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FORTIN, PIERRE-OLIVIER,JEAN

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PhD thesis from Pierre-Olivier J. Fortin  
under the supervision of David Barr<sup>1</sup> & Reint Gropp<sup>2</sup>

# **Exploring the expansion of credit on the demand and the supply side: What are the Macroeconomic Implications of high Household Debt and Equity Ownership, and are Asset Based Credit (ABC) Institutions different from Banks?**

## **Abstract**

During the last two decades, the way credit is handled has profoundly changed on both the demand and supply sides, mostly due to the new role of collateral assets. On the demand side, household debt that is collateralized with real estate, cars, and other tangible assets has reached record levels. On the supply side, the use of collateralized credit has become widespread. Banks now use collateralized credit for a number of purposes such as risk management, issuing fees, etc. . . . , and a new type of lender has entered into competition with banks through the use of assets instead of deposits for credit generation. These modifications, coupled with a stable financial environment and low interest rates, have led to the issuance of considerable amounts of collateralized credit. All these changes have macroeconomic implications, either creating new risk or magnifying existing financial systemic risk.

To study the increased demand for household credit, I develop a theoretical model of the macro dynamics of households, with financial stability moderated by asset prices. I show that household real estate debt has quantifiable drawbacks in terms of financial stability. To study the supply of credit, I examine the link between collateral assets and financial stability in two ways. First, I develop a theoretical model of the dynamics between financial stability and assets used as collateral for bank debt. I show that a simple link exists between the price dynamics of bank loan collateral assets and optimal leverage of the financial system. Second, I empirically investigate the characteristics of lenders that do not hold deposits, also called asset-based credit institutions, since they substitute deposit liquidity with short loans securitized by assets. I show that in liquidity generation, risk, and market discipline, asset-based credit institutions mostly behave like banks.

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**Exploring the expansion of credit on the demand  
and the supply side:**

**What are the Macroeconomic Implications of high  
Household Debt and Equity Ownership, and are Asset  
Based Credit (ABC) Institutions different from Banks?**

Perspectives on the link between financial stability and collateralization.

A dissertation presented

by

Pierre-Olivier J. Fortin

to the Economic and Finance Department in partial  
fulfillment of the requirement for the degree of

Doctor of Philosophy

in the subject of Macroeconomy

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*for Marion and Joachim Gaius*





# Chapter 1

## Introduction

The amount of credit issued during the last 20 years has been increasing at an impressive rate. The outstanding amount of debt in the eurozone of euro-denominated debt securities in January 2010 was €13.7 trillion, up from €2.4 trillion in January 1990, a 470% increase. Considering only non-financial corporations in the eurozone, the outstanding amount of debt went from €176 billion in January 1990 to €681 in January 2010,<sup>1</sup> an increase of “only” 286%. In the same time period, the outstanding amount of US public debt rose from US\$ 3.2 trillion to US\$ 13.5 trillion,<sup>2</sup> an increase of 321%.

Sustained economic growth coupled with historically low interest rates have certainly contributed to the rise in the amount of credit issued. Another factor specific to the current period is the development of new ways of dealing with credit, including the volume of debt issued, the type of credit issued—for example, credit derivatives—and the new participants of this market.

On a personal note, it was a speech by Tim Frost, a member of Cairn Capital<sup>3</sup>, at a 2007 sales show, to a terrified crowd of company executives that originally set my mind on these topics. He said, “As a trader for Cairn Capital, I own a significant share of all your companies’ debt. Even if you never heard of Cairn Capital.” The focus of this research project is to examine the economic effects of the development of credit. Specifically I wish to investigate the consequences of certain aspects of credit demand, specifically, household demand. I would then like to determine the im-

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<sup>1</sup>Data published by the European Central Bank.

<sup>2</sup>Data published by the US Department of the Treasury .

<sup>3</sup>Cairn Capital is a hedge fund specializing in the credit market. As of November 25, 2007, Cairn Capital managed portfolios totaling over US\$30 billion, employing over US\$8.9 billion of investor capital.

plications of various aspects of the credit supply, specifically the development of collateralized debt and new kinds of credit suppliers. Both areas are described below.

## 1.1 The New Demand for Credit

The volume of credit has greatly increased during the last two decades, with corporations using more credit, banks assets growing steadily, and even households taking on more debt. The average household leverage in the US has risen from 50% to 160% of annual disposable income during the last 20 years. The largest proportion of household debt is from real estate mortgages. The figure 1.1 plots the volume of home mortgages that US households took on during 1980 to 2010 (data from the US Census Bureau, amounts in billions of dollars):

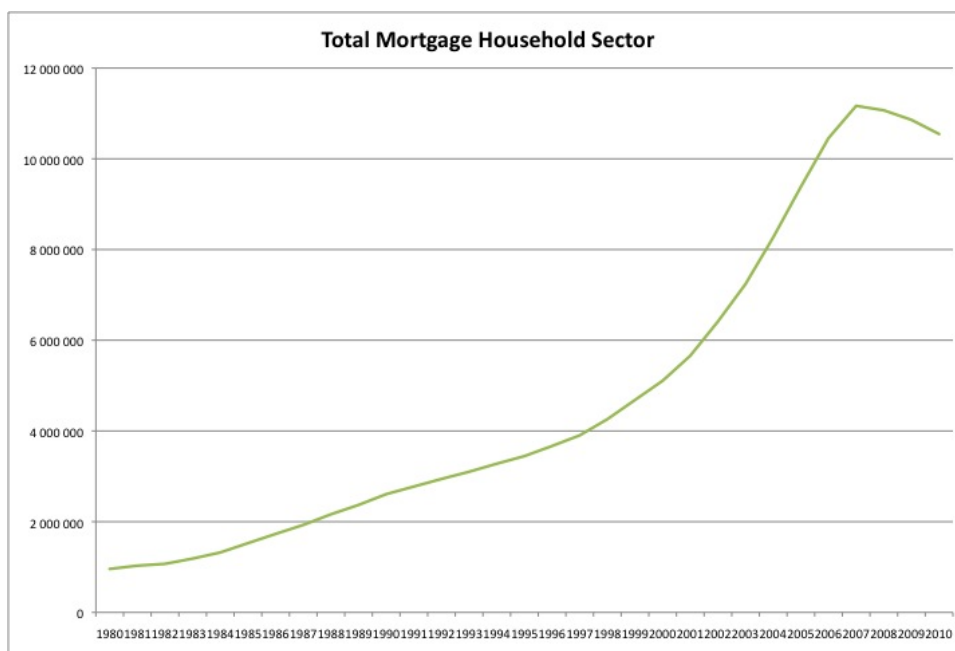


Figure 1.1: Total Mortgage for the Household Sector

The growth depicted is impressive mainly because households are not such sophisticated investors as corporations and banks. With the development of credit facilities such as complex mortgage deals—for example, floating rate and interest-only mortgages—households also took on more complex risks. The risk due to larger amounts of mortgage debt, of greater complexity, for households has created a new kind of macroeconomic risk. While the social costs of a household defaulting on its debt can be high, it seems that these risks have now become systemic.

Note also that real estate mortgage debt is linked to actual real estate prices; I would argue that the investigation of the macroeconomic implications of high levels of mortgage debt held by households and their relation to real estate prices is a very promising area of research.

The intuition here is that households can take a high debt position to acquire an asset—mainly real estate—whose ownership, in turn, makes them more vulnerable, since they are more leveraged, and more sensitive to price moves of this asset. This investigation examines the link between high levels of household debt and economical and financial stability, focusing on asset prices as a moderator between them. I therefore build on an existing macroeconomic model that links asset prices and financial stability by increasing the amount of debt a household can take on. The aim of this research is to find the implications of high household debt. This should put us in a position to propose regulatory recommendations concerning levels of household debt and one of its main causes, the level of real estate ownership.

## **1.2 The New Supply of Credit**

Recent changes in the way credit is issued have affected not just the demand side, but also the supply side. The supply of credit has been associated with the development of two significant changes: the growth of collateralized credit products and the fact that corporations that are not banks issue noteworthy amounts of debt.

### **1.2.1 Collateralized Credit Supply**

One of the most successful financial innovations in the last 20 years has been the development of collateralized credit products. They were initially created to allow institutions with large pools of debt to risk-manage their credit positions, mainly by selling their debt. As the market grew, investors of all types came to speculate.

To better understand this market, consider first its three main instruments:

- Asset-backed security (ABS): An ABS is a simple securities debt with an asset as collateral. The securitization process makes these assets available to a wide set of investors, since they can be customized to fit any given investment purposes. The underlying assets are

any kinds of receivable, from the common—such as credit card payments, auto loans, and mortgages—to esoteric cash flows such as aircraft leases, royalty payments, and movie revenues.

- Corporate bonds: It is a bond that a corporation issues to raise money in order to expand its business. The term is usually applied to longer-term debt instruments, generally with a maturity date falling at least a year after their issue date<sup>4</sup>.
- Collateralized debt obligation (CDO): A CDO allows any kind of initial debt to be restructured in tranches, as, for example, corporate or mortgage debt. Each tranche offers a varying degree of risk and return so as to meet investor demand. The CDO is the most popular vehicle for debt restructuring: “Sales of collateralized debt obligations reached a record \$251bn globally in the first quarter of this year, the Bank for International Settlements said on Monday” (*Financial Times*, June 11, 2007).

It is important to note that 20 years ago, only corporate bonds were in use.

Whether this development is a good or bad thing has generated much controversy. Derivatives have allowed credit actors to restructure their existing exposure by spreading the credit risk and transforming it. In the 2002 annual report of his company, Berkshire Hathaway, Warren Buffett warned, “In my view, derivatives are financial weapons of mass destruction, carrying dangers that, while now latent, are potentially lethal.” On the other hand, Alan Greenspan (2004) pointed out that credit derivatives have contributed “to the development of a far more flexible, efficient, and hence resilient financial system than existed just a quarter-century ago.”

One of the many interesting aspects of the recent development of this market is the fact that collateralized credit is now linked with the asset price of the collateral. As with the subprime crisis, there is now a link between collateralized credit and the collateral.

The systemic implications caused by any disruption to the collateralized credit market are now clear; if only by looking at the size of the market — for example the US ABS outstanding in 2006

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<sup>4</sup>The golden age of corporate bonds was the rise of junk bonds market, with such figures as Michael Milken, Ivan Boesky, Martin Siegel, and Dennis Levine. Stewart’s (1991) *Den of Thieves* provides a very vivid picture of their activities.

was 2.5 trillions (Reuters data). The development of a model that studies the links between asset prices with macroeconomic risk and financial stability is certainly useful. I hope this study will help identify previously unsuspected potential systemic risk. If successful, this study can then be used to suggest new regulations.

### 1.2.2 Non-Bank Lenders

Recent developments in the financial market have allowed new participants to enter and have changed the behavior of existing players. Historically most of the credit issuance was supplied by banks—deposit-taking loan institutions—but recently the development of non-bank credit issuers has been observed.

To satisfy different needs, specialized lending companies have been created. One of the reasons is to develop niche lending, such as credit cards or student loans, to satisfy a growing demand. Another important reason is to allow individuals or companies to acquire given assets. These lending companies allow individuals to buy large assets such as real estate and cars, and allows companies to buy business assets, such as when airline companies buy their planes on credit.

The main difference between these lending companies and banks is the fact that they do not have any deposits and need to manage liquidity through the repo market. These companies are part of the so-called shadow banking system that has been accused of bearing serious responsibility for the 2007 crisis. The main issue is the fact that there is very little literature on these institutions and it is not obvious how to evaluate their risk. Since these types of lending companies are similar to banks, however, one could use the risk toolkit developed for banks. The main question is how to adapt this toolkit to non-bank institutions?

I investigate whether such lending companies behave like banks or if their business model is different. The intuition is that these companies do behave like banks, and it should therefore be possible to use the bank risk toolkit to analyze them. The results from this risk analysis should contribute to the discussion about sources of risk for these institutions: Do they have a similar risk profile as banks? This analysis can also reveal much about the true nature of these institutions and may be a step toward an informed decision about their role in the 2007 crisis. The

study should also provide more information about the sustainability of this sector: Is non-bank lending just an accident due to the expansion of credit or is it a sustainable business model? In any case, this study may have regulatory implications regarding whether to limit the sector's existence or help shape more appropriate regulations.

### 1.3 Motivation

The way credit is used, whether on the demand side or the supply side, has changed profoundly. At the heart of those changes lies the relationship between assets and credit, which is now characterized by more reliance on collateralized debt.

On the demand side, we will see that the literature focuses mainly on the microanalysis of high levels of household debt, and on how the ability of households to release home equity allows them to smooth inter-temporal spending. Following this literature, a rise in credit demand would require some regulatory adaptation to cope with household over-leverage. Such regulation would for example aim at increasing lender communication on the risk of debt, or at improving the processes for personal bankruptcy. The rise of real estate ownership for households was mainly seen as a good thing as it would help smoothing various liquidity shocks. On the supply side, the credit literature focuses on different aspects of the development of asset-backed securities, but mainly on the micro side. On the macro side the focus is mainly on unsecured debt, whereby asset dynamics and credit dynamics are mostly exogenous. So the literature interprets the rise of collateralized credit as an opportunity to make this market more efficient by for example clarifying risk-sharing agreements.

The aspects I am most interested in are the amount of debt households are taking on, how widespread collateralized credit has become, and that non-bank lenders are now issuing large amounts of credit. These changes certainly have macroeconomic implications, mainly creating systemic risk in places where it did not exist previously, which is the reason I feel it is important to investigate these issues.

## 1.4 Contribution

The recent development of credit has upset quite a few economic equilibria. Every macro model makes assumptions to fit the economic environment described. It is my belief that the latest credit development has rendered certain assumptions inadequate to describe the current economic environment. This contribution is an attempt to change some of these assumptions and introduce new ones; to investigate the various implications of the current economic environment.

A strong concern is the fact that recent credit developments may have created systemic risks that did not exist beforehand or increased the likelihood of certain systemic risks. This contribution centers around an investigation of systemic risks linked with the new credit environment. What risk is associated with the greatly increased amounts of household debt? What existing risks have been magnified by the popularity of collateralized products? What kinds of risk are caused by the development of lenders that do not hold deposits? Understanding these questions will help gain insight into the systemic implications of credit developments on financial stability.

I first develop a theoretical model of some macro dynamics of households, with financial stability moderated by asset prices. I then develop a theoretical model to show some of the dynamics between financial stability and assets used as collateral for bank debt. Finally, I empirically investigate some risks and incentives of the sector of lenders that do not hold deposits.

This work should be a natural fit in the financial stability and macroprudential policy literature. The first theoretical model developed describes the relation between financial stability and household debt issuance, and the second theoretical model describes the relation between financial stability and specific types of collateral used for bank loans. The empirical portion helps better understand institutions that issue loans with no deposit, to assess their contribution to systemic risk.

This work can be of use to central bankers and macroprudential regulators across the world, since it addresses sources of possible systemic risk, such as high levels of household debt and the price of collateral assets. The two models I develop provide a quantitative measure of how much

household debt is too much, and how much capital erosion due to collateral asset is expected after a productivity shock. The last empirical section can also help central bankers and macroprudential regulators handle institutions that issue loans with no deposit.

This study can also be used by investors who want to consider the macroeconomic risks of the financial sector. The first model of the relation between household debt and the financial system can help determine whether the real estate bubble burst has reached a low point or can sink further, and can thus help decide whether to go long or short on real estate. The second model can be very useful in evaluating whether a country's financial system is at risk due to the types of collateral assets used by its financial institutions, and can thus help decide whether to go long or short on a given country's government bonds. The last empirical section can be very useful for an investor in understanding how to evaluate the risk on non-deposit-taking lenders, which, in turn, should provide an edge in the evaluation of the share price of such a firm.

## 1.5 Overview

This thesis is structured as followed. After this introduction, I review the literature in the areas that are useful in the development of macroeconomic credit models; examining the participants of the credit market and the main underlying theories.

Regarding the body of the thesis, Chapter 3 presents a macroeconomic model of the impact of household debt. This is followed in Chapter 4 by a model that describes relations between asset price dynamics and macroprudential policy. Chapter 5 then examines lending institutions that have no deposits, followed by Chapter 6's analysis of risk and market discipline specific to these institutions. I conclude by summarizing the contributions of this thesis.

The appendixes are structured as followed. The first appendix covers some proofs of lemmas from Chapter 3. It also includes some non-core theory development on probability density applied to macroprudential policy for Chapter 4. I then include the STATA code for Chapter 6.



## Chapter 2

# Critical Literature Review

As a former mathematics student I never followed a formal business teaching so in order to grasp economics I spent a significant time looking at its foundation; this literature review is a reflection of this research. This is why this literature review is more generic than it could have been.

The overall goal for this work was a chance for me to look at the numerous contributions that credit has on the macro-economy, whether in terms of growth or cost. The fact that this PhD started after 2007 and the fact that I had been professionally involved in the genesis of credit derivatives, made me dedicate a significant effort to look at the contribution of credit derivatives on the macro-economy.

Credit is closely linked with most parts of the economy, and although credit derivatives are mainly traded and owned by a very small set of economic agents, they are also related to the rest of the economy. In order to look at the economic implications of the credit and the credit derivatives market, each component of this market needs to be investigated. A good metaphor to describe credit is a “layer cake”. First, debt is issued from a company, a household or a government; it is then packaged and is re-sold either as it is or sliced to a wide range of investors. Specialized companies rate those packages for quality. Then a secondary market takes over, involving most types of investors from hedge funds, to banks, to a Norwegian town<sup>1</sup>, etc.

In order to deconstruct the “layer cake” it is thus necessary to cover a large range of macroe-

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<sup>1</sup>One can see in Landler (2008) the story of a Norwegian town that lost millions in bad collateralized debt obligation investments. They now fear that they will have to cut local services.

conomic areas. As each layer plays its role in the overall picture, it is important to look at each layer individually to define which one is important and which one is not. This is why I am aiming to examine at a very wide variety of macroeconomic aspects as part of this review.

The three main users of debt – as issuers or as holders – are companies, governments and households. Companies and households have seen their debt issuance capacity increased considerably. The development of credit derivatives has impacted on governments mostly in their roles as lenders of last resort.

The next section will firstly provide a historical view of the development of credit and a topology of credit in the economic literature. The review will then focus on the use of credit in corporations, before describing the specific needs and treatment of household debt. Thirdly, I will look at the literature specific to credit derivatives and the financial intermediaries that trade them. Only at that point will I look at credit as a macroeconomic subject, and actors and new products will be introduced. Finally, I will consider credit as a market.

## 2.1 History of the Macroeconomic Financial Structure

Credit and financial structures are not ‘elementary particles’ in the economic science. The study of those concepts was brought about through the elaboration of existing theories. Gertler (1988) provides a very good summary of the financial structure through the economy, mainly by specifying the role of credit. He describes the history of economic theory and the importance of lending and borrowing.

The historical relationship between the credit and financial structure and economic theories has developed in different phases. The Great Depression writers recognize the importance of the financial industry delinquency during that period. In Fisher’s debt-deflation theory (Fisher 1933), loans and bank runs are a central element. Within the Keynes’s tradition (e.g., Minsky (1975)), credit exists but is not a central area of study. The same is true for the founding article of the monetary school by Friedman & Schwartz (1963), in which the relationship between output and money is seen to explain most of the financial markets role in the Great Depression.

On the one hand the importance of financial consideration of macroeconomics behaviors is central to Gurley & Shaw's (1955) works. The stress is put on the development of financial institutions for economic development. On the other hand, the famous article by Modigliani & Miller (1958) reports that the state of an economy is independent of the financial structure. The assumption that allows Modigliani & Miller to reach their conclusion is the a perfect market. The success of this theory comes from the ability that its gives to researchers to model large areas of business study, like business cycles, without the complexity of the financial structure.

It is interesting to note that the Great Depression returned the focus to the financial structure. The main Great Depression explanation by Friedman & Schwartz (1963) was primarily monetarist. The financial system only responded, without feedback, to the declines in aggregate output; the mechanisms were to reduce the wealth of bank shareholders, but more significantly by leading to a rapid plunge in the supply of money. Those monetary forces alone were "quantitatively insufficient' to explain this phenomenon (Bernanke 1983). It is the collapse of the financial system that explained the depth and persistence of the Depression.

Bernanke (1993) provides a good summary of the more recent activity during the 1980s. The main motivation for Bernanke to look at this issue is the role of credit as a transmission mechanism of monetary policy. This emphasizes two research points. The first is the role of information asymmetry between the lender and the borrower. The second is the importance of the balance sheet as a tool to define the credit worthiness of the borrower. The balance sheet is also the main source of information for the lender.

## 2.2 Corporation

Corporations use their workforce and resources to produce revenue. Debt allows the increase of financial resources. Those new financial resources can be put into work to generate more income.

### 2.2.1 The Role of Debt

The free cash flow theory developed by Jensen (1986), states that managers' objectives may conflict with the value maximization because of the corporate governance structure. Managers have control over the free cash flow within a company, and they have the tendency to develop companies for growth, even if it does not maximize the profit. The conflict is more important in the case in which the firm has large free cash flows – more cash than profitable investment opportunities. Debt is usually comes under the scrutiny of the loaner, which reduces the control of the managers. Shareholders can use this to gain more control over the company objective toward of value maximization.

Extending this idea Zwiebel (1996) develops a theory whereby long-term debt is used to control the empire-building managers tendency. Managers themselves can use a methodology to adapt dynamically a capital structure coordinated with a dividends policy. This is performed by setting the level, the frequency and the maturity structure of debt as a function of outside investment opportunities.

### 2.2.2 Capital Asset Structure

Internal funds, retained earnings, bonds, loans and stocks compose the main part of the capital asset structure. The mechanism of the capital structure is significant for this study as it investigates the desired proportion of outside money. It can explain the motivation of some managers to take on different forms of debt. A useful measure of the capital asset structure is the leverage level. There are many different capital leverage measures such as the total debt on book assets. Frank & Goyal (2009) provide an interesting survey of the most commonly used ratios.

The theory behind the capital structure begins with Modigliani & Miller (1958) who state that the capital structure is irrelevant for value creation, but as described previously, this theory works only in perfect capital markets. The perfect market assumption can be altered in a number of ways. Corporate and personal tax considerations can change the value creation, as debt is not taxed like capital. The costs associated with leverage, such as bankruptcy costs and agency costs modify the picture again. Some decisions are made based on financial grounds as opposed to operational grounds. For example, if debt has been contracted the company will most cer-

tainly spend it even if this is not optimal operationally.

Myers (1984) develops the founding theories on capital asset structure, trade-offs and pecking order. The trade-off theory states that high levels of leverage correspond to high levels of cost of financial distress. Several empirical studies support this idea e.g. Warner (1977), Andrade & Kaplan (1998) and Bris, Welch & Zhu (2006). The trade-off theory implies that an ideal level of debt can be reached.

The pecking order theory states that companies prefer internal funds instead of outside money. The main reason for the internal funds being choice is the full control that company managers have over it. When the inside money runs out, the next best choice is debt, before equity is issued. The choice of debt against equity could be explained by the long and labour-intensive process of issuing equity.

The trade-off and the pecking order theories suggest opposite effects. Fama & French (2002) analyze the two influences:

“Confirming predictions shared by the trade-off and pecking order models, more profitable firms and firms with fewer investments have higher dividend payouts. Confirming the pecking order model but contradicting the trade-off model, more profitable firms are less levered. Firms with more investments have less market leverage, which is consistent with the trade-off model and a complex pecking order model. Firms with more investments have lower long-term dividend payouts, but dividends do not vary to accommodate short-term variation in investment. As the pecking order model predicts, short-term variation in investment and earnings is mostly absorbed by debt.” (Fama & French 2002, abstract)

In this section the analysis of the capital asset structure was based only on the balance sheet. Financial techniques allow taking some liability to be taken of the balance sheet. The main one is securitization; a debt can be package in a security – such as an ABS or CDO – and then sold. This is generally called securitization. Those techniques allow companies to put reduce the balance sheet liability, but they creates some credit risk that is usually not properly recorded. This raises the question of the evaluation of the off-balance-sheet leverage. It also raises the

questions of the increased credit risk management due to securitization.

### 2.2.3 Credit Ratings and Capital Structure

To finish this section I would like to investigate the implication of credit rating on for the asset capital structure. Kisgen (2006) looks at the relationship between credit rating and capital structure. Kisgen's findings cannot be explained by the usual capital structure theories. The effect of a credit upgrade or downgrade is mostly temporary. Companies react mainly in reaction to an upcoming credit upgrade or downgrade. When close to such a credit event a company is less likely to issue debt relative to the equity level than the same company far from any credit event.

## 2.3 Household

I will first look at the household consumption, at its relationship with debt, then at the different type of household debts. Subsequently I will be able to talk about the wealth effect, bankruptcy, the household balance sheet and the impact of credit rationing.

### 2.3.1 Consumption and Credit

The last two decades of the twentieth century saw the emergence of previously unseen credit facilities for households. These take different shapes, like credit cards, 100% or tracker mortgages... Ludvigson (1999) finds evidence that the availability of credit is positively correlated with predictable consumer credit growth in the aggregate data. This finding has two economic implications.

First, good access to the credit market increases the volatility in the aggregate consumption. This specific volatility is not correlated with the usual shocks to common aggregate consumption indicators like the asset price or interest rate. The disconnection between this new cause of volatility in the aggregate consumption and the other causes has lead the economic actors to be more prepared to cope with volatility. Ludvigson considers that this is a positive outcome and that it has made the economy more resilient. Second, as consumer growth increases with the credit availability, it increases the sensitivity of the credit consumption to pro-cyclical borrowing.

In short, credit availability for households makes consumption more sensitive to the credit market, which increases the tendency of the credit market to be cyclical. In fact this new feature of household consumption makes it a “financial accelerator” in the sense of (Bernanke, Gertler & Gilchrist 1996); this means that it increases the speed of credit cycles.

This is confirmed by Büyükkarabacak & Valev (2010), who finds that the credit expansion for households had not much effect on long-term income and created financial vulnerabilities. Those financial vulnerabilities of household have been found by Büyükkarabacak & Valev to be a “statistically and economically significant predictor of banking crises”. Another contribution of Büyükkarabacak & Valev (2010)’s article is the fact that the same effects on firms have not been found to be as good a predictor of banking crises.

Following this literature it seems that household credit expansion has a different effect on consumption than firm credit expansion; and while it has some positive effects it also seems to create financial fragility for the banking system.

### 2.3.2 Consumer Unsecured Debt

The surge in the use of credit cards is illustrated by Ausubel:

“Credit cards are the currency of late 20th-century America. The aggregate charge volume on plastic in the United States was estimated at \$375 billion in 1987.” (Ausubel 1991, p 50)

The most interesting finding is the fact that even though the credit card business in the 1980’s was provided by around 4,000 firms, the profit generated by those companies was three to five times the ordinary rate of return in banking for the same period. The reason for this abnormal profit comes from the exceptionally sticky rate charged to the customer compared with the market interest rate. According to Ausubel, the reason why the market was not competitive comes from the customer behavior. Customers, when they make credit card purchases, do not take into account the fact that they are entering into a debt contract, and will pay a high interest rate.

More recently Agarwal, Liu & Souleles (2004) analyzed the reaction of households to ‘lumpy’

increases in income, like tax rebates. The results is initially to pay back some of their outstanding debt, but after a short period the level of debt raises again to the initial level. This result is in opposition to the theory of life-cycle/permanent-income model and related models. It suggests that the liquidity constraints are strong, mainly for credit-constrained households.

The total US consumer debt (which includes installment debt, but not mortgage debt) reached \$2.46 trillion in June 2007 (data from the US Federal Reserve).

### 2.3.3 Real Estate Market

For households, the consumer debt is often a means to smooth their income and spending. Real estate is the source of the highest debt commitment as the amount borrowed is usually very high compared with the household income. Another reason is the fact that the ownership of real estate reduces spending as it can be used as a substitute for rent.

Miles (1992) provides a survey of the real estate market in developed economies. The most interesting aspect is the very high heterogeneity of this market across countries. This can be seen in owner the occupation level, the ratio of mortgage debt to disposable income or the average price of housing compared with the income.

The real estate and the mortgages markets have been liberalized during the last three decades. In a study of the UK market during the period 1971–1990 Muellbauer & Murphy (1997) show that the liberalization of the market has increased the indebtedness of households. This is consistent with the finding on unsecured debt.

Figueira, Glen & Nellis (2005) look at the mortgage arrears in England and Wales in the period 1993–2001. They confirm that the loan-income ratio and debt-service ratio are important, but also show how the level of equity withdrawn or 'unwithdrawn' acts as a cushion to avoid mortgage arrears and its various side effects, like repossession.

This review would be incomplete without mentioning re-possession. Brookes, Dicks & Pradhan (1994) study the cause of mortgage arrears and repossessions. They conclude that the level



of mortgages, incomes, interest rates and inflation are the main drivers of repayment difficulties. Somewhat less obviously the un-withdrawn equity – increases and employment are also positive factors against arrears and repossessions.

Brunnermeier & Julliard (2007) look at the illusion of wealth and the 'housing frenzies'. Inflation is an element of house prices that is often misinterpreted by buyers. The fact that inflation lowers future real mortgages costs is not seen. Brunnermeier and Julliard find that inflation *and nominal interest rates* explain a large share of this mis-pricing. The effect is that a reduction in inflation can push housing prices higher. The corollary to this finding is that if people suffer from money illusion, then an inflation increase would hit the housing market strongly as its effect is not anticipated

#### 2.3.4 House Price Dynamics

One of the important aspects is the link between rent and house prices.

A survey of the literature can be found in Cho (1996). In this survey the basic model for house prices is the present value of the rent plus a speculative input. From a theoretical point of view the question is whether the property market is efficient; from a practical point of view the measurement of the price-to-rent ratio is very complex. This might be counter-intuitive as surveys of property prices and rents are readily available, but the main issue is to ensure that the comparison of prices and rents is performed in a consistent manner. There are five types of statistical bias: (1) renovation bias – whether the quality is comparable with the quality of the rented property –, (2) hedonic bias, (3) trading-frequency bias – the property price might be misrepresented as there is a very low trading frequency, (4) sample-selection bias – the property market is full of niches, which makes it very sensitive to selection bias – and (5) aggregation bias – a small neighborhood can increase or decrease in value very quickly.

The speculative aspect of the price to rent ratio is studied by Himmelberg, Mayer & Sinai (2005) in the USA from the 1980's up to 2004. They find elements of overvaluation for the 1995 to 2004 period.

### 2.3.5 The Wealth Effect

The wealth effect is the tendency of increasing consumption due to an increase in the perception of wealth. The recent rise in house prices in most developed economies has increased the wealth of a significant share of households. This allows us to test the wealth effect.

Tang (2006) looks at the Australian market from 1998 to 2003. Australia has experienced a positive growth coupled with a financial deregulation of residential mortgages. This had the effect of increasing the debt-equity ratio. The main finding is the size of the wealth effect. In the short run a \$1 increase in housing wealth raised the consumption between 1.5% and 1.8%. In the long run the increase is estimated to be 6% for housing wealth, which is 3 times the consumption increase for a \$1 increase in financial wealth. Tang concludes with a warning on the effect of a sharp change in real estate prices.

### 2.3.6 Bankruptcy

If a household cannot repay its debt, then it becomes bankrupt. Most of the studies reviewed are conducted in the US and for the US, but they may be generalizable to other markets, as the bankruptcy laws are not very different for other Western countries.

Does bankruptcy regulation have a negative impact on the economy? Li & Sarte (2006) develop a general equilibrium model to evaluate the impact of bankruptcy on output and welfare. They conclude that completely eliminating bankruptcy provisions would cause significant declines in output and welfare, as it would reduce capital formation and labor input.

Fay, Hurst & White (2002) detail the two main types of US bankruptcy, namely Chapter 7 and Chapter 13. Under Chapter 7 bankruptcy debtors are discharged of unsecured debt and they are not obliged to use their future earnings to re-pay their debt, but they have to turn over all their assets above a given threshold. Under Chapter 13 bankruptcy debtors do not need to give up any assets but they must propose a plan to re-pay a portion of their debts from their future incomes.

Domowitz & Sartain (1999) find that, in the US in the 1980's, the causes of bankruptcy were

mainly medical and credit card debt. Real estate ownership plays an important role in deciding whether bankruptcy should be declared or the bankruptcy alternative that should be taken.

Hart, La Porta Drago, Lopez-de Silanes & Moore (1997) are propose a new way to conduct bankruptcy that does not have to go through the capital market. The general idea is to perform multiple auctions of the various assets. This is an interesting way to implementing a bankruptcy, as it can be scaled to a small-size asset holding like a household.

### 2.3.7 The Household Balance Sheet

The overall household balance sheet can vary depending on various economic factors. In his works on the Great Depression, Mishkin (1978) looks at the impact of the household balance sheet on the aggregate demand. The aggregate demand is linked with balance-sheet movements following theories of consumer expenditure. The application of these theories points out that the level of indebtedness heightened the impact of the Great Depression.

Up to now households used to have had a very simple balance sheet, and due to this simplicity the literature did not even use the concept of balance sheets for households. The rise of credit card debt and mortgages made households a more complex economic entity. I think that the concept of household balance sheets could be an interesting area of research. For example, the transposition of the concept of 'financial fragility'<sup>2</sup> to households could be a valuable contribution.

### 2.3.8 The Impact of Credit Rationing

The concept of credit rationing relates to the fact that credit issuers e.g. banks, could provide more credit to their customers than they do. Stiglitz & Weiss (1981) use the idea that banks cannot distinguish between good borrowers and bad borrowers. I will look at this concept in more depth into this concept in section (2.8.2); for now I will look specifically at its impact on households.

The empirical study by Jappelli & Pagano (1994) on OECD<sup>3</sup> countries, shows that credit ra-

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<sup>2</sup>The concept of financial fragility will be studied for companies in more details in section 2.8.5.

<sup>3</sup>Organisation for Economic Co-operation and Development

tioning increases the savings rate. It also increases the effect of growth on savings and strengthens productivity growth in models in which growth is endogenous. Given the time of the data used (1971–1987), the study by Japelli and Pagano can explain the decline in national saving and growth rates that has been observed in OECD countries, as this period witnessed a liberalization of the consumer credit market.

A study of credit rationing in Kenya for the time period of 1973 to 1990 (Adam 1999) shows that credit rationing can push economic actors to access more self-financing. It also shows that, when interest rates are low and stable, relaxing the credit rationing rule may decrease the level of saving deposits, even sometimes to become negative.

Those two studies are examples of the effect of credit rationing on households. Relaxing the rules on consumer credit has been found to reduce the savings rate and to increase the debt level. As seen in section 2.3.7 high levels of indebtedness played a role in the Great Depression. I could not find any in-depth analysis of the current high level of household indebtedness in the economy in the academic literature.

## **2.4 Government**

This survey would not be complete without a glance at the role of government in the credit market. I will look at the specific governmental debt issuance activity. I will then look at their activity of lender of the last resort, before considering the involvement of governments in their attempt to prevent systemic risk.

### **2.4.1 Financial Crisis**

One of the tasks of governments is to avoid financial crisis. Governments are responsible for monitoring the financial intermediaries and in times of crisis act as a lender of last resort or to guarantee deposits. A reference for financial crisis and issues related to the lender of last resort (LOLR), from the point of view of the history of the economy and from the point of view of the recent academic development, is (Goodhart & Illing 2002). From a more historical perspective I would recommend the book by Kindleberger & Aliber (2005).

The first to consider the concept of LOLR was Thornton (1802), but this is Bagehot (1873) who developed the concept of LOLR in a more detailed way. The role of the lender of last resort is:

“(1) to protect the money stock, (2) to support the whole financial system rather than individual financial institution, (3) to preannounce its policy in advance of crisis so as to remove uncertainty.” (Humphrey 1989)

For Bagehot the *raison d’être* of an LOLR is to lend to solvent institutions when the market breaks down. The two main occasions that cause market breakdowns are a bank run or a failure in the inter-bank money market.

From a more general point of view the motivation for this activity is to avoid that a singular event spreading panic to the whole market, causing a drop in the money stock or causing solvent banks to become bankrupt – disorganizing the market unnecessarily. The general idea is for the LOLR to protect the system as a whole. To achieve this, two means are given to the LOLR: a loan to the market as a whole or a loan to a given institution. Supporting a given institution provides the wrong kind of incentive. A financial institution could think that it can take inconsiderate risk because it will be saved by the LOLR (Freixas & Rochet 1997). This subject is still extremely topical as the Bear Stearns bail out has raised a lot of criticism — I will quote only one article, by Stein (2008), but the literature on this subject is vast.

In a more recent work Kahn & Santos (2005) raise the question of the structure of the bank regulation: should a central regulator take on the two functions of the lending of last resort and deposit insurance or should they be separate? They find that linking the two functions leads to excessive forbearance and leads banks to invest sub-optimally in loans.

Finally, the latest moral hazard that has been raised for example by Cohan (2008) is the fact that financial services employees are paid as a portion of the income that they generate. This has been reported numerous times for chief financial officers (CEOs), but M&A (merger and acquisition) bankers are paid only if the deal is closed. It is no surprise that bankers are more interested in closing the deal than providing impartial advice. The Cohan proposal to avoid the moral hazard would be to pay M&A bankers with an hourly rate, like lawyers and accountants.

Investment bankers sometimes use the acronym IWBT YWBT (I won't be there, you won't be there) to describe the fact that everybody knows that the deal has highly risky implications, but the dealmaker will not be around when they happen. The story of Jérôme Kerviel at the Société Générale is symptomatic of a system that rewards only the revenue, providing the incentive for the employees to gamble with their company balance sheet. Some company, like JP Morgan, have tried to balance the employees' earnings with the risk for the company, but a company alone can not put in place such a system unilaterally, as the competition could attract employees by not using this kind of pay scheme.

### 2.4.2 Systemic Risk

Governments are responsible for ensuring that financial systemic risk – the risk that cannot be diversified away – is minimized.

Systemic risk impacts on the economy through the availability of liquidity and credit. The credit relationship between the financial institution and the rest of the economy is essential. Bernanke & Gertler (1995) describe how a household or small firm would not be able to raise money directly in the capital market without banks. A breakdown of the availability of credit could have a serious impact on the economy. Then each bank is linked with the others in increasing this risk. Rochet & Tirole (1996) is studying several aspects of the systemic risk due to the inter-banking activity; the main contribution of this paper is to stress the importance of peer monitoring to improve the overall financial system monitoring.

Systemic risk can impact on the economy, but it is still needed to define the term 'systemic risk' more specifically. de Bandt & Hartmann (2000) provide a survey of the different theoretical systemic risks such as the banking market – bank run and aggregate shocks and lending booms, the financial market as a source of systemic shocks, and systemic risk in payment and settlement systems. Those theories are examined for empirical works. One of the most striking conclusions is, that it is still difficult to define and measure contagion in bank crises.

In the quest to define systemic risk in a better way Summer (2003) proposes to first making

the distinction between diversifiable risk and un-diversifiable risk. In regard to the diversifiable risk Summer looks at the hidden aggregate exposure of the banking system, incentive and coordination issues within the financial services. Acharya (2003) looks at the specific issue of the international convergence of capital adequacy regulation and shows that it is not the best solution as the system converges towards a the worst policy:

“The central banks of initially less forbearing economies also adopt greater forbearance.” (Acharya 2003)

The problem with all the previous studies is the fact that they do not reflect the modern financial system by leaving out hedge funds. Hedge funds represent at the present time a great financial force. Chan, Getmansky, Haas & Lo (2005) are propose a quantification of the potential impact of hedge funds on systemic risk, such as:

“illiquidity risk exposure, nonlinear factor models for hedge-fund and banking-sector indexes, logistic regression analysis of hedge-fund liquidation probabilities, and aggregate measures of volatility and distress based on regime-switching models.” (Chan et al. 2005)

They find that the systemic risk due to hedge funds is increasing.

## 2.5 Financial Credit Products

Historically, banks were only issued loans, letters of credit and certificates of deposit, commercial papers... Those debt products were for some not very liquid, the maturity and underlying spectrum was incomplete and most of all it was not possible to short credit. The credit derivative ‘revolution’ allows the trading of credit by putting a price on the default probability of the underlying debt.

I will examine the literature associated with the major tradable financial credit instruments: corporate bonds, credit default swaps, asset-backed securities, and collateralized debt obligations.

### 2.5.1 Asset-Backed Securities

The other major trend in the credit market is the packaging of collateralized debt into a new vehicle called asset-backed securities (ABS). The two main collaterals for this type of security

are corporate debt and household debt. Corporate debt can take the form of bonds, bank loans or any other collateralized debt. Household ABS are usually called mortgage-backed security (MBSs), even if those securities also contain unsecured debt.

Salomon Brothers was the first place to trade those securities were traded in large volumes since the beginning of the 1980's. A good introduction to the rise of this financial instrument can be found in Lewis (1989)<sup>4</sup>. A more academic reference is the guide for ABSs (Hayre 2001) was written by Salomon Smith Barney.

The two main aspects of ABSs are the extreme asymmetric information between the issuer and the buyer, and the low liquidity of the underlying asset. The pricing of this instrument is fairly complex. Riddiough (1997) provides some insights into the pricing methodology. The two main recommendations for efficient pricing are the diversification of the pool of assets and loan bundling.

