4.9) divides the change in the LQ-dealer's nett worth at date t into two components: the direct effect of the securitization shock, Σ, and the indirect effect of the capital gain arising from the unexpected rise in price, $\widehat{p}_t^A$. In order to compute (4.9), from (2.16), (4.1) and (4.6), we have that the RHS of (4.9) is given by

$$\frac{1 + r^{\mathrm{B}}}{r^{\mathrm{B}}}\widehat{p}_t^A - \Sigma = \frac{u(A_t)A_t}{\mu A^*} - 1.$$

Also, from (2.16), (4.1) and (4.6), we have that the LHS of (4.9) is given by

$$\left(1+\frac{1}{\eta}\right)\widehat{A}_t = \left(\frac{A_t - A^*}{A^*}\right) + \left(- \frac{d\log P'(A')}{d\log A'}\bigg|_{A'=1/n(\overline{A}-A^*)} \times \frac{A^*}{\overline{A}-A^*}\right)\left(\frac{A_t - A^*}{A^*}\right).$$

Crucially, the impact of $\widehat{p}_t^A$ is scaled up by the factor $(1 + r^{\mathrm{B}})/(r^{\mathrm{B}})$ because of leverage. Furthermore, the factor $1 + 1/\eta$ on the left-hand sides of (4.9) and (4.10) reflects the fact that as the LQ-dealer's asset demand rises, the transaction fee must rise for the market to clear and, this in turn, partially chokes off the increase in the LQ-dealer's demand. The key point to note from (4.10) is that, except for the limit case of a perfectly inelastic supply $\eta = 0$, the effect of a shock persists into the future. The reason is that the LQ-dealer's ability to invest at each date $t + s$ is determined by how much screening costs they can afford from their nett worth at that date, which in turn is historically determined by their level of securitization at the previous date $t + s - 1$.

4.1.2 Dynamic Multiplier: Asset Price and Input, Derivative Price and Output as well as Profit

We will determine the size of the initial change in the LQ-dealer's asset holdings, $\widehat{A}_t$, which, from (4.9), can be jointly determined with the change in asset price, $\widehat{p}_t^A$. Also, we would like to compute the proportional change in derivative output and profit denoted by $\widehat{C}_{t+1}$ and $\widehat{\Pi}_t$, respectively.

Theorem 4.1.1 (Dynamic Multiplier: Shocks to Asset Price and Input, Derivative Price and Output and Profit): *Assume that the asset bubble does not burst during the securitization process and that $p_t^A \leq \overline{p}_t$, for all t in (2.5). In this case, we have that the proportional change in asset price and input, derivative price and output as well as profit subject to a negative shock is given by*

$$\widehat{p}_t^A = -\frac{1}{\eta}\Sigma, \tag{4.11}$$

$$\widehat{A}_t = -\frac{1}{1+\frac{1}{\eta}}\left(1+\frac{1+r^{\mathrm{B}}}{\eta r^{\mathrm{B}}}\right)\Sigma. \tag{4.12}$$

$$\widehat{p}_t^C = -\frac{1}{\eta}\Sigma \tag{4.13}$$

$$\widehat{C}_{t+1} = \frac{\mu+\nu-(1+r^{\mathrm{B}})\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\widehat{A}_t \tag{4.14}$$

$$\widehat{\Pi}_t = \frac{\left(r_t^A + c_t^p r_t^f - (1-r_t^R)r_t^S\right)p_t^A A_{t-1} + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t}{\left(r_t^A + c_t^p r_t^f - (1-r_t^R)r_t^S\right)p^{A}{}_t^* A_{t-1}^* + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t^*} - 1, \tag{4.15}$$

respectively.

Proof. Since there are no bursting bubbles, (2.24) intimates that the asset price, p_t^A, is the discounted sum of future opportunity costs given by

$$u_{t+s} = u(A_{t+s}),\ \ s \geq 0.$$

Linearizing around the steady-state and then substituting from (4.10) given by

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

we obtain

$$\widehat{p}_t^A = \frac{1}{\eta}\frac{r^{\mathrm{B}}}{1+r^{\mathrm{B}}}\sum_{s=0}^{\infty}(1+r^{\mathrm{B}})^{-s}\widehat{A}_{t+s} = \frac{1}{\eta}\frac{r^{\mathrm{B}}}{1+r^{\mathrm{B}}}\frac{1}{1-\dfrac{\eta}{(1+r^{\mathrm{B}})(1+\eta)}}\widehat{A}_t. \tag{4.16}$$

We have to verify that

$$\sum_{s=0}^{\infty}(1+r^{\mathrm{B}})^{-s}\widehat{A}_{t+s} = \frac{1}{1-\dfrac{\eta}{(1+r^{\mathrm{B}})(1+\eta)}}\widehat{A}_t = \frac{(1+r^{\mathrm{B}})(1+\eta)}{(1+r^{\mathrm{B}})(1+\eta)-\eta}\widehat{A}_t.$$

is standard for infinite series. The dynamic multiplier

$$\left[1 - \frac{\eta}{(1+r^{\mathrm{B}})(1+\eta)}\right]^{-1} = \frac{(1+r^{\mathrm{B}})(1+\eta)}{(1+r^{\mathrm{B}})(1+\eta)-\eta} \tag{4.17}$$

in (4.16) captures the effects of persistence in dealers' reference asset portfolio holdings, and has a dramatic effect on the sizes of $\widehat{p}_t^A$ and $\widehat{A}_t$. In order to find $\widehat{p}_t^A$ and $\widehat{A}_t$ in terms of the size of the shock Σ, we utilize (4.9) and (4.16). The calculations above verify that (4.11) and (4.12) as well as (4.13) hold.

Next, we prove that (4.14) holds. As we saw in Figure 2.3, aggregate derivative output - the combined harvest of LQ- and HQ-dealers - is positively correlated to the LQ-dealer's asset holdings, since such dealers marginal product is higher than the HQ-dealers'. Suppose that the proportional change in aggregate output, $\widehat{C}_{t+s}$, is given (compare with $\widehat{p}_t^A$ and $\widehat{A}_t$ above) by

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

In this case, we can verify that at each date $t+s$ the proportional change in aggregate output, $\widehat{C}_{t+s}$, is given by

$$\widehat{C}_{t+s} = \frac{\mu+\nu-(1+r^{\mathrm{B}})\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\widehat{A}_{t+s-1}, \text{ for } s \geq 1. \tag{4.18}$$

The RHS of (4.18) yields

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

In order to verify (4.18) we have to show that

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

This, of course, is true since

$$C^* = (\mu+\nu)A^* \text{ and } (1+r^{\mathrm{B}})\mu A_{t+s-1} = (1+r^{\mathrm{B}})\mu A^* \text{ or } A_{t+s-1} = A^*.$$

The proportional change in profit, $\widehat{\Pi}_t$, given by (4.15) is a direct consequence of its definition. □

The proportional changes in derivative output, $\widehat{C}$, and profit, $\widehat{\Pi}$, given by (4.14) and (4.15), respectively, have important connections with the LQ asset crisis. This relationship stems from the terms involving the asset and prepayment rates, refinancing as well as house equity.

At date t, (4.11) tells us that, in percentage terms, the effect on the asset price is of the same order of magnitude as the temporary securitization shock. As a result, the effect of the shock on the LQ-dealer's asset holdings at date t is large. In this case, the multiplier in (4.12) exceeds unity, and can do so by a sizeable margin, thanks to the factor $(1+r^{\mathrm{B}})(r^{\mathrm{B}})^{-1}$. In terms of (4.9), the indirect effect of $\widehat{p}_t^A$, scaled up by the leverage factor $(1+r^{\mathrm{B}})(r^{\mathrm{B}})^{-1}$, is easily enough to ensure that the overall effect on $\widehat{A}_t$, is more than one-for-one.