### 2.5.2 Collateralized Debt Obligations

The much talked about collateralized debt obligation (CDO) is a specific kind of ABS. A CDO structure involves a special purpose vehicle (SPV) which is a company owning one or several ABSs. This company has, like any company, several levels of debt: super senior, senior and mezzanine. It has also equity. Each type of debt or equity can be sold to investors, a procedure is called 'tranching'<sup>5</sup>. A CDO issuer often keeps the senior tranche and sells the mezzanine tranche; the reason being that investors are looking for an enhanced yield in a given sector. The consequence is that investment banks are still exposed to the CDO even if only for the most senior tranches. One of the main reasons for bank write-ups in 2007 was the holding of sub-prime CDO senior tranches.

Two underlying aspects need to be taken into account for CDO pricing: the individual default probability of each element of the CDO and the correlation of the default probability of those elements. The reference paper for CDO pricing and risk management is by Duffie & Garleanu (2001). This article is uses a simple jump-diffusion setting to model the correlated default inten-

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<sup>4</sup>This is not an academic book, but it is a useful source describing how this innovation came to play.

<sup>5</sup>The word 'tranche' literally means slice in French.



sities.

Practitioners are currently concentrating their efforts on developing a variety of models to price CDOs. Fender & Kiff (2004) note that the main issue with CDO pricing is the strong model dependency. It is therefore very difficult to evaluate a realistic economic value of a CDO. The results of the uneconomic CDO pricing in 2007 as the sub-prime CDOs were due to an extreme under pricing of the risk. Another risk that was under estimated is the systemic risk borne by those instruments; most of the sub-prime CDOs defaulted at the same time.

## 2.6 Financial Intermediaries

In order to understand the different aspects of credit derivatives let's look at the specificity of each financial intermediary involved in this market. Financial intermediary firms are fundamentally information based service companies. Allen (1990) develops a game theory model of a viable information market and how it can be applied to financial intermediaries.

### 2.6.1 Banks

Nowadays banks conduct most of the financial intermediaries' activities. What is specific about banks? It is the commonly accepted idea that banks can take advantage of the information asymmetry surrounding the loan business by specializing in credit pricing. Fama (1985) shows some empirical evidence of the specificity of banks to evaluate credit worthiness.

This idea is developed in a macroeconomic model by Bernanke & Gertler (1985) who show that banks are better at loan evaluation. A central concern discussed in this article is whether the introduction of collateralized debt could eliminate the special role of banks. The answer from Bernanke & Gertler is that this concern is 'somewhat overstated'.

To demonstrate this assertion, Bernanke and Gertler take the example of the mortgage-backed security (MBS) market. They make two main points: first that the agency costs of intermediation are not overcome, only the structure of those costs is changed. Even with the perspective of 2008 I believe that this point is still valid. It is interesting to note that this question raised in 1985 is now more timely than ever before. The second point is that 'these securities do not permit

the complete separation of mortgage origination and mortgage ownership'. The idea developed is that the issuer would 'explicitly or implicitly' guarantee their debt against default and then mortgages used are supposed to be insured 'primarily by the Federal government'. In actuality it looks like the balance is tipping in favor of a full separation between mortgage origination and mortgage ownership.

Given the current position of Ben Bernanke as chairman of the board of governors of the United States Federal Reserve, his view carries special weight:

"Thus, as with the introduction of deposit insurance, the most significant real change is that the responsibility for monitoring intermediary actions has devolved from intermediary creditors to the government." (Bernanke & Gertler 1985, p 38)

To conclude on banks, Diamond & Rajan (2000) elaborate a theory of bank capital. They detail the relationship among deposit amounts, bank capital and the ability to loan money. By doing so they explain possible reasons for a 'bank run' or a credit shortage.

### **2.6.2 Non-Banks Lender**

The emergence of lenders that are not banks is a noticeable development of financial intermediaries. The existence of lenders that are not banks, like real estate companies, has been well documented by (Pozsar, Adrian, Ashcraft & Boesky 2010). I will call those lenders that are not banks Asset Backed Credit (ABC) institutions. While Freixas & Rochet (1997) define a bank as a deposit taking lending institution, an ABC institution is a lending institution that does not hold a deposit and then create credit from asset. For banks, deposits are a means of providing liquidity for the lending business, while an ABC institution must find other avenues of access to liquidity.

The access to liquidity leads us to a way of segregating between ABC institutions. The simplest type of ABC institutions, which I will call "pure ABC", has access only through the wholesale money market. Investment banks are ABC institutions, as they issue credit, and even if they are called "banks" do not take deposits. The specificity of investment banks is the fact that they couple underwriting and financial consulting — fee business — with the traditional lending business. Then their other activities generate liquidity that can be used with the loan business, which is the reason why they need to be differentiated from "pure ABC" institutions. This is

the second type of ABC institution called “investment banks”. Finally, some other institutions benefit from explicit or non-explicit but real government backing that enlarges their access to liquidity. This is the reason why institutions like Freddie Mac or Fannie Mae also need to be separated from the other types of ABC institutions. This is the third type of ABC institution called “government backed ABC”.

### 2.6.3 The Credit Monitoring Delegation

Credit rating agencies are companies that externalize the credit monitoring. Credit rating is critical for companies that issue debt, as a large number of investors are restricted in the quality of credit that they are allowed to or willing to invest in. The role of the Credit rating agencies is very important in the modern economy. Cantor & Packer (1994) voice concerns about the consistency of the ratings and on the adequacy of their use in public oversight.

Hand, Holthausen & Leftwich (1992) study the impact of credit rating agency announcements on the price of bonds and stocks. The main result is that an impact exists, but each market behaves in a different way. A more recent study on the impact of the credit rating announcement is that of Hull, Predescu & White (2004). In this study, the CDS market is found to be much more reactive than the bond yields, as it anticipates most of the rating announcements. The market usually reacts much more strongly to a ‘review for downgrade’ than to an actual downgrade or a negative outlook.

## 2.7 The Market for Credit

This review has studied the market participants and the product use of the credit derivatives market. The idea that the ability of the credit derivative market to transfer risk and to avoid ‘lemons’<sup>6</sup> problems is supported by Duffee & Zhou (2001), even if it changes the existing equilibrium in more established markets like loan-sales.

Before starting the analysis of the market for credit I would like to stress the fact that the new market products and participants often help to make the market more efficient. The presence of those new products and participants is changes the previously existing dynamics.

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<sup>6</sup>The use of lemons is a reference to the famous work from Akerlof (1970).

### 2.7.1 Credit Market Efficiency

The important question is whether it is possible to consider the credit and credit derivative market as efficient? For that purpose the definition of efficiency is given by Fama (1970). Is the credit market efficient in the weak sense, meaning that not all the public information is available in the price with time, in the semi-strong sense in that all the public information is factored into the price, or even in the strong sense, where all the information, public and private, is included in the price?

Before the existence of a credit market, banks would, in the most centralized way, decide who should get access to credit and at what price. Through the credit market, the decision on credit worthiness has been decentralized. Dewatripont & Maskin (1995) point out that this decentralization helps credit issuers in the selection of unprofitable projects, as they help in the estimation process. The model they develop also shows that it puts too high a premium on short-term returns. This decentralized vs. centralized approach to credit can be found in the difference between the Anglo-Saxon model and the German-Japanese financing practices.

One way to look at the information efficiency of the credit market is to consider at the price reaction of CDSs to a specific piece of credit information in the market, for example, when a rating agency publishes an upgrade, downgrade, reviews for upgrade or reviews for downgrade. Norden & Weber (2004) examine at the share abnormal return and adjusted CDS spread changes. Their finding is that the share and CDS markets anticipate rating downgrades, and reviews for downgrade by all three rating agencies.

Since the agreement of Basel II<sup>7</sup> banks have been pushed to use credit ratings from rating agencies as a benchmark for loans. The Enron scandal shows us that credit rating agencies are often slow and react to peer pressure to update their grade<sup>8</sup>. Breger, Goldberg & Chetty (2003) look at the credit rating implied by the credit market price. The finding is very interesting:

We have demonstrated that classifying bonds using markets spread data provides a more reliable basis for modeling return relationships than does a classification

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<sup>7</sup>see the latest version of the agreement (Basel 2006) for more details.

<sup>8</sup>Let's note that no credit rating agency has been found guilty in the Enron case, see Liberman (2003) for the government report on Moody's.

driven by agency ratings. (Breger et al. 2003, p 12)

It is an indication that the credit market can provide more information than the credit rating agencies.

A drawback of the credit derivative market is the fact that at any one point in time it is not possible to know exactly what debt is owned by whom. Morrison (2005) uses this argument to show that in some cases the second-best behavior can be observed in the bond issuance process. This is another occurrence of the phenomenon where the existence of credit derivatives forces older credit processes to change.

The study from Acharya & Johnson (2007) shows that insider trading in the credit derivative market is happening in a measurable scale. It does not affect prices or liquidity adversely. This would lead us to believe that this market would have a more than 'semi-strong' efficiency<sup>9</sup>.

### 2.7.2 Bubbles

During the last two decades the growth in credit issuance has been very impressive. The issue of junk bonds has allowed the takeover of massive corporations; the contemporary private equity business is highly leveraged and even industrial companies are issuing many more bonds than ever. Households now have access to and use widely secured and unsecured debt; for example small-scale chief financial officer (CFO) individuals tap into their home equity to finance projects on a routine basis. The obvious question is: Is it a bubble?

Before looking specifically at bubbles I would like to look at one possible cause of bubbles: investors' overconfidence, as discussed by Daniel, Hirshleifer & Subrahmanyam (1998). Investors are overconfident about the holding and the information that they have on their investment. This kind of bubble is called an irrational bubble, because the economic participants do not behave as rational agents.

A very interesting type of rational bubble is the speculative bubble. Caballero, Farhi & Hamour (2004) study at speculative growth. They describe it as an optimistic view of the avail-

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<sup>9</sup>The terminology used here is the Fama's (1970).

ability of funds for investment coupled with an economic equilibrium set on high levels of investment and a low effective cost of capital. Those growth patterns are not always bubbles, but they can be the generating mechanism of a rational bubble.

A possible idea would be to say that in the presence of a market bubble, some arbitrageurs would take this opportunity. However, as seen in Abreu & Brunnermeier (2003), even in the presence of arbitrageurs bubbles can continue to exist. Those arbitrageurs do not co-ordinate their action. The dual action of this 'synchronization problem' with the fact that arbitrageurs want to sell at the highest and 'time the market' results in the persistence of bubbles over substantial periods of time.

I would like to conclude on bubbles with the paper by Shim & von Peter (2007) about distress selling. The idea is simple: a given distress sale of assets can trigger more sales. This article also looks at policy options to limit the damage of such events.

### **2.7.3 The Market Price of Credit**

Not much empirical work has been published on the market price of credit. One of the most important studies was undertaken by Blanco, Brennan & Marsh (2005): a CDS price analysis in a time-series framework. There are some technicalities that separate the credit spread, as it is defined by Duffie (1999), from the CDS price. The CDS market leads the bond market in determining the price of a company's credit risk. Another interesting fact is that the CDS spread is more sensitive in the short run to company-specific rather than to macro-economic changes.

I believe that there is a great opportunity to work on this topic, as it has been under-researched and the validity of the credit price of risk is a critical information for most of the credit participants.

## **2.8 Macroeconomic Theories of Credit**

The fundamental article by Modigliani & Miller (1958) provides a model in which the total value of the bond and equities issued by a company is independent of the interest rate of the bond and the amount of the bond outstanding. The assumptions for this model are numerous: no fixed

costs, transactions costs, asymmetric information, etc... The idea is that the capital structure of a firm is irrelevant to its economic activity. The very existence of this theorem has shifted to the side of the study of credit as a macroeconomic subject for a while and it was only around the 1980's that credit came back into fashion.

I will first look at the reason for the growth of the credit market. Second I will focus on the imperfections of the capital market, starting with credit rationing, financial accelerators and credit cycles. Then a description of the specific macroeconomic credit models will be provided.

### 2.8.1 Growth of Credit Issue

The issuing of debt to corporate borrowers or households has been exploded during the last two decades. For households, the fact that a wide range of mortgages and unsecured debt like credit card was proposed can explain the increase in the use of credit – see in section 2.3, the two main references being Muellbauer & Murphy (1997) and Ludvigson (1999).

For companies, the motivation behind the credit derivative growth was mainly capital regulatory arbitrage, or the ability to circumvent the existing regulation on minimum capital requirements. This theory is developed by Calomiris & Mason (2004) in the context of off-balance sheet financing of credit card receivables by banks. The conclusion of this study is reassuring – for the period studied – in the sense that credit derivatives are not used to cancel out the minimum capital requirements but to optimize the capital structure.

To mitigate the previous statement, it is important to understand that CDSs are also off-balance-sheet instruments that can be used to reduce firm leverage by buying credit protection. Minton, Stulz & Williamson (2005) studied the use of CDSs to reduce credit exposure for US banks from 1999 to 2003. The results show that not all banks use credit derivatives, but the ones that do are mainly net buyers of credit protection.

An area of concern is the leveraged buyout (LBO) business. It is very difficult to determine the exact financing structure of LBO funds due to their private nature. This is one of the arguments that Warren Buffett uses to qualify derivatives as 'financial weapons of mass destruc-

tion' (Buffett 2002) .

### 2.8.2 Credit Rationing

A significant part of the economic credit literature deals with credit rationing. The idea is that for various reasons banks do not issue loans to all the parties that request one, even at a higher rate. The initial reason for credit rationing is the *a priori* inability of banks to distinguish between 'honest' borrowers and 'dishonest' borrowers. The idea developed by Jaffee & Russell (1976) is that 'dishonest' borrowers will default more often, so by rationing the access to credit to new borrowers and by developing a relationship between lender and borrower, banks can distinguish between the two types of borrower.

In the model by Stiglitz & Weiss (1981), the debt issuer still cannot *a priori* distinguish between good borrowers and bad borrowers, but it is possible to maximize the bank profit by setting an optimal interest rate. The idea is that good borrowers are more sensitive to the interest rate than the bad ones, as the good borrowers know the level of return that they expect from the project they are trying to fund. On the other hand the bad borrower will over-estimate the return they expect. By raising the loan interest rate, banks increase their income but by raising it too much they discourage good borrowers and attract only the bad ones who are likely to default and cause loss. By taking a portfolio approach it is possible to find an optimal interest rate. It is interesting to note that in this model the amount of funds available is irrelevant to the level of the optimal interest rate.

In a more recent paper, de Meza & Webb (2006) examine in more depth at the relationship between the credit rationing due to asymmetric information and agency costs that shape the interaction between investment and financing. One of the implications is the fact that entrepreneurs have a great incentive to cut their loans to avoid rationing, this is implemented by scaling down projects, reducing consumption or putting the project on-hold to accumulate more savings. In the de Meza & Webb model credit rationing is put in place as much by banks as by the companies themselves.



### 2.8.3 Financial Accelerators

The theory developed by Bernanke et al. (1996) states that credit as a transmission vehicle can transform small economic shocks into large ones. The two main conclusions are:

1. “borrowers facing relatively high agency costs in credit markets will bear the brunt of economic downturns (the flight to quality);”
2. “reduced spending, production, and investment by high-agency-cost borrowers will exacerbate the effects of recessionary shocks.” (Bernanke et al. 1996, p 15)

Credit and then credit derivatives can be financial accelerators. The following quotation from (Bernanke et al. 1996) supports this view:

Quantification of the importance of the financial accelerator in macroeconomic dynamics is an equally important topic for future research.

Credit is now a developed market and as it is discussed by Brunnermeier & Pedersen (2005) markets can exhibit trading techniques that amplify market moves.

### 2.8.4 Credit Cycles

In a neoclassical model of the business cycle, Bernanke & Gertler (1989) develop the idea that borrowers’ balance sheet is a critical element in understanding economic fluctuation.

The thesis developed by Greenwald & Stiglitz (1993) is that financial market imperfections, like the asymmetric information in financial markets, are a source of business cycles and sensitivity of the economy to small perturbations.

Kiyotaki & Moore (1997) study the interaction between general business cycles and credit constraints to develop a theory of credit cycles. It exhibits interaction between credit limits and asset prices as a transmission mechanism by which shocks effects are amplified. Small or temporary shocks can be the results of real fluctuations in output and asset prices.

### 2.8.5 Macroeconomic Credit Models

In order to understand the role of banks in the aggregate economic activity, Bernanke & Gertler (1985) develop a general equilibrium model including banks. In this model, all financial interme-

diaries are represented by banks, which have better ways to evaluate credit, than the rest of the economic actors. The conclusion concerns mainly the adequacy of bank capital, the riskiness evaluation of bank investments and the costs of banks' monitoring. The goal, of this research, is to gain insight into the macroeconomic effects of phenomena such as financial crises.

In another article Bernanke & Gertler (1990) pursue the idea that the net worth of the borrower balance sheet positions, is a determinant of investment spending and output. The higher the cost of external investment finance, the lower is its net worth. They develop a model of external finance processes with asymmetric information between borrowers and lenders about the quality of the project to be undertaken. In a general equilibrium, the lower the borrower net worth is, the higher the average quality of the projects undertaken will be. One of the great contributions is the concept of 'financially fragile'. This is a state in which companies in this economy have such a weak balance sheet that it may cause underinvestment, misallocation of investment and the possibility of a complete investment collapse.

In the case of 'financially fragile' companies, one of the recommendation of Bernanke & Gertler is as follows:

“Our policy analysis suggests that, under some circumstances, government 'bailouts' of insolvent debtors may be a reasonable alternative in periods of extreme financial fragility.” (Bernanke & Gertler 1990, abstract)

This is a very interesting comment if it is compare with the recent activity of the Bank of England with Northern Rock.

These models could be improved by changing the ownership, the cost of monitoring and the source of credit. Let's remember that at the time when those paper were written the ownership and the monitoring were only conducted by banks.

On a similar subject, Chen (2001) looks at the relationship between the banking sector, asset prices and aggregate economic activity. I find this paper particularly interesting because it provides a model of the overall economy using durable assets as productive means as well as collateral for loan. He finds that:

“The propagation mechanism of a negative productivity shock is enhanced and prolonged through the interaction of credit constraints and asset prices, where the bank loan and the investment are squeezed by a higher bank capital–asset ratio for lending and at the same time, a stricter collateral requirement for borrowing. The model explains why banking crises often coincide with depression in the asset markets. The results also bear policy implications for the debates over regulatory bank capital adequacy and credit control policies.” (Chen 2001, abstract)

This is a very interesting approach because it models indirectly, and imperfectly, the existence of credit derivatives through the dual existence of durable assets as productive means and loan collateral. Then it explains the relationship between asset price, credit market and output.

In more recent research von Peter (2004) examines at a similar relationship between asset price and credit distress. He refines the concept of ‘financially fragile’ with the ‘balance sheet vulnerability’, with the goal of look specifically studying the feedback from credit deterioration to asset price. This work makes an important contribution because it shows a model reflecting that a purely financial crisis can propagate to the rest of the economy.

## 2.9 Financial Market Frictions

The aim of this thesis is to advance knowledge on how asset prices impact credit growth and economic activity. The above review of the literature on the actors of these phenomena ( i.e. corporation, household, government and financial intermediaries) has identified several tools that link asset price and credit before looking at the way credit is being dealt. Finally the review also discussed the role that credit plays for the macro-economy. On the basis of this review I will complete here the link between credit and the macro-economy, before developing a new contribution by addressing the question of what are the main financial market frictions that involve asset prices, credit growth and economic activity.

The most general overview about credit market frictions has been developed by Bernanke, Gertler & Gilchrist (1999), who suggests that credit can be considered as a “financial accelerator” that amplifies and propagates shocks to the macro-economy. Two other factors that this

work brings forward are price stickiness and heterogeneity among firms with different abilities to access the capital market. More recently, Iacoviello (2005) developed a business cycle model that links loans and collateral constraints to house values and looks at the reaction of the economy after a demand shock.

Brunnermeier & Pedersen (2008) highlight a new aspect regarding the liquidity aspect of the asset market and its link with availability of funding, by modeling several empirically observable behaviors like sudden stops on liquidity, its commonality across securities and “flight to quality” market movements.

More specifically on the current financial crisis Brunnermeier (2009) describes in detail some of the mechanics that were at play during the 2007 financial crisis, which involved real estate assets credit growth in general and securitization growth in particular. Following Brunnermeier’s view, this crisis was a fairly typical over-leverage crisis that was exacerbated by the extent and opacity of the securitized business. Brunnermeier also describes the expected spillover of this financial crisis on the real economy.

Another interesting market friction significant for modeling is the decoupling of money and credit aggregates, as empirically observed by Schularick & Taylor (2009). This decoupling effect should promote the credit component of macro model, away from the typical monetary view of financial crisis. The article from Schularick & Taylor also suggest that that credit growth is a powerful predictor of financial crises.

Finally, as reviewed above, von Peter (2004) investigates the link between asset price, credit and financial stability. Financial instability brings non-linear behavior to the model as when the financial system goes into crisis the rest of the economy is irreversibly impacted. The financial stability will be the main friction that this thesis will focus on.

## Chapter 3

# Macroeconomic Impact of Household Debt

### 3.1 Introduction

*You load sixteen tons, what do you get?*

*Another day older and deeper in debt.*

*Sixteen Tons, 1946, Merle Travis*

Wide spread real estate investment has traditionally been seen as a good thing. This was one of the motivations for promoting home ownership for a large portion of the population in the United States. This policy was advanced through the Community Reinvestment Act, initiated in 1977, which promotes lending to low and moderate-income households.

These policies, couple with financial deregulation, had implication: high levels of debt were taken on by households. Even if a high level of real estate ownership generated by collateralized loans has macroeconomic benefits, it is not exempt from drawbacks. A good illustration of such drawbacks is the 2007 financial crisis. What started with the default of mortgage owners became a widespread financial crisis that led to the bailout of numerous large banks and the disappearance of major banks such as Bear Stearns and Lehman Brothers.

This section investigates positive and negative macro implications of different levels of house-

hold real estate investment.

### 3.1.1 Literature Review

Reinhart & Rogoff (2010) find empirically that private debt surges are a recurring antecedent to banking crises. The main locus of household debt is real estate. I investigate how household participation in the real estate market can accelerate financial crises. The causes of financial crises form part of the literature on financial stability. Within the area of financial stability, we focus on the link to asset prices. To fully frame the literature, I review the fundamentals of household participation in the real estate market.

#### Financial Stability and Asset Prices

Financial stability, a core element of central banking, must be distinguished from the common concern of economic stability. Economic stability refers to stability of price levels and out-put. Financial stability can be defined as the smooth and uninterrupted operation of both credit and payment mechanisms. The most detailed definition of this concept can be found in (Federal Reserve Bank of St. Louis 2002). Within the area of financial intermediation, the best model of risk in the lending business is (Kiyotaki & Moore 1997).

Kiyotaki & Moore (1997) use a model with overlapping-generations to study how credit constraints interact with aggregate economic activity over the business cycle. The model describes a dynamic economy where assets like land or real estate are used as means for production and as collateral for debt. The key conclusion of the model is that borrowers' credit limits are affected by the prices of the collateralized assets.

Financial stability is linked with asset prices, as described by (Chen 2001) and (Bernanke & Gertler 1999). There is also a vast literature on banking crises, particularly the literature that links demand for liquid deposits to bank runs (e.g. Diamond & Dybvig (1983); Diamond & Rajan (2001)). In this context, the main issue to consider is that bank assets and their deterioration are exogenous. The deterioration of bank assets has been found to be an empirical cause of banking distress, as shown in Caprio & Klingebiel (2003).

In this subsection I will extend the von Peter (2009) macro model that links asset prices and the banking system. Financial crises in the von Peter's model are links to asset prices through the banking system. It models a possible vicious circle linking an asset price shock to default that feeds back to bank capital, and then to asset prices by using the bank capital constraints. It details the stages of a productivity shock on the financial system, i.e., firm wealth effect, loan losses and falling capital, financial instability due to capital erosion, and finally banking system insolvency.

### **Real Estate Price Dynamics**

Here, I examine links between financial stability issues and the residential real estate market by investigating the connections between rent and real estate prices.

A survey of this literature is found in Cho (1996) in which the basic model for house prices is found to be the present value of rent plus a speculative input. One theoretical question is whether the property market is efficient; in empirically testing this hypothesis, there is a counterintuitive element that makes pursuing this question difficult. That is, for rigorous analysis, the price-to-rent ratio is quite difficult to estimate. The fact that surveys of property prices and rents are easily available does not mean that they reflect reality.

The main issue is to ensure that the comparison of price and rent is done in a consistent manner. There are five types of statistical bias with respect to real estate: (1) renovation bias —whether the quality of the sold property is comparable with the quality of the rented property; (2) hedonic bias; (3) trading-frequency bias —the property price might be misrepresented because of very low trading frequency; (4) sample-selection bias —the property market is full of niches, which makes it very sensitive to selection bias; and (5) aggregation bias —a small neighborhood can go up or down in value very quickly.

### **Literature Gaps**

Real estate mortgage is the largest debt that households undertake and it is also very wide spread. This has two main effects: firstly, household can be leveraged; and secondly households are exposed to the real estate price. While the impact of the relationship between asset price and

credit on firms and banking systems has already been studied, and while rent and real estate asset prices for household have been researched; there is a gap in the literature concerning the link between household exposure to real estate through debt/ownership.

### 3.1.2 Contribution

There is some empirical evidence uncovered in Reinhart & Rogoff (2011) that domestic debt over the last century across the world was historically high. The largest locus of debt for households is linked with real estate. That level of debt for such a critical economic actor as the household is very likely to have implications for the economy as a whole, and for the financial system in particular. The financial system can be impacted by household debt via the fact that banks simultaneously hold household deposits and loan to the household sector.

A natural research question is then:

How do large amounts of household real estate debt impact the economy during times of financial stability and instability?

The aim of this work is to contribute toward developing a macro model that quantifies the impact of household real estate debt on the economy through the financial sector. To achieve this, I extend the model developed in von Peter (2009)), which examines the relationship between credit and asset prices by considering household ability to take on debt for real estate purchases. Real estate is considered a long-term asset that offsets part or all household shelter costs. Household real estate ownership can be split into two aspects: shelter services on the one hand, and property investment on the other. This division facilitates investigation of the consequences of different levels of real estate ownership on the economy.

It should be noted that I developed this model in 2008, so I had access to the bank for international settlements (BIS) report (von Peter 2004), but not the *Journal of Financial Stability* article (von Peter 2009). This explains why I spend more time in this work detailing the model than I would have if this model were published at the time of its creation.



### 3.1.3 Objective

The objective of this section is to show the macroeconomic impacts of household real estate ownership through debt. I will show that some level of household debt linked with real estate ownership can have a positive impact on the economy, but that high levels of debt can deepen the effect of productivity shocks. To do this, the level of household debt is modeled as an exogenous parameter.

This section is structured as follows. First I examine a static model linking asset prices with banks; this model has firms and households as agents. Then, I present this model with an unexpected productivity shock, looking at its impact on the different actors, and more specifically on the banking system. I conclude with some policy implications.

### 3.1.4 Model Overview

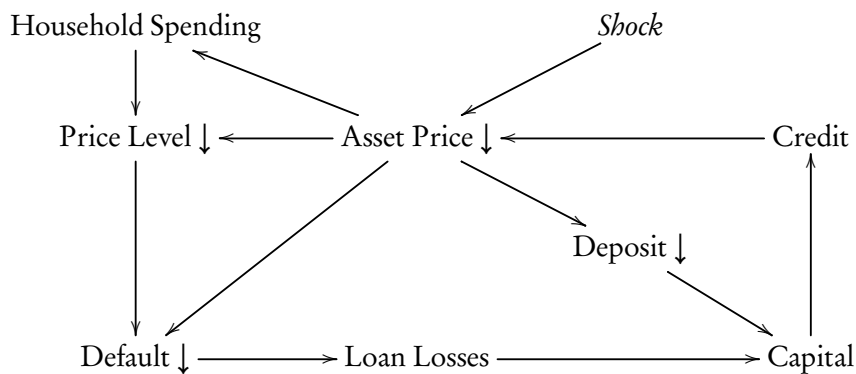
I develop a formalism close to that of von Peter (2009). The main addition to this model is the ability for households to take on debt.

This model is an overlapping-generations type, where assets play a central role. Households decide a level of non-productive asset ownership that we will consider constant. The way it works is firms buy productive assets, like machineries or productive real estate on bank credit. During the next period firms resell their assets to the next generation of firms, and sell their output at the clearing price level. This gives rise to a natural debt structure in which households keep deposits with banks, whose assets consist of debt claims on firms' assets.

The model described above is static; however through shocking the system we create a dynamic. When expected productivity declines, the forward-looking asset price falls to reflect the reduced consumption spending, and the price level may fall as well. This effect is accelerated by the fact that household wealth is linked with asset price. Thus, when household wealth is decreasing, this leads to adaptations in household spending. The results is old firms suffer a loss on assets sold. The associated wealth effect reduces consumption spending and the price level may fall as well. When these declines are large, firms end up in default and losses spill over to the banking system and diminish bank capital. Then banks in turn react to losses by reducing credit issuance.

Their attempt to keep leverage from rising produces feedback from the banking system to asset markets, causing further losses in the aggregate. The interaction between asset prices and bank losses can now give rise to a range of financial extremes, either in the form of fundamental or as self-fulfilling outcomes.

The core contribution of this model is the idea that failing asset prices have an impact on the banking system, which is indirect, non-linear and produces feedback.



This model is close to the one from Kiyotaki & Moore (1997) as it is an overlapping-generations model where assets play a central role. The main differences with Kiyotaki & Moore (1997) are the following:

- this model includes the ability of households to take debt.
- while sharing the emphasis on balance sheets in a macroeconomic context, this model is simpler regarding borrowers (demand for credit), but incorporates a banking system (supply for credit).
- in the Kiyotaki & Moore (1997) model the financial accelerator is about borrowers' investment, output and, ultimately, macroeconomic stability. By contrast, the present model focuses on financial stability, and the way loan losses may interrupt the intermediation of credit and payments.
- in the Kiyotaki & Moore (1997) model the financial accelerator confines itself to small deviations from steady state, and thereby excludes the financial extremes that had motivated

its development. This is due to the fact that Kiyotaki & Moore (1997) restrict contracts to rule out default.

## 3.2 Static Model

This section describes the static version of the developed model. After describing its basis, I examine the perfect foresight equilibrium. I finish with a note about the model foundations before exploring possible extensions.

### 3.2.1 Model Description

My model has three actors: firms, banks, and households; two types of asset are used: real estate and industrial. The government as lender of last resort will not be modeled as this would add to the complexity of the model without adding much explanatory power.

I am going to use the mathematical notation  $(\cdot)^+$ , which is defined as follows:

$$(x)^+ = \max(0, x)$$

#### Asset Types

This model has two types of asset. First, there is the productive asset or industrial asset  $H^I$ , this asset type is used by firms to produce goods. Firms will use  $H^I$  to produce goods in exchange for goods. Second, there is the non-productive asset or non-industrial asset  $H^{nI}$ , this asset type is owned by household for housing services and  $H^R$  is the asset owned by real estate renting firms that hold these assets to rent them to households. The total amount of asset  $H$  is defined as  $H = (H^I + H^{nI} + H^R)$ .  $H$  will stay constant across time, i.e., no depreciation.

All of these assets will have a unique price<sup>1</sup> at time  $t$ ,  $q_t$ . The fact that the prices of real estate assets for sale and for rent are the same stems from the assumption that the market is efficient. This assumption greatly simplifies calculation, as it removes the need to develop two asset markets. This assumption for  $H^I$  and real estate assets is justified by the fact that, over a long period, real estate price growth is close to inflation, as shown in Shiller (2006). One factor that favors

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<sup>1</sup>This would be an interesting assumption to relax for future work.

distinguishing real estate assets from other assets is the fact that the housing wealth effect may distort real estate prices compared with other asset markets. The housing wealth effect is uncovered in several studies that seem to lack controls for changes in expected permanent income, as shown in Calomiris, Longhofer & Miles (2009). After controlling for changes in expected permanent income, the housing wealth effect seems to disappear.

### Firms

At time  $t - 1$  firms have a portfolio of assets  $h_{t-1}$ , which help them to produce  $f(h_{t-1})$  consumption goods.

At time  $t$  the goods are sold at price  $p_t$  and assets are re-sold (I assume here no depreciation) at the asset price  $q_t$ . Note that consumption  $c_t^f$  is dependent on time  $t$  and the production function  $f$ . I assume the production function  $f$  to be convex-concave. The interest rate is  $R_t$  — ( $R_t > 1$ ) i.e. no negative rates — and for a given time  $t$  the rate is considered constant for all maturities. Finally  $\Pi_t$  is the profit at time  $t$ , and then by adding the constraint  $\Pi_t > 0$ . Profit is set to be positive, as in this model firms do not pay dividends and borrow all their assets each period; therefore, negative profit — also called losses — will be transferred to the banking sector as bad loans. Firms are run by owner-entrepreneurs, who maximize profits from purchasing output from other firms<sup>2</sup>:

$$\begin{aligned} & \sup_{h_{t-1}} u(c_t^f) \\ & 0 \leq p_t c_t^f \leq \Pi_t \\ & \Pi_t + R_{t-1} q_{t-1} h_{t-1} = p_t f(h_{t-1}) + q_t h_{t-1} \end{aligned} \quad (3.1)$$

The full profit  $\Pi_t$  is spent at time  $t$ , and no profit is retained from one period to the next one.

Equation (3.1) reflects the fact that firms borrow the full asset value before, the production takes place and they pay back this debt at interest rate  $R_t$ . The first-order marginal revenue product to the user cost of holding assets is:

$$p_t f'(h_{t-1}) = R_{t-1} q_{t-1} - q_t \quad (3.2)$$

<sup>2</sup>To maximize the utility of consumption, I use the *sup* function instead of the *max* function, which would not allow to keep the continuity of the utility. This is an open bounded  $u(c)$  set whose supremum could not be reached.

Note that I exclude the rental market for all firms<sup>3</sup>. The reason for this assumption is that otherwise it would not been possible to have no debt in equilibrium, as in the case of a rental housing firms would financing their holdings of assets exclusively out of sales revenue.

I classify real estate rental companies as firms, even if in this context they do not follow the constraint of being goods producing firms. Real estate rental companies operate in a very simple way — they own real estate assets, collect the rent paid by households (see section (3.2.1) for details rental prices), then at each period spend the full amount of rent collected in the goods market. In this section, real estate rental companies are passive firms that do not change the level of their ownership or keep money from one period to the next. They own the total asset share  $H^R$ ; I assume that this amount is an initially set exogenous variable.

One possible model for these economic actors would have been to create a new kind of leveraged firm with a mechanical production function — the discounted price of the asset used. This would have made the model much more complex, mainly on the market clearing condition. On the other hand, it would have given us only one additional feature from the current model, i.e., the ability of the renting firm to go bankrupt. The current assumption pertains mainly to making the rental business exogenous to the model; this is not an issue, as the core of this contribution does not deal with the rental business. I believe that the tradeoff between complexity and explanatory power given by this hypothesis is appropriate. This also reflects the fact that a large number of investors disappointed with the market decided to invest in real estate and invested without leverage.

And finally, the firm set-up contrasts with Kiyotaki & Moore (1997) as borrowing is not constrained by the future market value of assets: firms can also pledge their future sales revenue in (3.1).

### **Households**

Households live indefinitely. They derive utility from consuming goods and services. They are endowed at date  $H$  of productive assets. I denote  $D_t$  the wealth carried over; this money is

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<sup>3</sup>One specific case of rental market will still be allowed but only for households, as shown in the next section. This residential rental business is a service that firms provide only to households.

deposited in banks and accrued with  $R_t$ . I assume that banks are rewarding households at the same rate  $R_t$  that they charge firms. Households can run their own production, with production function  $g$ , but this production would be very small compared with the firm production ( $\forall h \ g(h) < \epsilon f(h)$  where  $\epsilon > 0$  is small and  $g'(0) < f'(H)$ ). In this scenario, use of household production occurs only in extreme cases called *autarky*, when the production capacity of firms has been destroyed.

Households also have bank debt, but let us assume that households have no debt at time 0. One departure from the von Peter (2009) model is the fact that owning some real estate assets allows the household to offset part of its own cost of accommodation. The motivation behind this assumption is coming from the empirical observation that households have the choice between renting or buying — or a mix between the two — to satisfy their need for shelter. The need for shelter is basic so it cannot be removed. This assumption models the set of reasonable motives why households decide to buy real estate, i.e. avoiding to pay a rent as well as investing in a real estate asset. The way this is implemented in this model is through an index that sets the level of household real estate ownership, in order to describe several possible scenarios, namely:

- no ownership level, the household rents only
- some level of sheltering needs are fulfilled by real estate, but some rent is still necessary (we can think of self storage unite)
- the needed level of sheltering is fulfilled by real estate ownership but not more, no rent is required
- the needed level of sheltering is fulfilled by real estate ownership and more (we can think of two persons living in a castle), no rent is required

The specific level of this ownership level will be exogenous to this model; it will help to investigate a given environment.

I assume here that the property market is efficient in the sense that the price of real estate  $P_t$  is the present value (PV) of the current housing rent  $r_t$

$$P_t = \text{PV}(r_t) = \sum_{n=1}^{+\infty} \frac{r_t}{R_t^n}$$

This assumption is fairly standard as shown in Martin (2008).

I consider housing rent to be sheltering services provided by real estate companies. I assume that only households are allowed to rent; as defined above, firms cannot rent their means of production.

Note  $e$  the unit amount of assets, this can be a house, an apartment or any other kind of shelter, needed to provide accommodation for one household. This amount  $e$  is taken as constant and uniform across households. As noted above, I assume that there is only one type of asset with price  $q_t$ . The real estate price is then going to be  $q_{t-1}$  and the price of a household shelter is  $P_t = eq_{t-1}$ ; I consider the real estate rent at time  $t - 1$  defined one year in advance. By inverting the previous PV function it becomes possible to obtain the annual household rent as  $r_t = PV^{-1}(P_t) = PV^{-1}(eq_{t-1})$ .

Note  $l_t$  the amount of assets owned by households at the time  $t$ . This quantity,  $l_t$  is exogenous to the model; agents do not use this variable to optimized for consumption or wealth<sup>4</sup>. As  $l_t$  is not always equal to  $e$ , let's quantify how much a given of shelter ownership  $l_t$  can reduce the annual cost of accommodation.

- if the ownership level is zero ( $l_t = 0$ ) then the rent is  $r_t = PV^{-1}(eq_{t-1})$
- if  $0 < l_t < e$ , then ownership reduces to sheltering costs from a fraction of the rent equal to  $PV^{-1}((e - l_t)q_{t-1})$ . The ownership of the asset fulfills a portion of the need for shelter, the rest should still be obtained through housing rental services (it is possible to think of this as a kind of self-storage facility)
- if the ownership level  $l_t$  is greater than  $e$  ( $l_t \geq e$ ) then the rent is zero, as the household has more than enough real estate assets for their shelter needs

It can be summarized by

$$PV^{-1}(\max(0, eq_{t-1} - l_t q_{t-1}))$$

or in a more concise way

$$PV^{-1}(q_{t-1}(e - l_t)^+)$$

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<sup>4</sup>It would be possible to plug in some national statistics to obtain a numerical example.

It is evident that a rational agent would not decide to own more real estate than  $e$  and it is not possible to own a negative amount, so  $0 \leq l_t \leq e$ .

Let us define spending standard consumption as  $s_t$  and living consumption as  $PV^{-1}(q_{t-1}(e - l_t)^+)$  the total spending is  $S_t$ , where  $S_t = s_t + PV^{-1}(q_{t-1}(e - l_t)^+) = p_t c_t^h$ . It is possible to see the housing spending as a minimum expenditure and the standard consumption as a non-housing consumption.

Thus, let's write the inter-temporal consumption/debt problem as:

$$\begin{aligned} s_0 + D_0 &= q_0 H \\ s_t + PV^{-1}(q_{t-1}(e - l_t)^+) + D_t + R_{t-1}q_{t-1}l_{t-1} &= D_{t-1}R_{t-1} + q_t l_{t-1} \end{aligned} \quad (3.3)$$

The utility function  $u(c_t)$  of the consumption to maximize function is the following:

$$\sup_{c_t} \sum_{t=0}^{+\infty} \beta^t u(c_t^h) \quad (3.4)$$

To summarize the household balance sheet is:

Household Balance Sheet	
Asset	Liability
$R_{t-1}D_{t-1}$	$s_t + PV^{-1}(q_{t-1}(e - l_t)^+)$
$q_t l_t$	$R_{t-1}q_{t-1}l_{t-1}$
	$D_t$

It is evident that household equity is the bank deposit  $D_t$ . The variable  $l$  is external and  $q_{t+1}$  is independent so the variable controlled by the household is the bank deposit  $D_t$ . The Bellman equation to solve is

$$V_t = \max_{c_t} (u(c_t) + \beta V_{t+1}(D_{t+1}))$$

The first-order condition is

$$u'(c_t) + \beta V'(D_{t+1}) \frac{\partial D_{t+1}}{\partial c_t} = 0$$



which gives us

$$u'(c_t) = \beta R_t p_t V'(D_{t+1})$$

The envelop condition is, then

$$\begin{aligned} V'(D_t) &= \beta V'(D_{t+1}) \frac{\partial D_{t+1}}{\partial D_t} \\ &= \beta R_t V'(D_{t+1}) \end{aligned}$$

This gives us the slope of the optimal consumption for the control  $D_t$ :

$$u'(c_t^h) = \beta R_t \frac{p_t}{p_{t+1}} u'(c_{t+1}^h) \quad (3.5)$$

To determine how households deviate from this perpetuity rule out of the steady state, I posit a time-separable utility — the constant relative risk aversion (CRRA) function with a  $\gamma \in ]0, 1[$ <sup>5</sup>:

$$u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}$$

In steady state, all variables are constant across time such that price and consumption are as follows:  $p_t = p_{t+1}$  and  $c_t = c_{t+1}$ . Therefore, the only way to ensure that (3.5) stays true is to have  $R = \beta^{-1}$ . In steady state the interest rate is equal to the inverse of the rate of time preference. Then it is evident that  $s = (R-1)(D-ql) - PV^{-1}(q(e-l)^+)$ . Since, in steady state, a  $PV$  function is a simple discount factor as  $R_t = R$ , then it is evident that

$$PV(x) = \sum_{n=1}^{+\infty} \frac{x}{R^n} = \frac{x}{(R-1)}$$

By rearranging the steady state spending is

$$s = (R-1)(D-ql-e)^+ \quad (3.6)$$

or

$$S = (R-1)(D-ql) \quad (3.7)$$

---

<sup>5</sup>In this interval the function is well defined, positive and increasing.

At this stage let's look at the scale of the variable  $e$ . This variable represents the amount of asset needed to provide shelter to a household. It is evident here that this variable  $e$  must be small compared with  $D$ , as the cost of housing in most developed country is around 30% of income. The variable  $e$  is then such as

$$e < \frac{D}{3q}$$

Let's define the bankruptcy level of a household. Bankruptcy can not happen because of high spending  $s_t$ , as  $s_t$  is constrained under the maximization of the utility function, and if an household spent everything it has at a period  $t_0$  it would not be able to spend anything else for any  $t > t_0$  which is clearly not a good maximization strategy. The only way household can bankrupt is if it expose to the asset market and the given asset market has fallen in value. I will define the bankruptcy level as the  $q_t$  for which  $s_t = D_t = 0$ . Given that the bankruptcy is given at the begin of a period I can also set without loss of generality  $l_{t-1} = l_t = l$  so:

$$R_{t-1}q_{t-1}l \geq D_{t-1}R_{t-1} + q_t l - PV^{-1}(q_{t-1}(e - l)^+) \quad (3.8)$$

I assume that there is no housing cost at time  $t = 0$ . From (3.7) it is possible to find the permanent income form wealth

$$D = \frac{qH^l}{R} + ql \quad (3.9)$$

### Banks

Households are both lenders and borrowers. Each period, firms borrow enough to buy their means of production. The specificity of this model is the fact that the inter-temporal exchange is generated by a successive generation of firms.

Barter is the rule in this model. To make this barter work, banks interpose themselves in all financial transactions, for firms to buy assets and sell goods or for households to buy goods or services. One of the advantages of this system is that banks can enforce debt payments, as it is possible to block payments for actors that do not pay their debts. Unlike Kiyotaki & Moore (1997) borrowing is not constrained by the future market value of assets, and revenues cannot be pledged.

The banking system intermediate works as follows. Each period  $t$ , the banking system creates deposits worth  $q_t h_t$  by extending loans to new firms; this enables them to purchase assets by transferring the deposits to old firms. Old firms use these deposits to reduce their existing debt with the bank to  $(R_{t-1}q_{t-1} - q_t)h_{t-1}$ . This balance is repaid using sales revenue  $p_t f(h_{t-1})$  leaving profit consistent with (3.1). At the same time, households have their debt accounted for as well as their savings. Going backward, the first payment of  $q_0 H$  is received by the initial sellers of assets, the households, who hold their asset wealth on deposit to finance their spending  $s_t$  with their debt  $q_t l$ .

The banking system works as follows, at  $t$  it creates deposits worth  $q_t h_t$  by extending loans to new firms.

Bank Balance Sheet	
Asset	Liability
$q_t(H^I + H^{nI})$	$D_t$
	$K_t$

Competitive behavior in this model leads to a zero spread between lending and deposit rates. Bank capital evolves as  $K_t = R_{t-1}K_{t-1} - Div_t$ . Let us add the assumption that the banks have the following dividend policy:

$$Div_t = ((R_{t-1} - 1)K_{t-1})^+ \quad (3.10)$$

I forbid negative dividends, as this makes no sense. This allows us to keep the bank capital constant at  $K_t = K$  as long as there are no large loan losses. The last issue to examine is what happens to the capital at the beginning of the time period. I will assume that banks are endowed with goods. As the goods production begins at time 1, I consider that the first household spends  $s_0$  to purchase  $\alpha\beta y$  of bank endowment. This means that to become bank owners, household must give up a share of their own consumption. This allows the banking system to acquire a deposit claim on itself, which constitutes bank capital. This results in the fact that the bank capital begins with  $K_0 = s_0$ .

Another simplifying assumption is the fact that banks cannot issue new stocks<sup>6</sup>. We can see empirically that banks find it difficult to raise equity when they need it the most, i.e. when sustaining losses. The assumption is also not uncommon in the related literature as in Rochet (1992) or den Heuvel (2006). On the other hand, providing the ability for banks to issue some new stocks would add an additional loss buffer for the economy but would ultimately not change the overall dynamic that this model is describing.

One thing important to note is the absence of money from this model. The banking system is central to each payment transaction and each credit transaction. Here, I treat the banking industry as a passive balance sheet — which allows the assumption of a well behaved financial system — meaning the supply of money and credit is determined solely by demand. This choice in the model allows clear separation of the effect on the banking system and the feedback from the credit activity of the banking system. Finally, the the last point is the size of the bank balance sheet is equal to the value of the asset market  $q_t H$  at all times; the implication is of course an extremely strong link between the availability of credit and asset prices.

### 3.2.2 Perfect Foresight Equilibrium

A *perfect foresight equilibrium* is a sequence of endogenous prices  $\{p_t, q_t, R_t\}_{t=0}^{+\infty}$  and choices  $\{b_t, s_t, l_t, \Pi_{t+1}, Div_{t+1}\}_{t=0}^{+\infty}$  such that firms maximize the equation (3.1), household maximize the equation (3.3) and banks follow the dividend rule equation (3.10). Let us assume that the goods market clears each period. I assume here that  $R = \beta^{-1}$ , this assumption will be relaxed later. I also assume that loans and borrowing will occur at the same rate  $R$ .

#### Asset market equilibrium

All firms are under the same constraints. Each household is under the same constraint that it is possible to increase spending by holding a quantity  $l \in [0, e]$  of an asset. Then, each household holds in steady state that quantity  $l$  of the asset. This defines in a unique way the amount of non-industrial assets held

$$H_t^{nl} = \sum_{\text{all household}} l$$

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<sup>6</sup>In order to incorporate costs of issuing bank capital to this model one could follow the methodology developed in Gorton & Winton (1995) and Bolton & Freixas (2001), which would be an interesting future extension to this model.

The knowledge of  $l$  and the level of  $H^R$  gives us the amount of industrial asset  $H_t^I$ . Market clearing and (3.2) impose:

$$b_t^d = (f')^{-1}([Rq_t - q_{t+1}]/p_{t+1}) = H_t^I$$

Inverting the preceding expression gives

$$(Rq_t - q_{t+1})H_t^I = \alpha p_{t+1}y \quad (3.11)$$

I define  $y = f(H_t^I)$  as aggregate output and  $\alpha = \frac{H_t^I}{y} f'(H_t^I)$  is the output elasticity. It is then possible to rewrite firm profit as

$$\Pi_t = p_t c_t^f = (1 - \alpha)p_t y \quad (3.12)$$

and develop equation (3.11) into an asset pricing equation,

$$q_t = \frac{\alpha p_{t+1}y}{RH_t^I} + \frac{q_{t+1}}{R} \Rightarrow q_t = \frac{\alpha y}{H_t^I} \sum_{i=1}^{+\infty} \frac{p_{t+1}}{R^i} \quad (3.13)$$

### Goods market equilibrium

Goods market equilibrium is reached when aggregate supply equals aggregate demand. Aggregate demand is the sum of household spending, firm profit, and bank dividends.

$$p_t y = S_t + \Pi_t + Div_t$$

By rearranging (3.10) and (3.12) that gives

$$\begin{cases} s_0 = S_0 = \alpha\beta y \\ S_t = \alpha p_t y - (R-1)K \quad \forall t > 1 \end{cases} \quad (3.14)$$

I set  $p_0 = 1^7$ . Successive goods market clearing conditions are connected by the Euler equations (3.5), which simplify into

$$S_t = \left( \frac{p_{t+1}}{p_t} \right)^{\frac{1-\gamma}{\gamma}} S_{t+1} \quad (3.15)$$

### Basic Economy

The term leverage in this section I refers only to the ratio of debt over equity, and not debt over total assets. I demonstrate the following:

**Proposition 3.2.1** *The perfect foresight equilibrium is unique and stationary*

To demonstrate this proposition it is possible to substituted  $S_t$  and  $S_{t+1}$  into (3.15); this yields equation of the form  $g(p_{t+1}) = g(p_t)$  which then implies that  $p_{t+1} = p_t = p, \forall \geq 0$ . Then going backward the price level remains constant at  $p_0 = 1$ . So does the asset prices, since (3.13) becomes:

$$qH^l = \frac{\alpha}{R-1} p\gamma \quad (3.16)$$

The results is given the choices (exogenous variables) the following endogenous variable  $\{h_t, s_t, l_t, \Pi_{t+1}, Div_{t+1}\}_{t=0}^{+\infty}$  remain constant. The economy remains in steady state because all variables look the same looking forward from any time  $t$ .

**Proposition 3.2.2** *Firms and the banking system are leveraged*

It is simple to express the leverage as debt over net worth. For firms, this is  $RqH^l$  over profits  $(1-\alpha)p\gamma$ . For the banking system, it is deposits  $D$  over capital  $K = s = (R-1)(D - q(l-e)^+)$ .

Then

$$\text{Firm Leverage} = \frac{\alpha}{1-\alpha} \frac{R}{R-1} > 1$$

$$\text{Bank Leverage} = \frac{1}{R-1} \frac{D}{D - q(l-e)^+}$$

and by using the fact that  $D > q(l-e)^+$  and  $q(l-e)^+ > 0$  it is evident that  $D/(D - q(l-e)^+) > 1$  then

$$\text{Bank Leverage} = \frac{1}{R-1} \frac{D}{D - q(l-e)^+} > 1$$

This shows that firms and banks are leveraged in steady state.

<sup>7</sup>The normalization  $p_0 = 1$  can then be justified by a reserve requirement: a central bank can create and lend non-circulating reserves to the banking system, to be kept on deposit with the central bank. See Skeie (2004) and Woodford (1995) for more details.

**Proposition 3.2.3** *Households can have debt in steady state but are not leveraged in all cases*

To demonstrate this proposition, in steady state each household can have some level of debt  $ql \in R^+$ . At this point it is possible to assume that households have level  $l$  of asset so  $H^{nl} = \sum_{\text{each household}} l$ . Finally the total household debt is  $qH^{nl}$  or  $ql$  over equity  $D$ .

$$\text{Household Leverage} = \frac{qH^{nl}}{D}$$

Households have debt in steady state, but they are leveraged only in the case where  $qH^{nl} \geq D$ .

Firms are leveraged because they buy and sell durable assets whose value exceeds outputs. The banking system is leveraged by nature, as it is an intermediation of large values of credits and payments.

### 3.2.3 Notes on the Model Foundation

It is possible to link elements of household consumption in the model described above with Ricardian theories.

David Ricardo (18 April 1772 — 11 September 1823) has gives his name to the Ricardian equivalence (Seater 1993). This equivalence assesses that, under some circumstances, the government's choice to pay for government expenditures using immediate tax levies or to issue debt and run a deficit has no effect on the economy; more specifically, it has no impact on aggregate demand for goods. The tool he uses to estimate this equivalence is the present value of debt issued compared with an immediate tax. The fact that this theory carries Ricardo's name is ironic, as he did not seem to have believed in it.

The model presented above has some resemblance with the Ricardian equivalence; i.e., each household has to choose to own some level of assets or to pay rent. Ownership with associated debt is similar to a Ricardian debt issue, and rent is similar to a Ricardian tax. On this matter, the model agrees with the Ricardian equivalence, as households have no preference between ownership and renting, and present value is the tool used for comparison.

Ricardo also developed theories on rent, wages, and profits. His definition of rent is “the difference between the produce obtained by the employment of two equal quantities of capital and labor” (Ricardo 1821). Again, the definition of rent in the above model complies with Ricardo’s definition.

Barro (1989) describes the limits of the Ricardian equivalence to government deficit. The first limit is that people do not always take into account what the next generation will have to bear in terms of spending. The second is that capital markets are not perfect and the household discount rate is not equal to the government discount rate. The third limit comes from tax and income uncertainty. The fourth is that taxes are raised as a fraction of income, spending, wealth, etc., and are not lump sum. The final limit is that the Ricardian result assumes full employment. Each of these limits are consistent with the model developed here.

It is then possible to use the Ricardian equivalence finding and be confident that the choice of ownership vs. renting has no impact on the aggregate demand for goods.

### 3.2.4 Limits and Possible Extensions

The main limit appears to be the fact that the total amount of real estate is not a variable in the model, it is a given at the start date. The introduction of a building industry could eliminate this issue. Another limit of this model is the fact that the level of household ownership the variable  $l$  is exogenous and constant. This is a useful extension to put a constraint on the variable  $l$  in terms of wealth creation or consumption. Finally another limit of this model is the fact that the link between the level of ownership and the level of household indebtedness is static.

The model develop in this section may be extended by adding:

- a two-asset market: one for the industrial asset and one for the non-industrial asset, with a compensation mechanism between the two. This would have an impact on the amount of debt — i.e. the variable  $l$  — held by households.
- credit constrained agents
- a distinction between listed companies (leverage constrained) and private companies (not



leverage constrained)

- a price of credit — the difference between the rate of loan and the rate of borrowing
- changing the rental and sales formula via introduction of rental or ownership bias
- a new type of real estate rental company that would also have a production function similar to goods producing firms
- introduction of a government that would raise taxes and bail out firms and households

### 3.3 Model with Productivity Shocks and Defaults

I show that in perfect foresight equilibrium, no financial distress can appear as the model is static. Let us abandon the perfect foresight equilibrium assumption to study an unexpected productivity shock to the steady state — more precisely a shock that permanently reduces total productivity.

We assume a zero-probability shock because fully stochastic models make explicit solutions almost impossible to obtain. Zero-probability shocks are similarly used in Kiyotaki & Moore (1997) and Allen & Gale (2000) who discuss why a sufficiently small probability of a shock would not change results. And arguably, the assumption may reflect financial crises well, as several historical crises were linked to events that nobody appears to have expected, see Kindleberger & Aliber (1996).

The size of the shock is defined as  $\tau \in [0, 1]$  and the production will become:

$$y_{t+1} = (1 - \tau)f(h)$$

A direct consequence of this shock is a falling asset price. This allows an examination of falling asset prices on the banking system.

#### 3.3.1 Reaction to Shock

Let us examine the impact on firm joining the market at  $t$  — the new firms, and the old firms and those already in the market at  $t - 1$ . Then, let us examine the impact of the shock on house-

holds and banks.

We will set  $p$  as a notation for  $p_{t-1}$  as in  $t - 1$  — the system is in steady state. For the time being, let us use the simplifying assumption that  $R$  is constant. This assumption will be relaxed later.

Let us examine each market participant: both new and old firms, households, and the banking system.

### New Firms

The new firms — those entering the market at  $t$  — pay less for assets, as assets are less productive. The first-order condition is now

$$p_{t+1}(1 - \tau)f'(b_t^d) = Rq_t - q_{t+1} \quad (3.17)$$

### Old Firms

The old firms — the ones that were in business before  $t$  — face a debt-deflation situation, they have a debt on an asset that is worth less than before. At  $t - 1$ , they have borrowed  $qH^I$  assuming that at  $t$  they would be able to sell goods and assets at a steady price. Production  $y$  is not affected by the shock because the production decisions were taken at  $t - 1$ . As in a debt-deflation situation the debt is predefined but the income is lower than expected. Profit is the first buffer to take a loss, but if the profit is not enough, the debt is then passed throughout to the banking system as a non-performing loan. Their budget constraint (3.1) becomes:

$$\Pi_t + (RqH_t^I - \lambda_f) = p_t y + q_t H_t^I$$

where  $\lambda_f$  is the loss generated by the shock, which can be written as:

$$\lambda_f = (RqH_t^I - (p_t y + q_t H_t^I))^+$$

$\lambda_f \leq \Pi_t$  means that the firm takes the loss against its profit, while  $\lambda_f > \Pi_t$  means that the loss must be passed to the banking system as a non-performing loan. This also ensures that

firm profit cannot become negative. Let us re-write  $\lambda_f$  as a function of non-performing loan  $\lambda_f = (\omega - \Pi)$  where  $\omega$  is defined as:

$$\omega = \delta q H_t^I + (\alpha p - p_t)y \quad (3.18)$$

and  $\delta$  is defined as the proportional decline in asset values

$$\delta = \frac{q - q_t}{q}$$

where  $(\alpha p - p_t)$  is the loss of sales revenue to deflation.

Let us note that real estate rental companies are not touched by default and the current productivity shock, because of their extremely simple methods of operation, e.g., they are not dependent on loans.

### Households

Households are sensitive to asset markets in a similar way as old firms. At steady state households have a debt level of  $l \in [0, e]$ . Asset price decrease has a negative impact on the household balance sheet, but let us assume that each household does not going to change the level of assets owned after asset depreciation. The only exception to this rule are bankrupt households, for whom asset holding will be taken away. The equilibrium after the shock is

$$s_t + D_t + Rql = RD + q_t l - PV^{-1}(q_{t-1}(e - l)^+)$$

with the same utility maximization seen in (3.2.1).

The difference for firms is the fact that they have no profit, so the asset loss goes to deposits or spending. Households can go bankrupt if the asset loss exceeds the sum of assets and deposits. So by rearranging (3.8), we define  $\lambda_b$  as

$$\lambda_b = (Rql - [RD + q_t l - (R - 1)q_{t-1}(e - l)^+])^+$$

$\lambda_b$  can not become negative, and if its value is zero this means that the household goes bankrupt.

$$s_t + D_t + Rq_l - \lambda_b = RD + q_t l - PV^{-1}(q_{t-1}(e - l_t)^+)$$

We introduce a new variable to measure the impact of the asset market on the household wealth

$\theta_t$  as

$$\theta_t = (Rq - q_t) l$$

We can re-write the household basic function:

$$S_t + D_t + \theta_t - \lambda_b = RD$$

Two impacts can be examined  $\theta_t$  and  $\lambda_b$ .

$\theta_t$  can be summarized as:

- if  $\theta_t = 0$  there is no appreciation or depreciation of household wealth
- if  $\theta_t < 0$  there is an appreciation of household wealth
- if  $\theta_t > 0$  there is a depreciation of household wealth

and  $\lambda_b$

- if  $\lambda_b = 0$  the household is solvent and
- if  $\lambda_b > 0$  the household is bankrupt and the  $\lambda_b$  loss is transmitted to the bank.

A rational agent will seek the opportunity to move back to steady state spending such that  $s' = (R - 1)(D' - q'(l - e)^+)$  as soon as the information has been perceived at  $t$ .

In the case where a household goes bankrupt ( $\lambda_b > 0$ ) this household disappears. The question is what happens to the spending  $s_t$  in case household wealth is decreasing ( $\theta_t < 0$ ). Let us assume that households do not change their spending pattern for the first period between  $t$  and  $t + 1$ , as they are not as well informed as the bank or firms.

To summarize, households do not change their spending patterns when information on price

changes becomes available, but only when the price has actually changed. To justify this, we use the household money illusion described by Brunnermeier & Julliard (2007). This is a pricing bias that neglects the effect of inflation on real estate; it can explain the financial accelerator of household behaviors in front of changes in inflation. This coupled with the fact that household are only following the utility function (3.4) they do not readjust their real estate holding even if rational expectation can anticipate decrease in real estate prices.

### The Banking System

The banking system must write off non-performing loans from firms and household defaults, when the loss is certain at  $t$ . For this purpose, let us note  $\lambda = \lambda_f + \lambda_b$ .

At steady state, banks would earn  $(R - 1)K$  and the bank capital would stay constant but in this situation they would earn less. The first buffer is the dividend payment, but I consider only positive dividends. In the case where losses are higher than the dividend payment these losses come directly from capital; in this case the capital decreases from  $\lambda - (R - 1)K$ .

To summarize:

- if  $\lambda < (R - 1)K$  then bank capital is kept at  $K_t = K$  and the dividend is  $Div_t = (R - 1)K - \lambda$
- if  $\lambda > (R - 1)K$  then bank capital is then  $K_t = RK - \lambda$  and no dividend is paid,  $Div_t = 0$

### 3.3.2 Modified Fundamental Equilibrium

Let us now aggregate the reactions to determine the new equilibrium price for good and assets,  $\{p_t, q_t\}_{t=0}^{+\infty}$ . I still assume that the shock incurred does not change the fact that the system is in steady state so  $R = \beta^{-1}$ .

#### Asset Market Equilibrium

As above, however (3.17) modifies (3.11) and (3.12) to reflect the negative impact of the shock on the output of the old and the new firms,

$$\begin{aligned} (Rq_t - q_{t-1})H_t^I &= \alpha(1 - \tau)p_{t+1}\gamma \\ \Pi_{t+1} &= (1 - \alpha)(1 - \tau)p_{t+1}\gamma \end{aligned} \tag{3.19}$$

Households then take part in the asset market as some of them are bankrupt. The asset previously owned by these households are then taken to the bank and sold to new firms.

$$\begin{aligned}\sum l_t &= H_t^{nI} \\ H &= H_t^n + H_t^{nI} + H^R\end{aligned}$$

The result of this shock is probably to increase the level of industrial assets in the market, but this does not change the form of the market.

### Goods Market Equilibrium

Clearing requires that aggregate demand equal supply. The default possibility for old firms and the bankruptcy possibility for household is.

$$p_t y = \begin{cases} S_t + [p_t \gamma + q_t H^I - RqH^I + \lambda_f] + (R-1)K - \lambda & \text{if } \lambda \leq (R-1)K \\ S_t & \text{if } \lambda \geq (R-1)K \end{cases} \quad (3.20)$$

The first line applies when loan losses remain small for firms. The second line corresponds to cases where profit and aggregate dividend are going to zero; only the remaining households continue to spend.

Goods market clearing in  $t + 1$  equates the value of reduced output with the sum of remaining household spending, new firm's profits, and bank dividends

$$(1 - \tau)p_{t+1}y = S_{t+1} + (1 - \alpha)(1 - \tau)p_{t+1}y + (R - 1)K_t \quad (3.21)$$

at  $t$  households continue to spend as if nothing had happened and follow (3.15).

### 3.3.3 Model Dynamics

I have described the basic model, which is static, as we assumed that it starts at  $t = 1$  in equilibrium. Then productivity shocks and defaults are added to this initial model and we see the changes in the asset–goods market equilibrium. This section details the model dynamics in the sense of what steps the economy follows following a productivity shock.

### Dynamics Description

The dynamic assumptions are in  $t - 1$  the system is at steady state as described in the basic model; at time  $t$  an unexpected productivity shock happens such that

$$y_{t+1} = (1 - \tau)f(b_t)$$

At time  $t$  the model is under stress and the system is in an intermediate situation. The effect on the fundamental equilibrium is described in Section (3.3.2). The time  $t$  is the most complex to calculate, as it is a transitory state, we will see the specificity of this state; is described below.

At  $t + 1$  the productivity is  $f' = (1 - \tau)f$ . The unexpected productivity shock then creates a temporary state at time  $t$  to fall back on a new steady state at time  $t + 1$ . The way to understand this is to realize that the state of the world is different from (3.21) and that we have returned to details of the hypothesis of Proposition (3.2.1). It is evident that at  $t + 1$  the system is back in a new steady state.

To summarize  $t - 1$  is the former steady state,  $t$  corresponds to a transitory state and  $t + 1$  is a new steady state. So going forward we only need to study the transitory state  $t$  and the end game  $t + 1$  the new steady state — this new state can be comparable to the initial state or can be autarky.

### Deflation and Asset Price Decline

The following two technical lemmas should prove useful. The proof is given in the annex.

**Lemma 3.3.1** *The productivity shock has the following effects on household consumption:*

1. Household consumption  $S_t$  increases compared with time  $t - 1$ , i.e.,  $S_t > S$
2. Household consumption  $S_{t+1}$  falls compared with time  $t - 1$ , i.e.  $S_{t+1} < S$

**Lemma 3.3.2** *The productivity shock has the following effects on prices:*

1. Asset price  $p_t$  falls compared with time  $t - 1$ , i.e.  $p_t < p$
2. Asset price  $p_{t+1}$  increases compared with time  $t - 1$ , i.e.  $p_{t+1} > p$

If we define fundamentals of the new state the  $\tau$ . This leads to:

**Proposition 3.3.1** *Relative to steady state, worst fundamentals (a large  $\tau$ ) cause*

1. *greater asset price decline  $\delta'(\tau) > 0$*
2. *greater deflation  $p'_t(\tau) \leq 0$*

The fact that the dynamic is short lived is due to firms exiting the market.

Lemma 3.3.2 shows that the deflation is limited to the time  $t$  and it reverts at  $t+1$  to a  $p_{t+1}(\tau) > 1$  which is still above the initial steady state  $p = 1$ . Lemma 3.3.1 shows that the fact that the over-spending  $S_t(\tau)$  is followed by a  $S_{t+1}(\tau)$  lower than the previous steady state.

An interesting property of this model is that deflation is limited, just as in spending. The lower bound of the noted price level is  $\bar{p}_t$ . By substituting  $p_t y = S_t$  from (3.20) into (B.4) to obtain  $p_t = (p_t y / S)^{\frac{\gamma}{\gamma-1}}$ . Replacing  $s$  by  $S = \alpha y / R$  yields

$$\bar{p}_t = \left( \frac{R}{\alpha} \right)^{-\gamma} \quad (3.22)$$

Given that we know that  $\bar{S}_t = \bar{p}_t y$  it is immediately clear that

$$\bar{S}_t = S \left( \frac{R}{\alpha} \right)^{1-\gamma} \quad (3.23)$$

### Balance Sheet Losses

To analytically describe this model, let us split the space of losses into four sectors:

1. wealth effect for firms and household losses for households
2. firm and/or household defaults and generated bank loan losses
3. falling bank capital
4. insolvency of the banking system



Let us categorize the two  $(\delta_i, \tau_i)$  shock variables using the following thresholds

$\lambda_f$ turn positive:	$\lambda_f > 0$	$\rightarrow \delta_{\Pi}$	$\rightarrow \tau_{\Pi}$
$\lambda_b$ turn positive:	$\lambda_b > 0$	$\rightarrow \delta_D$	$\rightarrow \tau_D$
$\lambda$ turn positive:	$\lambda > 0$	$\rightarrow \delta_0$	$\rightarrow \tau_0$
$\lambda$ eliminates bank dividends:	$\lambda = (R - 1)K$	$\rightarrow \delta_{Div}$	$\rightarrow \tau_{Div}$
$\lambda$ eliminates bank capital:	$\lambda = RK$	$\rightarrow \delta_K$	$\rightarrow \tau_K$

Beginning with the two extreme cases if  $w(0) = 0$  then no firm bear losses when  $\tau = 0$  — then  $\delta > 0$ ; on the other hand,  $w(1) > RK + \Pi$ , so  $\tau = 1$  implies losses exceeding the firm's and banking system's combined ability to cope with them — we have then  $\delta < 1$ . As  $\delta$  is continuous we order the value of  $\tau$  as  $0 < \tau_0 < \tau_{Div} < \tau_K < 1$ .

It would be quite useful to obtain the closed form of the different values of  $(\delta_i)$ . To get  $\delta_D$  we need to know at what point  $\lambda_b \geq 0$ . Rearrange  $\lambda_b$  between  $t - 1$  and  $t$  to be

$$\lambda_b = (\delta ql + (R - 1)q(l - e)^+ - RD)^+$$

so  $\delta_D$  can be defined as

$$\delta_D = \frac{RD}{ql} - (R - 1)\frac{(l - e)^+}{l}$$

Then rewrite  $\lambda_D$  as

$$\lambda_b(\delta) = (\delta - \delta_D)^+ ql$$

By definition  $\delta_{Div}$  is

$$(R - 1)K = \lambda = \lambda_b(\delta_{Div}) + \lambda_f(\delta_{Div})$$

as it is known that firm profit is set to 0 ( $\Pi = 0$ ), then I can use the definition of  $\omega$  from (3.18) and at this level it is known that the price has reaches its minim, so by using (3.22) yields

$$(R - 1)K = \delta_{Div} q H^I + (1 - \bar{p}_t) \alpha \gamma + (\delta_{Div} - \delta_D)^+ ql$$

Knowing that  $K = \alpha \beta \gamma$ , by noticing that  $\delta_{Div} > \delta_D$  and by using (3.16) I obtain

$$\delta_{Div} = \frac{R - 1}{R} \frac{H^I}{H} \left( \frac{R}{\alpha} \bar{p}_t - 1 \right) + \frac{\delta_D l}{H}$$

or

$$\delta_{Div} = \frac{R-1}{R} \frac{H^l}{H} \left( \frac{R}{\alpha} \bar{p}_t - 1 \right) + \frac{RD}{qH} - (R-1) \frac{(l-e)^+}{H}$$

then using (3.16) yields

$$\delta_{Div} = \frac{R-1}{R} \left[ R \bar{p}_t - 1 + \frac{l}{H^l} \right]$$

or

$$\delta_{Div} = \frac{R-1}{R} \left( R \left( \frac{R}{\alpha} \right)^{-\gamma} - 1 + \frac{l}{H^l} \right)$$

In the same way I calculate  $\delta_K$  as

$$\delta_K = (R-1) \left( R \left( \frac{R}{\alpha} \right)^{-\gamma} - 1 + \frac{l}{H^l} \right)$$

And let us define  $\delta^*$  as

$$\delta^* = \frac{R-1}{R} \left( R \left( \frac{R}{\alpha} \right)^{-\gamma} + \frac{l}{H^l} \right) \quad (3.24)$$

To calculate the value of  $\tau_{Div}$  or  $\tau_K$ , let us back it out from (B.1) and use the  $\delta^*$  defined above.

$$\begin{aligned} 1 - \tau_{Div} &= (1 - \delta^*/R)/(1 - \delta^*)^{(\gamma/(\gamma-1))} \\ 1 - \tau^* &= (1 - \delta^*)^{1/(1-\gamma)} \\ 1 - \tau_K &= (1 - \delta^*)^{1/(1-\gamma)}/R \end{aligned} \quad (3.25)$$

### 3.3.4 Productivity Shock Impacts

Now that we have characterized the state after a productivity shock, we examine its impact on balance sheet, monetary volume, and bank capital.

#### Deterioration of Balance Sheet

There is a shock effect on the balance sheet, but first let us examine

**Proposition 3.3.2** *The impact of a productivity shock  $\tau$  has the following properties:*

1. Total company losses  $w(\tau)$  and total loan losses  $\lambda(\tau)$  are monotonically increasing in  $\tau$
2. Small losses are borne by firms as high as the profit
3. Each household's losses are shared by the whole economy

4. For bank balance sheets, credit reduction is matched by

(a) monetary contraction for any  $\tau > 0$

(b) falling capital for  $\tau > \tau_{Div}$

The proof of 1. is simple application of proposition (3.3.1). Property 2. meaning that firm profit acts as a buffer for small losses. Property 3. is the direct application of (B.2), as household losses have a direct impact on their spending, which finally has an impact on the rest of the economy. The rest of the proof is detailed in the next two sections.

One interesting point is that compared with the case where  $l = 0$  is the fact that in the case where  $l > 0$  household losses are immediately put in the bank. The impact on the economy depend $\hat{A}$ s on the level of leverage of households.

### Monetary Contraction

Monetary contraction is generated by productivity shock  $\tau$ , as follows:

**Proposition 3.3.3** For a given  $\tau$  we have three possibilities

- $\tau < \tau_{Div}$  then we have  $D_t = D - \delta(\tau)q(H^I + l)$
- $\tau > \tau_{Div}$  and  $\tau < \tau_D$  then  $D_t = D + S - \bar{S}_t - \delta(\tau)ql$
- $\tau > \tau_{Div}$  and  $\tau > \tau_D$  then  $\bar{D}_t = D + S - \bar{S}_t - \delta_D ql$

By noting that  $\bar{S}_t$  is not a function of  $l$ , (see (3.23)), an important aspect of this break-down becomes evident; the impact of household ownership level  $l$ . That is, the higher ownership level, the higher is the monetary contraction.

**Proof** So long as the cumulative loan losses stay within the bank dividend, the bank capital stays constant. This results in losses on deposits, which is consistent with the increase in household spending  $S_t > S$

$$S_t + D_t - (S + D) = \lambda_b - \delta ql$$

When  $\tau < \tau_{Div}$  this gives using (B.2):

$$D_t = D - \delta q(H^I + l)$$

Where  $\tau > \tau_{Div}$ , (B.2) is not longer true. We can simplify this equation by using the definition of  $\delta_D$  and note that we can re-write  $\lambda_b$  using its definition:

$$\lambda_b(\tau) = (Rql - q_t l + (R-1)q(e-l)^+ - RD)^+$$

By splitting  $Rql = (R-1)ql + ql$  we have

$$\lambda_b(\tau) = (\delta(\tau)ql + (R-1)q((e-l)^+ + l) - RD)^+$$

So we have

$$\lambda_b(\tau) = (\delta(\tau) - \delta_D)^+ ql$$

and

$$\delta_D = \frac{RD}{ql} - \frac{(R-1)}{l} \max(e, l)$$

Because we know that  $S_t$  has reached its minimum  $\bar{S}_t$  we can rewrite  $D_t$  as

$$D_t = D + S - \bar{S}_t + (\delta - \delta_D)^+ ql - \delta ql$$

The monetary contraction has a minima

$$\bar{D}_t = D + S - \bar{S}_t - \delta_D ql$$

The situation where  $l = 0$  is much more stable as  $S_t + D_t - (S + D) = 0 \forall t$ .  $\square$

### Falling Bank Capital

Capital depreciation which is  $K - K_t = \lambda(\tau) - (R-1)K$ , and by using the definition of  $\lambda$  we get

$$K - K_t = \lambda_f(\tau) + \lambda_b(\tau) - (R-1)K$$

We just have seen that

$$\lambda_b(\tau) = (\delta(\tau) - \delta_D)^+ ql$$

Similarly with  $\lambda_f$  we have

$$\lambda_f(\tau) = (\delta(\tau) - \delta_{\Pi})^+ qH^I$$

We can then rewrite capital depreciation as

$$K - K_t = (\delta(\tau) - \delta_D)^+ ql + (\delta(\tau) - \delta_{\Pi})^+ qH^I - (R - 1)K \quad (3.26)$$

It is evident that for the two different loss sources, firms and households, the relationship is not linear from a given  $\delta$ .

Loss of  $D$  implies a loss in  $qH^I$ , which implies a loss in asset price  $q$ . Asset price loss increases by the size of  $l$ . The question is which of the two starts to generate losses first. We have

$$\delta_D = \frac{RD}{ql} - \frac{(R-1)}{l} \max(e, l)$$

and

$$\delta_{\Pi} = (\bar{p}_t - 1) \frac{\alpha y}{qH^I}$$

It is evident that, depending on the level of ownership  $l$ , the value of  $\delta_D$  varies considerably. Also note that  $\delta_D(l)$  as a function of  $l$  is decreasing, with  $l = 0$  then  $\delta_D = +\infty$ . It is now possible to characterize a level of household ownership  $l_D$  such as  $\delta_D(l_D) = \delta_{\Pi}$ . The impact of the level of household ownership as a function of bank dividend ownership.

**Proposition 3.3.4** *For a given level of ownership  $l$*

- *if  $l < l_D$  this level of ownership constitutes a buffer for the bank dividend and capital. In case of loan losses the bank dividend and capital is less sensitive than in the case where there is no household ownership.*
- *if  $l = l_D$  the bank dividend and capital are behave as if households have no ownership. There is no difference for the bank capital if  $l = 0$  or  $l = l_D$ .*
- *if  $l > l_D$  the household ownership is acts as a financial accelerator for bank dividend and capital losses.*

**Proof** The proof is immediate from (3.26) and the fact that the function  $\delta_D(x)$  is decreasing in  $x$ . If  $l = l_D$  then  $\delta_D(l_D) = \delta_{\Pi}$  and (3.26) looks like

$$K - K_t = (\delta(\tau) - \delta_{\Pi})^+ q(H^I + l) - (R - 1)K$$

□

### 3.4 Effect on the Banking System of a Productivity Shock

In the previous sections of this thesis, lending behavior was not expected to change as bank capital fell and as credit demand was always met with the same interest rate  $R$ . This is not a realistic assumption, since bank shareholders are likely to react in such a scenario. To avoid further capital depreciation, banks usually limit the availability of credit to match their minimum capital needs.

Therefore the interest rate  $R_t$  is a function of time. By imposing a capital asset constraint, look at differences emerge at the equilibrium. This allows for investigation of extreme conditions, examining economic and financial vulnerability.

#### 3.4.1 Asset Capital Ratio Constrained

In this section, we will note  $H^K = H^I + H^{nI}$  serves as the asset portion of bank capital. The model constraints are the following capital asset ratio requirement<sup>8</sup>  $\mu$ :

$$\frac{K_t}{q_t H^K} \geq \mu \quad (3.27)$$

Introduction of some level of household ownership does not change the feed back process developed in von Peter (2009).

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<sup>8</sup>A typical ‘real life’ value for  $\mu$  in western bank is 8%.

### Impact on the Fundamental Equilibrium

By using the permanent income from wealth (3.9) and the definition of the bank capital we can rewrite the bank capital as  $K = \frac{(R-1)}{R} qH^I$  then

$$q_t H^K \leq \frac{K_t}{\mu} = \begin{cases} \frac{(R-1)}{R\mu} qH^I & \text{if } \lambda \leq (R-1)K \\ \frac{1}{\mu} ((R-1)qH^I - \lambda) & \text{if } (R-1)K \leq \lambda \leq RK \\ 0 & \text{if } \lambda \geq RK \end{cases} \quad (3.28)$$

We keep the assumption that bank capital cannot be negative.

Then (3.13) can be changed as  $R_t$  now depend on  $t$

$$q_t H_t^I = \frac{\alpha(1-\tau)}{R_t} p_{t+1} \gamma + \frac{q_{t+1} H_t^I}{R_t} \quad (3.29)$$

The rate  $R_t$  is rising to compensate for the capital constraint (3.27). A capital constraint equation is a set of endogenous variable  $\{p_{t+i}, q_{t+i}, R_{t+i}\}$  that satisfy (3.27) with (3.29), and goods market clearing (3.20) and (3.21). The last constraint is  $H_t^I = H - l_t$  to take account of a possible bankrupt household. This shows that the asset price  $q_t$  (and then  $\delta$ ) is dependent on the capital constraint.

### Equilibria

Before examining the equilibria let us set some notation; we rewrite (3.28) in derivation state — we have

$$\delta q H^K \leq \begin{cases} \frac{q}{R\mu} (R\mu H - (R-1)H^I) & \text{if } \lambda \leq (R-1)K \\ \frac{q}{R\mu} \frac{1}{\mu} (\lambda - (R-1)K) & \text{if } (R-1)K \leq \lambda \leq RK \\ qH & \text{if } \lambda \geq RK \end{cases} \quad (3.30)$$

It is evident that the first line is not binding, but, on the other hand, the last two lines are binding. Let us note  $\delta'_1$  the  $\delta$  that makes the first line of (3.28) an equality and note the  $\delta'_2$  the  $\delta$  that makes the second line of (3.28) an equality. Let us define  $\delta'$  as:

$$\delta' = \min(\delta'_1, \delta'_2)$$

This  $\delta'$  is the  $\delta$  that makes condition (3.28) binding. We also note  $\tau'$  the  $\tau$  that causes  $\delta'$ .

**Fundamental Equilibrium** The case where  $\delta = 1$  is the simplest fundamental equilibrium. It represents a bank crisis in which bank capital has been exhausted. If  $\tau = 1$ , this implies that  $\delta = 1$ .

In general, fundamental equilibria are the  $\delta(\tau)$  such as  $\delta(\tau) \geq \delta'$ ; as for any  $\delta(\tau) < \delta'$ , the capital constraint corresponds to the third line of (3.28) and is not binding.

**Unstable Equilibrium** The existence of multiple equilibrium can be thought of as a self-fulfilling equilibria. The market expectation creates the condition for the market to meet the market expectation.

If the market expects rationing of credit, then asset prices will fall until loan losses force banks to ration credit. In a similar way, if banks expect loan losses, then they will reduce lending to avoid higher losses; the result will be a reduced asset price, which is going to trigger the very loan losses that were anticipated.

This continues the financial instability that can drive the economy to a systemic banking crisis, e.g., a capital crunch or a bank run.