4.1.3 Dynamic Multiplier: Shocks to LQ Profit

In the low quality asset context, the paper [5] provides a relationship between the asset rate, r^A, LTVR, L, and prepayment cost, c^p, by means of the simultaneous equations model

$$
\begin{aligned}
r_t^A &= \alpha^0 L_t + \alpha^1 c_t^p + \alpha^2 X_t + \alpha^3 Z_t^{r^A} + u_t \\
L_t &= \psi^1 r_t^A + \psi^2 X_t + \psi^3 Z_t^L + v_t \\
c_t^p &= \gamma^1 r_t^A + \gamma^2 X_t + \gamma^3 Z_t^{c^p} + w_t.
\end{aligned}
\tag{4.19}
$$

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 [5], 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. [5] 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 4.1.2 (Dynamic Multiplier: Shocks to LQ Profit): *Suppose that the hypothesis of Theorem 4.1.1 holds. Then the relative change in profit may be expressed in terms of r^A, c^p and L as*

$$\widehat{\Pi}_t(r^A) = \frac{F_t p_t^A A_{t-1} + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t}{F_t p^{A}{}_t^* A_{t-1}^* + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t^*} - 1; \tag{4.20}$$

$$\widehat{\Pi}_t(c^p) = \frac{G_t p_t^A A_{t-1} + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t}{G_t p^{A}{}_t^* A_{t-1}^* + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t^*} - 1; \tag{4.21}$$

$$\widehat{\Pi}_t(L) = \frac{H_t p_t^A A_{t-1} + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t}{H_t p^{A}{}_t^* A_{t-1}^* + r^B B_t - r^{\mathrm{B}}\mathrm{B}_t^*} - 1, \tag{4.22}$$

respectively. Here, we have in (4.20), (4.21) and (4.22) that

$$\begin{aligned} F_t &= r_t^A(1+\gamma^1 r_t^f) + (\gamma^2 X_t + \gamma^3 Z_t^{c^p} + w_t) r_t^f - (1 - r_t^R) r_t^S, \\ G_t &= c_t^p(1/\gamma^1 + r_t^f) - 1/\gamma^1(\gamma^2 X_t + \gamma^3 Z_t^{c^p} + w_t) - (1 - r_t^R) r_t^S \end{aligned}$$

and

$$H_t = \left[\gamma^1\left\{\frac{1}{\psi^1}L_t - \frac{\psi^2}{\psi^1}X_t - \frac{\psi^3}{\psi^1}Z_t^L - \frac{1}{\psi^1}v_t\right\} + \gamma^2 X_t + \gamma^3 Z_t^{c^p} + w_t\right][\gamma^1 + r_t^f]$$
$$+\alpha^0 L_t + \alpha^2 X_t + \alpha^3 Z_t^{r^A} + u_t - (1 - r_t^R) r_t^S,$$

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 LQA 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 (4.20) to (4.22) in Corollary 4.1.2. 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.

4.2 Static Multiplier: Response to Temporary Shocks

At the beginning of this section we made a distinction between static and dynamic multipliers. Imagine, hypothetically, that there were no dynamic multiplier. In this case, suppose p_{t+1}^A were artificially pegged at the steady-state level p^{A^*}. Equation (4.9) would remain unchanged. However, the right-hand side of (4.16) would contain only the first term of the summation - the term relating to the change in transaction fee at date t - so that the multiplier (4.17) would disappear. Combining the modified equation, we have that

$$\widehat{p_t^A} = \left[\frac{r^{\mathrm{B}}}{\eta(1+r^{\mathrm{B}})}\right]\widehat{A}_t.$$

The following result follows from the above.

Corollary 4.2.1 (Static Multiplier: Shocks to Asset Price and Input): *For the static multiplier, suppose that the hypothesis of Theorem 4.1.1 holds. Then we have that*

$$\widehat{p_t^A}|_{p_{t+1}^A = p^{A*}} = -\frac{r^{\mathrm{B}}}{\eta(1+r^{\mathrm{B}})}\Sigma, \tag{4.23}$$

$$\widehat{A}_t|_{p_{t+1}^A = p^{A*}} = -\Sigma. \tag{4.24}$$

Proof. We prove the result by considering (4.9) and (4.16) where the changes in the asset price and the LQ-dealer's asset holdings that can be solely traced to the static multiplier. □

Subtracting (4.23) from (4.11), we find that the additional movement in asset price attributable to the dynamic multiplier is $(1 + r^{\mathrm{B}})^{-1}$ times the movement due to the static multiplier. And a comparison of (4.12) with (4.24) shows that the dynamic multiplier has a similarly large proportional effect on the LQ-dealer's asset holdings. The term

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

reflects the difference between the LQ-dealer's securitization (equal to $\mu + \nu$) and the HQ-dealers securitization (equal to $(1 + r^{\mathrm{B}})\mu$ in the steady-state). The ratio $(\mu + \nu)A^*C^{*-1}$ is the share of the LQ-dealer's output. If aggregate securitization were measured by $C_{t+s}\overline{A}^{-1}$, it would be persistently above its steady-state level, even though there are no positive securitization shocks after date t. The explanation lies in a composition effect. In this regard, there is a persistent change in asset usage between LQ- and HQ-dealers, which is reflected in increased aggregate output.

Chapter 5

Numerical Quantitative Results and Discussion

5.1 Examples of Shocks to LQA Products

In this section, we provide a numerical and real-world example to illustrate the effects of shocks to asset and CDO prices.

5.1.1 Numerical Example

In this example, we primarily illustrate dealer equilibrium (see Subsection 5.1.2.1 for more details) and shocks to low quality assets and their structured products (see Subsection 5.1.2.2). Importantly, in Subsection 5.1.1.3, we provide a summary and analysis of the aforementioned subsections. For periods t and $t-1$, we make choices of appropriate asset parameters in Table 5.1 below.

Parameter	Value	Parameter	Value	Parameter	Value
μ	0.001	ν	0.1	α	0.5
p_{t+1}	0.013	c^{p}	0.05	r^{f}	0.01
$\overline{A}_t$	680 000	$\overline{A}_{t-1}$	420 000	r^{A}	0.051
r^{R}	0.5	r^{S}	0.15	$\mathtt{B}_t$	\$ 4 000
$\mathtt{B}_{t-1}$	\$ 2 100	$r^{\mathtt{B}}$	0.1	B_t	\$ 3 500
r^{B}	0.105	K_t	\$ 3 000	n	1
Σ	0.0010	C^{*}	200 000	$P(A'_{t-1})$	240 000

Table 5.1: Asset Parameter Choices

5.1.1.1 Numerical Example: Dealer Equilibrium

The coverage offered by the example in this subsection includes the securitization function, balance sheet as well as the cash flow, LQ-dealer cash flow, LQ-dealer flow of funds, HQ-dealer budget and HQ-dealer cash flow constraints, given by (2.2), (2.6), (2.9), (2.10), (2.12), (2.15), respectively. Also, the variables p^{C}, Π', A', p^{A*}, $\mathtt{B}^{*}$, u_t, A, $\mathtt{B}$ and $\overline{A}$ presented in (2.5), (2.13), (2.14), (2.16), (2.17), (2.19), (2.20), (2.21) and (2.23), respectively, are incorporated in our numerical example. Suppose that the LQ- and HQ-dealer borrowings, marketable securities and capital are equal at the outset. In this case, notice that the LQ- and HQ-dealer 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 $A' = (1-\alpha)\overline{A} = (1-0.5) \times 680000 = 340000$.

We begin by computing the sub-dealer's CDO output in period $t+1$ by considering the securitization function (2.2). Therefore, the CDO output can be computed by

$$C_{t+1} = (\mu+\nu)A_t = (\mu+\nu)\alpha\overline{A_t} = (0.001+0.1) \times 0.5 \times 680000 = 34340.$$

Next, the upper bound of the LQ-dealer's retention rate is less that the discount factor β in (2.1) so that

$$\beta > \left(\frac{0.001}{0.001 + 0.1}\right) = 0.00990099.$$

The value of LQ-dealer assets in period t is computed by using (2.6). Thus,

$$p_t^A A_{t-1} = \mathrm{B}_t + K_t - B_t = 4000 + 3000 - 3500 = 3500.$$

The asset price in period t is therefore

$$p_t^A = 3500/A_{t-1} = 3500/(\alpha \overline{A}_{t-1}) = 3500/(.5 \times 420000) = 0.0167.$$

The LQ-dealer's profit is computed by considering the cash flow constraint (2.9) so that

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

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

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

We compute the LQ-dealer's additional consumption, $x_t - \nu A_{t-1}$, by considering the flow-of-funds constraint (2.10) given by

$$\begin{aligned} 0.00\overline{1} \times 0.5 \times 420000 + 4000 - (1 + 0.1) \times 2100 - 0.0167(0.5 \times 680000 - 0.5 \times 420000) \\ = -271 \end{aligned}$$

Thus, $x_t = 20729$.

Next, we concentrate on the pri-dealer constraints. Such a dealers' securitization at date t is computed by using the budget constraint (2.12), so that

$$\begin{aligned} x_t^{'} &= 240000 + 4000 - 0.0167((1 - 0.5)680000 - (1 - 0.5)420000) - (1 + 0.1) \times 2100 \\ &= 239519. \end{aligned}$$

Next, we compute the HQ-dealers' profit, (2.13), at face value at date t as

$$\Pi_t^{'} = 0.051 \times 3500 + 0.105 \times 3500 - 0.1 \times 4000 = 146$$

Also, the value of assets (2.14) can be computed as

$$p_t^A A_{t-1}^{'} = \frac{146 - 0.105 \times 3500 + 0.1 \times 4000}{0.051} = 3500$$

The HQ-dealers' cash flow constraint (2.15), given by

$$\Pi_t^{'} \geq 0.051 \times 3500 + 0.105 \times 3500 - 0.013 \times (1 - 0.5)680000 + 4000 = 126.$$

The screening cost incurred by an LQ-dealer to purchase an asset unit is financed by the LQ-dealer's nett worth. This cost is represented by (2.19) and may be computed as

$$u_t = 0.0167 - \frac{0.013}{1 + 0.1} = 0.00488.$$

The motion of the aggregate asset holding and borrowing, A_t and $\mathtt{B}_t$ of the dealer represented by (2.20) and (2.21) may be computed as

$$A_t = \frac{1}{0.00488}\left[(0.001 + 0.0167) \times 0.5 \times 420000 - (1 + 0.1) \times 2100\right] = 288319.6721 \text{ and}$$

$$\mathtt{B}_t = \frac{1}{1 + 0.1} 0.013 \times 0.5 \times 680000 = 4018.18.$$

The sum of the aggregate asset demand by LQ- and HQ-dealers represented by (2.23) is computed by

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

Next, the steady-state asset price and borrowings for the LQ-dealer, represented by (2.16) and (2.17), are

$$p^{A^*} = 0.001 \frac{1 + 0.1}{0.1} = 0.011 \text{ and } \mathtt{B}^* = \frac{0.001}{0.1} 210000 = 2100.$$

Notice that the required screening costs per asset unit equals the LQ-dealer's securitization of marketable output, $u^* = \mu = 0.001$, also $A_{t-1} = A^*$ and $\mathrm{B}_{t-1} = \mathrm{B}^*$.