**Interest Rate Spread** Bank dividend policy is built to enforce the capital stability, so  $K_{t+1} = K_t$ , so unless there are significant loan losses, the capital constraint will stay constant for  $t' > t$ . As  $K$  and  $H$  are constant in this model, the only variable of the capital constrained equilibrium (3.27) is the asset price  $q$ . Given the fact that the constrained asset price  $\bar{p}_{t+1}$  remains constant after  $t$ , we can rewrite (3.29) as

$$q_t H^I = \frac{\alpha(1-\tau)\bar{p}_{t+1}^\gamma}{R_t - 1}$$

### Financial Extremes

Let us examine how feedback from banking on asset prices leads to financial instability. First, define two levels of shock: light and serious productivity shocks. A light productivity shock is a shock that does not make the constraint (3.27) binding. It is evident that for  $\tau < \tau'$ , this is



true, as it implies  $\delta < \delta'$ . On the other hand a serious productivity shocks makes the capital constraint (3.27) binding. This is true for  $\tau > \tau'$  as it implies that  $\delta < \delta'$ .

This yields the following

**Proposition 3.4.1** *For a given  $\tau$*

- *Light productivity shock ( $\tau \leq \tau'$ )*
  - *the fundamental equilibrium as it was before the shock*
  - *a self-fulfilling capital crunch and/or*
  - *a self-fulfilling banking crisis*
- *Serious productivity shock ( $\tau > \tau'$ )*
  - *a systemic capital crunch*
  - *a systemic banking crisis*

### 3.4.2 Vulnerability

The aim of this chapter is to show what effects a given shock  $r$  has depending on the economic fundamentals, such as  $(\alpha, \beta, \gamma, l)$ .

This model differentiates between macroeconomic and financial stability. Macroeconomic stability depends on the parameters governing deflation and output ( $\gamma$  and  $\tau$ ). Financial stability, by contrast, depends on asset prices and loan losses ( $\delta, \lambda$ ). We have then two different concepts of macroeconomic vulnerability and financial vulnerability. It is possible to have independent macroeconomic or financial crises; it is also possible that such crises cause each other. After examining some useful results, let us have a look at the specific vulnerability sensitivity of output elasticity, household time preference, intertemporal elasticity of substitution, and household leverage.

#### Intermediate Lemmas

The following lemmas apply to the current sections.

**Lemma 3.4.1** *The exogenous variables  $(\alpha, \beta, \gamma)$  are decreasing in terms of the endogenous variables  $(\tau, \delta)$ .*

It is evident from (3.25) that  $(\tau_{D_{iv}}, \tau^*, \tau_K)$  are increasing in  $\delta^*$ . Then  $\alpha$  is related to the  $\tau_i$  only through  $\delta^*$ . Given the definition of  $\delta^*$  (3.24), it is evident that  $\alpha$  is decreasing in  $(\tau_{D_{iv}}, \tau^*, \tau_K)$ .

From (3.25) it is evident that  $R$  is increasing in  $(\tau_{D_{iv}}, \tau^*, \tau_K)$ . As we have set  $\beta^{-1} = R$  in this section it is clear than  $\beta$  is decreasing in  $(\tau_{D_{iv}}, \tau^*, \tau_K)$ .

By definition of  $\delta^*$  (3.24) it is evident that  $\gamma$  is increasing in  $\delta^*$ . So, it is clear that  $\gamma$  is decreasing in  $(\tau_{D_{iv}}, \tau^*, \tau_K)$ .

**Lemma 3.4.2** *The exogenous variable  $(l)$  is increasing in terms of the endogenous variables  $(\tau, \delta)$ .*

This result is obvious by looking at the definition of  $(\delta_{D_{iv}}, \delta^*, \delta_K)$  and  $(\tau_{D_{iv}}, \tau^*, \tau_K)$  (3.24) and (3.25).

### Output Elasticity

Output elasticity  $\alpha$  is a measure of the firms leverage in steady state, as the firm leverage is:

$$\frac{\alpha}{1 - \alpha} \frac{R}{R - 1}$$

The greater is  $\alpha$ , the higher is the firms leverage. This is consistent with the fact that higher productivity encourages firms to purchase more and then to take on more debt. Following lemma 3.4.1, this makes the banking system more vulnerable.

### Household Time Preference

Following lemma 3.4.1, a higher level of household time preference  $\beta$  leads to smaller thresholds  $(\tau_i, \delta_i)$ . This means that high levels of  $\beta$  lead to higher balance sheet vulnerability.

As the interest rate at steady state is  $R = \beta^{-1}$ , low levels of interest rates are prone to financial vulnerability. It has been noted that after liberalization, financial instability is often observed (Graciela & Reinhart 1999). The low levels of interest rates that has been seen during the 1990's and the beginning of the 2000s may have contributed to the 2007 economical crisis.

### Intertemporal Elasticity of Substitution

Following lemma 3.4.1, the intertemporal elasticity of substitution  $\gamma$  leads to the same type of financial vulnerability as output elasticity and household time preference.

### Household Leverage

Following lemma 3.4.2, household leverage  $l$  opposite to  $(\alpha, \beta, \gamma)$  is increasing in terms of  $(\tau, \delta)$ . So the vulnerability to shocks is decreasing as a given productivity shock is less likely to cause a banking crisis. Also in the case of loan losses, the asset price deflation is marginally smaller than in the case of no household leverage. This is consistent with the findings from Greenspan & Kennedy (2005) and Greenspan & Kennedy (2008) showing that mortgage equity withdrawal allowed US real estate owners to access new funding methods, which in turn makes the economy more resilient.

On the other hand in the case of serious losses ( $\tau > \tau_{Div}$ ), proposition 3.3.3 indicates that the monetary contraction is higher than it would be in the case of no household leverage. The size of this additional monetary contraction  $\delta ql$  is proportional to  $(l)$ .

Proposition 3.3.4 describes another inference from household leverage. In the case of a productivity shock  $\tau > \tau_{\Pi}$  a household ownership lower than  $l_D$  slows down the capital erosion due to loan losses. On the other hand for any  $l > l_D$  household debt losses will hit bank capital faster than in the case of a lower household ownership. The maximum additional capital losses due to a high level of ownership is  $ql\delta_D$ . The specificity of this feature is the fragility tipping point.

In this model, household leverage has quite some positive impact on the economy, as it lowers financial vulnerability to a limited productivity shock; this enhances the capacity for an economy to suffer limited shocks. This is mitigated by the fact that for high values of household leverage, a productivity shock would create deeper monetary contraction and larger bank losses than with a lower level of household leverage.

### 3.5 Concluding Remarks

*If you owe your bank a hundred pounds, you have a problem.*

*But if you owe a million, it has.*

*John Maynard Keynes*

*as quoted in The Economist (13 February 1982), p. 11*

The main contribution of this work is to add household ownership to the relation between asset price and the banking system. It confirms, in a sense, the common view that high levels of household ownership make the economy more resilient, as it allows households to buffer small liquidity shocks using mortgage equity withdrawal. On the other hand, it raises the quantifiable downside of household ownership.

Let us examine the quantitative systemic implications of high levels of household real estate ownership before looking at the regulatory implications.

#### 3.5.1 Literature Contribution

This thesis extends the model developed by von Peter (2009) by adding household debt/ownership and by investigating the implication of different levels of debt/ownership. The conclusion found by von Peter are still valid in this setting i.e. a financial system is more vulnerable to failing asset prices in the presence of:

- greater leverage
- lower interest rates
- greater deflationary tendency

In addition the model developed in this thesis has provided some additional financial system vulnerability of high levels of household debt/ownership, namely deeper monetary contraction and faster bank capital erosion.

Another important parallel is the article from Kiyotaki & Moore (1997). What of the present model adds to the work by von Peter are predictions regarding the extremes. Even though the

setting is similar, the present model focuses on the non-linear aspects of the financial stability. While Kiyotaki & Moore (1997) examines the system within the bound of “normality”- this contribution looks at what are the consequences of a given economic situation after a crisis of the banking system.

On the other hand, the present contribution also has limitations compared with Kiyotaki & Moore (1997), specifically because productivity shocks are assumed to be zero probability events. This implies that regulators have not put in place policies to cope with productivity shock. It is however consistent with this model because no government exists in this setting. Consequently, the consequences predicted by this model are worse than they would be if a productivity shock with a non-zero probability was expected and if the government had put in place policies to deal with such an event. As seen in countries where the financial system has been in distress, the government is the first in line to bail out the failing banks. Only where bank bailouts are not practicable, there are other tools like currency devaluation and/or debt cancellation to cope with the distressed financial system.

An exciting future research opportunity is to extend this model by introducing the probability of productivity shock and a policy to deal with such events. This could be done based on optimal contracting theory.

### **3.5.2 Systemic Implication of Household Leverage**

Confirming the empirical literature e.g. Greenspan & Kennedy (2008), I show that household ownership can make households more resilient to limited productivity shocks. This shows that for a given productivity shock, higher levels of home ownership reduce asset price depreciation.

The main contribution here is to limit the idea that household debt/ownership is a good thing. Or what aspects of high levels of home debt/ownership can hurt the economy in the long run? Two possible sources of instability are identified through this model with respect to productivity shocks:

- deepened monetary contraction as soon as bank dividends are eliminated
- fasten bank capital erosion if the level of household ownership is above a certain threshold.

It is interesting to note that this model does not take into account agency issues, like information asymmetry; yet it provides interesting insight on the systemic implication of household real estate leverage. So one of the main limitations of this model can also be considered a positive feature. If this model is extended with some level of agency issues, the existing effects are likely to be amplified, as the strong externalities of household bankruptcy would amplify the effect of such a crisis. This could of course be a subject for further research.

### 3.5.3 Regulatory Implications

From a regulatory perspective, I hope that this work raises awareness of the downsides of household real estate debt/ownership. During good times, ownership makes the economy more resilient, but when a financial crisis hurts bank capital, a high level of household home ownership has negative impacts. The ex ante macro prudential policy implications of this contribution could help monitor the evolution of ownership in an economy, and help to decide up to what level access to ownership should be encouraged.

The fact that, in the case of monetary contraction, high levels of household home ownership can deepen monetary contraction is not straightforward. Noting  $E(M)$ , the cost expectation of a monetary contraction, and noting  $p$  the probability of such monetary contraction, the present model gives us  $c_M$  the cost of the monetary contraction that has occurred. Note that the cost of a monetary contraction that does not happen is zero. This leaves

$$E(M) = p \times c_M$$

From the regulatory perspective, the value to minimize is  $E(M)$ . A tradeoff could be achieved between the probability of a productivity shock occurring and its amplitude with respect to household home ownership level. The main issue here is of course the evaluation of the probability of a productivity shock.

On the other hand, from the perspective of the banking system, we can calculate a level of household ownership that slows down bank capital depreciation or at least does not speed up capital depreciation in case of a significant shock. This level could become a household owner-

ship target not to exceed.

#### **3.5.4 Interpretation of the 2007 Crisis Aftermath**

A large chunk of the coverage of the 2007 financial crisis has focused on agency issues, like asymmetry of information between issuer and buyer of securitized products, and opacity of pricing of such securitized products. This section, however, shows that it is possible to find links between the cost of the financial crisis and high levels of home ownership in the absence of agency issues.

The results from this section can also help clarify the 2007 crisis aftermath *ex post*. Some countries, like the United States and the United Kingdom, have initiated large programs of quantitative easing with little impact on inflation. The fact that even with such a large amount of money creation no inflation was generated might mean that the actual monetary contraction due to the 2007 crisis was stronger than in other countries, like France or Germany. One element that could have contributed to this fact is that in 2007, the levels of home ownership were high for the United States and the United Kingdom — around 68% of the population owned real estate — while the level of ownership was lower for France and Germany, 57% in France and 46% in Germany. The model developed in this chapter shows that high levels of ownership can lead after a financial crisis to a deeper monetary contraction compared with the same financial crisis in a country with a lower level of ownership.





## Chapter 4

# Asset Price Involvement in Macro-prudential Policy

### 4.1 Introduction

This section demonstrates a link between asset prices and financial stability before describing my contribution to the financial and macroprudential regulation literature.

#### 4.1.1 Motivation

The global 2007 credit crisis was caused by the deterioration of the U.S. subprime credit market, and its effects are still felt today, four years since it began. Total losses were approximately USD 200 billion in a USD 1 trillion market (Adrian & Shin 2008), which is fairly small compared with the USD 16 trillion capitalization of the US equity market. A loss of USD 200 billion on the US equity market corresponds to a 1% market loss, a daily occurrence. An interesting comparison can be made with the dot-com crash, or the bursting of the Internet bubble, which caused a stock market crash that dropped the market value of companies by USD 5 trillion from March 2000 to October 2002. Both crises were due to some level of market failure that led to the overvaluation of assets, namely, technology stock for the Internet bubble and real estate for the 2007 crisis. However, the social cost of the bursting of the Internet bubble was much smaller than that of the 2007 credit crisis.

The following general question is asked: Why did the crisis that incurred the greater financial

loss not have a greater social cost?

Part of the answer is the fact that the Internet bubble burst was an equity crisis, and the 2007 crisis was caused by debt. I develop an explanatory model that can be used to monitor the economy to avoid high-cost crises. I focus on the argument that an asset price boom coupled with an extension of credit can have a very large social cost, especially compared with an asset price boom not coupled with credit extension. This is due to the critical participation of the financial system and its recent evolution, as with the development of securitization markets.

### **4.1.2 Contribution**

Since the implementation of credible low-inflation policies in the 1980s, credit and asset price booms and busts have become more prominent (Borio & White 2004). An important aspect of such asset price booms and busts is their social cost. A financial crisis can have a significant economic impact and can damage the economy by disrupting money intermediation, credit flow, and even bank deposits causing high social costs. These financial effects thus have serious implications for the real economy, since they disrupt business, reduce investments, and possibly reduce overall wealth because of reductions in deposits. I will focus this work on the social costs due to a financial crisis.

To determine the mechanism of a financial crisis, I draw on the work of Kindleberger & Aliber (2005), who investigate financial crises throughout history. One common kind of crisis follows the pattern of rapid credit extension driving overinvestment in a type of asset that leads to an asset price boom, and when the bubble bursts, it hurts bank capital, which in turn creates the financial crisis. This pattern is confirmed by Reinhart & Rogoff (2008), who find empirical evidence that banking crises are usually preceded by asset price bubbles and credit booms, affecting rich and poor countries alike. From a general perspective, Adrian, Moench & Shin (2010) also find empirical links between asset prices and financial industry balance sheets.

The first research question is then as follows: What is the theoretical link between asset prices and a costly financial crisis?

von Peter's (2009) macro model can help one understand how asset prices and financial crises are linked, since it links asset price shocks to bank capital. To use this model with a full-fledged financial stability framework, one needs to separate assets fueled by credit extension from other assets. This is why I develop a macro model based on the work of von Peter (2009) that will explore the relation between the price levels of different kinds of assets and the risk of financial crisis.

This contribution should be categorized within the macroprudential literature and should help in formulating financial stability recommendations. I show that by imposing certain macroprudential conditions, a relation exists between asset price inflation and the overall leverage a banking system. From a macroeconomic perspective, the financial system is very procyclic; that is, it tends to amplify the existing economical cycle. The macroprudential recommendation of the Working Group on Macroprudential Policy (2010) is to lean against the procyclic features of the financial system, and one of the elements they recommend examining is leverage. The relation between price dynamics and overall leverage developed in this chapter could be used as a macroprudential tool and thus allow regulators to put in place rule-based recommendations.

The second research question in this case is the following: How should the overall leverage of the banking system cope with asset price dynamics?

Another contribution of this thesis is the development of a tool to help understand the cause of costly asset price bubbles, and an additional tool to forecast them. I explore different numerical methods of implementing these macroprudential evaluation tools.

### **4.1.3 Literature Review**

This section reviews how asset price bubble spillover can be managed through macroprudential policy, motivated by the change in the banking space's scope from microprudential to macroprudential. It reviews the literature on asset price bubbles and the different points of view on appropriate regulator actions. Finally, it reviews the literature on recent risk management techniques to handle bank capital.

The bank prudential was initially investigated by Dewatripont & Tirole (1994), who developed a theoretical framework to take into account information asymmetry. Their recommendations are mainly at the bank level, involving, for example, capital requirements. Financial stability is the underlying concept behind the bank prudential literature, and although regulations at the bank level are critical, a system perspective needs to be taken into account. Crockett (2000) specifically distinguishes between the microprudential and macroprudential dimensions of financial stability. The microprudential aspect deals with the soundness of individual institutions, while the macroprudential aspect has to do with the stability of the system as a whole.

The idea that the solvency of individual institutions is enough to ensure the stability of the system overlooks possible spillover effects.<sup>1</sup> Each institution may be solvent individually, but the system can be prone to failure since the gain of one institution can create serious issues for the others. Financial macroprudential practices have recently received the attention of the chairman of the US Board of Governors of the Federal Reserve. At his opening speech at the 2008 Jackson Hole Symposium, Bernanke (2008) argued for the superiority of the macroprudential perspective. From an academic position, the following definition of macroprudential policy can be used. Borio (2009, p. 26) characterizes macroprudential policies according to two objectives:

- A proximate objective, “limit financial system-wide distress”
- An ultimate objective, “avoid output (gross domestic product) costs”

One of the regulation proposals to limit financial systemic risk proposed by Morris & Shin (2009) is a “system-weighted capital requirement”:

The rationale for a leverage ratio derives not from the traditional view that capital is a buffer against loss on assets but, rather, from the stability of liabilities in an interrelated financial system. (Morris & Shin 2009, Summary)

A real-life application of this idea is dynamic provisioning in Spain (Saurina 2009a, Saurina 2009b). The idea is to build up capital reserves during good times for use during hard times.

From the ultimate macroprudential objective of avoiding output (gross domestic product) costs,

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<sup>1</sup>This idea is generally rejected by large banks, mainly because it would lead to more regulations and an unwelcome focus on “too big to fail” institutions.

Borgy, Clerc & Renne (2009) find evidence that house price booms are more likely than stock price booms to turn into costly recessions. Sarno & Taylor (1999) also examine the 1997 Asian crisis, linking the asset price bubble with dysfunctional financial intermediation. Those empirical evidences leads to an assessment of the cost of asset price bubbles and how regulators should react to them. Even if Mishkin (2008) agrees “that asset price bubbles associated with credit booms present particular challenges because their bursting can lead to episodes of financial instability that have damaging effects on the economy,” monetary policy should not try to burst potential asset bubbles. The externalities of the very action of fighting asset price bubbles may be too difficult to estimate: “Just as doctors take the Hippocratic oath to do no harm, central banks should recognize that trying to prick asset price bubbles using monetary policy is likely to do more harm than good.” (Mishkin 2008)

On the other hand, Borio & Lowe (2002*b*) and Borio & White (2004) believe that monetary policy should be used in the fight against asset bubbles as soon as these endanger financial stability. I side with Borio, since this thesis develops new model and tools to evaluate the implications of such a monetary policy. To substantiate my position, I cite the following work examining monetary policy in dynamic stochastic general equilibrium models, extended by financial intermediaries: (Curdia & Woodford 2008, Gertler & Karadi 2010, Cohen-Cole & Martinez-Garcia 2009, Meh & Moran 2010, Christiano, Ilut, Motto & Rostagno 2008, Dellas, Diba & Loisel 2010)

Finally, current regulations, such as Basel II, focus mainly on risk and use dated tools such as value at risk (VaR). There exists a vast literature on risk management tools for estimating credit risk. I cite only the Schönbucher’s (2003) book — the quantitative credit derivative researcher’s bible—for this area of research, even if more recent or advanced studies exist, because I am more interested in applications to financial stability.

One of the few articles adapting such techniques to financial stability is that of Jarrow (2007). Jarrow’s (2007) criticism of Basel II is that systemic risks are misrepresented mainly because of the limitations of the risk management tools used. The author describes in detail the differences between the way a credit derivative model views the risk of default and the way Basel II views the

bank risk of defaults. He demonstrates that current credit modeling tools are more appropriate to refining the minimum capital requirement in conjunction with the methods used by Basel II. I also use simple derivative risk management tools to help define banking system leverage.

#### 4.1.4 Review of Regulations

The implementation of macroprudential policy is relatively new and requires a brief review from the regulatory perspective. Most regulatory bodies can summarize macroprudential policy as counteracting the procyclical tendencies of the financial industry. The Group of Thirty's Working Group on Macroprudential Policy (2010) note the following, from a regulator's perspective:

Macroprudential policy has not been a major focus of national governments. The Turner Review explains that the Bank of England's focus on monetary policy through an inflation target and the Financial Services Authority's (FSA's) focus on individual institutions rather than on system-wide risk led to a situation in which macroprudential concerns "fell between two stools" in the United Kingdom. (Working Group on Macroprudential Policy 2010, p. 21)

This report identifies four macroprudential instruments for policy implementation:

- Leverage
- Liquidity
- Credit extension
- Supervision of market infrastructure and business conduct

One recommended, Group of Thirty's, policy tool is the adoption of a maximum aggregate gross leverage to guard against underestimating risk, thus limiting the risk of aggregated positions and the feedback from fire sales. I provide a theoretical model and numerical implementation for the maximum aggregate gross leverage.

The Bank for International Settlements' Committee on the Global Financial System (2010) also examines macroprudential instruments and frameworks and lists the following macroprudential instruments:

- Leverage
- Liquidity, or market risk
- Interconnectedness

Within these categories, note that up to now most policy implementations were carried out mainly based on judgment—for example, the very widely publicized stress test—instead of a rule-based system. A rule-based system would be more transparent and predictable for the firms concerned, which could help them preemptively adapt to these rules. It is also possible that the existing tools are not well defined, and I hope this work will contribute to the literature by defining them.

Finally, Saporta (2009), of the Bank of England, overviews macroprudential issues and categorizes them as follows:

- Incentive problems, such as being too big to fail or incomplete contracts
- Information friction, such as network externalities, risk illusion, and adverse selection
- Coordination problems, such as peer benchmarking, fire sales, and credit crunch externalities

In this paper the Bank of England propose one way of dealing with these risks, it is to impose a systematic capital surcharge, specifically using option pricing to calibrate it to weather crises Merton (1974). This is one of the few cases where modern risk management techniques are used to find the level of capital needed for the banking system.

Saporta (2009) also shows that, within a financial system, institutions are categorized by their degree of leverage and business, and not by the kind of assets they own. This is a consistent categorization, since some firms, such as mortgage houses, own mainly real estate mortgages, but the Saporta approach does not capture firms such as large investment banks, which own different kinds of assets.

This thesis shows that the types of loan collateral assets on the balance sheet of a financial firm have systemic significance.

### 4.1.5 Securitization

The securitization business is not central to this work, but it is clearly pertinent here, since this thesis investigates the significance of bank loan collateral assets. The financial press has widely blamed collateralized debt obligations (CDOs) for the 2007 crisis, and this work hopes to shed some light on this issue. First, some specific features of securitization must be described.

Securitization has allowed market participants to resell on-balance-sheet debt and to take targeted credit exposure for risk management. Securitization has also been used to circumvent capital requirements in two ways. First, securitization allows debt to be passed on to someone else. This is a good way to deal with the capital–asset ratio, the only issue being that the end holder of the credit risk does not always understand it, which is quite often the case. Risk manager have used securitized instruments to circumvent regulation. For example, since regulators' risk management measures are blind to long tails, transferring risk to the long tail makes it disappear.

The popularity of securitization in the United States and in Europe can be estimated from the following two figures. The European graph show all outstanding securitization, while the US graph shows only asset-backed securities. The sources are Bloomberg, Dealogic, Fitch Ratings, Moody's, prospectus filings, Standard & Poor's (S&P), Thomson Reuters, and the Securities Industry and Financial Markets Association.



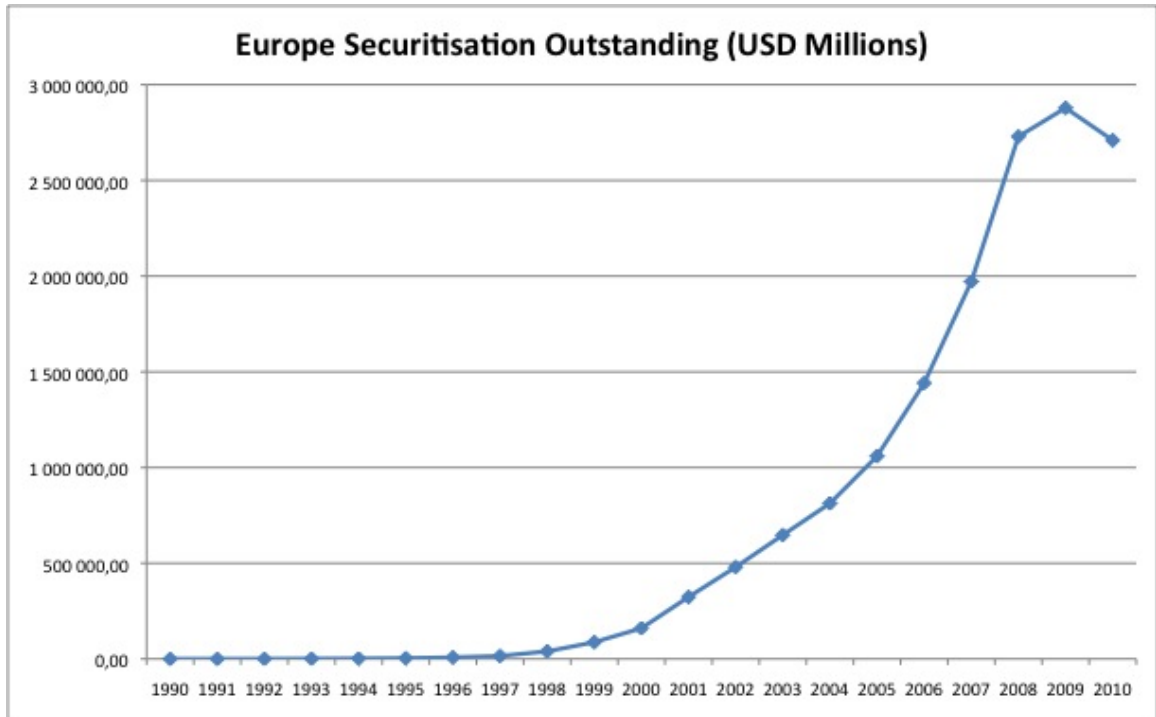


Figure 4.1: European Securitization Outstanding (USD millions)

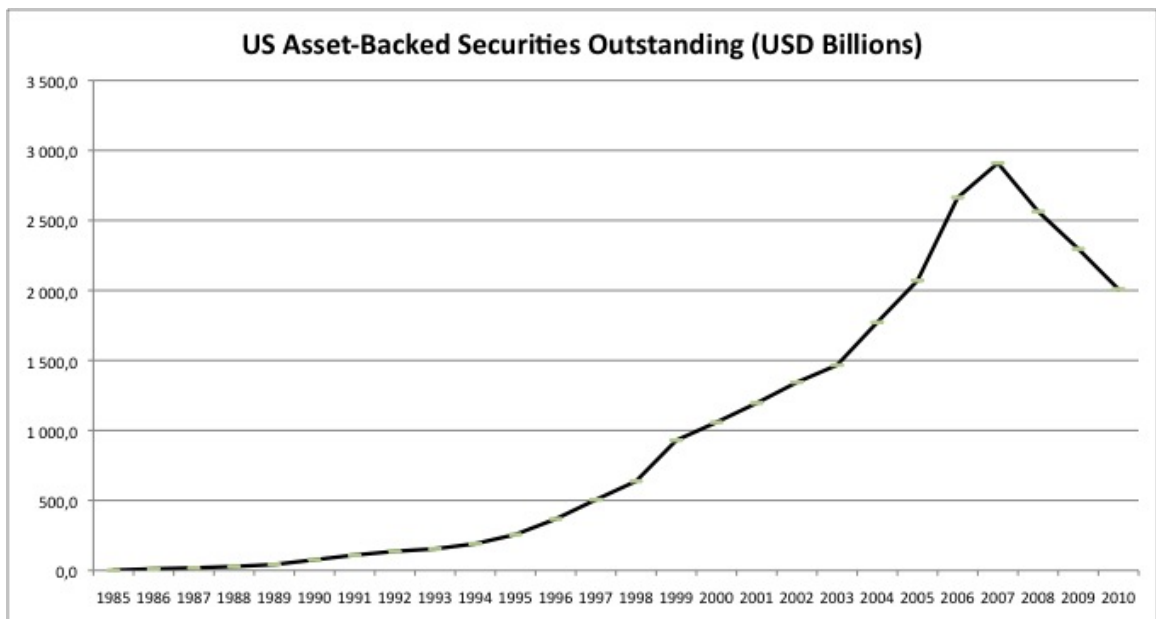


Figure 4.2: US Asset-Backed Securities Outstanding (USD billions)

On the one hand, collateralized loan obligations and loans behave similarly, from a lender's perspective (Benmelech, Dlugosz & Ivashina 2009). The main risk for this kind of instruments is due to two externalities because of the way these instruments were priced during 1990–2008,

with risk shifting and an inability to price in the risk of fire sales.

Risk shifting arises from the fact that securitization can fool the current regulatory system's measures of risk, that is, the value at risk. Value at risk looks at the first percentile of risk but assumes a normal distribution and is therefore blind to a long tail. For example, the risk on subprime debt can damage the first percentile risk of a bank, so the bank sells this risk and buys a AAA CDO tranche of subprime investments. The new CDO does not impact the first percentile of risk because its risk is high but with a much lower probability. Overall, the substitution of a subprime investment with a subprime AAA CDO tranche only shifts the risk on the right side of the distribution, making it invisible to value at risk management.

The other main weakness of most credit derivative models, including that used by the credit rating agencies, is that a firm's probability of default is taken in isolation from the rest of the economy. Default is a first-order effect of company risk; it does not appropriately take into account the risk of the entire economy to be stressed. For most banks, the credit risk model assumes that recovery is a fixed number—40% to be exact, which was invalidated after the crisis. Only in late 2008 did most investment banks move to stochastic recovery.<sup>2</sup> Amraoui & Hitier (2008) describe the first and now most commonly used stochastic recovery model, as well as the fact that the previous model cannot be calibrated with the current level of credit spread. Brunnermeier & Sannikov (2010) model the fact that financial specialists were basically underestimating credit risk by not including the risk of the asset sold in large quantities.

Securitization is seen as the origin of quite a few systemic risks. First, as Adrian & Shin (2010*b*) describe, a “shadow banking system” has grown out of the securitization of assets and the integration of banking with capital markets. This had the effect of disconnecting the lender from the quality and quantity of the credit supply to the economy. This partial disconnect between a lender's financial condition and the credit supply is empirically tested by Loutskina & Strahan (2009). Another cause of systemic risk is the fact that, as in bank lending, securities are prone to runs. Covitz, Liang & Suarez (2009) find empirical evidence of runs on asset-backed commercial paper.

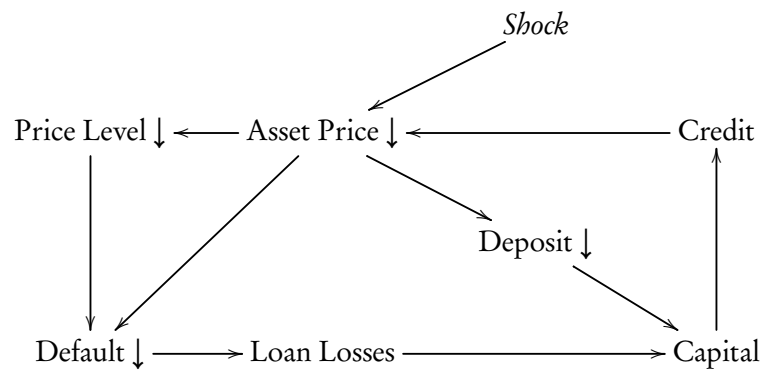
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<sup>2</sup>This information was obtained by personal discussions with quantitative researchers in different investment banks, for example, Benjamin Schiessle at JP Morgan and Sebastien Hitier at Banque nationale de Paris.

In conclusion, levels of collateralized debt have recently risen to new heights, motivating this study of the systemic implications of collateralized lending.

## 4.2 Financial Stability Model

This section develops a new variation of the model of the von Peter's (2009) model. A world without friction is assumed. In this model, households cannot take on debt, but they can hold equity. I keep the von Peter's model overall mechanism



### 4.2.1 Static Model

Firms have two sources of funding: equity and debt. A large share of firm assets comprises collateral for firm debt. The concept behind this study is to separate these two types of assets within firms: assets collateralized by debt and other assets. It is assumed that the other assets are considered to be funded by equity, that is, household equity.

This model uses two types of assets. Assets collateralized with debt by the bank are denoted  $H^L$ —L for leverage—and the other assets kept on the balance sheet are denoted  $H^E$ —E for equity. Finally, total assets in the economy are denoted  $H$ , such that  $H = H^E + H^L$ . This model sets the two amounts  $H^L$  and  $H^E$  as *exogenous* variables.

The goal of this model is to separate assets collateralized by debt from others assets to investigate their economic implications.<sup>3</sup>

<sup>3</sup>It would be very interesting to investigate the case where the proportion  $H^L/H^E$  is an endogenous variable in future work. It would allow one to model the effect of deleveraging a firm on the economy after a shock.

### Firms

At time  $t - 1$ , firms have a portfolio of assets  $h_{t-1}$  that helps them produce a quantity  $f(h_{t-1})$  of consumption goods.

At time  $t$ , the goods and services are sold at a price  $p_t$  and collateralized assets are resold (it is assumed that there is no depreciation) at asset price  $q_t^L$ . The assets  $H^E$  are re-evaluated at the market price at the end of each period. Note that consumption  $c_t^f$  is dependent on time  $t$  and the production function  $f$ . The production function  $f$  is assumed to be convex-concave. The interest rate is  $R_t$  ( $R_t > 1$ ), that is, there are no negative rates—and for a given time  $t$  the rate is considered constant for all maturities. The term  $\Pi_t$  is profit at time  $t$ , and the constraint  $\Pi_t > 0$  is added. Profit is also set to be positive in this model, since it is assumed that firms do not have access to short-term liquidity. Negative profit—also called losses—are transferred to the banking sector as bad loans. Assets originate from either household equity shares  $h_t^E$  or debt investments  $h_t^L$  from the bank, with  $h_t = h_t^E + h_t^L$ . Firms are run by entrepreneurs, who maximize profits from purchasing output from other firms<sup>4</sup>:

$$\begin{aligned} & \sup_{h_{t-1}} u(c_t^f) \\ & 0 \leq p_t c_t^f \leq \Pi_t \\ & \Pi_t + R_{t-1} q_{t-1}^L h_{t-1}^L = p_t f(h_{t-1}) + q_t^L h_{t-1}^L \end{aligned} \tag{4.1}$$

The full profit  $\Pi_t$  is given to households at time  $t$ , and no profit is retained from one period to the next. To summarize, the firm balance sheet is as follows.

Firm Balance Sheet	
Asset	Liability
$q_t^E h_{t-1}^E$	$R q_{t-1}^L h_{t-1}^L$
$q_t^L h_{t-1}^L$	$e_t$
	$\Pi_t$

<sup>4</sup>To maximize the utility of consumption, *sup* instead of *max* is used, since the latter does not allow for the utility's continuity. This case involves a bounded open  $u(c)$  set whose supremum cannot be reached.

Given the fundamental accounting equation,

$$q_t^E h_{t-1}^E + q_t^L h_{t-1}^L = e_t + \Pi_t + R q_{t-1}^L h_{t-1}^L \quad (4.2)$$

With (4.1), a simple description of the equity  $e_t$  is given:

$$e_t = q_t^E h_{t-1}^E - p_t f(h_{t-1}) \quad (4.3)$$

Equation (4.1) reflects the fact that firms borrow asset value before production takes place and then pays back the debt at the interest rate  $R_t$ . We can see that firms might be in a situation where they are not able to pay back their debt. In this case, assuming a world without friction on firm bankruptcy where everybody has the same information, the liquidation process is done at market price. Then  $e_t$  is fully defined as soon as  $p_t f(h_{t-1})$  is known, because the price  $q_t^E$  is defined by market clearing. The effect is the fact that firms cannot benefit from any adjustment in their equity prices in case of productivity shocks.

The first-order marginal revenue product to the user cost of holding assets is

$$p_t \frac{\partial f(h_{t-1})}{\partial h_{t-1}} = p_t f'(h_{t-1}) = R_{t-1} q_{t-1}^L - q_t^L \quad (4.4)$$

Note that the rental market for firms is ruled out. The reason for this assumption is to not have any debt in equilibrium, since in the case of a rent market firms would finance their asset holdings only out of sales revenue.

### Households

Households are supposed to live indefinitely. They derive utility from consuming goods and services. They are endowed at date 0 with a fixed supply  $H$  of productive assets. The wealth carried over is denoted  $D_t$  and is deposited into banks and accrued at a rate  $R_t$ . It is assumed that banks reward households at the same rate  $R_t$  they charge firms. Households could run their own production, with a production function  $g$ , but it would be very small compared to the firms' production ( $\forall b \ g(b) < \epsilon f(b)$ , where  $\epsilon > 0$  is small and  $g'(0) < f'(H)$ ). Then household production would occur only in extreme cases called *autarky*, when the production capacity of

firms has been destroyed.

Households have an equity share  $e_t$  of the firms and receive profit  $\pi_t$  from them directly. Since no government is assumed in the model, no dividend tax is assumed either. In addition, households invest in the equity market according to the rule where their investment must be a share  $\mu \in ]0, 1[$  of their cash deposits. This method is commonly used in such asset pricing models as the capital asset pricing model; the fact that  $\mu < 1$  reflects households' expectations and risk aversion.

Drawing on the seminal theory by Treynor (1961), the capital asset pricing model (CAPM), I hypothesize that households like CAPM investors have the choice to invest either at the bank or in a risk asset like the equity market. Thus, household investment will be a part of their capital at the bank in form of deposit  $D_t$  and a part  $e_t$  in the equity market. We add the fact that households spend each period  $s_t$  and earn  $D_{t+1}R_{t+1}$  from their deposit at the bank and earn  $\pi_t$  in dividend from their equity position. We can now write the following inter-temporal consumption/debt equation at time  $t$ :

$$s_t + D_t + e_t = D_{t-1}R_{t-1} + \pi_{t-1} + e_{t-1}$$

Then if we assume some level of risk aversion and the fact that household use a CAPM type for their investment decision, we can see that two weights define their risky asset decision, such that their total wealth will be invested as follows:

$$\gamma_1 D_t + \gamma_2 e_t$$

with  $\gamma_1 + \gamma_2 = 1$

We will take  $(\gamma_1, \gamma_2)$  as constant as following the CAPM model they reflects only the household risk aversion. Then in order to model only the risk aversion variable we note  $\mu$  such as:

$$\gamma_1 = \frac{1}{1 + \mu} \text{ and } \gamma_2 = \frac{\mu}{1 + \mu}$$

We have then defined a new parameter  $\mu$  that describes the household risk aversion and gives households a systematic way of investing in the equity market.

The inter-temporal consumption/debt problem can thus be written as

$$\begin{aligned} s_0 + D_0 &= q_0^E H \\ s_t + (1 + \mu)D_t &= (R_{t-1} + \mu)D_{t-1} + \pi_{t-1} \\ (1 + \mu)D_t &= (1 + \mu) \left( \frac{1}{1 + \mu} D_t + \frac{\mu}{1 + \mu} e_t \right) \end{aligned} \quad (4.5)$$

This equation can be reformulated as

$$\begin{aligned} s_0 + D_0 &= q_0^E H \\ s_t + D_t + e_t &= D_{t-1} R_{t-1} + \pi_{t-1} + e_{t-1} \\ e_t &= \mu D_t \end{aligned} \quad (4.6)$$

The utility  $u(c_t)$  of the consumption  $s_t = p_t c_t$  that maximizes the function is

$$\sup_{c_t} \sum_{t=0}^{+\infty} \beta^t u(c_t^h)$$

The main investment decision of households is to determine the deposit amount  $D_t$ . The Bellman equation to solve is

$$V_t = \max_{c_t} (u(c_t) + \beta V_{t+1}(D_{t+1}))$$

The first-order condition is

$$u'(c_t) + \beta V'(D_{t+1}) \frac{\partial D_{t+1}}{\partial c_t} = 0$$

This yields

$$u'(c_t) = \beta p_t \frac{(R_t + \mu)}{(1 + \mu)^2} \beta V'(D_{t+1})$$

Then the envelope condition is

$$V'(D_t) = \beta V'(D_{t+1}) \frac{\partial D_{t+1}}{\partial D_t}$$

$$V'(D_t) = \beta \frac{R_t + \mu}{1 + \mu} V'(D_{t+1})$$

The slope of the optimal consumption for the control  $D_t$  is

$$u'(c_t^b) = \beta \frac{R_t + \mu}{1 + \mu} \frac{p_t}{p_{t+1}} u'(c_{t+1}^b) \quad (4.7)$$

To find out how households deviate from this perpetuity rule out of steady state, this model posits time-separable utility, the constant relative risk aversion function with  $\gamma \in ]0, 1[^5$ :

$$u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}$$

In steady state, all variables are constant across time, so the price and consumption are  $p_t = p_{t+1}$  and  $c_t = c_{t+1}$ , respectively. Then the only way to make sure that (4.7) remains true is for

$$R = \frac{1 + \mu}{\beta} - 1$$

In steady state, the interest rate is equal to the inverse of the rate of time preference modified by the risk aversion and return expectations. In addition,

$$s = (R - 1)D + \pi \quad (4.8)$$

Bankruptcy cannot occur because of the high spending  $s_t$ . Since  $s_t$  is constrained under maximization of the utility function, if a household spends everything it has at period  $t_0$ , it will not be able to spend anything else for any  $t > t_0$ , which is clearly not a good maximization strategy. It is assumed that there is no firm profit at time  $t = 0$ . From (4.8), one can determine the permanent income from wealth,

$$D = \frac{q^E H + \pi}{R} \quad (4.9)$$

## Banks

Households are lenders and firms borrow each period to buy some of their means of production. The specificity of this model resides in the fact that the intertemporal exchange is generated by successive generations of firms.

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<sup>5</sup>In this interval the function is well defined, positive, and increasing.



Bartering is the rule in this model. To make this barter system work, banks interpose themselves in all financial transactions for firms buying assets and selling goods and households buying goods. One of the advantages of this system is that banks can enforce debt payments, since it is possible to block payments to actors who do not pay their debts. Unlike the case in Kiyotaki & Moore (1997), borrowing is not constrained by the future market value of assets, and revenues cannot be pledged to the payment of debts.

This intermediate banking system works as follows. Each period  $t$ , it creates deposits worth  $q_t^L b_t^L$  by extending loans to new firms, enabling them to purchase assets by transferring deposits to old firms. Old firms use these deposits to reduce their existing debt with the bank to  $(R_{t-1} q_{t-1}^L - q_t^L) b_{t-1}^L$ . This balance is repaid using sales revenue  $p_t f(b_{t-1})$ , leaving profit consistent with (4.1). Going backward, the first payment of  $q_0 H^L$  is received by the initial sellers of assets, the households, who hold their asset wealth on deposit to finance their spending  $s_t$ .

At time  $t$  the banking system creates deposits worth  $q_t^L b_t^L$  by extending loans to new firms, as follows.

Bank Balance Sheet

Asset	Liability
$q_t^L H^L$	$D_t$
	$K_t$

Competitive behavior in this model leads to a zero spread between lending and deposit rates. Bank capital evolves as  $K_t = R_{t-1} K_{t-1} - Div_t$ . The assumption is then added that the banks have the following dividend policy:

$$Div_t = ((R_{t-1} - 1)K_{t-1})^+ \quad (4.10)$$

Negative dividends are forbidden, since they do not make sense. This allows bank capital to be kept constant at  $K_t = K$  as long as there are no loan losses. The last issue to consider is what happens to capital at the beginning of the time period. It is assumed that banks are endowed with goods. Since the production of good starts at time 1, the first household spending  $s_0$  is considered

to purchase  $\alpha\beta y$  of bank endowments. This means that to become a bank owner, households must give up a share of their consumption. This allows the banking system to acquire a deposit claim on itself, which constitutes bank capital. The result is that bank capital starts with  $K_0 = s_0$ .

It is important to note the absence of money from this model. The banking system is central to each payment and credit transaction. The banking industry is treated as a passive balance sheet—which allows one to assume a well-behaved financial system—resulting in the quantity of money and credit to be solely determined by demand. This model allows one to clearly separate the effect on the banking system from feedback from the banking system’s credit activity. Finally, the size of the bank’s balance sheet is equal to the value of the asset market  $q_t^L H^L$  at all times; the implication is, of course, an extremely strong link between credit availability and collateralized asset prices.

Because this model does not use money, the meaning of liquidity needs to be redefined; as a common definition of liquidity is how easy it is to monetize an asset. The working definition used here is: liquidity is an asset’s ability to be sold without causing a significant movement in prices. In this work I am going to use the term liquidity mainly to define banks’ ability to buffer risks and avoid bankruptcy, the buffer being defined as dividend and capital. In other words, if a bank runs out of liquidity, then the bank fails and will cause significant disruption in the credit and payment system, which in turn causes large movements in asset prices.

### Perfect Foresight Equilibrium

A *perfect foresight equilibrium* is a sequence of endogenous prices  $\{p_t, q_t^L, q_t^E, R_t\}_{t=0}^{+\infty}$  and choices  $\{b_t, s_t, \Pi_{t+1}, Div_{t+1}\}_{t=0}^{+\infty}$  such that firms maximize (4.1), households maximize (4.6), and banks follow the dividend rule (4.10). It is assumed that the goods and equity markets clear every period. It is also assumed that  $R = (1 + \mu - 1)/\beta$ , which will be relaxed later, and that loans and borrowing are carried out at the same rate  $R$ .

Asset market equilibrium is achieved as follows. All firms are under the same constraints. Mar-

ket clearing and equation (4.4) impose

$$b_t = (f')^{-1}([Rq_t^L - q_{t+1}^L]/p_{t+1}) = H$$

Inverting the previous expression yields

$$(Rq_t^L - q_{t+1}^L)H = \alpha p_{t+1}y \quad (4.11)$$

where  $y = f(H)$  is defined as aggregate output and  $\alpha = \frac{H}{y}f'(H)$  is output elasticity. Firm profit can then be rewritten as

$$\Pi_t = p_t c_t^f = (1 - \alpha \frac{H^L}{H})p_t y \quad (4.12)$$

and (4.11) developed into an collateralized asset pricing equation,

$$q_t^L = \frac{\alpha p_{t+1}y}{RH} + \frac{q_{t+1}^L}{R} \Rightarrow q_t^L = \frac{\alpha y}{H} \sum_{i=1}^{+\infty} \frac{p_{t+1}}{R^i} \quad (4.13)$$

Regarding the goods market, equilibrium is reached when aggregate supply equals aggregate demand. The aggregate demand is the sum of household spending and bank dividends,

$$p_t y = s_t + Div_t \quad (4.14)$$

Note that a difference between this model and that of von Peter's (2009) is that firm profit is given to households so that its impact is through  $s_t$ . Equation (4.14) can be rearranged with (4.10) into

$$\begin{cases} s_0 = \alpha \beta y \\ s_t = p_t y - (R-1)K \quad \forall t > 1 \end{cases} \quad (4.15)$$

In addition,  $p_0 = 1$ .<sup>6</sup> Successive goods and services market clearing conditions are connected by the Euler equations (4.7), which simplify into

$$s_t = \left( \frac{p_{t+1}}{p_t} \right)^{\frac{1-\gamma}{\gamma}} s_{t+1} \quad (4.16)$$

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<sup>6</sup>The normalization  $p_0 = 1$  can be justified by a reserve requirement: A central bank can create and lend non-circulating reserves to the banking system, to be kept on deposit with the central bank. See Skeie (2004) and Woodford (1995) for more details.

Finally, one can look at the equity market equilibrium. The equity price can be deduced, since it is a function of household deposits,

$$e_t = \mu D_t$$

and

$$e_t = q_t^E h_{t-1}^E - p_t \gamma$$

which leads us to the asset  $q^E$  clearing. The first step is the households that decide for a level of spending  $s_t$ . After the spending decision what is left can be split between risky and risk-free assets given by  $\mu$ . The level of risky asset purchases by households sets the equity price  $e_t$ , which, in turn, defines the price of assets  $q^E$  such that

$$q_t^E = \frac{\mu D_t - p_t \gamma}{h^E}$$

The following results can then be established.

**Proposition 4.2.1** *The perfect foresight equilibrium is unique and stationary.*

To demonstrate this proposition, substitute  $s_t$  and  $s_{t+1}$  into (4.16), yielding an equation of the form  $g(p_{t+1}) = g(p_t)$ , which then implies that  $p_{t+1} = p_t = p, \forall \geq 0$ . Then, going backward, it is determined that the price level remains constant at  $p_0 = 1$ . So do the asset prices, since (4.13) becomes

$$q^L H = \frac{\alpha}{R-1} p \gamma \quad (4.17)$$

Then

$$e = \mu \frac{q^E H + \pi}{R}$$

and finally

$$q^E = \frac{\mu(q^E H + \pi) + p \gamma}{H^E}$$

The result is that the choices of the exogenous variables set  $\{s_t, \Pi_{t+1}, D i v_{t+1}\}_{t=0}^{+\infty}$  remain constant. The economy remains in steady state because all variables are back to a similar state than in the steady state looking-forward form at any time  $t$ .

**Proposition 4.2.2** *Firms can be leveraged.*

It is simple to express the leverage as debt over net worth. Firms have  $Rq^L H^L$  over profits  $(1 - \alpha)py$ . Then

$$\text{Firm Leverage} = \frac{\alpha}{1 - \alpha} \frac{R}{R - 1} \frac{H^L}{H}$$

The section  $\alpha(1 - \alpha)R/(R - 1) > 1$  is true, what need to be defined is the condition is on  $H^L/H$ . If firms have borrowed for all their assets, that is,  $H^L = H$ , then they are leveraged, depending on  $\alpha$ ,  $R$ , and  $H^L/H$ . This shows that firms can be leveraged in steady state.  $\square$

**Proposition 4.2.3** *The banking system is leveraged.*

It is simple to express leverage as debt over net worth. For banks, one has deposit  $D$  over capital  $K = s = (R - 1)D + \pi$ . Then

$$\text{Bank Leverage} = \frac{D}{(R - 1)D + \pi}$$

One can see that the profit  $\pi$  is such that  $D > \pi$ ; the amount of household deposits is much larger than firm profits. This shows that the banking system is leveraged in steady state.  $\square$

## 4.2.2 Productivity Shocks and Defaults

It has been seen that in perfect foresight equilibrium no financial distress arises, since the model is static. The perfect foresight equilibrium assumption can be abandoned to study an unexpected productivity shock to the steady state, more precisely, a shock that permanently reduces total productivity. The size of the shock is defined as  $\tau \in [0, 1]$ , and the production becomes

$$y_{t+1} = (1 - \tau)f(b)$$

A direct consequence of this shock is falling asset prices. This approach allows one to study falling asset prices on the banking system.

### Reaction to Shock

This section determines the impact of a shock on new firms, which join the market at  $t$ , and old firms, that is, those already in the market at  $t - 1$ . Then it examines the impact of the shock on households and banks.

The term  $p$  is used to denote  $p_{t-1}$  at time  $t - 1$ , the system in steady state. For the time being, the simplifying assumption is made that  $R$  is constant, which will be relaxed later. Each market participant—new and old firms, households, and the banking system—is now examined.

New firms pay less for assets, since assets are less productive. The first-order condition is now

$$p_{t+1}(1 - \tau)f'(b_t) = Rq_t^L - q_{t+1}^L \quad (4.18)$$

Old firms face debt deflation; they have debt on an asset that is worth less than before. At  $t - 1$  they borrow  $q^L H^L$ , assuming that at  $t$  they will be able to sell goods, services, and assets at the steady price. Production  $y$  is not affected by the shock because the production decision is made at  $t - 1$ . As in the situation of debt deflation, the debt is predefined but the income is lower than expected. Profits are the first buffer to take on the loss, but if these are insufficient, the loss is then passed throughout the banking system as a non-performing loan. The firm budget constraint (4.1) becomes

$$\Pi_t + (Rq^L H^L - \lambda) = p_t y + q_t^L H^L$$

Then one can simplify with the budget constraint (4.1) and, considering that firms have limited liability,

$$\lambda = (Rq^L H^L - (q_t^L H^L + p_t y))^+$$

By extension, the equity price  $e_t$  is

$$e_t = (q_t^E H^E - p_t y - \lambda)^+$$

If  $\lambda = 0$ , the firm takes the loss on its profits so that it is still solvent, but if  $\lambda > 0$ , the loss must be passed to the banking system as a non-performing loan. The term  $\delta$  is defined as the proportional decline in values of collateralized assets:

$$\delta = \frac{q^L - q_t^L}{q^L}$$

As seen in (4.6), households are dependent on firm profits and equity prices. The equity price decrease has a negative impact on the household balance sheet. The equilibrium after the shock

is

$$s_t + D_t + e_t = RD + \pi + e$$

with the same utility maximization as before. The way households make spending decisions is determined by the utility function; the amounts of deposit and equity are then found using the portfolio condition  $e_t = \mu D_t$ .

The banking system must write off non-performing loans when firms default when the loss is certain at  $t$ . It has been noted that  $\lambda > 0$  corresponds with firm profits being zero, and some loss is transmitted to the banking system as bad loans. In steady state, banks would earn  $(R-1)K$  and bank capital would remain constant, but in this situation they earn less. The first buffer is the dividend payment, but only positive dividends are considered here. When losses are higher than the dividend payment, they erode the bank capital; in this case the capital decreases from  $\lambda - (R-1)K$ .

To summarize,

- If  $\lambda < (R-1)K$ , then bank capital is kept at  $K_t = K$  and the dividends are  $Div_t = (R-1)K - \lambda$ .
- If  $\lambda > (R-1)K$ , then bank capital is  $K_t = RK - \lambda$  and no dividends are paid  $Div_t = 0$ .

When the dividends are consumed by losses, it is noted that the corresponding lambda  $\lambda_{Div}$  i.e.  $\lambda_{Div} = (R-1)K$ . One also notes  $\tau_{Div}$ , which leads to the loss  $\lambda_{Div}$ .

### Modified Fundamental Equilibrium

The reactions are now aggregated to determine the new equilibrium price for goods and assets,  $\{p_t, e_t, q_t^E, q_t^L\}_{t=0}^{+\infty}$ .

The equity market equilibrium is

$$e_t = \mu D_t$$

with the additional constraint

$$e_t = (q_t^E h_{t-1}^E - p_t y - \lambda)^+$$

or

$$e_t = (q_t^E b_{t-1}^E - (Rq_t^L - q_t^L)H^L)^+$$

The asset market equilibrium is as before, but (4.18) modifies (4.11) and (4.12) to reflect the negative impact of the shock on the output of old and new firms,

$$\begin{aligned} (Rq_t^L - q_{t-1}^L)H_t^L &= \alpha(1-\tau)p_{t+1}y \\ \Pi_{t+1} &= (1 - \alpha \frac{H^L}{H})(1-\tau)p_{t+1}y \end{aligned} \quad (4.19)$$

Assets previously owned by bankrupt firms are then taken to the bank and sold to new firms.

For the goods to clear, aggregate demand must equal supply. Then by adding the default possibility for old firms that lead to

$$p_t y = \begin{cases} s_t + (R-1)K - \lambda & \text{if } \lambda \leq (R-1)K \\ s_t & \text{if } \lambda \geq (R-1)K \end{cases} \quad (4.20)$$

The first equation applies when loan losses remain small for banks. The second line corresponds to the case where profits and dividends tend to zero and only the remaining households continue spending.

The goods market clearing at  $t+1$  equates the value of reduced output with the sum of the remaining household spending and bank dividends,

$$(1-\tau)p_{t+1}y = s_{t+1} + (R-1)K_t \quad (4.21)$$

where at time  $t$  households continue spending as if nothing had happened and follow equation (4.16).

### Model Dynamics

This section describes the basic model, which is static, since it is assumed that it starts at  $t=1$  in equilibrium. Productivity shocks and defaults are added to this initial model, as well as modifications on the assets, goods, and services market equilibrium. This section details the model's



dynamics in the sense of the steps the economy goes through following a productivity shock.

The dynamic assumptions of the basic model are that at  $t - 1$  the system is in a steady state and at time  $t$  an unexpected productivity shock occurs so that

$$y_{t+1} = (1 - \tau)f(h_t)$$

. At time  $t$  the model is under stress and the system is in an intermediate state. Section 4.2.2 has just shown the effect on the fundamental equilibrium. The time  $t$  is the most complex to calculate, since it is a transitory state. The specificity of this state is determined below.

At  $t + 1$  the productivity is  $f' = (1 - \tau)f$ . The unexpected productivity shock then creates a temporary state at time  $t$ , to fall back onto a new steady state at time  $t + 1$ . The way of seeing that is to released that the state of the world is different from that described by (4.21) and one is back to the hypothesis of Proposition 4.2.1. One can see that at  $t + 1$  the system is back to a new steady state.

By rearranging (4.19), one can describe the new steady state  $p_{t+1}$ :

$$q_t^L = (1 - \tau) \frac{\alpha y}{H} \sum_{i=1}^{+\infty} \frac{p_{t+i}}{R^i} \Rightarrow q_t^L H = (1 - \tau) \frac{\alpha p_{t+1} y}{R - 1}$$

Differentiating with (4.17) yields

$$\delta(\tau) = \tau p_{t+1} + (1 - p_{t+1}) > 0 \quad (4.22)$$

as the initial price  $p = 1$ .

Then there are three cases to consider:

- If  $\lambda = 0$ , then, looking at (4.20) and (4.15) yields

$$s_t = s + (p_t - p)y$$

- If  $0 < \lambda < \lambda_{D_{iv}}$ , some losses have been transmitted to the banking system, but there is still a buffer before bank capital is eroded. Then one has to use (4.20), (4.15), and (4.17) with the definition of  $\lambda$  to obtain

$$s_t = s + \delta q^L H^L + \left(1 - \alpha \frac{H^L}{H}\right) p \gamma \quad (4.23)$$

By noting that  $H^L/H < 1 < (R-1)/(\alpha R)$ , one can see that  $\forall \delta \ s_t > s$ .

- If  $\lambda \geq \lambda_{D_{iv}}$ , using (4.20) and (4.15) yields

$$s_t = s + (p_t - p)y + (R-1)K$$

to obtain  $s_t > s$ .

Then one can rewrite (4.16) as  $p = 1 = p_t$ :

$$p_{t+i} = \left(\frac{s_{t+i}}{s}\right)^{\frac{\gamma}{\gamma-1}} \quad \forall i \geq 0 \quad (4.24)$$

This equation holds for the period  $[t-1, t]$ . This formula works for  $i > 0$ , since  $p = p_{t-1} = 1$  and because the system reaches a new steady state at  $t+1$ .

The behavior of  $\delta(\tau)$  and  $p_t(\tau)$  is sought, and thus  $p_{t+1}(\tau)$  is examined. One can introduce (4.24) in (4.21) and, after using the fact that  $K = \alpha y/R = s$  (i.e., the way bank capital is created), one obtains

$$p_{t+1} = \left(1 - \frac{R}{\alpha} [1 - (1-\tau)p_{t+1}]\right)^{\frac{\gamma}{\gamma-1}}$$

This equation defines the solution function  $p_{t+1}(\tau)$ . One can see that  $p_{t+1}(0) = 1$  for any  $\gamma$ ; then  $\delta(0) = 0$  and  $p_t(0) = 1$  and the rest of the variables remain stable. Unity of the solution is achieved for  $\gamma < 1$ . Then one can derive  $p_{t+1}(\tau)$ :

$$p'_{t+1}(\tau) = \frac{p_{t+1}}{(1-\tau) + \frac{1-\gamma}{\gamma} p_{t+1}^{-1/\gamma}} > 0$$

such that  $p'_{t+1}(\tau) > 0 \ \forall \tau \in [0, 1]$ .

Then, using (4.22), one can deduce that  $\delta'(\tau) > 0$ . One of the specificities of this model is the fact that most impacts are short lived and deflation, for example, lasts only for a time  $t$ .

At time  $t + 1$  the form of the equation is the same as at steady state, so one sees that this model can reach a new steady state at  $t + 1$ . To demonstrate this, by using (4.8), one can see that

$$\sum_{i=0}^{+\infty} \frac{s_{t+i}}{R^i} = R \left( D + \frac{\Pi}{R-1} \right)$$

Using the fact that  $t + 1$  is a new steady state also yields

$$\sum_{i=0}^{+\infty} \frac{s_{t+i}}{R^i} = s_t + \frac{s_{t+1}}{(R-1)} = R \left( D + \frac{\Pi}{R-1} \right)$$

By the difference, one obtains

$$s_{t+1} - s = -(R-1)(s_t - s) \quad (4.25)$$

given  $s_t < s$ , which proves that  $s_{t+1} > s$ . Using the fact that  $s_t < s$  and  $s_{t+1} > s$  and (4.24), one sees that  $p_t > p$  and  $p_{t+1} < p$ .

The dynamics are short lived because firms exit the market whatever happened to them and the fact that household are in infinity lived agents. An interesting property of this model is that deflation is limited, as is spending. The higher bound of the price level is denoted  $\bar{p}_t$ . If one substitutes  $p_t \gamma = s_t$  from (4.20) into (4.24), one obtains  $p_t = (p_t \gamma / s)^{\frac{\gamma}{\gamma-1}}$ . Replacing  $s$  by  $s = \alpha \gamma / R$  yields

$$\bar{p}_t = \left( \frac{R}{\alpha} \right)^{-\gamma} \quad (4.26)$$

Given that  $\bar{s}_t = \bar{p}_t \gamma$ , one immediately obtains

$$\bar{s}_t = s \left( \frac{R}{\alpha} \right)^{1-\gamma} \quad (4.27)$$

If one notes  $\tau_{D_i v}$  the shock size that causes firm profit to be eliminated. One is now in a position to demonstrate the following.

**Proposition 4.2.4** *The impact of a productivity shock  $\tau$  has the following properties:*

1. Total company losses  $w(\tau)$  and total loan losses  $\lambda(\tau)$  are monotonically increasing in  $\tau$ .
2. Small losses are borne by firms as high as their profits.
3. For bank balance sheets, credit reduction is matched by

(a) Monetary contraction for any  $\tau > 0$

(b) Falling capital for  $\tau > \tau_{Div}$

The proof of item 1 comes from the fact that the function  $\delta'(\cdot)$  is increasing in  $\tau$ . Item 2 means that firm profits act as a buffer for small losses. Item 3 is the direct application of (4.23), since household losses have a direct impact on their spending, which has an impact on the rest of the economy.

### 4.2.3 Financial Stability Model Results

This section looks at the implications of the productivity shock on monetary contraction and bank capital. It then examines the effects of the feedback loop caused by bank capital constraints and ends with possible extensions of this model.

#### Monetary Contraction, Equity Price Decreases, and Bank Capital Erosion

The monetary contraction generated by the productivity shock  $\tau$  is examined. The factor of the reduction in production technology that eliminates firm profit is denoted  $\tau_0$ . The following is demonstrated.

**Proposition 4.2.5** For  $\tau$ , with  $\lambda_0 = (\alpha \frac{H^L}{H} - 1)py$

- If  $\tau < \tau_0$ , then  $D_t = D - \frac{1}{1+\mu}(p_t - p)y$ .
- If  $\tau > \tau_0$ , then  $\overline{D}_t = D - \frac{1}{1+\mu}(\delta(\tau)q^L H^L + \lambda_0)$ .

This is good news for the equity market and the asset price  $q_t^E$ ; as noted previously, for a large enough shock, price  $p_t$  and spending  $s_t$  reach their minima. Given these elements,  $D_t$  is defined, which allows one to define the value of equities  $e_t$ , since equity prices are defined by the willingness of households to hold them. Finally, the asset price  $q_t^E$  is obtained:

$$q_t^E = \frac{e_t + p_t y + \lambda}{H^E}$$

**Proof** As long as the cumulated loan losses stay within the bank dividends, bank capital remains constant. The impact on deposits depends only on price changes, so

$$s_t + D_t - (s + D) = e - e_t$$

When  $\tau < \tau_0$ , using (4.15) and (4.6), one obtains

$$D_t = D + e - e_t - (p_t - p)y$$

When  $\tau > \tau_0$ , one can use (4.23), which yields

$$\overline{D}_t = D + e - e_t - \delta(\tau)q^L H^L + (1 - \alpha \frac{H^L}{H})py$$

□

One can then obtain the following results using the household holding equity constraint.

**Corollary 4.2.1** For  $\tau$  one has, with  $\lambda_0 = (\alpha \frac{H^L}{H} - 1)py$ ,

- If  $\tau < \tau_0$ , then

$$e_t = e - \frac{\mu}{1 + \mu}(p_t - p)y$$

- If  $\tau > \tau_0$ , then

$$\overline{e}_t = e - \frac{\mu}{1 + \mu}(\delta(\tau)q^L H^L + \lambda_0) \quad (4.28)$$

The banking system's capital depreciation is now considered.

**Proposition 4.2.6** The reaction of banking system capital after a productivity shock is

$$K - K_t = (\delta(\tau) - \delta_e)^+ q^L H^L - (R - 1)K \quad (4.29)$$

with  $\delta_e = (R - 1) - \frac{p_t y}{q^L H^L}$ , or, reformulated,

$$K - K_t = (q_e - q_t^L)^+ H^L - (R - 1)K \quad (4.30)$$

with  $q_e = Rq^L - \frac{p_t y}{H^L}$ .

One can see that the introduction of an equity market does not change the fundamental contribution from the study of von Peter's (2009) study, which can be summarized by the following quote:

This one-to-one relation between asset prices and bank capital is noteworthy: it obtains even when the banking system holds none of the traded assets — its exposure to asset prices is entirely indirect, through the condition of its borrowers. (von Peter 2009, p. 310)

**Proof** By the definition of bank capital,

$$K - K_t = \lambda - (R - 1)K$$

The loss  $\lambda$  can be rewritten

$$\lambda = (\delta q^L H^L + (R - 1)q^L H^L - p_t y)^+$$

Then

$$\delta_e = (R - 1) - \frac{p_t y}{q^L H^L}$$

This allows one to verify (4.29)

by noting that

$$q_e H^L = Rq^L H^L - p_t y$$

One can see that (4.30) is verified.  $\square$

This result fits within the framework developed by von Peter (2009), meaning that with a shock that reduces bank capital, a financial crisis can trigger a banking crisis or a capital crunch.

One can see that the asset depreciation due to the productivity shock has similar behavior on equity (4.28) than on bank capital (4.30). In each case, after a liquidity buffer, the impact of the productivity shock is proportional to  $\delta(\tau)q^L H^L$ . Given the fact that the total market capital-

ization is much larger than the aggregate bank capital for the banking system, one can see that asset price depreciation has a much stronger impact on the banking system than on the equity market. A given asset price depreciation  $\delta(\tau)q^L H^L$  can produce harmless fluctuations in the equity market but at the same time strongly damage the capital of the banking system. This model helps us understand that a relatively small asset price depreciation can create lasting financial instability.

### Capital-Constrained Equilibrium

In the previous section, lending behavior did not change as bank capital fell and the credit demand was always met with the same interest rate  $R$ . This is not a very realistic assumption, since bank shareholders do not like to see that without reacting. To avoid further capital depreciation, banks usually ration the availability of credit to match their minimum capital needs.

For this purpose, the interest rate  $R_t$  is a function of time. This section starts by imposing a capital asset constraint and looking at different inferences at equilibrium.

The model constraints are the following capital–asset ratio requirement<sup>7</sup>  $\mu$ :

$$\frac{K_t}{q_t^L H^L} \geq \mu \quad (4.31)$$

The fact that some level of household equity ownership has been introduced does not change the feedback process developed in von Peter (2009).

By using the permanent income from wealth (4.9) and the definition of bank capital, one can rewrite bank capital as  $K = \frac{(R-1)}{R}(q^L H^L + \pi)$ , and then

$$q_t^L H^L \leq \frac{K_t}{\mu} = \begin{cases} \frac{(R-1)}{R\mu}(q^L H^L + \pi) & \text{if } \lambda \leq (R-1)K \\ \frac{1}{\mu}((R-1)q^L H^L + \pi - \lambda) & \text{if } (R-1)K \leq \lambda \leq RK \\ 0 & \text{if } \lambda \geq RK \end{cases} \quad (4.32)$$

<sup>7</sup>A typical “real life” value for  $\mu$  in a Western bank is 8%.

The assumption that bank capital cannot be negative is kept.

Then equation (4.13) can be rewritten as  $R_t$  now depend on  $t$

$$q_t^L H = \frac{\alpha(1-\tau)}{R_t} p_{t+1} \gamma + \frac{q_{t+1}^L H}{R_t} \quad (4.33)$$

The rate  $R_t$  is rising to compensate for the capital constraint (4.31). This equation models what is called credit-constrained asset pricing. A capital constraint equation is a set of endogenous variables  $\{p_{t+i}, q_{t+i}^L, q_{t+i}^H, R_{t+i}\}$  that satisfy (4.31) with (4.33), goods market clearing as in the equations (4.20) and (4.21). This shows that the asset price  $q_t^L$  (and thus  $\delta$ ) is dependent on the capital constraint.

Some features of the von Peter's (2009) model kept in my adaptation are the following. There is some value of  $\tau$  that make good fundamental—the fundamental equilibrium is the same as before. For other values of  $\tau$ , the economy is in poor fundamental, that is, a banking crisis. Finally, the banking system can get into self-fulfilling capital crunches even if the fundamentals are good.

As was determined in (von Peter 2009), the asset price  $q_t^L$ , even in stable equilibrium, is negatively impacted by the combined effects of a productivity shock and the capital–asset ratio constraint. It is important to note that the asset price  $q_t^E$  is impacted only in the case of the banking system's total collapse. The asset price  $q_t^E$  is not impacted by “normal” credit cycles.

#### 4.2.4 Intermediate Conclusion

I extend the von Peter's (2009) model to add an equity market so one can compare the impact of a productivity shock on equity assets and that on the collateral assets of a loan. One has seen that the introduction of an equity market does not change the von Peter's main contribution.

To quote the von Peter's (2004) version of this work,

Loss given default (LGD) depends on the performance of collateral (the asset price).

In the presence of uncertainty one could say the banking system is exposed to market risk via credit risk. (von Peter 2004, p. 16)



The contribution of the current thesis has been to segregate the collateral assets of loans on the asset side of the banking system balance sheet from other assets, to track more precisely assets that can incur financial stability issues. An asset price bubble for assets that are not bank loan collateral—in this case, equity—poses limited financial stability risk, since the bubble bursting will reduce the total value of equity without directly hurting the financial system. Price bubbles for bank loan collateral assets, however, can be a very direct financial stability risk, since they can damage bank capital. When bank capital is affected by a shock, the cost for the economy is significant, because a situation of credit rationing arises and depleted bank capital needs to be recreated.

Section 4.1.5 shows that the amount of securitized product has increased dramatically during the last two decades. It is not easy to know the exact amount of securitized products on banks' balance sheets, since banks do not like to share this information. Even though no hard numbers are available to substantiate this statement, there are strong reasons to believe that for financial institutions the amount of securitized products is large. One way of illustrating this is by examining failed banks, since one can then access the exact structure of their balance sheets. The following figure, from Morris & Shin (2009), shows the asset side of the balance sheet of Lehman Brothers at the end of 2007 before bankruptcy.

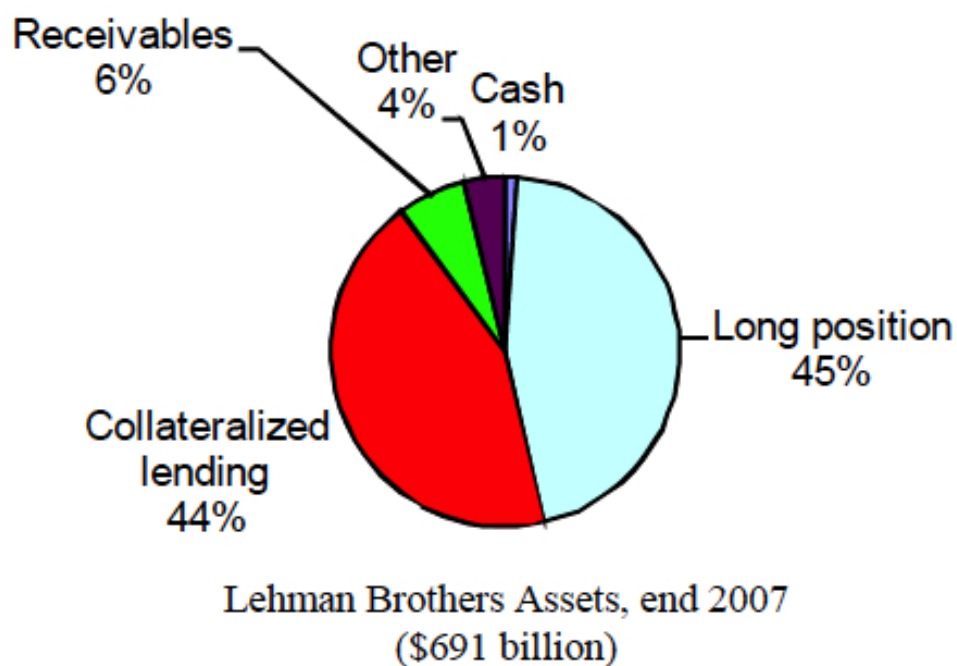


Figure 4.3: Lehman Brothers' Assets, end of 2007 (\$ 691 billion)

One can see that collateralized lending comprised 44% of the bank's assets. To examine the evolution of such a situation, the case of Northern Rock (Shin 2008) is shown here.

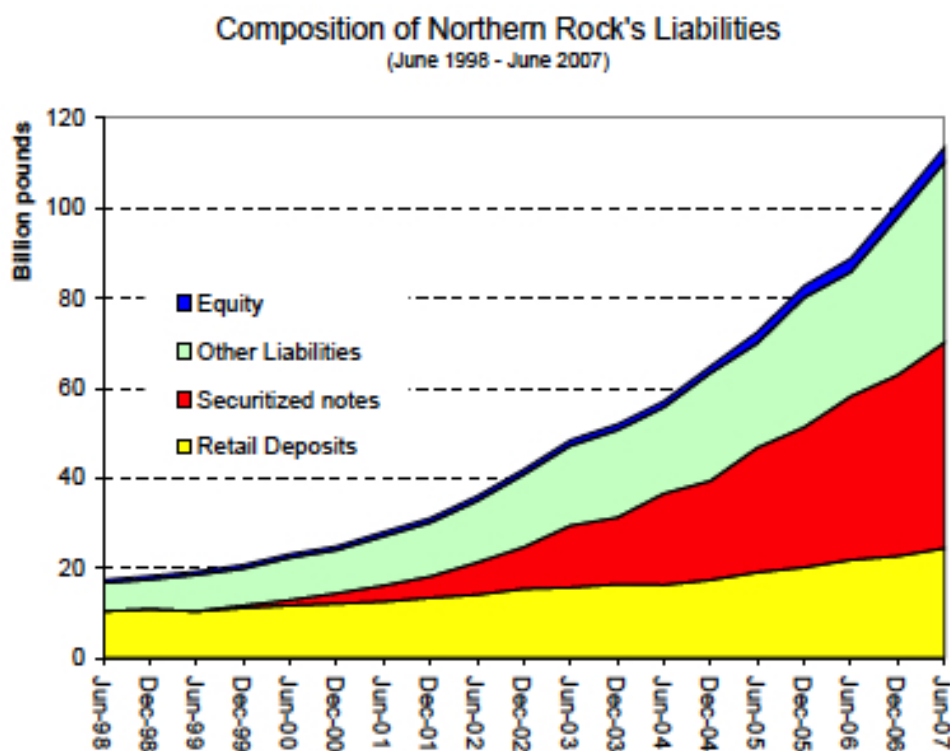


Figure 4.4: Composition of Northern Rock's Liabilities

From almost nothing in 1998, the amount of securitized notes was around a third of Northern Rock's balance sheet. One can see that Northern Rock's securitized notes on balance sheet exhibit growth similar to that of the overall market. This section develops a general framework to study collateralized loans. If one remembers that securitized notes are nothing more than packaged collateralized loans, it is clear that the development of securitization carries undeniable systemic risk. It is important to note that during the global credit crisis banks failed not only because of a lack of liquidity, but because they had securitized products or collateralized loans on their balance sheets. The fact that such products were on the balance sheets of failed banks caused large cost due to the vicious circle: large loan losses caused their collateral asset to be fire sale, which caused the asset price to decrease, which in turn caused larger loan losses.

The model developed here helps one understand how a bank liquidity crisis can transform into

a recession. The steps are as follows: Due to poor liquidity management, a few financial institutions fail. The failed financial institutions then sell their collateralized loans, depreciating the value of these loans. Finally, through feedback, these loans depreciate further, decreasing the price of their collateral (as in most of the real estate cases in 2007); this, in turn, hurts the capital of all remaining banks. Finally, because the entire banking system has been affected by a reduction of capital, the flow of credit is interrupted, causing a costly crisis.

Some elements are now in place to answer the first research question. If the collateral assets of loans on the asset side of the banking system balance sheet suffer a sufficiently large depreciation, a loss of capital for the banking system ensues, triggering a costly financial crisis. On the other hand, if assets that are not loan collateral suffer a large depreciation, wealth is lost but this does not directly lead to a financial crisis and, since the economy has not lost its ability to function, it can regrow.

A significant limitation of this model is the assumption that every loan made in the economy is guaranteed by collateral, which is, of course, hardly the case. In reality, uncollateralized loans are very common, from credit cards to commercial paper. The presence of such loans can, of course, induce different behaviors in the economy. Another limitation is the unrefined method for defining the amount of liquidity in the economy, that is, total firm profits. Most of the work on the 2007 crisis focuses on different approaches to liquidity management and their shortcomings. However, the mechanism at work in a financial crisis such as that of 2007 can be better understood using the model developed here, since its assumptions do not compromise the critical elements in such a crisis.

### 4.2.5 Possible Model Extensions

The purpose of this study is to examine the link between collateralized asset prices and financial stability, but the model this section has started to develop can be improved or used for numerous other purposes, with limited changes. A short list of possible extensions is as follows:

- Introduce uncollateralized debt.
- Determine the link between equity and the credit market; the equity price in the model in this section is very static. The equity price could be extended for that purpose.
- Extend the model to take into account the fact that the proportions of assets backed by collateralized debt and other assets can change due to shocks. This would model the deleveraging process observed after credit shocks.
- Relax the budget constraints (4.1) to reflect the funding of broker-dealers or, generally, a large section of the shadow banking system.
- Allow households to hold debt as well as equity to make the dynamic of the model more realistic.
- ...

## 4.3 Macroprudential Implementation

This section examines how the previously developed model can be applied to macroprudential regulation. For this, a macroprudential model of bank leverage is developed to see how it can be implemented numerically and used to manage the leverage of a banking system.

### 4.3.1 Macro Model of Bank Leverage

Let  $r_t = R_t - 1$  denote the annual interest rate. One can rewrite equation (4.30) as

$$K - K_t = (q_e - q_t^L)^+ H^L - r_t K \quad (4.34)$$

Here one can clearly see that owning a bank is equivalent to owning the bank's capital and a short put position on the bank's collateralized assets. This is a very similar approach to that

developed by Merton (1977), who examines the optional position of deposit insurance. The difference between Merton and this thesis is that I look at the costs and risks for the entire banking system.

Financial stability requires the stability of banking system capital, so, in probabilistic terms (I denote  $E_t$  as the risk-neutral expectation function conditional on  $t$ ),

$$E_t (K_{t+1}) = K_t \quad (4.35)$$

If one combines (4.34) with (4.35), one obtains

$$E_t \left[ \frac{1}{r_t} \left( \frac{q_e}{q_t^L} - \frac{q_{t+1}^L}{q_t^L} \right)^+ \right] = \frac{K_t}{q_t^L H^L} \quad (4.36)$$

If bank leverage—assets on capital—is denoted

$$L_t = \frac{q_t^L H^L}{K_t}$$

and asset inflation is

$$\theta_{t+1} = \frac{q_{t+1}^L}{q_t^L} \text{ and } \theta_e = \frac{q_e}{q_t^L}$$

one can rewrite (4.36) as

$$E_t \left[ \frac{1}{r_t} (\theta_e - \theta_{t+1})^+ \right] = \frac{1}{L_t} \quad (4.37)$$

One can interpret  $\theta_{t+1}$  as collateralized asset inflation indices (note that it is not the return). Equation (4.37) provides a relation between a collateralized asset inflation put and bank leverage.

Equation (4.37) can be understood as the discounted value of a collateralized asset inflation put should be equal to the inverse of the bank's leverage, or equal to the capital–asset ratio.

Note that this equation can be rewritten in terms of asset returns. If the asset return is  $rt n_{t+1}$  at time  $t + 1$ , it can be expressed as a function of  $\theta_{t+1}$ , since  $rt n_{t+1} = \theta_{t+1} - 1$  and  $rt n_e = \theta_e - 1$ .

Then one can rewrite equation (4.37) as

$$E_t \left[ \frac{1}{r_t} (r t n_e - r t n_{t+1})^+ \right] = \frac{1}{L_t} \quad (4.38)$$

Equation (4.38) may be easier to implement numerically but this work uses the formulation (4.37) corresponding to asset inflation.

If the capital–asset ratio is much higher than the inflation put, this model implies that the bank is holding too much capital, given asset inflation expectations. On the other hand, if the capital–asset ratio is much lower than the inflation put, the model implies that banks do not hold enough capital, given asset inflation expectations.

Equation (4.37) represents a put option on collateral asset inflation, which is equal to the bank leverage. Even before trying to price the put option, one can use the put option’s standard properties, which can be translated in term of leverage:

- The increased current level of collateral asset inflation allows for leverage increases.
- The increased strike level of collateral asset inflation leads toward leverage decreases.
- The increased time to expiry of inflation leads toward leverage decreases.
- The increased volatility level of collateral asset inflation leads toward leverage decreases.

Like value at risk, this methodology allows for leverage to increase in boom times and to decrease in taut times, comprising procyclical behavior. On the other hand, there are two more variables that can have an impact on bank leverage: the inflation strike level and inflation volatility.

From a macroprudential perspective, this approach fits well within the existing scope of concern— inflation levels, price stability across time, and the downside of the economy—but allows one to qualify and quantify it by using extended option pricing and the risk management toolbox. This approach also allows macroprudential regulators to change bank capital requirements to cope with changes in the economy, that is, changes in expected inflation levels, changes in expected inflation volatility, and changes in the economy’s resilience.

### 4.3.2 Numerical Analysis Tools

This section examines different ways of analyzing bank capital to see how it can be used as a financial stability monitoring tool.