5.1.1.2 Numerical Example: Shocks to LQAs and Their Structured Products

The variables u^A, B, presented in (4.1), (4.3), (4.4), (4.5), (4.6), (4.7), (4.8), (4.9), (4.18), (4.23) and (4.24), respectively, are covered by the example in this subsection. At date t, the LQ-dealer's 146 asset demand and borrowings under a temporary shock given by (2.20) and (2.21), respectively, are computed as

$$\begin{aligned} A_t &= \frac{1}{0.00488}\left[(0.001 - 0.001 \times 0.001 + 0.0167) \times 0.5 \times 420000 - (1 + 0.1) \times 2100\right] \\ &= 288276.6393 \end{aligned}$$

and

$$\mathrm{B}_t = \frac{1}{1+0.1} 0.013 \times 0.5 \times 680000 = 4018.18,$$

respectively. In this regard, we compute the cost of funds (4.1) in period t, as

$$\begin{aligned} u(A_t)A_t &= (0.001 - 0.001 \times 0.001 + 0.0167 - 0.011)0.5 \times 420000 \\ &= 1406.79. \end{aligned}$$

Also, we see that the LQ-dealer's nett worth at date t is more than their current output immediately after the shock given by (4.3), so that

$$(1 - \Sigma)\mu A^* = (1 - 0.001)0.001 \times 0.5 \times 420000 = 209.79.$$

Here unexpected capital gains (4.4) are given by

$$(p_t^A + p^{A^*})A^* = (0.0167 + 0.011)0.5 \times 420000 = 5817$$

while the debt repayment (4.5) is

$$(1 + r^{\mathrm{B}})\mathrm{B}^* = (1 + 0.1)2100 = 2310.$$

The proportional changes in A_t and p_t^A in (4.6) can be computed by

$$\widehat{A}_t = \frac{0.5(680000 - 420000)}{0.5 \times 420000} = 0.619047619 \text{ and}$$
$$\widehat{p}_t^A = \frac{0.0167 - 0.011}{0.011} = 0.5182,$$

respectively. The steady-state profit for LQ- and HQ-dealers given by (4.7) and (4.8), respectively, are

$$\begin{aligned}\Pi_t^* &= (0.051 + 0.05 \times 0.01 - (1 - 0.5) \times 0.15)0.011 \times 0.5 \times 420000 + 0.105 \times 3500 - 0.1 \times 2100 \\ &= 103.215\end{aligned}$$

and

$$\begin{aligned}\Pi_t^{'*} &= 0.051 \times 0.011 \times (1 - 0.5) \times 420000 + 0.105 \times 3500 - 0.1 \times 2100 \\ &= 275.31\end{aligned}$$

respectively. Thus, the proportional changes in Π_t and $\Pi_t^{'}$ are

$$\widehat{\Pi}_t = \frac{-114.75 - 103.215}{103.215} = -2.1118 \text{ and } \widehat{\Pi}_t^{'} = \frac{146 - 275.31}{275.31} = -0.4697,$$

respectively. At date , t the elasticity of the residual asset supply to the LQ-dealers with respect to the transaction fee at the steady-state in (4.9) is

$$\eta = \left[\frac{\frac{1+0.1}{0.1}0.5182 - 0.001}{0.619047619} - 1\right]^{-1} = 0.1086.$$

Furthermore, the proportional changes in $\widehat{p}_t^A$ and $\widehat{A}_t$ in terms of the size of the shock Σ in (4.11) and (4.12) may be computed as

$$\widehat{p}_t^A = -\frac{1}{0.1086}0.001 = 0.0092 \text{ and}$$
$$\widehat{A}_t = -\frac{1}{1 + \frac{1}{0.1086}}\left(1 + \frac{1 + 0.1}{0.1086 \times 0.1}\right)0.001 = 0.01,$$

respectively. By considering (4.9), we see from (4.23) and (4.24) that $\widehat{p}_t^A$ and $\widehat{A}_t$ become

$$\widehat{p}_t^A|_{p_{t+1}^A=p^{A*}} = -\frac{0.1}{0.1086(1+0.1)}0.001 = 0.0008 \text{ and}$$
$$\widehat{A}_t|_{p_{t+1}^A=p^{A*}} = -0.001,$$

respectively. The proportional change in aggregate output, $\widehat{C}_{t+1}$, represented by (4.14) is given by

$$\begin{aligned}\widehat{C}_{t+1} &= \frac{0.001+0.1-(1+0.1)0.001}{0.001+0.1}\frac{(0.001+0.1)0.5\times 420000}{200000}0.619047619\\ &= 0.0649.\end{aligned}$$

5.1.1.3 Numerical Example: Summary and Analysis

We provide a summary of computed shock parameters in Table 5.2 below.

Parameter	Value	Parameter	Value
C_{t+1}	34 340	$\beta >$	0.00990099
$p_t^A A_{t-1}$	\$ 3 500	Π_t	\$ -114.75
$\Pi_t \geq$	\$ -134.75	x_t	\$ 20 729
$x_t^{'}$	\$ 239 519	$\Pi_t^{'}$	\$ 146
$p_t^A A_{t-1}^{'}$	\$ 3 500	$\Pi_t^{'} \geq$	\$ 126
u_t	0.00488	Aggregate A_t	288 319.6721
Aggregate B_t	\$ 4 018.18	$\overline{A}$	680 000
p^{A^*}	0.011	B^*	\$ 2 100
A_t under shock	288 276.6393	B_t under shock	\$ 4 018.18
$u(A_t)A_t$	1 406.79	$(1-\Sigma)\mu A^*$	209.79
$(p_t^A + p^{A^*})A^*$	\$ 5 817	$(1+r^{\mathrm{B}})\mathrm{B}^*$	\$ 2 310
$\widehat{A}_t$	0.619047619	$\widehat{p}_t^A = \widehat{p}_t^C$	0.5182
Π_t^*	\$ 103.215	$\Pi^{*'}$	\$ 275.31
$\widehat{\Pi}_t$	\$ -2.1118	$\widehat{\Pi}_t^{'}$	\$ -0.4697
η	0.1086	$\widehat{p}_t^A$ in terms of shock	0.0092
$\widehat{A}_t$ in terms of shock	0.01	$\widehat{p}_t^A$ where $p_{t+1}^A = p^{A*}$	0.0008
$\widehat{A}_t$ where $p_{t+1}^A = p^{A*}$	-0.001	$\widehat{C}_{t+1}$	0.0649

Table 5.2: Computed Asset Parameters

An analysis of the computed shock parameters has some interesting implications for the financial crisis. HQ-dealer consumption is much higher than that of the LQ-dealer. This may result from the fact that the high quality market was much more sensitive to changes in market conditions and that asset transformation may have been a greater priority. Also, the proportional negative change in profit for the LQ-dealer subsequent to a temporary shock is higher than that of the HQ-dealers. This is consistent with what happened during the financial crisis where the extent of low quality defaults were more severe than high quality defaults (compare with [15]). In turn, the negative impact on the performance of securitized low quality assets was greater than that of other securitized assets (compare with Table 1.2).

The computations involving CDOs done in Subsections 5.1.2.1 and 5.1.2.2 also point towards the mispricing of debt as a major contributor to the low quality asset crisis (see, for instance, Table 5.2). First of all 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. Also, the apparent value created by CDOs violates economic theory that postulates that similar reference assets and bonds should have similar values. During the financial crisis, another problem related to the mispricing of CDO collateral was short selling. The methods used to rate CDOs are complicated, arbitrary and opaque. In fact, during the low quality asset crisis, they create opportunities for dealers to create a ratings arbitrage opportunity without enhancing value.

5.1.2 Numerical Example

The following numerical example differs from 5.1 in that the asset parameter choices have been adjusted accordingly. The aggregate asset value $\bar{A}_t$ has been increased from 680, 000 to 720, 000. The asset borrowing of the dealer in periods B_t and B_{t-1} have been increased to \$5000 and \$2600 respectively. The aim is to find out what happens to LQ assets when they are hit with a shock (Σ) of 0.002.

Parameter	Value	Parameter	Value	Parameter	Value
μ	0.002	ν	0.2	α	0.3
p_{t+1}	0.113	c^p	0.03	r^f	0.2
$\overline{A}_t$	720 000	$\overline{A}_{t-1}$	460 000	r^A	0.061
r^R	0.5	r^S	0.15	B_t	\$ 4 800
B_{t-1}	\$ 2 600	r^{B}	0.2	B_t	\$ 5 000
r^B	0.205	K_t	\$ 3 000	n	1
Σ	0.002	C^*	240 000	$P(A_{t-1}^{'})$	240 000

Table 5.3: Asset Parameter Choices

5.1.2.1 Numerical Example: Dealer Equilibrium

Suppose that the low quality and high quality dealer's deposits, borrowings, marketable securities and capital are equal. In this case, notice that the low quality and high quality dealer's asset holdings, A and A' are a proportion, α and $1-\alpha$ of the aggregate assets, $\bar{A}$, respectively.

Thus $A = \alpha\bar{A} = 0.3720000 = 216000$ *and* $A' = (1-\alpha)\bar{A} = (0.6-0.3)720000 = 216000$.

We compute the low quality dealer's derivative output in period t+1 by considering the securitization function (2.2). Therefore, the derivative output can be computed by

$$C_{t+1} = (\mu+\nu)A_t = (\mu+\nu)\alpha\bar{A}_t = (0.002+0.2)\times 0.3\times 720000 = 43632$$

Next, the upper bound of the low quality dealer'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 low quality dealer assets in period t is computed by using (2.6). Thus,

$$p_t^A A_{t-1} = D_t + B_t + K_t - B_t = 1200 + 4800 + 3000 - 5000 = 4000$$

The asset price in period t is therefore

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

The low quality dealer's profit is computed by considering the cash flow constraint (2.7)

$$\Pi_t = (r^A + c_t^p r_t^f)p_t^A A_{t-1} + r^B B_t - r^D D_t - r^B B_t$$

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

Furthermore, the low quality dealer's profit is subject to the constraint (2.9), thus

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

We compute the low quality dealer's additional consumption, $x_t - \nu A_{t-1}$ 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, we concentrate on the high quality dealer's constraints. A high quality dealers' secondary securitization at date t is computed by using the budget constraint (2.12), thus

$$x_t^{'} = 280000 + 4800 - 0.011904761(1 - 0.3)720000 - (1 - 0.3) \times 460000 - (1 + 0.2) \times 2600 = -46319.99954$$

Thus $x_t = 54103.64210$

Next, we consider the high quality dealer's profit (2.13) at face value to compute profit at date t, thus

$$\Pi_t^{'} = 0.061 \times 4000 + 0.205 \times 5000 - 0.205 \times 1500 - 0.2 \times 4800 = 123.5$$

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

$$p_t^A A_{t-1}^{'} = \frac{123.5 - 0.205 \times 5000 + 0.205 \times 1200 + 0.2 \times 4800}{0.061} = 4991.8$$

The high quality dealer's cash flow constraint (2.15), given by

$$\Pi_t^{'} \geq 0.061 \times 4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.113(1 - 0.3) \times 720000 + 4800 = -51007$$

The screening cost a low quality dealer has to pay to purchase the asset unit is financed by the high quality dealer's net worth. This screening cost is represented by;

$$u_t = p_t^A - \frac{p_{t+1}^A}{1 + r^B} = 0.011904761 - \frac{0.113}{1 + 0.2} = -0.082261905$$

The motion of the aggregate asset holding and borrowing, A_t and B_t of the dealer may be computed as;

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

and

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

The sum of the aggregate asset demand from the originators by the low quality and high quality dealers' is computed by;

$$\bar{A} = A_t + nA_t^{'} = 0.3 \times 720000 + 1(1 - 0.3)720000 = 720000$$

The steady-state asset price and borrowings for the low quality dealer

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

Notice that the required screening costs per asset unit equals the low quality dealers' securitization of marketable output, $u^* = \mu = 0.001$, also $A_{t-1} = A^* and B_{t-1} = B^*$.

5.1.2.2 Numerical Example: Shocks to LQAs and Their Structured Products

Low quality dealer's asset demand and borrowings under a temporary shock at date t are computed by;

$$A_t = \frac{1}{-0.082261905}[(0.002 - 0.002 \times 0.002 + 0.011904761) \times 0.3 \times 460000 - (1+0.2) \times 2600] = 14608.15893$$

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

respectively. In this regard, we compute the cost of funds in period t, as

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

Also, we see that the low quality dealers' net worth at date t 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

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

While the debt repayment is,

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

Proportional change in A_t and p_t^A can be computed by,

$$\hat{A}_t = \frac{0.3(720000 - 460000)}{0.3 \times 460000} = 0.565217391$$

and

$$\hat{p}_t^A = \frac{0.011904761 - 0.022}{0.022} = -0.4588745$$

Steady state profit for low quality dealer

$$\Pi_t^* = (0.061 + 0.03 \times 0.2)0.022 \times 0.3 \times 460000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.2 \times 2600 \\ = 462.412$$

and Steady state profit for high quality dealer

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

Thus, the proportional changes in Π_t and $\Pi_t^{'}$ are

$$\hat{\Pi}_t = \frac{87 - 462.412}{462.412} = -0.81186$$

and

$$\hat{\Pi}_t^{'} = \frac{123.5 - 691.124}{691.124} = -0.82131$$

Elasticity of the residual asset supply to the low quality dealers with respect to the monitoring cost at the steady state at date t

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

The proportional changes for $\hat{p}_t^A$ and $\hat{A}_t$ in terms of the size of the shock Σ are computed by

$$\hat{p}_t^A = -\frac{1}{0.126718931} 0.002 = -0.015782961$$

and

$$\hat{A}_t = -\frac{1}{1 + \frac{1}{0.126718931}} \left(1 + \frac{1 + 0.2}{0.126718931 \times 0.2} \right) 0.002 \\ = -0.010875327$$

respectively. By considering (3.9), we see from (3.18) and (3.19) that $\hat{p}_t^A$ and $\hat{A}_t$ become

$$\hat{p}_t^A \Big|_{p_{t+1}^A = p^{A*}} = -\frac{0.2}{0.126718931(2 + 0.2)} 0.002 = -0.001434814$$

and

$$\hat{A}_t \Big|_{p_t^A + 1 = p^{A*}} = -0.002$$

respectively. The proportional change in aggregate output,C_{t+1},represented by (3.13) is given by

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

We provide a summary of computed shock parameters in Table 5.4 below.

Parameter	**Value**	**Parameter**	**Value**
C_{t+1}	43 632	$\beta >$	0.0099099
$p_t^A A_{t-1}$	\$ 4 000	Π_t	\$ 87
$\Pi_t \geq$	\$ -18 561	x_t	\$ 54 103.6421
$x_t^{'}$	\$ -46 319.9995	$\Pi_t^{'}$	\$ 123.5
$p_t^A A_{t-1}^{'}$	\$ 4 991.8	$\Pi_t^{'} \geq$	\$ -51 007
u_t	-0.082261905	Aggregate A_t	14 601.44865
Aggregate B_t	\$ 20 340	$\overline{A}$	720 000
p^{A^*}	0.012	B^*	\$ 2 600
A_t under shock	\$ 14 608.15893	B_t under shock	\$ 20 340
$u(A_t)A_t$	-1 117.69	$(1-\Sigma)\mu A^*$	275.448
$(p_t^A + p^{A^*})A^*$	\$ 4 679	$(1+r^{\mathrm{B}})\mathrm{B}^*$	\$ 3 120
$\widehat{A}_t$	0.565217391	$\widehat{p}_t^A = \widehat{p}_t^C$	-0.4588745
Π_t^*	\$ 462.412	$\Pi^{*'}$	\$ 275.31
$\widehat{\Pi}_t$	\$ -2.1118	$\widehat{\Pi}_t^{'}$	\$ 691.124
η	0.126718931	$\widehat{p}_t^A$ in terms of shock	-0.015782961
$\widehat{A}_t$ in terms of shock	0.01	$\widehat{p}_t^A$ where $p_{t+1}^A = p^{A*}$	-0.001434814
$\widehat{A}_t$ where $p_{t+1}^A = p^{A*}$	-0.002	$\widehat{C}_{t+1}$	0.064869

Table 5.4: Computed Asset Parameters

An analysis of the computed shock parameters shows that the aggregate output $\hat{C}_{t+1}$ increases to \$43 632. The value of low quality dealer assets $p_t^A A_{t-1}$ increases to \$5000. Low quality dealer asset demand A_t has reduced to \$14608.15893 while the borrowings B_t have increased to \$20340 implying that high market was much more sensitive to changes in market conditions and that the asset transformation may have been a greater priority. Also, the proportional negative change in profit for the LQ-dealer subsequent to a temporary shock is higher than that of the HQ-dealers. In addition, the steady-state asset price p^{A^*} and the borrowings B^* for low quality dealer increased to 0.012 and 2600 respectively. In summary, this example shows that when parameter choices are altered and the size of shock increased, low quality dealers suffer huge losses on their asset holdings and the rate of borrowing to refinance increases. This explains why most people could not pay back their asset loans during the financial crisis in the period 2007-2009.