#### Bank Leverage from Collateral Asset Inflation Volatility

To calculate bank leverage from collateral asset inflation requires determining which asset index to use. Bank assets are mainly composed of loans; the pertinent asset price for this calculation is the collateral of the loans on the bank balance sheet. For this purpose, a synthetic index is used composed of the following:

- The Dow Jones Industrial Average, to represent the stock market
- The Case–Shiller Composite-10 index, to represent the real estate market
- The S&P Goldman Sachs commodity index commodity (GSCI) Index, to represent commodities

Each type of bank has a different asset mix, and two possible types of banks are thus described: the generalist bank and the real estate bank.

For this calculation, the model uses a standard Black–Scholes–Merton pricing formula (Black & Scholes 1972, Merton 1973). Asset inflation  $\theta_t$  is then assumed to follow a lognormal law. If  $W_t$  is Brownian motion,  $\mu$  is the deterministic drift and  $\sigma$  is the deterministic volatility:

$$d\theta_t = \mu\theta_t dt + \sigma\theta_t \sigma dW$$

Given the fact that one is at time  $t$  and that the option expires at  $T$ ,  $\theta_e$  is the option strike,  $\theta_t$  is the spot asset inflation,  $r$  is the risk-free interest rate, and  $N(\cdot)$  is the normal cumulative function. One can then use the standard Black–Scholes formula for a put option:

$$d_1 = \frac{\ln(\theta_0/\theta_e) + (r + \sigma^2/2)(T - t)}{\sigma\sqrt{T - t}}$$

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

$$Put(\theta_0, \theta_e, r, \sigma, t, T) = \theta_e e^{-r(T-t)} N(-d_2) - \theta_t N(-d_1) \quad (4.39)$$

Combining the previous equation with (4.37) yields

$$E_t \left( \frac{1}{r_t} (\theta_e - \theta_{t+1})^+ \right) = Put(\theta_0, \theta_e, r_t, \sigma, t, T) = \frac{1}{L_t} \quad (4.40)$$

One can then directly calculate bank leverage or the capital–asset ratio.

### Calculation of the Implied Collateral Asset Inflation Volatility from Bank Leverage

It is possible to calculate the implied volatility of banks assets from their capital–asset ratio. The same index as defined above is used.

By using (4.40) and given the actual capital–asset ratio, interest rate, and level of asset inflation, it is possible to calculate an implied asset inflation volatility. Such implied asset volatilities can then be compared with the actual asset inflation volatilities.

The idea is to invert (4.39) to calculate the implied volatility. To do so, Newton’s method is used, with the delta calculated using the standard Black–Scholes vega:

$$Vega = \frac{\partial Call}{\partial \sigma} = \theta N'(d_1) \sqrt{T-t}$$

The time to expiry for all calculations in this study is one year: It is the current time lag used to calculate the capital–asset ratio and it allows for simple calculations.

### Model Details

In real life banks do not have to use full sets of assets as collateral for bank loans like the model assumes, but this section is still going to assume so. Note that the main variable  $\theta_t$  is not an index on asset prices but, rather, an inflation on asset prices. It is assumed that the time step between  $t$  and  $t + 1$  is one year. The following definition is obtained:

$$\theta_t = \frac{AssteIndex_t}{AssteIndex_{t-1}}$$



It is then possible to calculate the strike  $\theta_e$  by noting that

$$\begin{aligned} q_e H^L &= Rq^L H^L - p_t y \\ &= Rq^L H^L - \frac{\Pi_t}{1 - \alpha H^L/H} \end{aligned}$$

By examining(4.30), one obtains the empirical value for

$$q_e H^L = R \times BankAsset_{t-1} - \frac{CoportateProfit_t}{1 - \alpha \frac{H^L}{H}}$$

Then

$$\theta_e = R - \frac{CoportateProfit_t}{(1 - \alpha H^L/H) \times BankAsset_{t-1}} \quad (4.41)$$

The following reviews how this implied volatility is calculated. The implied volatility function is a function of the following:

- The interest rate  $r_t$
- The actual bank capital–asset ratio,  $BankCapital_t/BankAsset_t$
- Current asset inflation,  $\theta_t$
- The strike,  $\theta_e$
- Output elasticity,  $\alpha$
- The ratio  $H^L/H$

If  $ImpVol$  denotes the implies volatility function,

$$ImpVol \left( r_t, \frac{BankCapital_t}{BankAsset_t}, \theta_t, \theta_e, \alpha, H^L/H \right)$$

or

$$ImpVol \left( r_t, \frac{BankCapital_t}{BankAsset_{t-1}}, \frac{AssetLevel_t}{AssetLevel_{t-1}}, \frac{CoportateProfit_t}{BankAsset_{t-1}}, \alpha, H^L/H \right)$$

#### Data

This section uses US data from January 1991 to January 2009. The interest rates are from the US Federal Reserve and are the interest rate used is the market yield on US Treasury securities at

one-year constant maturity, quoted on an investment basis. The data used are the first available interest rates at the beginning of each month.

The Dow Jones Industrial Average is from the Dow Jones. The index point used is the closing rate for the first available trading day of each month. The S&P GSCI Commodity Index is from Goldman Sachs, who publishes monthly data. The Case–Shiller Composite-10 index is from MacroMarkets, a company founded by Robert Shiller that trades this index and macro products.

To create a synthetic index, I normalize the index to one for January 1991 and then apply weight to each type of bank. Finally, the annualized volatility for this asset index  $\sigma$  is the standard deviation of the index's logarithmic returns in a year, to be consistent, of course, with the assumed lognormality of the asset process.

The spot value of  $\theta_t$  is calculated as the annual return of the asset index. The calculation of the strike  $\theta_e$  for (4.41) is the most delicate step in this calculation. The asset price strike is defined as that obtained when all dividends from firms and banks have been canceled out by asset price deflation. As part of the published national account statistics, the corporate profits are calculated. Corporate profits from the U.S. Bureau of Economic Analysis (BEA) are only published quarterly; since monthly data are needed, these are linearly interpolated from the quarterly data.

One then needs to obtain the level of consolidated bank assets. The US Federal Reserve publishes the total assets of commercial banks.<sup>8</sup> Since these data are published on a monthly basis, no adjustment is needed. In a first step, one can use the commercial banks' total assets as the financial sector size. The advantage of using commercial banks is that the data are available, but the drawback is that these are only a subset of the lending institutions in the United States. On the other hand, each type of bank has a given asset profile, and this set of data helps us specifically examine commercial bank exposure.

For numerical implementation, the work of Al-Rabbaie & Rjoub (2010) is used to obtain the

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<sup>8</sup>See the websites <https://www.federalreserve.gov/econresdata/releases/statisticsdata.htm> and <https://www.federalreserve.gov/releases/h8/data.htm>.

US long-run output elasticity:  $\alpha = 0.26$ . The ratio  $H^L/H$  is calculated using federal commercial bank balance sheet data, with an average of 14% between 1990 and 2009. Therefore 14% is used for the numerical implementation of  $H^L/H$ . This number probably underestimates reality, because it takes into account only the asset size of the commercial banking system without considering the shadow banking system.

### Generalist Banks

A snapshot of bank collateral assets is taken using US Federal Reserve data from 2007. The asset index used for generalist banks is as follows:

- 45% stock market
- 45% real estate
- 10% commodities

The following figure shows the asset index and its inflation.

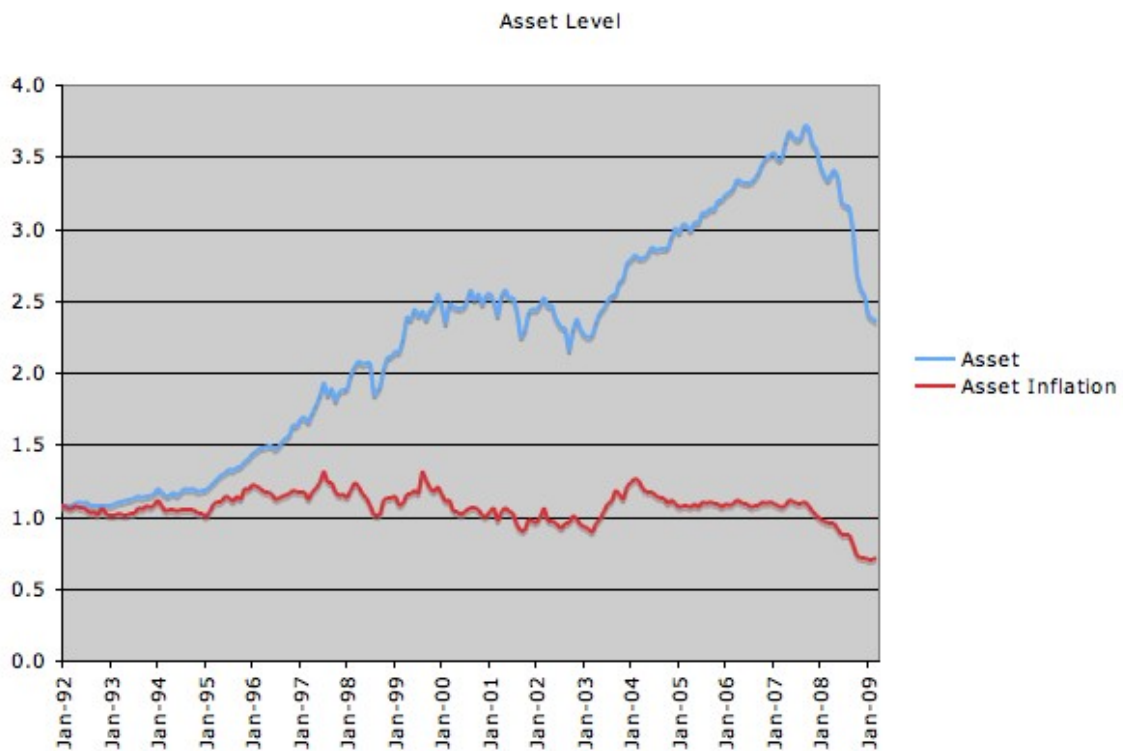


Figure 4.5: Asset Index and Asset Inflation Index

The numerical implementation is shown in the following figure.

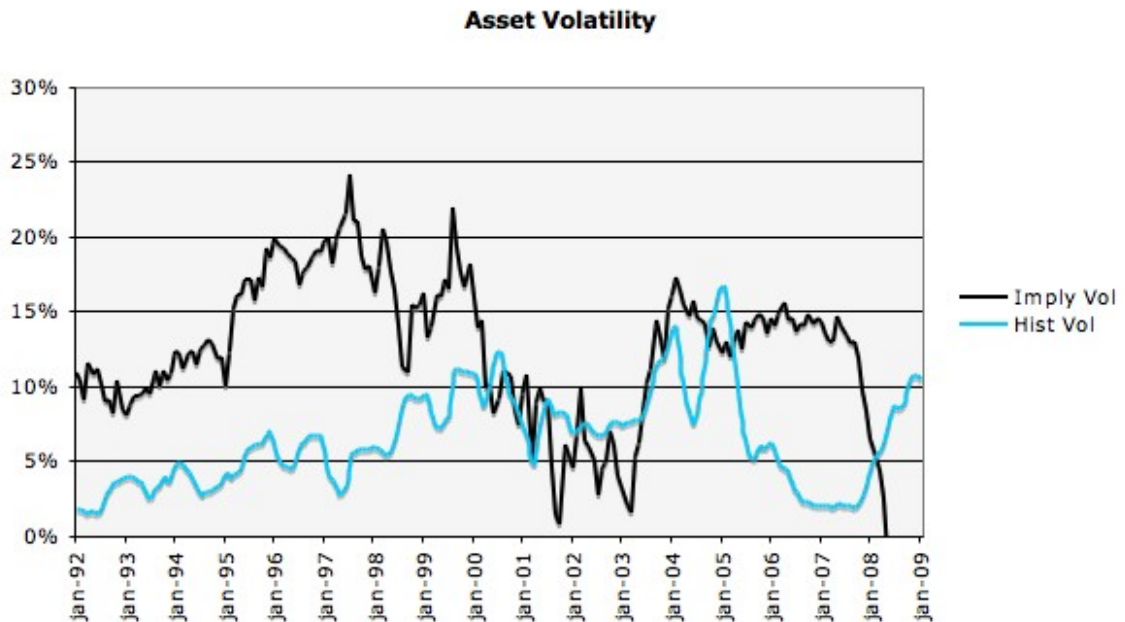


Figure 4.6: Generalist Banks' Asset Volatility: Historical vs. Implied

If a stable capital–asset ratio is used for banks, in this example the average ratio is 5.3% with a standard deviation of 0.9%. Following Gropp & Heider (2008) bank balance sheet are found empirically to be stable.

One of the first things this figure shows is the fact that in this model the asset inflation volatility implied by the current bank capital–asset ratio is far less stable than one may have been used to. The main reason for this is because balance sheet stability is a static variable, and bank managers change the balance sheet to fit static criteria. It may also be that bank managers do not take into account the full extent of the macroeconomic data available.

On the other hand, the model developed reacts to a very large scope of macroeconomic data, that is, the interest rate, bank capital, bank assets, asset prices, and corporate profits. The average implied volatility is 14.7%, much higher than the historical volatility of asset inflation, which is 6.7% (with a standard deviation of 3.2%). The main issue is that, for that period, the standard

deviation of the implied volatility is 5.2%.

Points where the historical volatility is higher than the implied volatility are limited, but this would imply that for a short time bank capitalization is inadequate from a macroeconomic point of view. One can find in the figure above quite a few points where the historical volatility is higher than the implied volatility.

I now calculate the bank capital–asset ratio from bank profits, bank assets, bank capital, and interest rates, using (4.40). The following figure is given (for the sake of clarity, I cap the maximum implied ratio at 200).

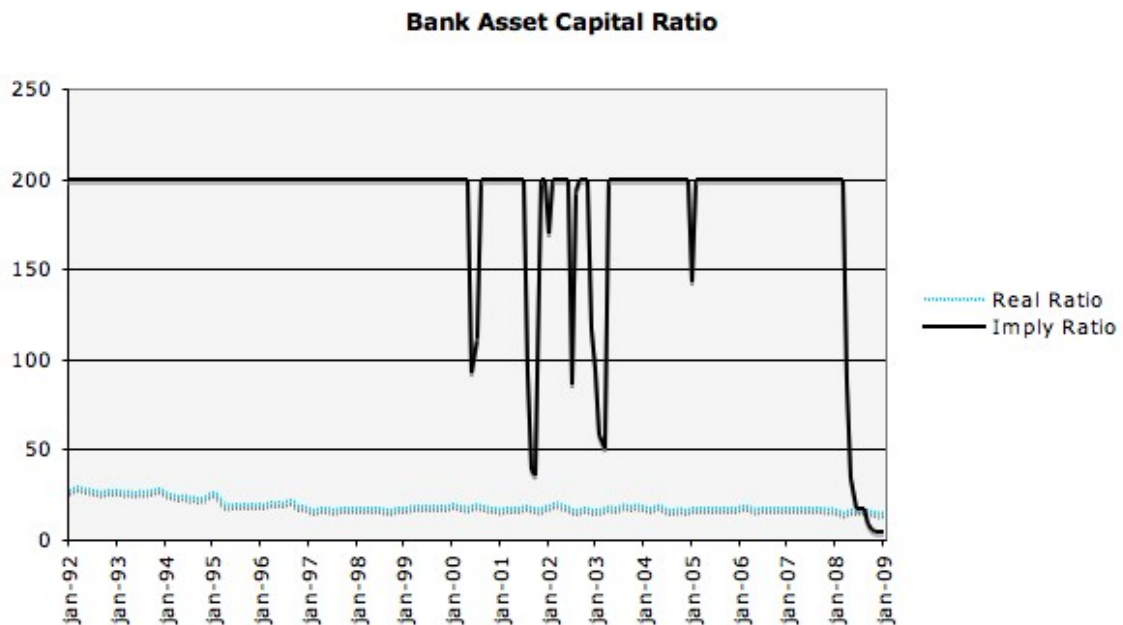


Figure 4.7: Real Estate Banks' Asset Capital Ratio: Real vs. Implied

One can see that most of the time the criterion (4.37) is not binding, which means that from the perspective of possible future losses due to collateral asset price depreciation, bank capital is appropriate. One notes a few times when the criterion (4.37), on the other hand, is stricter than the observed historical volatility.

### Real Estate Banks

This section assumes that the only assets on the bank balance sheet are mortgages. Then the banking industry is exposed only to the real estate market. The asset inflation index is set to be 100% real estate, but all the other data are as in the previous section.

This is not a realistic example but it can shed some light on the impact of the real estate market on lending institutions. The following figure represents the implied asset inflation volatility compare the actual asset inflation volatility.

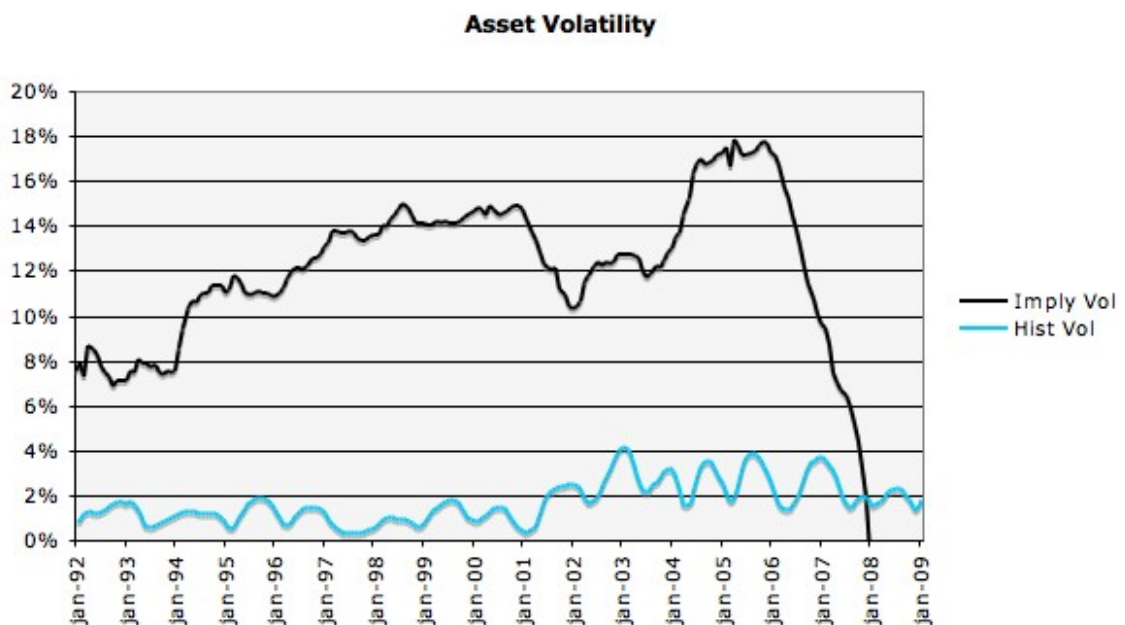


Figure 4.8: Real Estate Banks' Asset Asset Volatility: Historical vs. Implied

This figure is a good illustration of why real estate lending was very good business during the 1990s and the early part of the next decade. Actual volatility was very low and prices were rising, so the level of implied volatility was much higher than what was necessary up to February 2008. On the other hand, the figure shows that the implied volatility decreased steeply after March 2006.

### A Note on the Probability Density

For the sake of simplicity—and because this is commonly done in the literature—the lognormal density is chosen to describe asset price inflation. The result of this choice is that it assumes an almost normal density distribution for asset prices. The normal density distribution has great trouble describing rare events, since its tails are very slim.

Real estate research finds that real estate assets follow a mean reversion law (Case & Shiller 2003, Shiller 2006, Martin 2008). One can thus look for the model to implement the mean reversion of the real estate asset price.

One then obtains the Vasicek (1977) model,

$$dA_t = a(b - A_t)dt + \sigma dW$$

or the Hull & White (1993) model,

$$dA_t = (a_t - bA_t)dt + \sigma dW$$

The issue is that, for the commodity and share markets, evidence of mean reversion is not clear. A better distribution needs to be found.

Thurner, Farmer & Geanakoplos (2009) show that the very existence of leverage in an economy creates long tails and clustered volatility. Given that this study examines bank leverage, it would be suboptimal to use a short-tailed distribution. Longin (2005) empirically demonstrates that in finance a long-tailed probability provides more precise estimates, and Aït-Sahalia & Jacod (2009) find empirical evidence of infinitely active jumps—where the number of possible jumps is not denumerable—in index and stock quotations. Infinitely active jumps should then be a feature of the distribution used for this study, that is, long-tailed distributions. This should allow one to take into account the existence of the “black swan” that Taleb (2007) made so popular.

This leads me to use the Carr–Geman–Madan–Yor (CGMY) Lévy density developed in Carr,



Geman, Madan & Yor (2002). The full motivation for using the CGMY model and how to implement it numerically are detailed in Appendix C.1. This development is in an Appendix because it is fairly technical and not central to the development of the contribution of this thesis.

I use the CGMY Lévy density distribution that corresponds best to describing the macroeconomic situation and determine if it improve the results significantly.

#### Accurate Leverage Estimation

One can now recalculate the estimated leverage using equation (4.37) and an adequate CGMY Lévy density. This determines what the optimal bank leverage should be for a given point in time.

The model is calibrated on the monthly US data set described in Section 4.3.2 and the sample is mean adjusted. The calibration function used is similar to that in Carr et al. (2002), using maximum likelihood estimation and Matlab code (see Appendix C.2), as shown in the following.

CGMY Calibration	
$\nu$	0.0 (-0.02567 0.02567)
C	0.13594 (0.06822 0.20367)
G	30.78526 (17.46763 44.1029)
M	25.6306 (13.11929 38.14191)
Y	0.4997 (0.4479 0.5515)

Table 4.1: CGMY Calibration on US data

The same calculation using the normal density is given here.

Normal Calibration	
$\sigma$	0.040702 (0.037437 - 0.044595)

Table 4.2: Normal Distribution Calibration on US data

By running the put option calculation on the calibrated data for the Black–Scholes and CGMY models, one obtains a set of option prices that are then inverted and compared with the real bank leverage, as shown in the following figure.

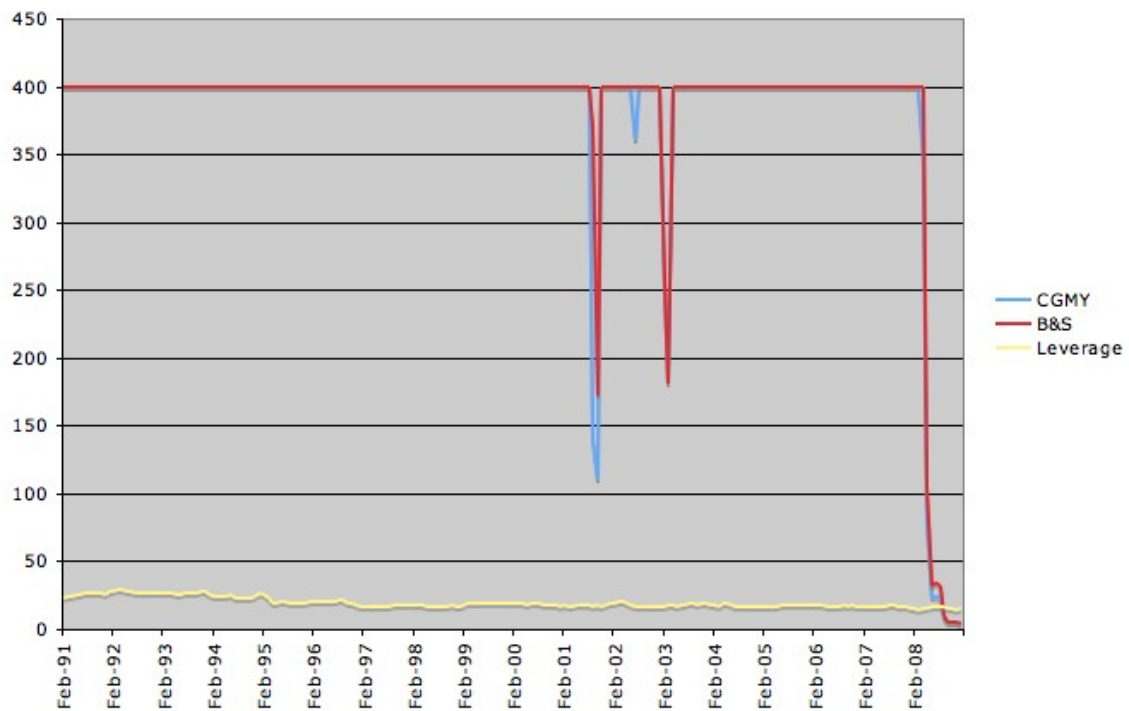


Figure 4.9: Leverage: Historical vs Calibrated

Data were capped at 400, since some option prices are zero and thus their inverted values would be infinite. One can see from the figure that the CGMY probability density improves the sensitivity of the approach developed in this section. On the other hand, to become really useful,

more work on the data calibration is needed, mainly through a more detailed analysis of the jumps for the index created. The process would be to analyze the jumps to calibrate the  $Y$  parameter and then calibrate the other parameters.

This is why the CGMY probability density is used more as an illustration of what it can do than as an actual tool. Analysis of such an in-depth calibration of the CGMY probability density to this index could be the basis for future work.

### 4.3.3 Optimal Leverage

The optimal bank leverage at any given point in time can be obtained, but this estimation provides a very volatile leverage number. This section therefore seeks ways of getting more stable leverage criteria, which can then be required for banks to limit their leverage.

Working Group on Macroprudential Policy (2010) recommends as a policy tool the adoption of the maximum aggregate gross leverage for a number of reasons, such as the underestimation of risk, thus limiting the risk of an aggregated position, and limitation of the effect of feedback from fire sales. I believe that the currently developed model can be added to the macroprudential regulator's tool kit to limit the effect of collateral assets on bank loan depreciation. This can be used in conjunction with established elements to define bank leverage. To be in position to find a criterion that define the ideal leverage is a motivation for the development of this model.

#### Systematic Approach

This section examines the option part of equation (4.37):

$$E_t [(\theta_e - \theta_{t+1})^+] \quad (4.42)$$

where  $\theta_e$  is the asset price inflation that wipes out any firm profit generated at  $t$ , and  $\theta_{t+1}$  is the asset price inflation at time  $t + 1$ . Up to now, an ex post view of the world was assumed, since the real value of  $\theta_e$  is known via access to historical data. I want to use this model to propose a given level of leverage at any given point of time and cannot assume that the current level of  $\theta_e$  is known. In practice, to forecast the value of this put option, an estimation of  $\theta_e$  needs to

assume the randomness of this value.

If  $\theta_t^e$  reflects time dependency, then one can rewrite (4.42) as a function of time and note that

$$\begin{aligned} E_t \left[ (\theta_t^e - \theta_{t+1})^+ \right] &= E_t \left[ E_t \left( (\theta_t^e - \theta_{t+1})^+ \mid \theta_t^e \right) \right] \\ &= E_t \left[ Put(\theta_t^e, \theta_0, \dots) \right] \end{aligned}$$

where  $Put(\theta_t^e, \theta_0, \dots)$  can be any put option function, either Black–Scholes, with

$$Put(\theta_t^e, \theta_0, \dots) = Put_{BS}(\theta_t^e, \theta_0, r, \sigma)$$

or CGMY, with

$$Put(\theta_t^e, \theta_0, \dots) = Put_{CGMY}(\theta_t^e, \theta_0, r, \nu, C, G, M, Y)$$

In this case, the only variable is the distribution of  $\theta_t^e$ , so it is the distribution of profit in the economy. A lognormal distribution is assumed for asset inflation, a very strong assumption, since  $\theta_e$  depends on bank assets and corporate profits.

Given the different sources of variability, that is, bank assets and corporate profits, using their autocorrelation in the model to describe  $\theta_t^e$  would require an in-depth study. Each of these two random variables is complex enough that a specific study on their randomness and correlation between them would be necessary. This could be the basis of further work. Given the fact that the standard deviation of  $\theta_t^e$  (from the US data set of Section 4.3.2) is 2.25%,  $\theta_t^e$  is considered a constant and, for the purpose of the model, its volatility is transferred to asset inflation.

### Volatility Settings

The first idea is to provide a volatility criterion: Banks should set the leverage ratio to be able to cope with a given volatility  $\sigma_L$ . The idea behind this criterion is to make sure that banks use the appropriate leverage to cope with the volatility in the price of collateral assets on their balance sheets. This methodology can be compared with dynamic provisioning, since this was implemented in Spain (Saurina 2009a). The similarity is that the banking system's capital needs to be build up to cope with a given shock, a spike of volatility in the case of the model here.

It is different from the Saurina model, which examines banking failures, while the model here examines only one specific bank risk, that is, the cost of the asset volatility.

The fact that this volatility setting is then plugged into an option pricing formula that will be adjusted real expectations sets a rule for banks to follow. First, this volatility setting is good because of the consistency that a rule brings, as it allow banks to expect macroprudential recommendations. The other interesting aspect is the fact that the volatility setting could provide incentives for banks to avoid collateral concentrations, such as the one seen in real estate.

The choice of numerical values is not definitive and is made here mainly to illustrate the methodology. Take  $\sigma_L = 24\%$  as a numerical example. One can set this volatility in the Black–Scholes model and obtain the leverage. To set a volatility in the CGMY model, one needs to use equation (C.2). I keep (C,G,M,Y) constant, to keep the shape of the density, but  $\nu$  will be changed to fit the volatility.

The following figure shows the real leverage with the Black–Scholes and CGMY estimations, with the data capped at 50.

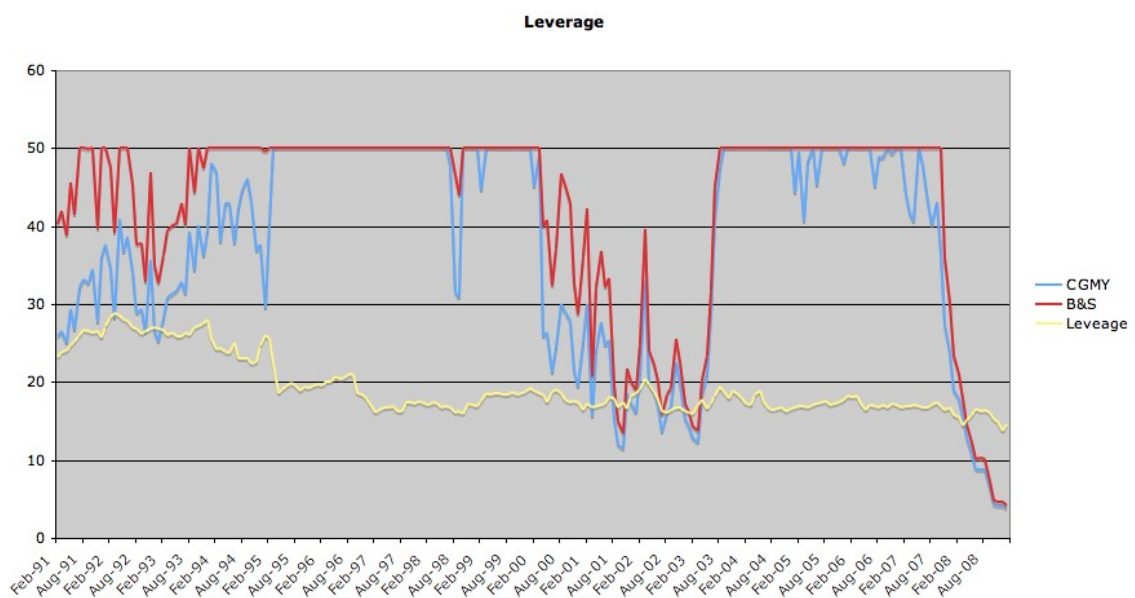


Figure 4.10: Leverage: Historical vs. Implied (Black–Scholes and CGMY)

One can see that using a fat-tailed probability density such as the CGMY distribution is in some cases better than the lognormal density, for example, during the period 1991–1995, probably a side effect of the 1990 Russian financial crisis and the United Kingdom’s recession of the 1990s. On the other hand, the CGMY density would not have been capable of forecasting the 2007 crisis any better than the lognormal density. The volatility was never large before or during the 2007 crisis; the issue was the market price expectations for assets used as collateral, for example, the false idea that real estate prices always increases. In option terms, if one looks at equation (4.37), the market expectation of  $\theta_{t+1}$  is vastly overvalued.

#### 4.3.4 Bank Lending Feedback

As seen in the model developed by von Peter (2009), the existence of capital constraints on the banking system impacts lending. The very fact that banks must fulfill capital constraints causes them to ration lending, which has a feedback impact on the economy. This feedback is included in the leverage calculation.

##### Lending Feedback Effects on Leverage

The relation (4.37) is only valid if the capital–asset ratio is non-binding. In the (more realistic) case, where the capital–asset ratio is binding, if the capital–asset ratio is denoted  $CAR$  and the asset price  $q_{t+1}$  is less than  $q_*$ , then the capital–asset ratio is binding. When the capital–asset ratio is binding, then, following the von Peter’s (2009) model, the economy will enter a capital crunch. The asset price depreciation now follows the slope of  $CAR^{-1}$ . So, since  $q_{t+1} > q_*$ , equation (4.37) is still valid, but for  $q_{t+1} \leq q_*$ , the slope becomes  $CAR^{-1}$ .

In summary, there is a bull spread in  $q_{t+1}$  from  $q_*$  to  $q_e$ , and then a put with strike  $q_*$  leveraged by  $CAR$ . To create a bull spread with puts, one needs to be long put with strike  $q_*$  and short put with strike  $q_e$ . The bull spread can therefore be written

$$BullSpread = (q_*H - q_{t+1}H)^+ - (q_eH - q_{t+1}H)^+$$

So, instead of a short put with strike  $q_e$ ,

$$-(q_e - q_{t+1})^+$$

one has the bull spread plus the leverage short put in  $q_*$ :

$$(q_* - q_{t+1})^+ - (q_e - q_{t+1})^+ - CAR^{-1} (q_* - q_{t+1})^+$$

This mean that one can rewrite (4.37) with the feedback condition as

$$K_{t+1} = (1 + r_t)K_t - (q_e H - q_{t+1} H)^+ + (1 - CAR^{-1}) \times (q_* H - q_{t+1} H)^+$$

So, by applying the constraint (4.35), that is,  $E_t(K_{t+1}) = K_t$ , one obtains the relation

$$E_t \left[ \frac{1}{r_t} (\theta_e - \theta_{t+1})^+ \right] - (1 - CAR^{-1}) \times E_t \left[ \frac{1}{r_t} (\theta_* - \theta_{t+1})^+ \right] = \frac{1}{L_t} \quad (4.43)$$

where  $\theta_e = q_e/q_t$  and  $\theta_* = q_*/q_t$ .

#### Calculation of $\theta_*$

The first thing to do is to calculate the value of  $\theta_*$ , where  $\theta_*$  is the value when the capital–asset ratio becomes binding:

$$\theta_* = \frac{q_*}{q_t}$$

given the fact that, by definition,

$$CAR = \frac{K_t}{q_* H}$$

Then

$$\theta_* = \frac{1}{CAR} \frac{K_t}{q_t H} = \frac{1}{CAR \times L_t}$$

It is also known that

$$\theta_e = R - \frac{CoportateProfit_t}{(1 - \alpha H^L/H) \times BankAsset_{t-1}}$$

So one has everything needed to calculate (4.43).

#### Numerical Implementation

The calculation is very similar to that in Section (4.3.2) on generalist banks. I take  $CAR = 8\%$ .

The following figure shows the historical volatility of the assets of generalist banks in dark and the implied volatility, using the model described previously in (4.3.4), in clear.

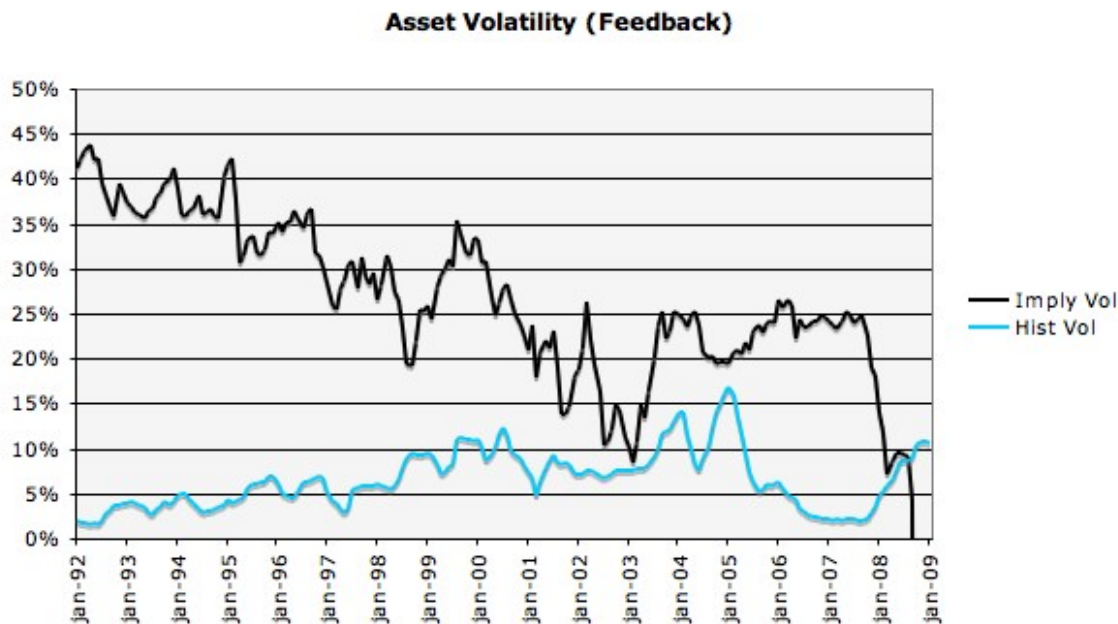


Figure 4.11: Asset Volatility with Feedback: Historical vs. Implied ( $CAR = 8\%$ )

The picture here is more reassuring than the previous numerical implementation for good times, but worse in bad times. This is consistent with the literature, since capital asset requirements make banks more robust during good times but trigger lending rationing during bad times.



One notes that the sensitivity to the  $CAR$  is strong, as can be seen in the case where  $CAR = 7\%$  we obtain the following figure.

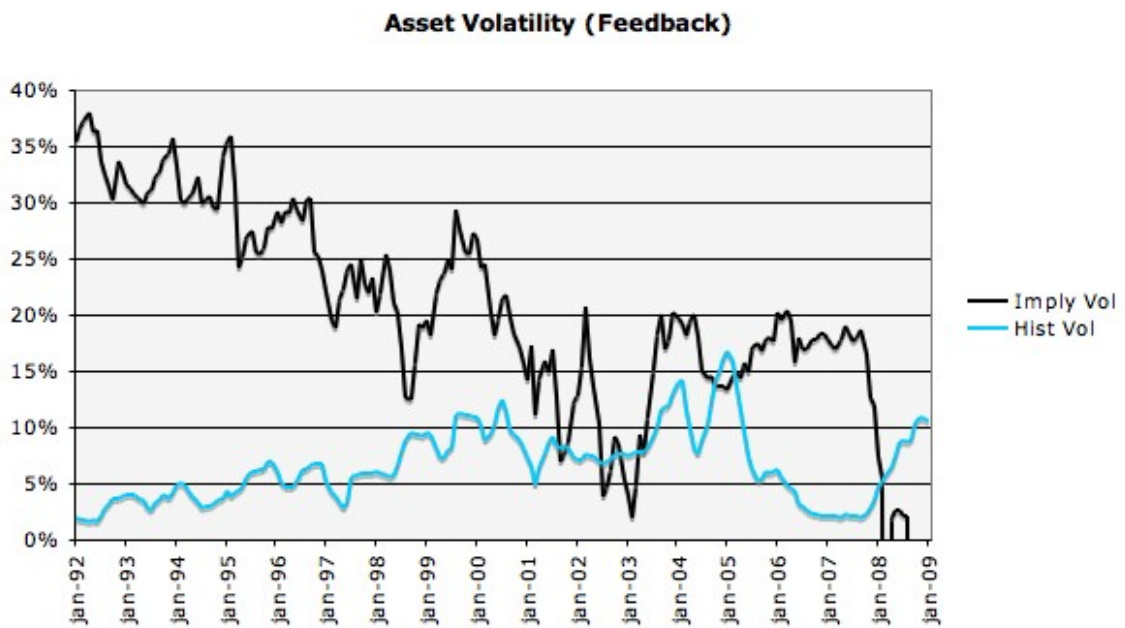


Figure 4.12: Asset Volatility with Feedback: Historical vs. Implied ( $CAR = 7\%$ )

As in Section (4.3.3), a volatility criterion is used to define where bank capital should be, but in this case a much lower volatility threshold  $\sigma_L = 15\%$  is used, and in the following figure  $CAR = 8\%$ .