5.1.3 Real-World Example of Shocks to Asset and SAP Prices

This real-world example involves the parameters r^A and ρ, c^p and X, p^C, Σ, and discussed in (1.1), (4.19), (2.5) and (4.1), respectively. In this subsection, we follow [14] by considering the amplification and persistence of shocks to asset and SAP prices (see, [2] for more on such classification). In particular, we address the impact of a temporary shock to speculative asset funding on the pricing of low quality assets (measured by risk premia) and SAPs (measured by ABX.HE indices). In this regard, we make use of techniques involving multivariate vector autoregressive models and generalized impulse response functions (see, also, [7]). The asset-related data was retrieved from the Federal Reserve Bank of St Louis Database and Financial Service Research Program's (FSRP) low quality database. These variables were analyzed using the Eviews 7 Quantitative Micro Software statistical package.

5.1.4 GIRFs for Asset Price

Figure 5.1 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, [15] 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, [4] and [13] for further details).

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 [7] 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.

A positive shock to asset rates results in a decrease in asset price. In addition, from Figure 5.1, 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 [15] that shows how asset rate volatility has a major impact on asset price in a low quality context (see. also, [13]). The shocks originating from prepayment rates and asset terms appear to have responses that are weakly amplified and persistent (see, for instance, [9] for more evidence).

5.1.4.1 GIRFs for ABX Price

Figure 5.2 elucidates the impulse responses of ABX price to shocks from several asset-related variables. It is clear that shocks to speculative asset funding, ABX price, investor risk characteristics and prepayment rate have positive, strongly amplified and persistent effects on ABX price. This tendency is to be expected (see, for instance, [7] and [8]). By contrast, shocks to asset price and rate as well as asset terms appear to have weaker amplification and persistence effects on ABX prices. This is in keeping with the results in [7] (see, also, [15]).

5.2 Two-Dimensional Modeling of Credit Default Swap (CDS) Pricing

The 2D models are made up of the following; The Runtime represents the period during which the monte carlo simulation is running, the MeanRevValue shows the level at which interest rates tend to revert back to the mean levels, the MeanRevSpeed shows the speed of mean reversion given by $dS = k(\theta - S)dt + \sigma dz$ where k is the continous-time speed of mean reversion, θ is the mean reversion level, and σ is the continous-time deviation of price changes. Furthermore, coupon rate shows how for example prepayments are not only path-dependent but the periodic coupon rate depends on the history of the reference rate upon which the coupon is determined. Walkers show random walks in the default probability and are in line with diffusion processes. The potential ϕ is represented by values on a regular array of mesh points while the mesh length shows the array size. Finally, the time-step shows the value of the asset at that period.

The model above examined two factors that are important for the valuation of credit default swaps (CDS): the stochastic evolution of both the interest rate and the default intensity. Keeping one of the factors fixed, 1D models have been validated against simple limiting cases. For the case of a large volatility in the interest rates of 10%, studies showed that the value of a typical CDS can increase up to 6% when it is compared with fixed interest rates. In the same manner a standard deviation of the hazard rate of 40% (typical of a speculative CCC bond) decreases the neutral point (where the contract is worthless) by 6%; this shows that a stochastic component in the hazard rate decreases the expected default and increases the value of the insurance contract. Because of the compounding of interest and the hazard rates, mean reverting drifts can, under the circumstances, be even more important.

Combining stochastic hazard and interest rates into a 2D model yields a value that is considerably different from the single factor models. For the same parameters as in the previous section, the value obtained from the 1D interest rate model can be more than 60% lower than the CDS value calculated with the 2D model. The largest difference is obtained for the one factor model of interest rate where the default probability does not evolve during the life time of the contract.

Note that this model neglected the correlation between the interest rate and the hazard rate. This is an obvious limitation that could be removed by making the default intensity $h = h(\sigma, r)$ dependent on the interest rate. The subject should be of sufficient interest to warrant more detailed studies.

5.1.3.1 GIRFs for Asset Price

The graphs below present the findings about asset prices and their responses to the temporary shocks mentioned above. Note that the abbreviations SMF, RML, MR and IR denote speculative mortgage funding, mortgages, mortgagor and mortgage rate, respectively, (mortgages are explained as assets in the paper).

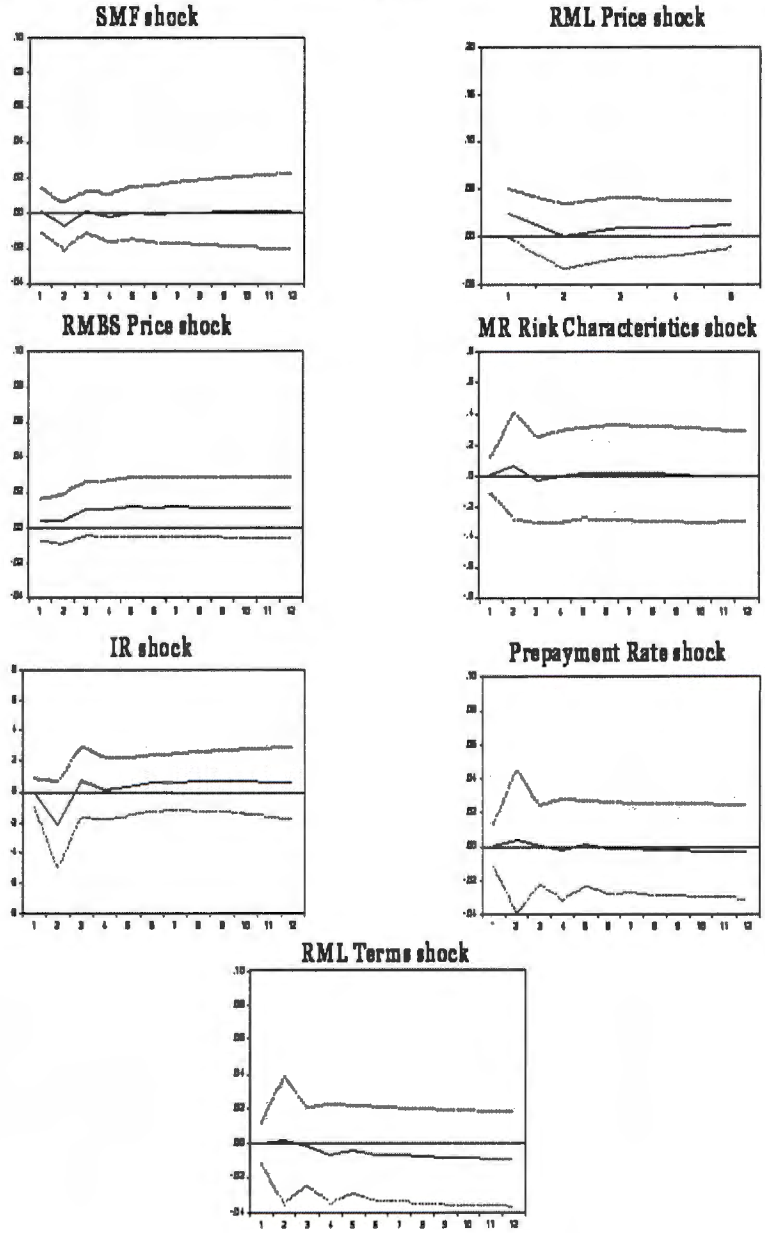

Figure 5.1: GIRF of Asset Prices Under Various Shocks

5.2.2 GIRF of ABX Prices Under Various Shocks

The following sketches summarize the above findings about ABX price and their responses to various financial shocks.

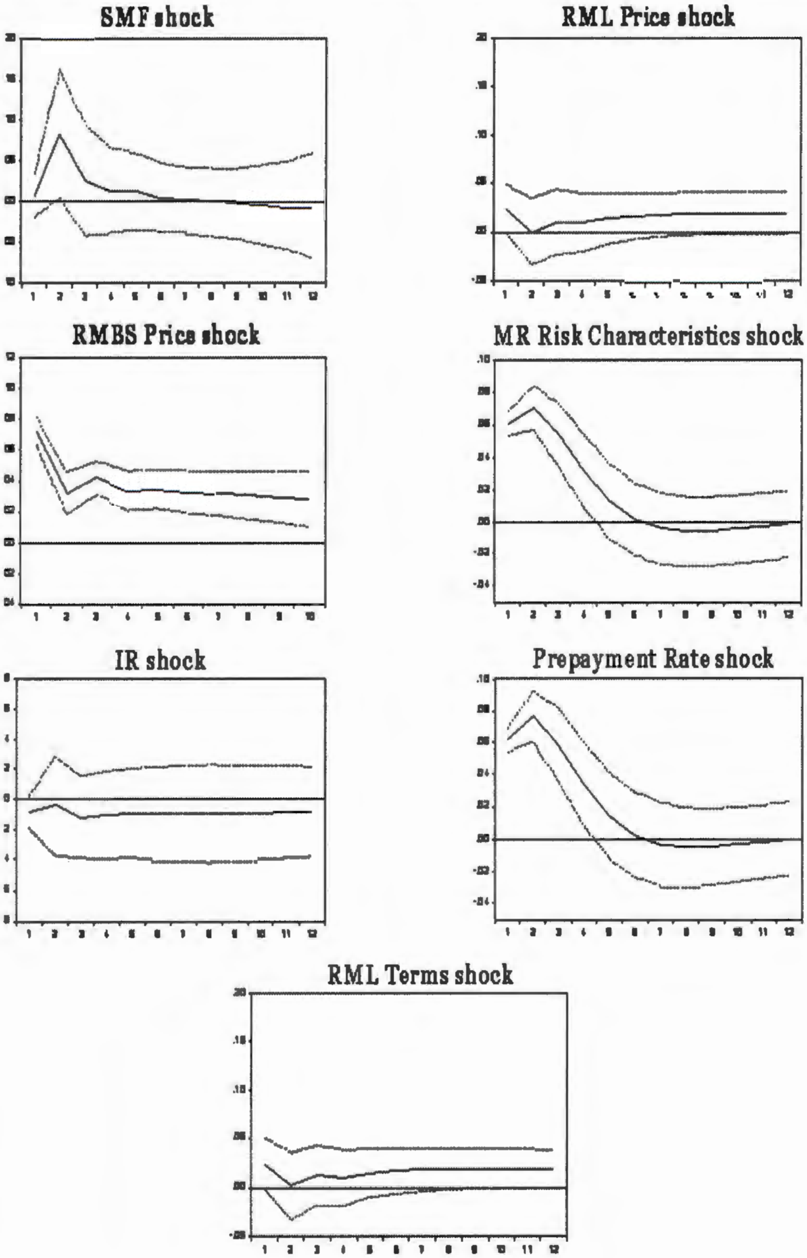

Figure 5.2: GIRF of ABX Prices Under Various Shocks

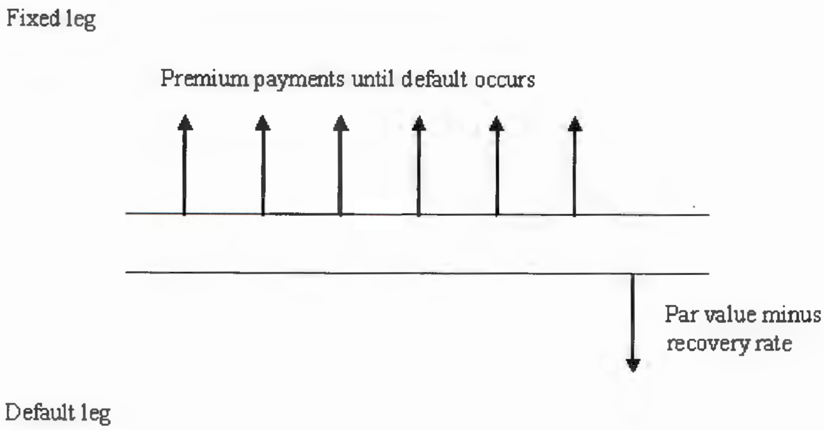

Figure 5.3: The credit default swap (CDS) cash flow structure

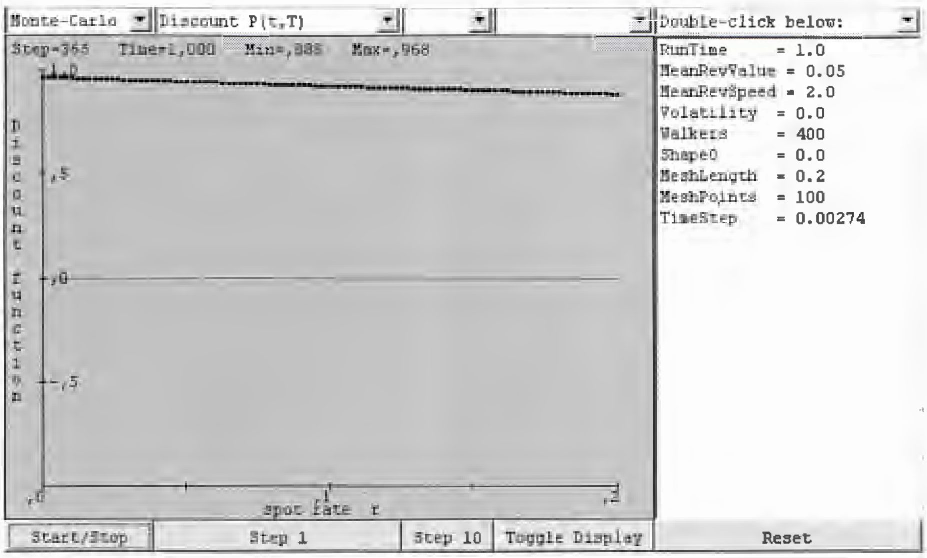

Figure 5.4: Vasicek model for the value of the discount Pr as a function of the spot rate $0 < r < 0.2$ one year before the maturity date T-1=1. Case with large value of mean reversion speed (MeanRevSpeed=2, MeanRevValue=0.05)

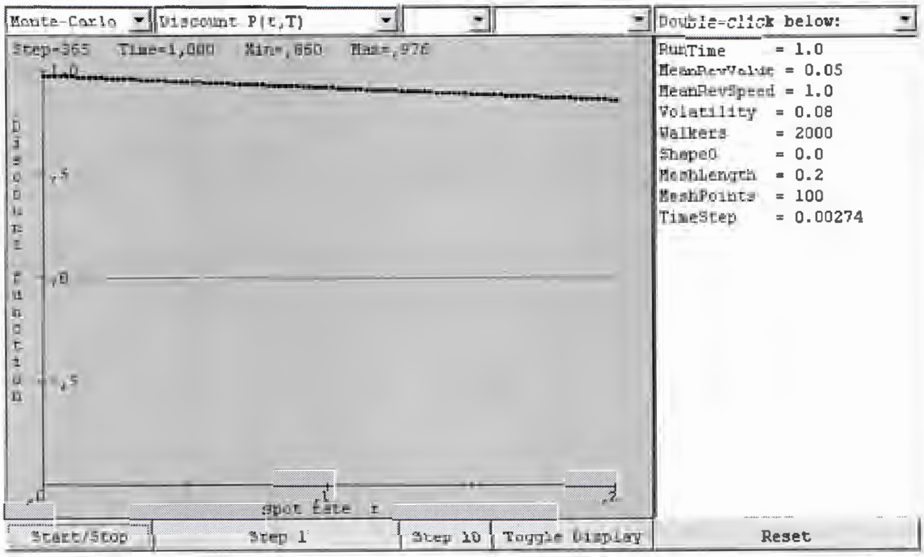

Figure 5.5: Case with large value of the drift and the volatility(MeanRevSpeed=1, MeanrevValue=0.05, Volatility=0.08)

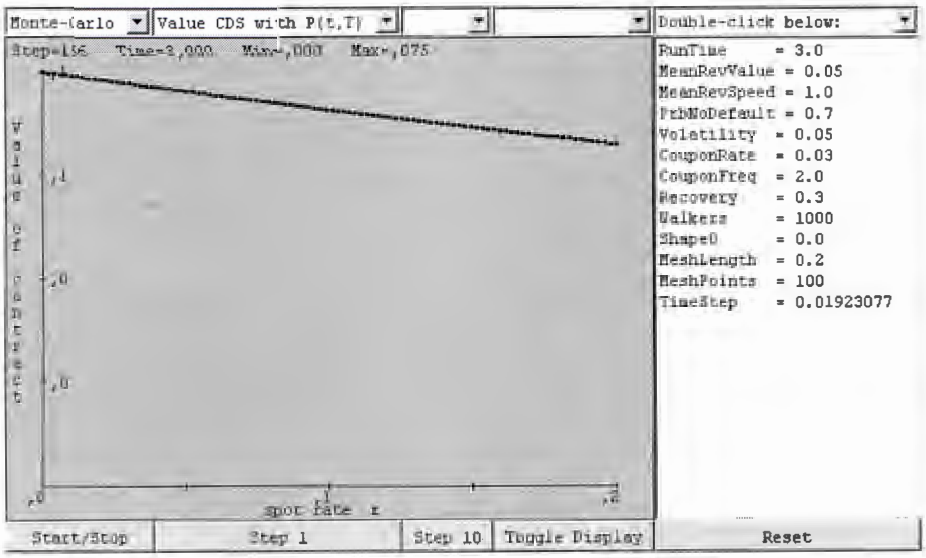

Figure 5.6: The value of the credit default swap, as a function of the spot rate using a mean revers model to forecast the interest rate (a=1, b=0.5, σ=0.05). The value is given 3 years before the expiry date, assuming a semi-annual payment of 3% insurance coupon, 30% recovery rate and a probability of having no default equal to 0.7.