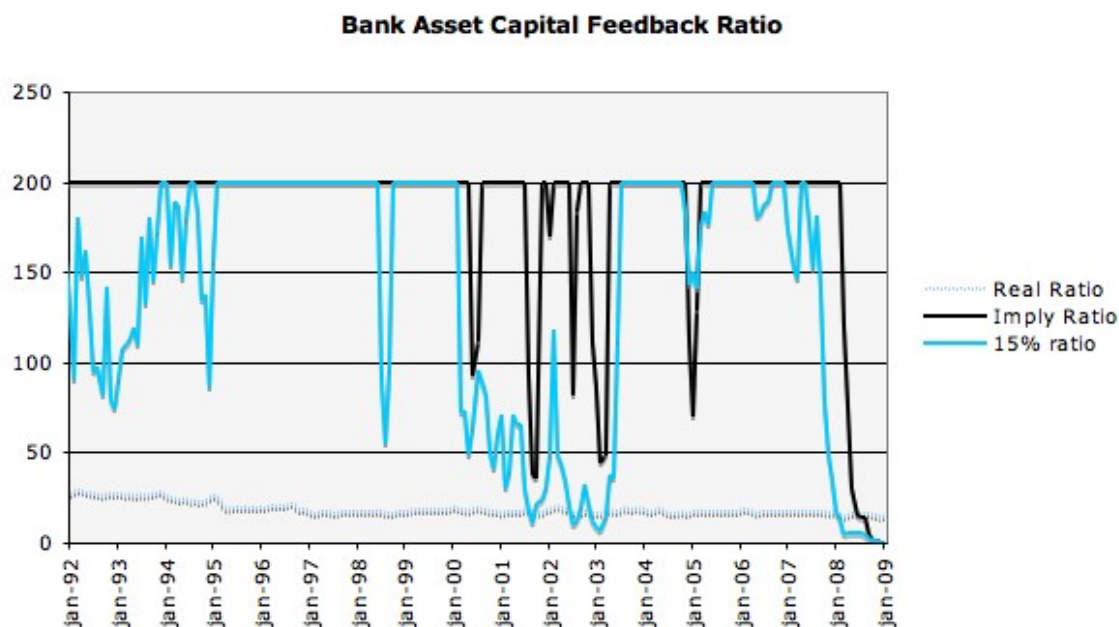


Figure 4.13: Bank Asset Capital Ratio with Feedback: Historical, Implied and with  $\sigma_L = 15\%$

One observes that this choice of threshold is often stricter than the conventional capital–asset ratio.

#### 4.3.5 Intermediate Conclusion

A macroprudential model is developed that says if the banking system capital is to be kept stable, a link exists between inflation or the returns of the asset collateral of bank loans and the overall banking system's leverage. Since one of the aims of financial macroprudential policy is to keep bank capital stable, this model can help define ideal levels of aggregate leverage. This model may be important, since it addresses one of the oldest issues with asset price bubbles, as described in the historical analysis by Kindleberger & Aliber (1996): rapid credit extension that leads to asset price bubbles that ultimately burst, depreciating asset prices. With the tool developed here, macroprudential regulators may have ways of estimating what asset bubbles are a direct risk to

the financial system and how to quantify them.

This model shows how to develop a tool that sets a maximum volatility with which the banking system should be able to cope. As soon as the set level of volatility  $\sigma_L$  has been publicized, this tool acts as a rule to limit the level of leverage within the banking system. This has all the benefits of a rule-based system—for example, predictability—but it also provides good incentives for banks to avoid concentrations of collateral assets. Banks look forward, and if they diversify their collateral assets, their overall leverage will not be impacted.

This is only one tool, among many, to define what should be the ideal level of aggregate leverage, since it only helps to take into account the damages that can cause asset price bubbles. This tool does not replace overall leverage limitations, since in quite a few cases of the numerical examples previously shown the ideal leverage this tool gives is infinite. This tool can be used in conjunction with the standard maximum level of leverage, which protects, for example, against the underestimation of risk.

This link between collateral assets and financial stability is critical, now more than ever, because of the expansion of securitization. The amount of securitized products is a very well documented issue in terms of the opacity of pricing and creating liquidity, but this thesis notes that it has also increased the cost of crises. This leads to the recommendation of greater transparency and more information to assess the systemic importance of securitized products.

The main limitations of the tool developed here is that it is based on option pricing, with all its pertinent issues. I implement pricing with both short- and long-tailed probability densities as examples, but this pricing is always dependent on the density used. More work needs to be done on this subject to determine the probability density that best fits this phenomenon. Another option pricing issue is the use of expected future asset inflation: If future asset inflation is estimated incorrectly—which is what happened with real estate prices—the option pricing is also incorrect.

Another limitation has to do with the fact that the model developed here has only two assets; in reality, loan collateral can be of many different types. The solution obtained in this section to

carrying out an empirical investigation is to use an index that summarizes actual loan collateral assets. It is not clear that this is the best possible approach to investigate this kind of bank risk, since future price expectations and volatility are not asset specific but, rather, index related. A possible approach is to find a way to assign a specific future price expectation, volatility, and probability density for each type of asset. This would in itself be a possible future contribution.

#### 4.3.6 Possible Model Enhancements

The following items would be interesting model enhancements:

- Improving the calibration of  $\theta_e$  and its correlation with  $\theta_t$
- Incorporating feedback from central bank model interest rate interventions
- Introducing stochastic interest rates in the model
- Examining profit model variability
- Improving asset inflation modeling according to, for example, Belgrade, Benhamou & Koehler (2004) and Mercurio (2005).

### 4.4 Conclusion

I provide partial answers for the two main research questions and examine the implications in the financial stability literature and macroprudential regulation. I look at the specificity of collateral assets from a financial stability perspective and then examine the way bank capital can be managed to make financial crises less likely.

As stated in chapter 3, this model assumes the existence of zero probability shocks. The model's limit is that it assumes no government and consequently no government intervention. The outcomes predicted by this model are therefore significantly worse than in reality, as no liquidity is provided by the government, no bank is bailed out and no devaluation is undertaken. . . On the other hand this model is useful to help us understand what can trigger a financial crisis and what would be its magnitude.

#### 4.4.1 Cost of an Asset Price Shock

The model developed in this thesis allows one to view the significance of collateral assets in a new way. I then explore the financial stability implications and application of this theoretical contribution to the empirical literature, focusing on forecasting costly asset bubbles and bank failures.

##### Significance of Collateral Assets

The collateral assets of bank loans—where the term *bank loan* is used in a broad sense and can mean any credit-collateralized contract— are critical in terms of financial stability. Asset price depreciation of these assets can hurt the banking system and the flow of credit in the economy. This thesis does not address the cause of price shocks, risk, or liquidity constraints and focuses instead on post-crisis effects. It concentrates on the specific assets that can cause financial instability.

Adalid & Detken (2007) find that residential property price developments help explain the depth of post-boom recessions. Similarly, while investigating the 1980s Scandinavian crisis, Berg (1998) finds that real estate prices were closely intertwined during both the boom and bust phases. This finding is consistent with my thesis, since real estate is an extremely wide spread collateral though mortgages.

The recent growth of securitized products can be observed from a fresh perspective. Many aspects of the securitization business are found to produce systemic risk: For example, it is complex and opaque, it decouples the relation between debtor and creditor (Hu & Black 2008), and it is prone to runs (Covitz et al. 2009) and inadequate risk sharing (Brunnermeier & Sannikov 2010). A new source of systemic risk is found: the financial stability threat of price depreciation for a specific set of assets.

##### Financial Stability Implications

This thesis sheds some light on the literature related with the research between asset price movements with cost of crisis. This could be part of an answer to the following statement from Adrian & Shin (2010*b*):

Financial stability and monetary policy should focus on tracking asset valuation distortions due to the excessive buildup of leverage and asset growth. Such financial stability monitoring should combine the use of quantitative asset pricing models, the collection of market intelligence, and the tracking of microeconomic distortions in the real economy. (Adrian & Shin 2010*b*, p. 30)

The empirical literature, as in Detken & Smets (2004), finds a strong correlation between the high cost of asset price crashes and real estate prices. Reinhart & Rogoff (2008) find that this effect occurs similarly in developed markets as for emerging markets. This finding is very well explained by the model developed in this thesis, since real estate is widely used as collateral and disruption of the financial system generates high costs.

Goodhart & Hofmann (2008) find, as in the previously quoted literature, that house prices and monetary variables are strongly correlated during the period 1970–2006. What is interesting is the fact that “the link between house prices and monetary variables is found to be stronger over a more recent sub-sample from 1985 to 2006.” Goodhart & Hofmann (2008, p. 180) These results can be explained by the development of securitized products during this period and the implications for financial stability found by the model developed here. An interesting research project would be to test this hypothesis.

In practice, this model could be used by central bankers to firstly diagnose the existence of, and secondly justify the active bursting of, asset price bubbles. Before having collateral asset criteria, it was almost impossible to ex-ante segregate the asset price appreciation due to economic fundamental versus asset price appreciation due to an asset price bubble. Collateral asset criteria however state that asset price appreciation coupled with a large use of this asset as collateral of bank debt can be the symptom of an asset price bubble. By drawing on these criteria, central banks have a way to differentiate between the different types of asset price appreciation. Then, as those asset price bubble have been shown to be damaging for the financial system, central bankers can justify to actively manage them.

The typical central banking view is that a way of softening second round effects of a crisis can be dealt with by reducing interest rate. A further implication of this model is that when a

financial crisis has been identified, it might be possible to use the interest rate to deal with its consequences. As described above, some thresholds of risk for the financial system (like the level  $\delta_e$ ) depend on the interest rate. Thus, on the basis of this model it seems beneficial to reduce the interest rate to lower the effect of a financial crisis; but more work is needed to fully answer this question.

### **Empirical Applications**

There is a vast literature that examines warning indicators for costly asset bubbles, as in Alessi & Detken (2009), who use a signaling approach to predict asset price booms and busts that have relatively serious real economic consequences. The main characteristic of this signaling approach is the fact that it is unclear what assets should be included or excluded.

Borio & Lowe (2002a) review the evaluations of banking crises using a signaling approach. Borio & Drehmann (2009) note that the addition of real estate significantly improves the predictive ability of the model; but it is also noted that the statistical criteria used for this work are “fuzzy,” since they are not based on firm theory. Gerdesmeier, Reimers & Roffia (2010) examines asset mispricing and its relation to money and credit, carrying out a large empirical study of 17 countries to detect asset price busts. To test the asset side of the asset price misalignment, the authors use an asset price composite indicator incorporating both stock and house prices. They also find that the composition of this indicator is arbitrary.

The contribution of this thesis can provide a theoretical foundation for these works. The composition of criteria for banking crises and the composite indicator for asset price misalignment can be determined by looking at the composition of the collateral assets used for loans within the banking sector investigated. This method would then remove the “fussy” or “arbitrary” element of these signaling approaches.

#### **4.4.2 Bank Capital Management**

I develop a tool for the evaluation of systemic risk using modern risk evaluation techniques. This numerical tool can be used as part of a tool kit for the macroprudential management of bank capital. It can provide a way of monitoring the leverage capacity of a banking system, by linking

asset prices to adequate leverage. This tool can also be used to implement macroprudential policy, since it allows for rule-based regulation.

### **Bank Capital Risk: An Option Perspective**

Under the condition of bank capital stability, the model developed in Section 4.2 allows one to establish a relation between collateralized assets and bank leverage. This model provides an interesting tool to examine the relation between bank leverage and the forward expectation of collateralized assets. More precisely, this relation can be described using the formulation of a put option linking bank leverage and the forward expectation of collateralized assets.

This can be expressed as a relation with the Greenspan put—which became the Bernanke put—popularized by the financial press as the ability of the chairman of the US Federal Reserve to support the economy in times of crisis. The Greenspan put has been creating a moral hazard that provides incentive for economic actors to take on risk. As a former quantitative researcher for an investment bank, I have always been curious about the prices for such puts. This thesis focuses on evaluating one of the aspects of the Greenspan put, that is, the cost of bank-limited liability in terms of capital, given an asset depreciation risk.

The direction taken by this thesis is to adapt and implement relatively mature risk management tools, such as option pricing, in the macroprudential field. Such literature is nascent, but one can find research on the application of modern risk management theory to bank capital requirements, such as Jarrow (2007) and Das (2007). A common factor of this literature is the fact that these techniques are not there to replace existing capital requirement methods, but fill in the gaps of existing methods. Given the fact that one of the main targets of macroprudential policy, that is, investment banks, are already using these techniques to “arbitrage” existing regulations, I strongly believe that regulators should integrate these new risk management tools into their existing tool kits.

### **Macroprudential Monitoring**

It has been widely documented that the financial system behaves procyclically (Adrian & Shin 2010a). This means that asset price increases are correlated with leverage increases for investment



banks due to active balance sheet management. What to do to counteract this tendency of the financial system is one of the central questions for macroprudential regulators. The model of Section 4.2 can help formulate such a policy for a number of reasons.

- This methodology is more precise in its application than existing tools, since it examines the very specific composition of the banking system's loan collaterals.
- It allows one to take into account tail risks by using an appropriate probability density.
- It allows the integration of credit crunch risk feedback in the analysis.
- It allows sensitivity with respect to exogenous variables to be easily examined.
- These models can be forward looking and can integrate forward-looking data input as well as the traditional historical data. The forward-looking perspective can be useful for breaking the procyclical pattern of bank capital requirements, because as soon as macroprudential regulators change their forward expectations of the economy, these can be translated into actual changes in current capital requirements. This method is not without risk, since regulators, like other people, can be wrong. A wrong forward expectation can have negative implications for the appropriate level of credit.

### **Macroprudential Implementation**

This monitoring can lead to two possible recommendations. The first is simple and covers the maximum leverage of a banking system. The second recommendation concerns asset pricing and can be split into two aspects: should banks change their loan collateral; or should a regulator react to the existence of an asset price bubble. Both recommendations are discussed in turn.

The research presented in this thesis defines a maximum level of leverage for the banking system. The macroprudential implementation of this can be done through a rule that calculates the maximum leverage level and then enforces it. This implementation corresponds very much with what macroprudential regulators are doing, the only addition being the dynamic manner in which this maximum level is calculated, and the basis for a rule-based recommendation.

The second approach to macroprudential implementation is to examine the other side of the

equation, that is, the asset price. One aspect is to recommend the diversification of collateral assets for bank loans, in order to prevent the systemic risk from becoming too high and the put option from becoming too expensive. This method of limiting systemic risk is a constraint on banks, limiting the effects of bank behavior, exemplified by Charles “Chuck” O. Prince III, former Citigroup chief executive. In July 2007, referring to the firm’s leveraged lending practices, Prince stated, “When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you’ve got to get up and dance. We’re still dancing.” If the collateral of most investment banks’ loans had not been real estate in 2007, the liquidity crisis would have led to a financial crisis but it would have not been so costly.

The other way to view systemic risk due to collateral asset prices is to consider the existence of a credit-fueled asset price bubble. There is still much controversy about whether or not regulators should get involved in managing asset bubbles. The tool developed here can provide a qualitative and quantitative estimate of the spillover effects. This would allow the asset bubble discussion to focus on assets that can cause higher systemic damages. The model may explain why an equity bubble is not as dangerous from a systemic point of view as a real estate bubble.

## Chapter 5

# Asset Based Credit Generation: An Overview

### 5.1 Introduction

This section is an overview of institutions that produce credit using assets instead of deposits. This paper's aims to detail the specificity of such institutions and their difference with banks. The motivation for this research is first described before reviewing the existing literature. This is followed by an overview of credit creation and the existing data on institutions that produce credit using assets, before concluding with a quickly implemented measure of liquidity creation.

#### 5.1.1 Motivation

The consensus is that the worldwide recession started in August 2007, generated by inadequate credit generation. The financial press is still full of sensational articles about the “Shadow Banking System” (e.g., Roubini (2008)).<sup>1</sup> This is true that a new type of credit-generating institution was created that uses assets instead of deposits to generate credit.

Another change that, in my view, has not been fully examined is the development of leasing. In the 1970s, airline companies owned their planes, and this ownership was present on their balance sheets. Nowadays planes are owned by specialized leasing companies whose very business model is to create loans from assets, in this case planes. The same phenomenon is seen in the

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<sup>1</sup>The term *shadow banking system* was apparently created by Paul McCulley (PIMCO) in August 2007. McCulley (2009) aptly describes what he means by this term.

automobile industry, where car dealers developed their own car-financing branches into massive financial institutions. For example, GMAC, GM's financing branch, had \$ 287.439 billions in assets on its balance sheet in 2006.

Those institutions all generate credit and liquidity from assets.

### 5.1.2 Overview

Diamond & Dybvig (1983) develop one of the main frameworks for generating credit: Banks take deposits to issue debt. The main role of banks is to transform short-maturity liquid assets (deposits) into illiquid long-term assets (debt). Banks therefore act as maturity as well as liquidity transformation agents. The last two decades have witnessed the emergence of a new kind of institution that generates credit using assets instead of demand deposits. This type of institution includes real estate companies, automobile loan companies, and a few hedge funds.<sup>2</sup> This paper calls these asset-based credit (ABC) institutions.

Some of these companies are regulated, such as real estate companies and credit card companies, even if the regulations are much lighter than those for banks. A fair share of these ABC companies are not regulated at all.

## 5.2 Literature Review

This section is a critical review of the academic literature on ABC institutions and the theory of credit generation.

### 5.2.1 ABC Institutions

Pozsar et al. (2010) review what they call “nonbanks,” or what this paper calls ABC institutions. The authors make a few interesting distinctions, such as the “internal” ABC institutions—large companies, such as GMAC, that create credit—and “external” ABC institutions—-independent institutions that generate credit. The authors also look at the business model and funding of ABC institutions. While they provide a good overview, I put together this chapter on ABC institutions with an emphasis on their being a sign of change in the way credit is handled.

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<sup>2</sup>Most hedge funds trade shares and are leveraged very little, and therefore do not generate credit.

Gorton & Metrick (2011) describe what they call securitized banking institutions. The authors focus on the mechanism that caused the August 2007 meltdown, bringing to light the failure of the repo market. They do not look specifically at credit creation. Finally, they consider banks as institutions that generate credit only because they are backed by a government; they do not mention anything about capital fragility.

There is also a vast literature on real estate companies, credit card companies,<sup>3</sup> and so forth.

### **Shadow Banking System**

This study examines the shadow banking system, the unregulated side of ABC companies. Gorton (2009) is the most detailed academic study on the shadow banking system. It puts the 2007 credit crisis in perspective with the American bank runs of the late 19th century up to the creation of the Federal Reserve. It also details the underlying mechanism of the shadow banking system, thoroughly explaining the triangular relationship involving shadow banks with “traditional” banks and customers. The author’s best contribution is, for me, his explanation of the link between asset prices and credit generation through collateralization—more precisely, the connection between the repo and securitization markets.

### **Securitization**

Securitization is the business of packaging and reselling loans. It is an important step toward a full understanding of ABC institutions, since it allows the externalization of debt. Calomiris & Mason (2004) view securitization from a regulatory arbitrage perspective. The authors conclude that securitization is used mainly for optimal contracting and not to avoid capital constraints. The sample period covers data up to 2000, and I suspect the results would be different if the sample period covered up through the end of 2006.

To complement the Calomiris & Mason view on ABC companies, Kiff (2009) explains the International Monetary Fund’s view on how the securitization market should work.

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<sup>3</sup>Credit card companies do not collateralize their loans, but they securitize credit card debt and can then trade and use those assets as collateral.

## Repo

The specific repo literature is very limited, since the instrument is so simple. According to Geithner (2008), the repo market was worth around \$10 trillion in 2007.

### 5.2.2 Theories of Credit Generation

This research is about credit creation by ABC institutions, so the main theories underlying credit creation are now presented. In the academic literature, banks are the institutions that generate credit, and this credit generation links the two main theories of bank capital, the first where bank capital is considered a “risk absorption” device before government backing kicks in, and the other where bank capital fragility generates a fair price of credit, in which case government backing impedes credit creation.

The concept of credit creation is closely linked with two concepts of risk transformation and liquidity creation.

#### Bank as a Risk Transformation Institution

Banks can be viewed as a risk transformation institution, transforming low-risk short-term assets— that is, demand deposits— into riskier long-term assets—for example, loans. According to Allen & Gale (2004) and Bhattacharya & Thakor (1993), bank capital is considered a buffer to mitigate risk. Government backing has the same effect as bank capital, for it is a risk buffer that kicks in when the bank capital is exhausted. This policy is called “too big to fail” and is implemented mainly through deposit guarantees.

#### Liquidity Creator

Banks can also be considered liquidity creators. According to Diamond & Rajan (2000, 2001), bank capital should be fragile to promote good banking behavior in terms of the price of credit. This theory implies that too much capital can weaken bank liquidity creation and that government activity also has counterproductive effects.

Credit-generating institutions, whether traditional banks or ABC institutions, must be understood as risk transformation institutions as well as liquidity creators. Bank liquidity creation

strongly indicates the institution in question follows either the risk absorption theory or the capital fragility theory, according to Berger & Bouwman (2009). Their work is also very useful because it develops a methodology for empirically evaluating liquidity creation.

### **5.3 ABC Creation Model**

The aim of this research is to compare traditional banking (deposits for loans) with ABC “banking” (assets for loans). The first thing to note is that one side of the balance sheet is very similar between banks and ABC institutions. The asset side of ABC institutions looks very much like the asset side of a bank balance sheet, that is, with either uncollateralized and collateralized loans. The difference is mainly apparent on the liability side. Traditional banks have deposits on the liability side. For ABC companies, liability is mainly comprised of short-term loans, very often collateralized (repo or reverse repo).

An important feature of the relationship between traditional banks and ABC institutions is the fact that the former provide cash flow to the latter through the repo market. This underlines the dependence of ABC institutions on the traditional banking system.

#### **5.3.1 Underlying Theories**

At this stage, only a very limited set of specific theories for non-deposit-based credit creation is available. The only article that even approaches the subject is that of Gorton & Metrick (2011), who examine the relationship between the securitization and repo businesses.

The ABC institutions’ core business is to make loans, like banks; so it makes sense to apply existing bank theories to them. This paper now considers how risk transformation and liquidity creation apply to ABC institutions, before examining additional underlying mechanics.

#### **Capital as Risk Buffer**

The idea that capital is a risk buffer is not specific to banks; a firm’s capital can be used as a first-level buffer to absorb the risk of whatever shock hits it.

The ABC institutions are in the risky loan business; they issue debt and carry the counterparty risk up to the maturity of the deal. When one or more loans are not repaid, an ABC institution must have reserves to cope with the loss. When loss accumulations are greater than the standard reserves, with only balance-sheet arithmetic, the losses reduce the institution's capital. Therefore institutions with high levels of capital are in a better position to cope with high losses originating from the loan business. In the context of ABC institutions, capital can thus be considered a risk buffer.

### **Financial Fragility for ABC Institutions**

The financial fragility theory developed by Diamond & Rajan (2000, 2001), can be applied to ABC institutions. The idea is that for ABC institutions, which have no government backing, the argument of financial fragility can be applied without restriction.

The providers of short-term assets need to be widespread and indiscriminate, and the fact that short-term assets are not demand deposits but repo is irrelevant. On the other hand, the incentive for a run is real if the repo counterpart (instead of the depositor) believes the ABC institution is not solvent, as in, for example, the institutional bank run of Bear Stearns.

## **5.4 Scope Analysis**

What data are available, how can they be obtained, and can the relevant institutions be sorted?

### **5.4.1 Data**

Given the motivation for this study, it is important to define the limits of the data. The following discusses the scope of areas, time, and institutions.

#### **Areas**

As a means of existence, ABC institutions use leases and mortgages extensively. From a legal perspective, the United States and United Kingdom have very clear rules for the treatment of delinquent mortgaged debt: The delinquent mortgaged debt holder is very quickly expropriated and the asset resold on the market. In Continental Europe, the delinquent mortgaged debt holder is better protected, and the mortgaged debt less liquid. It then makes sense to examine



the US market first, even though the European market may be a very interesting follow-up.

The other reason for examining the US market first is that the data are easily available.

### **Time**

This study does not want to include data from the 2007 credit crisis, since it rather radically changed the state of the global economy; this is apparent in the very high level of financial institution bankruptcies, as well as strong balance sheet restructuring. The 16-year period from 1990 to 2006 is therefore appropriate. As far as I know, it also corresponds to the emergence of a secondary market for loans, which allowed the development of ABC institutions. This development is reflected by the growth in the credit derivatives market, namely, asset-backed securities (ABS), collateralized debt obligations (CDO), and CDS.

### **Institutions Categories**

For practical reasons, industrial classification is used. The reason why the term *institution* is used is because few of the big players in the ABC business are government agencies, such as Freddie Mac and Fannie Mae.

In the North American Industry Classification System (NAICS), a category that corresponds very well with the topic of this research is “Nondepository Credit Intermediation” (code 5222), as opposed to “Depository Credit Intermediation” (code 5221). The category Activities Related to Credit Intermediation (code 5223) is excluded because it is mainly a service provided to the first two categories; it therefore facilitates credit creation but does not generate any.

The category Securities, Commodity Contracts, and Other Financial Investments and Related Activities (code 523) contains few potentially credit-generating institutions.

Each element of the category “Nondepository Credit Intermediation” fits very well within the ABC criterion. The following table describe the composition of the “Nondepository Credit Intermediation” category:

NAICS Code	Code Industry Title
52221	Credit Card Issuing
522210	Credit Card Issuing
52222	Sales Financing
522220	Sales Financing
52229	Other Nondepository Credit Intermediation
522291	Consumer Lending
522292	Real Estate Credit
522293	International Trade Financing
522294	Secondary Market Financing
522298	All Other Nondepository Credit Intermediation

Table 5.1: NAICS Code and Industry Title

As far as institutions in the category Securities, Commodity Contracts, and Other Financial Investments and Related Activities (code 523), the following are kept, since they generate credit:

NAICS	Code Industry Title
52311	Investment Banking and Securities Dealing
523110	Investment Banking and Securities Dealing
523910	Miscellaneous Intermediation
52392	Portfolio Management
523920	Portfolio Management

Table 5.2: Other Industries included in ABC analysis

The firms in the following array are excluded from the research because of their very small cumulative assets, even if they correspond to the strict definition of ABC institutions:

NAICS	Code Industry Title
5321	Automotive Equipment Rental and Leasing
532112	Passenger Car Leasing
53212	Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing
532120	Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing
5324	Commercial and Industrial Machinery and Equipment Rental and Leasing
53241	Construction, Transportation and Mining and Equipment Rental and Leasing
532411	Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing
532412	Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing
53242	Office Machinery and Equipment Rental and Leasing
53249	Other Commercial and Industrial Machinery and Equipment Rental and Leasing
533	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
5331	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
53311	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
533110	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)

Table 5.3: Firm Types excluded from ABC analysis

#### 5.4.2 Database

For North American ABC institutions, data from Compustat are used. This database records a good number of non-depository institutions, but the balance sheet data are not always perfect. Even if the data quality is not perfect, it seems that Compustat North America is the best fit for this study.

### 5.5 ABC Institution Statistics

This section was written at European Business School in 2009 and provides some graphical descriptive statistics for ABC institutions. In-depth descriptive statistics can be found in Pozsar et al. (2010).

An important question that remains is how important is the ABC institution sector compared with deposit-taking banks?

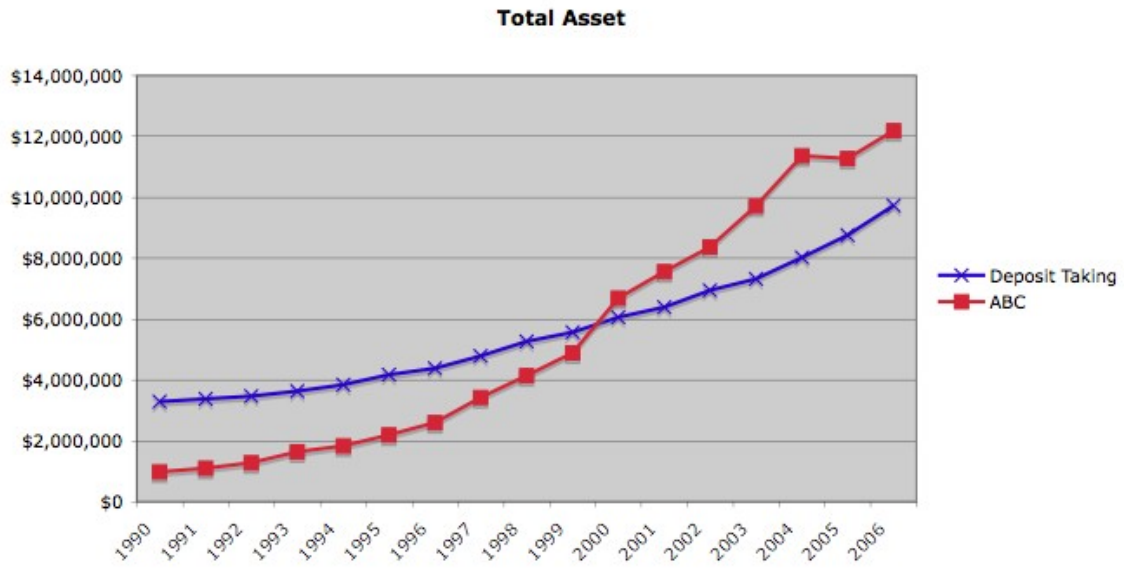


Figure 5.1: Total Assets: ABC Institutions vs. Deposit Taking Institutions

Deposit banks are under strong capital constraints, one of the main differences between banks and ABC institutions.

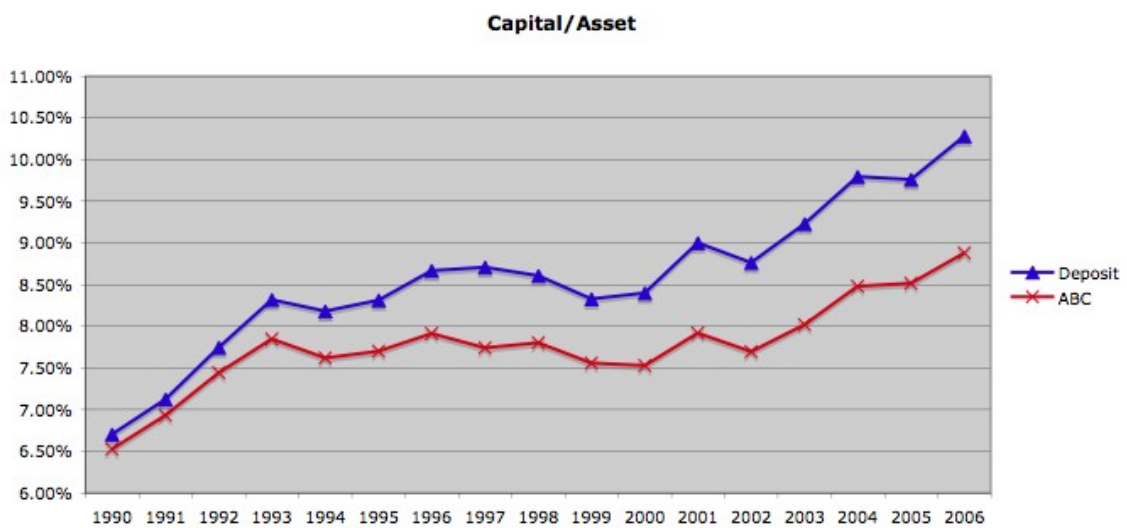


Figure 5.2: Capital on Asset: ABC Institutions vs. Deposit Taking Institutions

To determine the share of total credit creation generated by ABC institutions, two sources must be examined:

- Credit on balance sheets (e.g., bank loans)
- Credit sold as a security

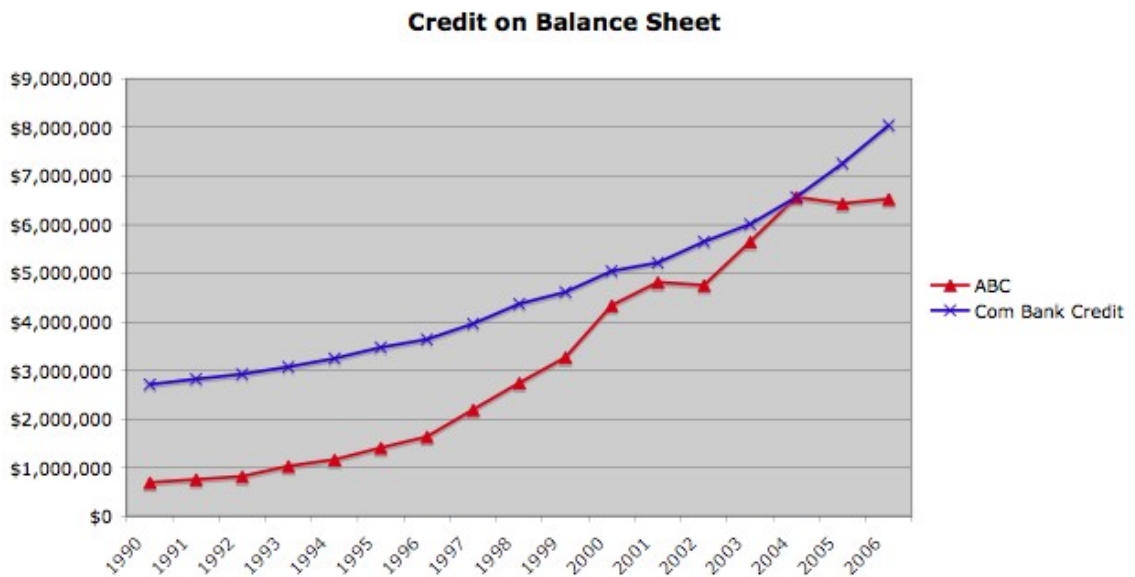


Figure 5.3: Credit on balance sheet: ABC Institutions vs. Deposit Taking Institutions

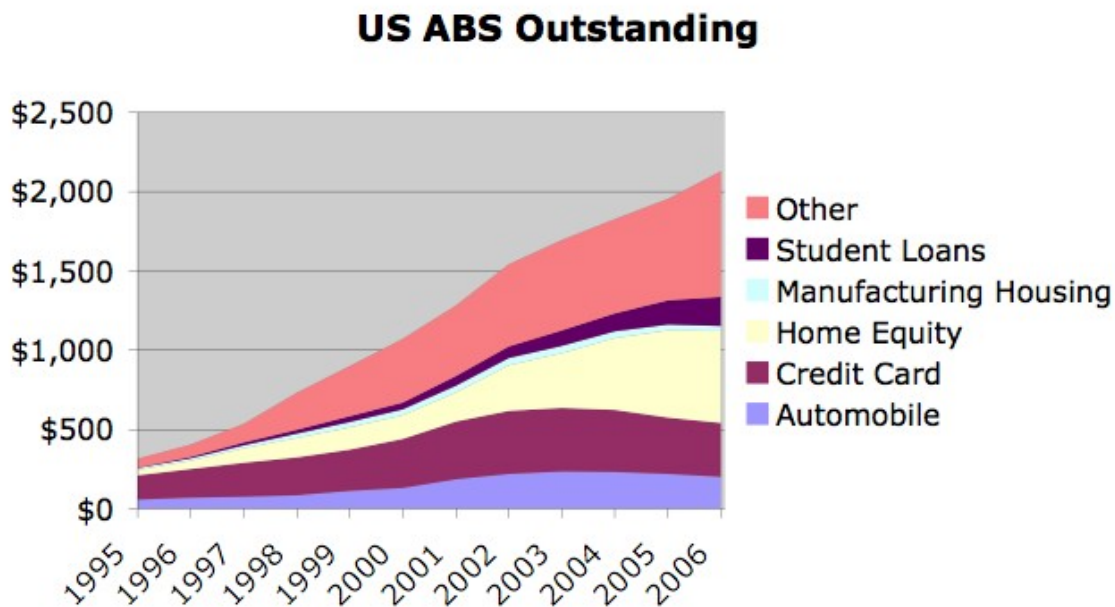


Figure 5.4: ABS in ABC institutions

This graph is one of the most salient representations of the rise of securitized products and indicative of the assets underlying these securitized products.

After this series of graphs I believe that it is clear that ABC institution have become a central part of the lending business.

## 5.6 Measuring Liquidity Creation

The following is a very brief look at the liquidity creation of ABC institutions, for comparison with the liquidity generation of banks.

### 5.6.1 Liquidity Creation of ABC Institutions

Like traditional banks, ABC institutions should generate liquidity. This study applies the techniques developed by Berger & Bouwman (2009) to measure the amount of liquidity generated.

### 5.6.2 Data

The data are annual financial data from Compustat North America from 1990 to 2006.

### 5.6.3 Methodology

The methodology used to measure liquidity is the one developed by Berger & Bouwman (2009): The first step assigns a weight and then sums the liquidity creation measures. The following weights are applied:

Account Sections	Weight
Cash and Short-Term Investments	-0.5
Receivables - Total	0.5
Inventories - Total	0.5
Current Assets - Other	0.5
Property Plant & Equip. - Total (Net)	0.5
Depr. Depl. and Amort. Accum.	0.5
Investment and Advances - Equity	-0.5
Investment and Advances - Other	0.5
Intangible Assets - Total	0.5
Assets - Other - Total	0.5
Debt in Current Liabilities	0.5
Accounts Payable	0.5
Income Taxes Payable	-0.5
Current Liabilities - Other	-0.5
Long-Term Debt - Total	-0.5
Deferred Taxes and Investment Tax Credit	-0.5
Liabilities - Other	-0.5
Minority Interest - Balance Sheet	-0.5
Preferred Stock Capital - Total	-0.5
Common Equity - Total	-0.5
Stockholders Equity - Total	-0.5

Table 5.4: Weights for Liquidity Measure

### 5.6.4 Results

The results are as follows. First, business alone generated \$1.32 trillion in total assets in 1990, and \$10.92 trillion in 2006, a 727% increase. The current sample comprises 335 different companies, 163 in 1990 and 115 in 2006.

Liquidity for our ABC institution sample was \$480.9 billion in 1990, climbing to \$4.45 trillion in 2006. If investment banks are removed, these numbers drop to \$340 billion in 1990 and \$1.25 trillion in 2006.

Interestingly, most ABC institution chosen for the sample generate liquidity, with only 4% of those institution generating negative liquidity in 1990, and only 2% in 2006.

In 1990 the top 10 liquidity generators generated 74% of the liquidity. This is an ordered list of the top 10 ABC liquidity generators in 1990:

- Gmac Llc
- Merrill Lynch & CO Inc
- General Electric Capital Svc
- General Electric Capital Corp
- Ford Motor Credit Coporation Llc
- Federal National Mortgage Association (Fannie Mae)
- MNC Financial Inc
- Chrysler Financial Corp
- Federal Home Loan Mortgage Corp (Freddie Mac)
- HSBC Finance Corp

In 2006 the top 10 liquidity generators generated 89% of the liquidity. This is an ordered list of the top 10 ABC liquidity generators in 2006:

- Federal National Mortgage Association (Fannie Mae)
- Federal Home Loan Mortgage Corp (Freddie Mac)
- General Electric Capital Corp
- Nomura Holdings Inc
- Countrywide Financial Corp
- Gmac Llc
- Ford Motor Credit Coporation Llc



- HSBC Finance Corp
- Toyota Motor Credit Corp
- Interactive Brokers Group

It is interesting to note that Fannie Mae and Freddie Mac came a the top of the list in 2006.

Berger & Bouwman (2009) note bank liquidity creation worth \$2.8 trillion in 2003. This comparison with ABC institutions is difficult because quite a few investment banks are backed by the Federal Deposit Insurance Corporation (FDIC), so if they are included, liquidity creation in deposit banks and in ABC institutions is counted. On the other hand, removing investment banks from the sample eliminates too many ABC institutions. The results need to be considered as a gross estimation of orders of magnitude of the liquidity. In 2003 the liquidity creation of ABC institutions, omitting investment banks, was \$0.97 trillion.

In 2003, therefore, ABC institutions and FDIC banks were of similar asset size, but liquidity creation was smaller for the former than for deposit-taking banks. That said, this amount is not insignificant. To conclude, the implementation of Berger & Bouwman (2009) is carried out, mainly to validate the fact that ABC institutions do, in effect, generate liquidity. This area of research is wide open and a more detailed analysis of the liquidity creation of ABC institutions in relation to deposit banks—ABC institutions still need deposit-taking banks to function fully—is a good opportunity for further work.

## 5.7 Overview of ABC

This section defines the concept of ABC creation and examines the theoretical framework before looking at the empirical aspects of ABC institutions. The bank theoretical framework can, with some adaptations, be used to examine ABC institutions. Then, given the size of these institutions relative to the banking system, their analysis is worth the effort. Finally, a quick adaptation of the work of Berger & Bouwman (2009) shows that these institutions indeed generate significant liquidity for the economy.



## Chapter 6

# Asset Based Credit Institutions Risk & Discipline

### 6.1 Introduction

This section is a research of the risk and the market discipline of Asset-Based Credit Institutions. This section aims to detail the specificity of such institutions with regard to risk and the market discipline. The motivation for this research is first described before an overview of this contribution.

#### 6.1.1 Motivation

Over the last two decades the market for loans, secure and unsecured, has experienced unprecedented growth. This recent credit growth did not originate merely from the banking system. Credit, for both firms and households, used to be issued mainly by banks, defined as deposit-taking institutions that provide credit. Recently a new kind of institution, one that does not take deposits, has been issuing an increasing share of credit.

This new institution is part of the so-called shadow banking system<sup>1</sup>, or a "non-bank" (Pozsar et al. 2010). Since such institutions issue credit without deposits, they are hereafter called asset-based credit (ABC) institutions. In 2006 ABC institutions in the US were larger in terms of total assets than the banking system covered by the Federal Deposit Insurance Corporation (FDIC).

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<sup>1</sup>The term *shadow banking system* was apparently created by Paul McCulley (of PIMCO) in August 2007. McCulley (2009) gives a good description of this term.

The 2007 credit crisis prompted great concern about the risk of lending institutions. While bank risk has been explored in depth, the risk of non-deposit-taking institutions—or ABC institutions—is still relatively unexplored.