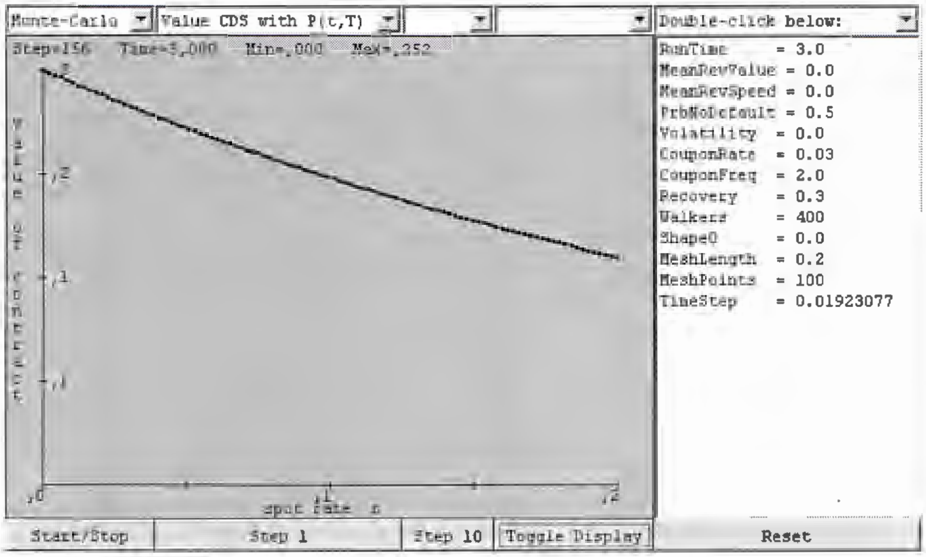

Figure 5.7: Case where the interest rate is forecasted to remain constant (a=0,b=0,σ=0) and a probability of having no default equal to 0.5.

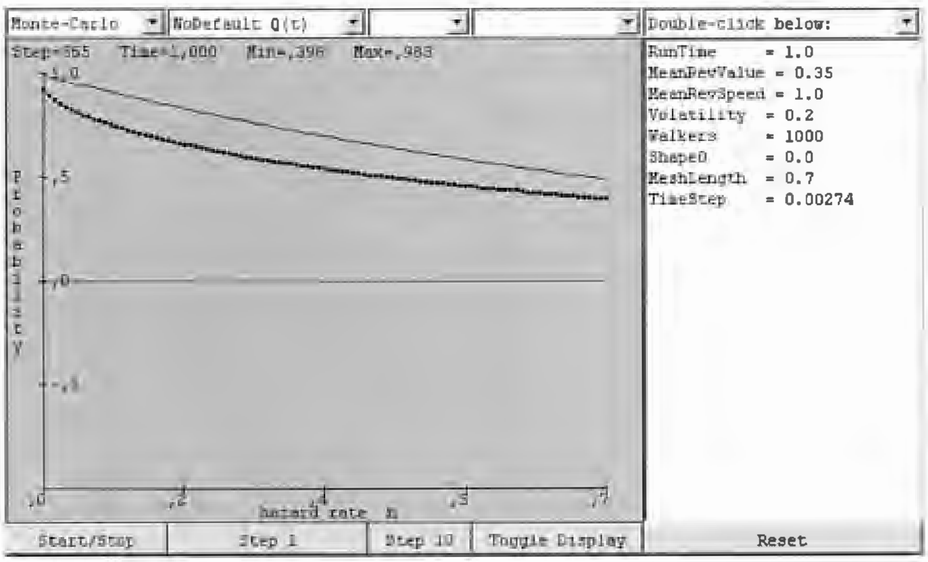

Figure 5.8: The value of the probability (the black dotted line) as a function of the default intensity with large value of the drift and the volatility (MeanRevSpeed=1, MeanRevValue=0.35, Volatility=0.2). The blue solid line corresponds to results obtained analytically when h remains constant

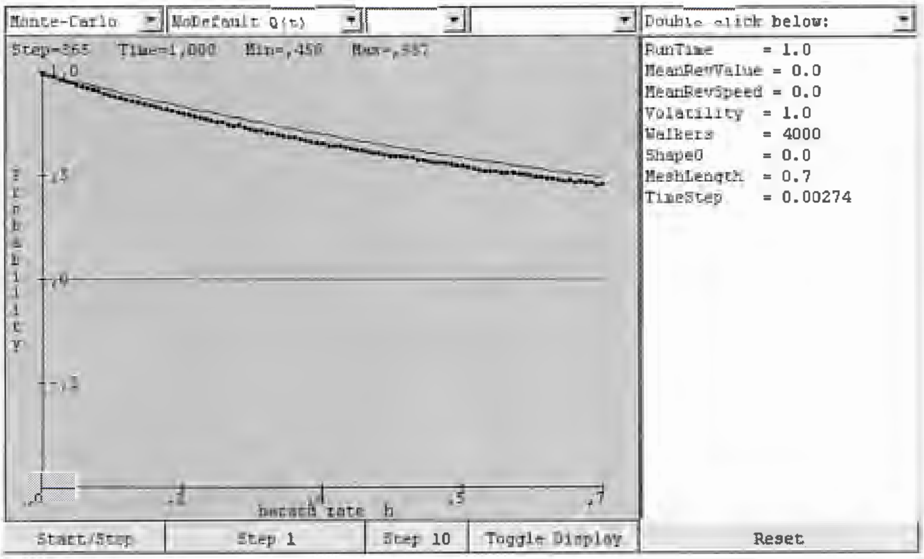

Figure 5.9: Case without drift and with large value volatility (MeanRevSpeed=0, MeanRevValue=0, Volatility=1)

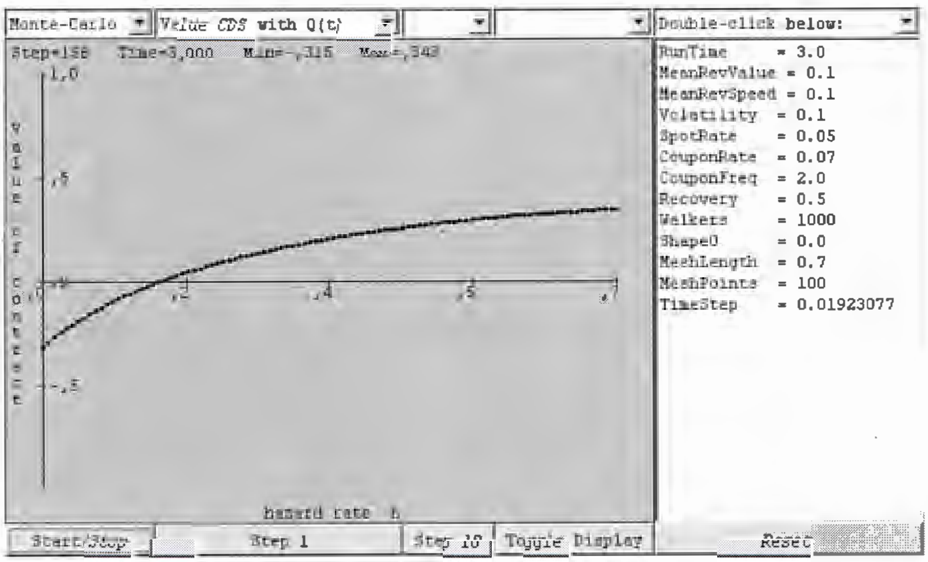

Figure 5.10: The value of the CDS as a function of the present value of the default intensity ($0 < h < 0.7$) assuming a mean reversion model to forecast future intensities (a=0.1, b=0.1, σ=0.1), a semi-annual 7% coupon, a 3 years lifetime, 50% recovery rate and a fixed 5% interest rate. The value of the CDS (black dotted line) intersects the horizontal axis at the neutral point h^*=0.157

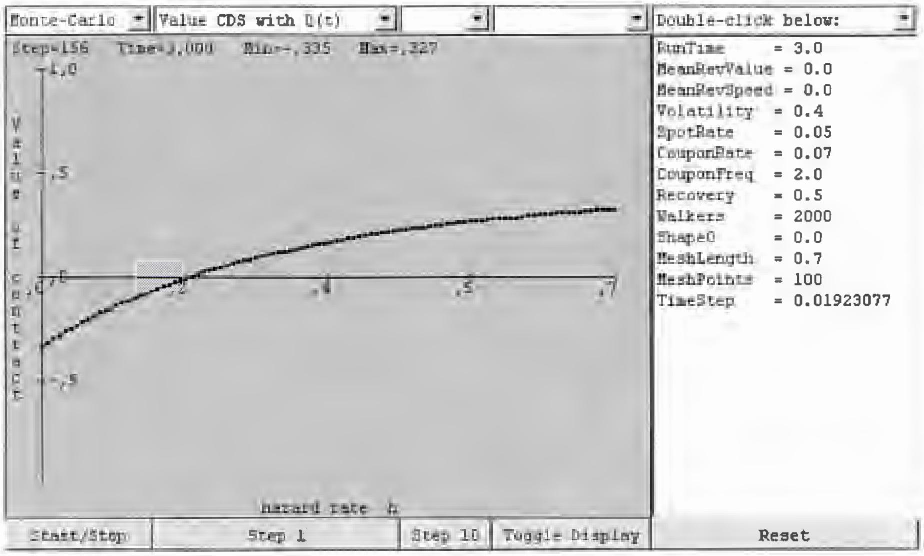

Figure 5.11: Case of a large variance in the hazard rate (a=0, b=0, σ=0.4). The value of the CDS intersects the horizontal axis at the neutral point h^{**}=0.190.

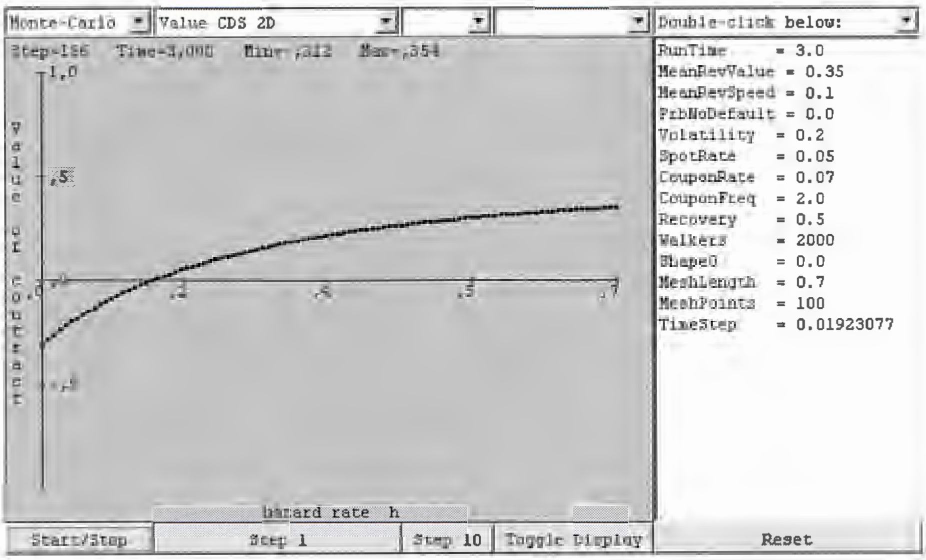

Figure 5.12: The value of the CDS obtained from a 2D model when one dimension is fixed (the spot rate is equal to 5%) and the CDS value is plotted as a function of the default intensity ($0 < h < 0.7$). The forecasted default intensity and the interest rate evolve with the drift and the volatility (a_h=0.1, b_h=0.35, σ_h=0.2, a_r=1, b_r=0.05, σ_r=0.05) and with no correlation between the components.

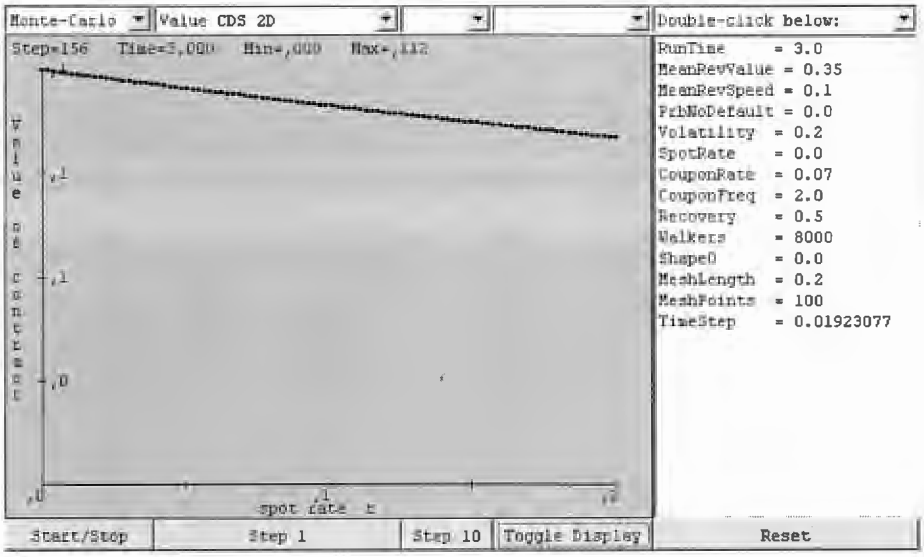

Figure 5.13: The value of the CDS obtained from a 2D model when one dimension is fixed (the default intensity is equal to 0.3) and the CDS value is plotted as a function of the interest rate ($0 < r < 0.2$). The forecasted default intensity and the interest rate evolve with the drift and the volatility (a_h=0.1, b_h=0.35, σ_h=0.2, a_r=1, b_r=0.05, σ_r=0.05) and with no correlation between the components.

Chapter 6

Conclusions and Future Directions

6.1 Conclusions

In this dissertation, the main accomplishments can be summarized as follows. Problems from the financial crisis relate to our models for assets and derivatives with respect to the reduction in incentives for banks to monitor dealers, 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 1.3.1).

In the presence of a multiplier, we quantify changes to asset price and holdings, derivative output as well as profit subsequent to negative shocks (compare with Question 1.3.2). Also, we quantify changes to profit in terms of asset and prepayment rates as well as house equity subsequent to negative shocks (see Question 1.3.3). We further provide a numerical example and illustrate the amplification and persistence of the impact of asset-related shocks on asset and ABX prices by means of a real-world example (compare with Question 1.3.4).

At business cycle frequencies, a major channel for shocks to net worth is through changes in the values of firms' assets or liabilities. Asset prices reflect future market conditions. When the effects of a shock persist (as they do in [1]), the cumulative impact on asset prices, and hence on nett worth at the time of the shock, can be significant. This positive feedback through asset prices and the associated inter-temporal multiplier process are the key innovations in this paper.

The two-way feedback between borrowing limits and the price of assets connects with the paper by [17] on debt capacity. They argue that when a firm in financial distress liquidates assets, the natural purchasers are other firms in the same industry. However, if one firm is experiencing hard times, it is likely that other firms in the industry will be too, and so demand for liquidated assets will be lower. The associated fall in asset price exacerbates the problem by lowering the debt capacity of all the firms. The essentially static nature of this argument which is akin to the static multiplier process we identified in the introduction misses the more important dynamic multiplier process, and the crucial interplay between amplification and persistence.

The pressing next step in the research is to construct a fully fledged stochastic model, in which a shock is not a zero probability event and is rationally anticipated. In the paper we constructed a model of a dynamic economy that, at the aggregate level, is deterministic; and we then hit the economy with an unexpected temporary shock. Although this approach succeeds in keeping the analysis tractable, it skirts around some central issues. A weakness of our model is that it provides no analysis of who becomes credit constrained, and when. We merely rely on the assumption that different agents have different technologies. One can instead assume that all agents have access to a common, concave technology, but differ in their levels of accumulated wealth.

Furthermore, it would be interesting to relax the assumption that, on the supply side, the credit market is anonymous. In the paper we have implicitly taken the position that debt contracts can be freely traded by creditors because the value of a debt contract equals the value of the collateral, land, which is priced in a market. However, the identity of the creditor may matter. A particular creditor may have additional information about, or leverage over, a particular borrower, which enables the creditor to lend more. Such debt contracts are unlikely to be tradable at full value.

Once anonymity is dropped, the net worth of creditors and the value of their collateral start to matter. The interaction between asset markets and credit markets that we have highlighted in this paper will be even richer if both sides of the credit market are affected by changes in the price of their collateralized assets.

Combining stochastic hazard and interest rates into a 2D model yields a value that is considerably different from the single factor models. For the same parameters as in the previous section, the value obtained from the 1D interest rate model can be more than 60 % lower than the CDS value calculated with the 2D model. The largest difference is obtained for the one factor model of interest rate where the default probability does not evolve during the life time of the contract.

6.2 Future Directions

Finally, our model included an intermediate step involving ABSs between assets and derivatives in order to reflect the securities chain. These securities originate from assets that are securitized and rated in categories according to their credit risk. These are then further securitized into derivative tranches. Also, apart from constructing a discrete-time model to determine the optimal control problem, the paper further constructed a more sophisticated continuous-time stochastic model. In future, we would like to extend the model by determining when an HQ-dealer becomes an LQ-dealer in order to distinguish between an unconstrained and constrained agent. Furthermore, the 2D Monte Carlo model neglected the correlation between the interest rate and the hazard rate. This is an obvious limitation that could be removed by making the default intensity $h = h(\sigma, r)$ dependent on the interest rate. The subject should be of sufficient interest to warrant more detailed studies.

Chapter 7

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Chapter 8

Appendices

In this chapter, we provide an appendix about economic conditions.

8.1 APPENDIX A: Economic Conditions Before and During the Financial Crisis

Table 8.1 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 8.1: Differences in Economic Conditions Before and During the FC