### 6.1.2 Overview

Traditional banks use deposits to fulfill their liquidity needs. Since ABC institutions do not take deposits, their liquidity needs are provided by the wholesale money market, short unsecured loan but mainly repurchase agreements (or repos) with a maturity shorter than a month. In addition, in the US, ABC institutions, unlike traditional banks, are not regulated or protected by the FDIC. Otherwise, the business model for ABC institutions is similar to that of banks, that is, they issue and service loans.

But do ABC institutions behave like banks? The risk of lending institutions has been well researched in the case of deposit-taking banks and, given the 2007 crisis, it is pertinent to ask how risky ABC institutions are. Can the answers be found in the banking literature? This study examines the specificity of ABC institution risk with an adapted version of the toolkit use to analyze bank risk.

Lending is a risky business, and therefore some market mechanism must exist to discipline institutions that take on too much risk. Since bank theory has considered the evaluation of risk in depth, this thesis first determines how bank risk metrics apply to ABC institutions. It then applies market discipline theory, developed mainly for banks, to ABC institutions.

This study specifically examines US ABC institutions for several reasons. First, a great deal of US data are available. Second, the clear separation between FDIC banks and other lending institutions is a very good framework for examining ABC institutions in isolation from regulated and protected banks.

To compare ABC institutions with banks, this study accesses balance sheet information. However, the same kind of data are not available for the two types of institutions. Due to regulatory

obligations, banks must report the structure of the loans on their balance sheet in detail, whereas ABC institutions do not. Therefore, one cannot access the same level of granularity for ABC institutions, particularly in terms of the maturity of the credit on the balance sheets<sup>2</sup>.

This empirical study on ABC institutions aims to improve our understanding of credit creation outside banks. While the 2007 crisis can help us understand credit creation outside the banking system, it is a singular event that needs to be studied outside the context of “business as usual.” This thesis thus uses data from before the 2007 financial crisis, from 1990 to 2006<sup>3</sup>.

## 6.2 ABC Institution Categories

ABC institutions create liquidity and represent a very significant share of the loan business in terms of assets; as seen in chapter 5. Several kinds of ABC institutions exist, fulfilling several aspects of the banking loan business. The literature states that non-banks, as defined by Pozsar et al. (2010), correspond to a more general definition than ABC institutions.

This thesis aims to determine what adapted bank theory can tell us about ABC institutions. Although banks and ABC institutions have the same types of assets, which makes them theoretically similar, their liability structure differs. This difference in liability, by definition, concerns the use of deposits, which are used mainly to provide liquidity to banks. The main difference between ABC institutions and banks is thus based on liquidity access, with numerous theoretical implications.

From a theoretical perspective, liquidity access separates ABC institutions from banks. Banks obtain liquidity through deposits and various government services that extend access to liquidity, for example, discount windows. Such government services are there to mitigate the systemic risk due to deposits. Deposits can be seen as a market disciplinary mechanism—depositors can remove their deposits if they lose confidence in a bank’s solvency—that punish badly manage banks — while government intervention is often seen as creating a moral hazard problem by rewarding bad behavior.

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<sup>2</sup>I will details later a call for ABC institution disclosure.

<sup>3</sup>I will be examining the 2007 crisis specifically, using similar tools to those used here, in the future.

To apply bank theory to ABC institutions, their different liquidity mechanisms must be clearly defined. The two main criteria for analyzing liquidity are the actual liquid liability on the balance sheets—deposits for banks and the wholesale market for ABC institutions—and potential government intervention. These two criteria help create categories of ABC institutions that facilitate the interpretation of this study's empirical results.

While each ABC institution uses the wholesale market to access liquid liability, the liability maturities can differ. Although the government helps access liquidity, its associated moral hazard should not apply to ABC institutions, since there is an explicit claim that these will not be bailed out in case of failure. On the other hand, in the case of government institutions such as Freddie Mac or Fannie Mae, this claim is not credible, since the government helped them each time they were in trouble. The category of government ABC institutions is thus considered in order to capture government involvement and reflect moral hazard.

From a liquidity point of view, an investment bank can be regarded as a conglomerate that conducts both a pure lending activity and a fee business activity. The fee business revenue can be used to smooth liquidity gaps. Since the 1999 repeal of the Glass–Steagall Act, investment banks can also conduct commercial bank activities, which falls under FDIC jurisdiction. Investment banks thus benefit from a level of safety that creates a moral hazard. Because of the fee business and possible FDIC involvement, a separate ABC institution category is created for investment banks.

The rest of the ABC institutions have similar access to liquidity and comprise the last category, pure ABC institutions.<sup>4</sup> This category allows one to assume no government involvement and no specific fee business that could smooth liquidity needs. This does not mean, however, that all companies in this category have the same business model or behave in the same way in the following empirical test.

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<sup>4</sup>A previous version of this work also used another category of ABC institutions: ABC institutions that are part of a larger company. This category definitely has different access to liquidity, but share prices are not available, since they are not quoted separately from the mother company. The use of stock volatility as a proxy for risk in this study, however, eliminates this ABC category.

To summarize, there are three main types of ABC institutions<sup>5</sup>:

- Government ABC institutions
- Investment banks
- Pure ABC institutions

This categorization is based on liquidity access, which allows ABC institutions to be compared with banks.

The following categorization, however, is not based on liquidity access. While there is no specific difference between pure ABC institutions companies in term of access to liquidity, it is possible to define a new set of categories, which offer a secondary distinction that allows a deeper investigation into the differences between pure ABC industries. Different business model coexist within pure ABC industries. Among pure ABC institutions, it is then possible to distinguish between the following:

- Credit card issuing companies
- Sales financing companies
- Consumer lending companies
- Real estate lending companies
- Portfolio management (private equity) companies
- All other non-depository credit intermediation companies

### 6.3 Risk Models for ABC Institution

I will briefly review the literature on the link between bank and ABC institution risk, before discussing each of the ABC institution risks individually.

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<sup>5</sup>The extensive news coverage of British Petroleum brought to my attention that in 2008 this company issued more than USD14 billion of loan and derivatives. The reason why this company does not qualify for this study is because, compared with its total assets (\$228 billion for that period), this amount of loans is relatively small—around 6%—since its central activity is energy.

### 6.3.1 Literature Review

As discussed in section 5, ABC institutions are overall behaving similar to banks. The report from Pozsar et al. (2010) by the Federal Reserve Bank of New York details how ABC institutions can be considered as the lending arm of the shadow banking world.

The question is whether from an academic perspective ABC institutions can be considered as deposit free banks? The literature, like for example the seminal book by Freixas & Rochet (2008), suggests that banks have three main properties: liquidity creation, asset transformation — convenience of denomination, quality transformation and maturity transformation — and risk management.

We have seen in section 5.6.4 that ABC institutions do create liquidity. Freixas & Rochet (2008) specify that an institution with a business model similar to an ABC institution like a pawnbroker is performing the three types of asset transformation that banks do. To find out if ABC institutions are, from an academic perspective, behaving like deposit free banks, we still need to know if ABC institutions manage risk like banks? Following Freixas & Rochet (2008), the main risk that a banks manage are credit risk, liquidity risk, interest rate risk and market risk.

At this stage we have been able to verify that ABC institutions share a similar business model with banks, replacing deposits with the wholesale market. We have tested empirically that ABC institutions generate liquidity and do asset transformation. It seems also highly likely that ABC institutions manage risk in the same way as banks, but we would need to test empirically whether this risk is similar to banks' risk, and what can be its specificity.

This requires a more in-depth review of the literature on bank risk. This investigation will be coupled with a discussion on how bank risk can be measured for ABC institutions.

### 6.3.2 ABC Institution Risk

We will look each at individual bank risk and then see how this can be applied to ABC institutions.



Among banks and ABC institutions, risk comes from different sources: maturity mismatch, capital, liquidity, leverage, insolvency, management capability, ownership structure, and so on. The following risk analysis allows us to test the hypothesis that ABC institutions behave like banks. Mainly due to data availability, this study concentrates on four main sources of risk: maturity mismatch, capital, leverage, and liquidity.

### **Maturity Mismatch**

Maturity transformation, or maturity mismatch, is key to the banking business. Is this also the case in the ABC business? Long-term and illiquid loans are issued on the asset side of the balance sheet, and to match them, short-term liquid assets are held as liability—deposits in the case of banks and the wholesale market in the case of ABC institutions. ABC institutions can issue different kinds of credit, in terms of assets, maturity, secure or unsecured, and so forth. For example, a credit card company issues monthly credit and finds monthly funding in the money market. For ABC institutions, maturity transformation is not as certain as for banks, however, and their financial reporting gives us only a partial picture of the actual maturity transformation. Investigation of the risk generated from maturity transformation can therefore be informative of their business model.

The nominal contracting hypothesis — initially described by French, Ruback & Schwert (1983) — states that a company's balance sheet composition in nominal assets and real assets is what makes it alter its position in reaction to unanticipated interest rate changes. Unanticipated interest rate changes then have an impact on stock prices and market risk perceptions. Most assets are real for financial institutions, as in loans and most liability, except for equity, where, for example, deposits are nominal. The nominal contracting hypothesis has been transformed into the maturity-mismatch hypothesis by Flannery & James (1984), who test the maturity mismatch of US banks and saving and loan associations during 1976–1981. Flannery & James (1984) and Yourougou (1990) successfully test the maturity-mismatch hypothesis by using interest rate risk. These authors determine that the effect of interest rate levels on firm equity value varies directly with the difference between the average maturity of the firm's nominal assets and liabilities.

Both Flannery & James (1984) and Yourougou (1990) had access to the detailed maturity pro-

files of the banks they were examining. Because ABC institutions are not banks, their reporting requirements are not as detailed but, with some work, the resulting data are sufficient for testing maturity mismatch. This study uses the same definition for interest rate sensitivity as in Flannery & James (1984) and Angbazo (1997), that is, a measure of ratio of net short-term assets to the market value of equity.

The measures developed in in Angbazo (1997), will be used for a varieties of risk (some risk, such as implicit interest payments, cannot be calculated from ABC institution data) with the independent variables liquidity risk and leverage.

### **Capital**

Capital is a subtle variable that links institution size and risk. Merton (1977) and Kareken & Wallace (1978) assert that, in the absence of regulations limiting risk taking, a lending institution manager acting in the interest of shareholders is motivated to make investment decisions such that the maximum feasible risk profile is achieved.<sup>6</sup> This implies a positive correlation between institutional capital and risk. This assumption must be compared, however, with the common view that considers capital as a risk buffer, according to which the correlation between capital and risk should be negative. Testing the level of capital compared to risk can thus verify whether the theory of Merton (1977) and Kareken & Wallace (1978) or the risk buffer theory applies.

### **Leverage**

The amount of debt in relation to available assets—that is, leverage—is a significant source of risk for companies. Given that the assets of ABC institutions are mostly illiquid, their leverage risk must be accounted for. Capital requirements for banks are an exogenous attempt to limit leverage risk. Those limits, however, do not apply to purely ABC institutions, since the leverage decision for such institutions is fully at their discretion.

### **Liquidity**

One of the main challenges in the loan business is to adequately fund low-liquidity loans. If funding liquidity dries up, the loan institution may not be able to meet their contractual financial

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<sup>6</sup>A study linking the company ownership of managers may provide further insight into this area, but this is for future work.

commitments. In banking theory, an institution that does not meet its liquidity commitments will cause its liquidity provider — depositors in the case of banks — to leave, leading to a bank run. Like banks, ABC institutions can fall victim to runs on the ABC, as happened to Bear Stearns and Lehman Brothers.

A firm's balance sheet liquidity can be measured by examining its liquid assets with respect to total assets. The issue with this metric is that it does not take into account liquidity transfer from assets to liability, and, in the case of ABC institutions, liquidity transfer is central to this study. A more precise metric for liquidity is the ratio of liquid assets to total liability. As an added benefit, this measure removes any volatility due to equity.

### Interaction between Liquidity Leverage and Liquidity

By definition, a highly leveraged institution has to service a large amount of debt. For a given productivity shock, a highly leveraged institution would thus need more liquidity than an institution that is less leveraged. Therefore, I expect a compounding effect between leverage and liquidity. The same level of liquidity may be assessed very differently in terms of risk, depending on the level of leverage. This is the reason why it is not sufficient to look at liquidity risk and leverage risk in isolation, but we need to look at them in conjunction.

This will be done by the introduction of an interaction term between liquidity and leverage in the statistical analysis.

### 6.3.3 Testable Hypothesis

We have looked at each type of bank risk and saw how to implement each of them for ABC institutions. This lead us to the empirical research question:

What specific bank risk measures apply to ABC institutions?

The risk decomposition into different sources of risk described above can be formalized as follows:

$$\text{Risk} = F(\text{Maturity Mismatch, Capital, Leverage, Liquidity, } \dots) \quad (6.1)$$

The assumption is that institution risk is caused by an institution's position in the independent

variables identified above.

## 6.4 Risk Data and Variables

This section examines the data to measure the dependent and independent variables of the hypothesis. It describes the database from which the data are obtained, as well as how the dependent and independent variables are calculated.

### 6.4.1 Data

The data are from the balance sheets and market data of US corporations collected by Compustat. The balance sheet data correspond to annual data from 1990 to 2006. The stock price data are monthly for the same period, which allows the calculation of the annual standard deviations for each stock price and the Standard & Poor's (S&P) 500 index.

The North American Industry Classification System (NAICS) is used to select ABC institutions in Compustat, since most are under code 5222 (Nondepository Credit Intermediation). ABC institutions are then categorized into three types: government ABC institutions, investment banks, and pure ABC institutions. One change in category is made, however, moving Citibank from the consumer lending business to the investment bank business. The reason are that the size of investment bank is too large to be neglected, and the fact that Citibank is a real banking conglomerate; so from a liquidity perspective it would be wrong to consider it as a pure consumer lending business. Data points where capital is not available or below \$1 million are eliminated.

The share prices are from the Compustat Security Monthly files.<sup>7</sup> Monthly prices from January 1989 to December 2006 were downloaded from Compustat. Annual returns were calculated using monthly prices. Interest rates—the 10-year US Treasury rates—were obtained from the US Bureau of Economic Analysis web site.

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<sup>7</sup>The Center for Research in Security Prices (CRSP) database may have been a better choice, e.g., in terms of share splits or outstanding shares, but matching back to the Compustat balance sheet data was problematic as they do not use similar identifying key.

### 6.4.2 Risk Variables

The dependent variable is a measure of the level of ABC institution risk. The literature focuses mainly on return betas, as in (Flannery & James 1984) and (Konishi & Yasuda 2004), which allows one to separate the effects of the interest rate and the market on risk.

The study uses six measures of risk: total risk, firm-specific risk, systematic risk, market risk, interest rate risk, and insolvency risk. The total risk is defined as the standard deviation of an ABC institution's monthly stock returns for each fiscal year measure, in percentage points. To estimate the rest of the risk measures, the following two-index model is used as a return-generating process:

$$R_{it} = \beta_0 + \beta_M R_{Mt} + \beta_I R_{It} + e_{it} \quad (6.2)$$

where  $R_{it}$  is the monthly stock return of ABC institution  $i$  at date  $t$ ,  $R_{Mt}$  is the monthly stock return of S&P 500 at date  $t$ ,  $R_{It}$  is the monthly change in the 10-year US Treasury yield at date  $t$ , and  $e_{it}$  is the residual of the two-index model.<sup>8</sup> In this model, the firm-specific risk is defined as the standard deviation of the residual of (6.2) for each ABC institution, and the systematic risk is measured as the difference between the total risk and the firm-specific risk. The market risk and interest rate risk are given by  $\beta_M$  and  $\beta_I$ , respectively.

The insolvency risk metric was initially developed by Boyd, Graham & Hewitt (1993) and then used by Konishi & Yasuda (2004) to focus on the risk of failure. Insolvency risk is a statistic indicating the probability of bankruptcy. The Z-score for each fiscal year is calculated as

$$Z_{it} = \frac{\sum_{j=1}^3 E_j/A_j + \sum_{j=1}^3 \pi_j/A_j}{S_r}$$

where  $\pi_j$  is the estimated market value of the total profits,  $E_j$  is the market value of total equity,  $A_j$  is the market value of total assets, and  $S_r$  is the estimated standard deviation of  $(\pi_j/A_j)$ .

An issue with this metric is the fact that we can access only annual profit values<sup>9</sup>; in an ideal world we would have access to monthly profit values to calculate the Z-score for each year. In

<sup>8</sup>I did not orthogonalize the interest rate and market return following the methodology of Konishi & Yasuda (2004), because such an adjustment can bias the results (Giliberto 1985).

<sup>9</sup>This is the main drawback to using Compustat instead of CRSP stock price data.

this case, the average of the last three years is used to calculate a Z-score. This metric is less than perfect and not expected to yield the same level of accuracy as for the other risk metrics. It is still considered, however, because it sometimes provides interesting results.

Given the fact that return volatility is used to obtain ABC risk, this study first controls for overall market volatility, using the S&P 500 return volatility.

### 6.4.3 ABC Institution Determinant Components

The independent variables are the ABC institution determinants. The determinant component variables are maturity mismatch, leverage, liquidity, and capital. The control used is the S&P 500 return volatility.

To evaluate the effect of the maturity mismatch, the variable used is SHORT, defined as

$$\text{SHORT} = \frac{\text{Current Assets} - \text{Current Liability}}{\text{Firm Market Value}} \quad (6.3)$$

with

$$\begin{aligned} \text{Current Assets} &= \text{Cash and Cash Equivalents} + \text{Accounts Receivable} \\ \text{Current Liability} &= \text{Debt in Current Liability} + \text{Other Current Liability} \\ &\quad + \text{Accounts Payable} \end{aligned}$$

The maturity-mismatch hypothesis suggests that interest rate risk exposure is negatively correlated with the average maturity of assets, as seen in Section 6.3.2: The higher the level of short-term assets, the lower the sensitivity to short-term interest rates.

The leverage variable, LEV, is defined as

$$\text{LEV} = \frac{\text{Capital}}{\text{Total Asset}} \quad (6.4)$$

where 'Capital' is defined as the balance sheet's total assets minus total liability. Leverage is a good proxy for solvency risk.

Liquidity risk, LIQ, is defined as

$$\text{LIQ} = \frac{\text{Liquid Asset}}{\text{Total Liability}} \quad (6.5)$$

One of the reasons why the denominator uses total liability instead of total assets is that it reduces equity noise (see Section 6.3.2).

The interaction term to test the link between leverage and liquidity will be simply the product of the two variable LEV and LIQ that we will note:

$$\text{LEV} \times \text{LIQ}$$

To control market-wide volatility, the S&P 500 return standard deviation is used:

$$\sigma_{\text{S\&P500}t} = \sqrt{\frac{1}{11} \sum_{j=1}^{12} (r_j - \bar{r}_t)^2}$$

where  $r_i$  is the monthly return during year  $t$  and  $\bar{r}_t$  is the average of the monthly S&P 500 return.

## 6.5 ABC Institution Risk Results

The relations between institution risk, interest rate risk, bank determinants, and control variables are estimated for 1990–2006 for the panel data, first using ordinary least squares (OLS) regression and then fixed effects regression. This section finishes by summarizing the ABC institution risk findings.

For the regression that will be perform I will show the regression results with the following details:

- $N$  which represent the number of observation used for the regression.
- $R^2$  is the square of the sample correlation coefficient between the outcomes and their predicted values.

- adj.  $R^2$  follow the definition from Theil (1961) of the adjusted  $R^2$ , this number adjusts for the number of explanatory terms in a model.
- $rmse$  which represent the root mean square error of the regression.

### 6.5.1 OLS Analysis

We start with an OLS regression analysis. From a timing point of view, the balance sheet data are a snapshot of the end of the year, and stock volatility a reflection of the previous year. To capture the effect of the bank determinant on risk, the bank determinant must thus be lagged by one period (a year) from the risk measure, which is stock volatility in this case. Since stock volatility is a reflection of the previous year, it is lagged by one year from the risk measure.

The regression equation is as follows:

$$\begin{aligned} \text{Risk}_{it} = & \beta_0 + \beta_1 \text{SHORT}_{i(t-1)} + \beta_2 \log(\text{Capital}_{i(t-1)}) + \beta_3 \text{LEV}_{i(t-1)} \\ & + \beta_4 \text{LIQ}_{i(t-1)} + \beta_5 \sigma_{\text{S\&P}500_t} + \beta_6 \sigma_{\text{S\&P}500(t-1)} + \epsilon_{it} \end{aligned} \quad (6.6)$$

where  $\text{SHORT}_{it}$ ,  $\text{Capital}_{it}$ ,  $\text{LEV}_{it}$ ,  $\text{LIQ}_{it}$ ,  $\sigma_{\text{S\&P}500_t}$ , and  $\sigma_{\text{S\&P}500(t-1)}$  are the time-variant regressors,  $(\beta_i)_{i \in [0,6]}$  are the standard regression coefficients, and  $\epsilon_{it}$  is the error term.

The previous year's S&P 500 volatility is used as an additional control. The rationale for this is the fact that trading cycles can thus be captured.

#### All ABC Institutions

We start by examining the full set of ABC institutions, controlled by the ABC categories and the return volatility of the S&P 500 for this period and the previous one.



	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0433 (0.0287)	-0.0232 (0.0278)	0.00163 (0.00227)	-0.00794 (0.00430)	-0.00632 (0.00395)	1.312** (0.424)
$\log(\text{Capital})$	-0.101 (0.0988)	0.283** (0.107)	-0.103*** (0.00566)	0.0332** (0.0108)	-0.0696*** (0.00969)	3.447** (1.162)
LEV	1.330 (0.820)	2.352** (0.827)	-0.132** (0.0483)	0.152 (0.0948)	0.0198 (0.0878)	16.40 (11.01)
LIQ	-0.458*** (0.0948)	0.0902 (0.113)	0.0157** (0.00529)	-0.00620 (0.00792)	0.00946 (0.00508)	-2.325* (0.960)
Govt	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)
IB	-0.0444 (0.724)	0.885 (0.674)	-0.0441 (0.0617)	0.202 (0.117)	0.158 (0.106)	8.792 (8.000)
Pure ABC	-0.641 (0.610)	-0.000621 (0.529)	-0.132* (0.0555)	0.355** (0.110)	0.223* (0.100)	30.54*** (9.035)
$\sigma_{S\&P500_t}$	0.426 (0.516)	0.485 (0.625)	0.0455 (0.0276)	0.176*** (0.0503)	0.222*** (0.0447)	3.262 (4.814)
$\sigma_{S\&P500_{(t-1)}}$	0.169 (0.530)	-0.476 (0.504)	0.0176 (0.0288)	0.184*** (0.0545)	0.201*** (0.0497)	-1.854 (4.901)
_cons	3.057 (1.659)	-1.482 (1.494)	1.205*** (0.118)	-1.776*** (0.231)	-0.571** (0.201)	-7.803 (19.79)
$N$	672	672	672	672	672	666
$R^2$	0.038	0.033	0.387	0.111	0.236	0.059
adj. $R^2$	0.027	0.021	0.379	0.100	0.227	0.048
rmse	4.717	4.808	0.280	0.535	0.477	52.97

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

Table 6.1: OLS Regression for the Risk of All ABC Institutions

Capital is significantly positively correlated with market risk, systematic risk, and bankruptcy risk, meaning that ABC institutions seem to follow the theory of Kareken & Wallace (1978), that increased capital generates increased risk. On the other hand, capital is significantly negatively correlated with firm-specific and total risk (controlled by market total risk). Market-level risk acts in accordance with the idea that capital is used to increase risk, even if on an individual level the risk is cushioned by the capital.

Leverage (LEV) is significantly positively correlated with firm-specific risk and negatively correlated with market risk. Even if, from a firm perspective, less leverage makes the company safer, from a market perspective it has the opposite effect. If the firm is safer because it has more liquid assets to face unexpected events, the market punishes it for not making the best use of its assets.

Balance sheet liquidity (LIQ) is significantly negatively correlated with interest rate and bankruptcy risk and significantly positively correlated with firm-specific risk. This finding can be interpreted as a high level of balance sheet liquidity reduces the risk of interest rate movements and bankruptcy, but has a negative impact on firm-specific risk, since those liquid assets could be put to better use.

The SHORT variable being significantly positively correlated with bankruptcy risk does not make much sense, since one expects a negative number here and there some degree of maturity transfer is taking place. To determine whether the OLS regression is responsible, a fixed effects regression is carried out, in section 6.5.2, for a more precise analysis.

### **Risk for Pure ABC Institutions by Categories**

The same OLS regression is run for pure ABC only, by categories:

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0982 (0.0546)	-0.0102 (0.0479)	0.00567 (0.00399)	-0.0190** (0.00699)	-0.0134* (0.00604)	1.300 (0.864)
$\log(\text{Capital})$	-0.130 (0.152)	0.362* (0.150)	-0.126*** (0.00821)	0.0452** (0.0146)	-0.0807*** (0.0141)	6.385*** (1.842)
LEV	1.486 (0.914)	1.990* (0.992)	-0.120 (0.0656)	0.188 (0.108)	0.0679 (0.104)	12.50 (13.76)
LIQ	-0.495*** (0.0822)	0.111 (0.117)	0.0115** (0.00387)	-0.00130 (0.00624)	0.0102* (0.00500)	-1.936* (0.777)
Credit	1.205 (0.703)	3.252*** (0.730)	0.163*** (0.0414)	1.448*** (0.133)	1.610*** (0.136)	-21.98 (11.78)
Sales	0.835 (0.752)	2.021* (0.828)	0.0844 (0.0555)	1.192*** (0.136)	1.276*** (0.138)	6.689 (14.75)
Consumer	0.798 (0.732)	2.872*** (0.856)	-0.128* (0.0562)	1.468*** (0.131)	1.341*** (0.139)	16.19 (19.09)
Real Estate	0.860 (0.913)	2.763** (0.932)	0.0792 (0.0586)	1.214*** (0.136)	1.293*** (0.136)	-18.11 (14.16)
Portfolio	1.121 (0.641)	2.993*** (0.658)	0.130*** (0.0393)	1.005*** (0.113)	1.135*** (0.118)	-1.456 (14.70)
All Others	0.182 (0.607)	2.739*** (0.628)	-0.00748 (0.0375)	1.291*** (0.120)	1.284*** (0.124)	13.86 (12.33)
$\sigma_{S\&P500_t}$	-0.0116 (0.556)	1.202 (0.718)	0.0558 (0.0324)	0.121* (0.0593)	0.176*** (0.0526)	4.272 (6.452)
$\sigma_{S\&P500_{(t-1)}}$	-0.0122 (0.590)	-0.587 (0.578)	0.0235 (0.0333)	0.202** (0.0647)	0.225*** (0.0570)	-0.765 (6.941)
_cons	-0.324 (1.864)	-2.295 (1.653)	1.170*** (0.121)	-2.818*** (0.238)	-1.647*** (0.225)	16.19 (22.51)
$N$	488	488	488	488	488	482
$R^2$	0.056	0.059	0.440	0.146	0.238	0.075
adj. $R^2$	0.032	0.035	0.425	0.124	0.219	0.051
rmse	4.513	4.595	0.275	0.524	0.465	59.77

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

Table 6.2: OLS Regression for the Risk of Pure ABC Institutions

As expected, SHORT is significantly negatively correlated with systematic and total risk, reflecting the maturity mismatch in the corresponding institutions. The rest of the results are consistent with Section 6.5.1. Most types of pure ABC institutions are significantly positively correlated with risk, with the exception of firm-specific risk, which is significantly negatively correlated with consumer lending. worthy of note

The OLS analysis is worthy of note but it examines a heterogeneous sample without providing enough specificity for individual institutions. In order to obtain a more specific analysis one each institution a fixed effect regression will be used.

## 6.5.2 Fixed Effects

The main reason for using fixed effects is that ABC institutions cover a large scope of access to liquidity and business model, so the raw aggregate of these institutions would not generate relevant results. On the other hand, the purpose of this study is to find the commonalities of these institutions, and fixed effects regression allows us to do so specifically with risk, without aggregating each institution with the others.

From a timing point of view, the balance sheet data are a snapshot of the end of the year, and stock volatility a reflection of the previous year. To capture the effect of the bank determinant on risk, the bank determinant must thus be lagged by one period (a year) from the risk measure, which is stock volatility in this case. Since stock volatility is a reflection of the previous year, it is taken at the same time period.

The regression equation is as follows:

$$\begin{aligned} \text{Risk}_{it} = & \beta_0 + \beta_1 \text{SHORT}_{i(t-1)} + \beta_2 \log(\text{Capital}_{i(t-1)}) + \beta_3 \text{LEV}_{i(t-1)} \\ & + \beta_4 \text{LIQ}_{i(t-1)} + \beta_5 \sigma_{\text{S\&P500}t} + \beta_6 \sigma_{\text{S\&P500}(t-1)} \\ & + \gamma Z_i + \alpha_i + u_{it} \end{aligned} \quad (6.7)$$

where  $\text{SHORT}_{it}$ ,  $\text{Capital}_{it}$ ,  $\text{LEV}_{it}$ ,  $\text{LIQ}_{it}$ ,  $\sigma_{\text{S\&P500}t}$ , and  $\sigma_{\text{S\&P500}(t-1)}$  are the time-variant regressors,  $Z_i$  is the time-invariant regressor,  $(\beta_i)_{i \in [0,6]}$  are the standard regression coefficients,  $\alpha_i$  is the unobserved individual effect, and  $u_{it}$  is the error term.

## All ABC Types

This is the full set of ABC institutions, controlled by the return volatility of the S&P 500 for this period and the previous one.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0776 (0.0814)	0.0179 (0.0794)	-0.00332 (0.00349)	0.00121 (0.00728)	-0.00211 (0.00704)	-0.570 (0.782)
$\log(\text{Capital})$	-0.174 (0.334)	0.809* (0.326)	-0.0728*** (0.0143)	-0.00300 (0.0299)	-0.0758** (0.0289)	5.898 (3.219)
LEV	-1.341 (2.010)	0.817 (1.959)	0.0574 (0.0862)	0.0393 (0.180)	0.0966 (0.174)	25.09 (19.35)
LIQ	-0.476*** (0.132)	0.266* (0.128)	-0.00366 (0.00565)	-0.00531 (0.0118)	-0.00897 (0.0114)	-0.621 (1.270)
$\sigma_{\text{S\&P500}_t}$	0.150 (0.499)	0.305 (0.486)	0.0306 (0.0214)	0.128** (0.0446)	0.158*** (0.0432)	7.563 (4.816)
$\sigma_{\text{S\&P500}(t-1)}$	0.592 (0.524)	-0.363 (0.511)	0.0335 (0.0225)	0.145** (0.0469)	0.179*** (0.0453)	5.687 (5.043)
_cons	4.372 (2.641)	-3.943 (2.574)	0.897*** (0.113)	-1.554*** (0.236)	-0.657** (0.228)	41.73 (25.47)
$N$	672	672	672	672	672	666
$R^2$	0.037	0.022	0.055	0.060	0.098	0.022
adj. $R^2$	-0.175	-0.193	-0.153	-0.147	-0.100	-0.196
rmse	4.841	4.719	0.208	0.433	0.419	46.46

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.3: Fixed Effects Regression for the Risk of All ABC Institutions

No significant relation can be found for maturity transfer (SHORT). Capital is significantly positively correlated with firm-specific and total risk, while it is significantly negatively correlated with market risk. The  $\beta$  corresponding to market risk is 10 times larger than that for either firm-specific or total risk. Even if, from a firm-specific risk perspective, capital buffers liquidity shocks, market risk is favoring the theory of Kareken & Wallace (1978), that is, the management of these firms takes on as much risk as possible.

Leverage has no significant relationship with risk. On the other hand, balance sheet liquidity is significantly positively correlated with market risk and significantly negatively correlated with interest rate risk. It seems that the availability of liquid assets on the balance sheet allows the institution to reduce unexpected interest rate movements, but only at the detriment of a market risk, since those assets are not put to more productive use.

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0819 (0.0815)	0.0130 (0.0794)	-0.00329 (0.00350)	0.000673 (0.00728)	-0.00262 (0.00704)	-0.541 (0.783)
$\log(\text{Capital})$	-0.150 (0.335)	0.836* (0.326)	-0.0729*** (0.0144)	-0.0000921 (0.0299)	-0.0730* (0.0289)	5.738 (3.227)
LEV	-1.276 (2.010)	0.892 (1.958)	0.0570 (0.0863)	0.0474 (0.180)	0.104 (0.174)	24.68 (19.37)
LIQ	-3.179 (2.553)	-2.857 (2.487)	0.0113 (0.110)	-0.343 (0.228)	-0.331 (0.220)	17.71 (24.60)
LEV $\times$ LIQ	2.754 (2.597)	3.182 (2.530)	-0.0153 (0.111)	0.344 (0.232)	0.328 (0.224)	-18.66 (25.02)
$\sigma_{\text{S\&P500}_t}$	0.151 (0.499)	0.305 (0.486)	0.0306 (0.0214)	0.128** (0.0446)	0.158*** (0.0431)	7.578 (4.818)
$\sigma_{\text{S\&P500}_{(t-1)}}$	0.583 (0.524)	-0.373 (0.511)	0.0336 (0.0225)	0.144** (0.0468)	0.178*** (0.0453)	5.735 (5.046)
_cons	4.582 (2.648)	-3.700 (2.580)	0.895*** (0.114)	-1.527*** (0.236)	-0.632** (0.229)	40.32 (25.55)
$N$	672	672	672	672	672	666
$R^2$	0.039	0.025	0.055	0.064	0.101	0.023
adj. $R^2$	-0.175	-0.192	-0.155	-0.144	-0.098	-0.197
rmse	4.841	4.716	0.208	0.432	0.418	46.48

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.4: Fixed Effects Regression for the Risk of All ABC Institutions with Interaction Term

The results show that the interaction term is not significant. Therefore, this interaction is not relevant to the present analysis.

There is no reason to assume that the impact of risk should be constant across time. Therefore, in order to analyze the contribution of each risk over time, I test for time-fixed effects.

First it is interesting to note that for market risk ( $\beta_M$ ) and insolvency risk (Z-Score) we failed to reject the null hypothesis that all years' coefficients are jointly equal to zero, therefore no time fixed-effects are needed. I have then used the full set of ABC institutions for this analysis, controlled by the return volatility of the S&P 500 for this period and the previous one to obtain the time-fixed effect.

The results show that while some years like 1994, 1998, 1999 and 2005 seem to have caused distortions to the risk profile, overall the pattern is relatively stable across time.



	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0925 (0.0821)	0.0290 (0.0811)	-0.00283 (0.00356)	0.00177 (0.00722)	-0.00105 (0.00703)	-0.398 (0.796)
$\log(\text{Capital})$	-0.676 (0.587)	1.187* (0.580)	-0.0395 (0.0254)	0.0358 (0.0516)	-0.00373 (0.0503)	10.57 (5.697)
LEV	-0.934 (2.035)	0.827 (2.011)	0.0275 (0.0882)	0.0221 (0.179)	0.0496 (0.174)	22.60 (19.79)
LIQ	-0.446*** (0.133)	0.261* (0.132)	-0.00481 (0.00578)	0.00668 (0.0117)	0.00187 (0.0114)	-0.280 (1.297)
$\sigma_{\text{S\&P500}_t}$	-0.243 (1.585)	0.326 (1.567)	0.0170 (0.0687)	-0.143 (0.139)	-0.126 (0.136)	-8.748 (15.37)
$\sigma_{\text{S\&P500}_{(t-1)}}$	1.498 (0.812)	-1.588* (0.802)	0.0526 (0.0352)	0.0836 (0.0714)	0.136 (0.0696)	1.106 (7.874)
1993	-2.681* (1.290)	0.411 (1.275)	-0.0136 (0.0559)	-0.0507 (0.113)	-0.0644 (0.111)	3.607 (12.55)
1994	-2.360* (1.020)	-0.101 (1.008)	0.0673 (0.0442)	-0.362*** (0.0897)	-0.295*** (0.0874)	0.357 (9.909)
1995	-1.649 (1.572)	0.127 (1.554)	0.0426 (0.0681)	-0.315* (0.138)	-0.273* (0.135)	-11.69 (15.24)
1997	-0.953 (0.936)	-0.0963 (0.925)	-0.0256 (0.0406)	0.0603 (0.0823)	0.0347 (0.0802)	20.17* (9.075)
1998	-0.621 (1.095)	0.338 (1.083)	-0.0482 (0.0475)	0.248* (0.0964)	0.199* (0.0939)	16.49 (10.73)
1999	-3.492*** (1.000)	1.251 (0.989)	-0.0447 (0.0434)	-0.0253 (0.0880)	-0.0701 (0.0857)	11.19 (9.722)
2000	-0.925 (0.903)	-0.227 (0.892)	-0.0154 (0.0391)	0.139 (0.0794)	0.123 (0.0774)	18.36* (8.886)
2001	-1.571 (0.941)	0.888 (0.930)	-0.0637 (0.0408)	0.195* (0.0828)	0.132 (0.0806)	9.202 (9.145)
2003	-1.019 (1.213)	1.292 (1.199)	-0.0609 (0.0526)	-0.0966 (0.107)	-0.157 (0.104)	5.857 (11.76)
2004	-0.892 (1.645)	0.372 (1.626)	-0.0984 (0.0713)	-0.210 (0.145)	-0.308* (0.141)	-8.772 (15.96)
2005	0.283 (1.610)	-2.187 (1.591)	-0.0628 (0.0698)	-0.345* (0.142)	-0.408** (0.138)	-24.51 (15.62)
2006	0.404 (2.052)	-1.157 (2.028)	-0.0830 (0.0890)	-0.221 (0.181)	-0.304 (0.176)	-10.80 (19.91)
_cons	9.648 (7.007)	-10.12 (6.926)	0.777* (0.304)	-2.841*** (0.616)	-2.064*** (0.601)	-56.60 (68.04)
$N$	672	672	672	672	672	666
$R^2$	0.080	0.039	0.078	0.131	0.154	0.047
adj. $R^2$	-0.147	-0.198	-0.150	-0.084	-0.056	-0.191
rmse	4.783	4.728	0.207	0.421	0.410	46.37

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

Table 6.5: Time-Fixed Effects Regression for the Risk of All ABC Institutions

**Risk by ABC Types**

This set of fixed effects regression is run on each type of ABC institution individually.

**Government** This sample should be large enough to potentially find a significant relation ( $N = 40$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0214 (0.0417)	0.0000258 (0.0231)	-0.00526 (0.00615)	0.0295* (0.0124)	0.0243* (0.0116)	-1.277 (0.947)
$\log(\text{Capital})$	1.217* (0.537)	0.157 (0.298)	-0.163* (0.0792)	0.387* (0.160)	0.224 (0.150)	-4.660 (12.20)
LEV	-26.25 (35.71)	31.73 (19.82)	6.131 (5.269)	3.802 (10.67)	9.932 (9.976)	367.9 (811.4)
LIQ	15.36* (5.941)	-6.888* (3.297)	-1.203 (0.876)	5.646** (1.774)	4.443* (1.660)	-43.96 (135.0)
$\sigma_{S\&P500_t}$	1.760** (0.609)	-0.151 (0.338)	-0.0142 (0.0898)	0.322 (0.182)	0.308 (0.170)	47.48** (13.83)
$\sigma_{S\&P500_{(t-1)}}$	-1.148 (0.621)	-0.166 (0.345)	0.0838 (0.0916)	-0.316 (0.185)	-0.233 (0.173)	-13.03 (14.11)
_cons	-8.739 (5.859)	-2.491 (3.251)	1.656 (0.864)	-6.917*** (1.750)	-5.262** (1.637)	193.4 (133.1)
$N$	40	40	40	40	40	40
$R^2$	0.290	0.302	0.171	0.309	0.309	0.308
adj. $R^2$	0.107	0.122	-0.043	0.131	0.131	0.129
rmse	1.405	0.780	0.207	0.420	0.393	31.93

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.6: Fixed Effects Regression for the Risk of Government ABC Institutions

The variable describing maturity transfer, SHORT, is significantly positively correlated with systematic and total risk. This is the opposite the sign expected in the presence of actual maturity transformation. Such institutions are in the secondary mortgages business, which is not obliged to undertake maturity transformations, which confirms that these companies are not transforming maturity.

Capital is significantly positively correlated with interest rate and systematic risk and significantly negatively correlated with firm-specific risk. The  $\beta$  link to interest rates is much larger than to the other types of risk. This finding is consistent with that from the test in Section 6.5.2, where even if firm-specific risk capital buffers liquidity shocks, management takes on as much risk as they can.

Balance sheet liquidity provides a point of view of government ABC institutions that is opposite that in the relation seen in Section 6.5.2. Balance sheet liquidity is significantly positively correlated with interest rate and systematic risk and significantly negatively correlated with market and total risk. This finding can be explained by the fact that these institutions are implicitly protected by the state, even if some of them are explicitly not protected by the state. The guarantees provided by the government extend the liquidity buffer of these institutions, such that more liquidity is not seen as a positive element but, rather, as a waste of resources. Bebhuk & Fried (2005) and Emmons & Sierra (2004) document the fact that management incentives at Fannie Mae and Freddie Mac are not aligned with risk reduction.

This is the same regression with an interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0200 (0.0430)	0.0130 (0.0198)	-0.00498 (0.00634)	0.0270* (0.0126)	0.0220 (0.0118)	-1.272 (0.978)
$\log(\text{Capital})$	1.202* (0.551)	0.292 (0.254)	-0.160 (0.0813)	0.361* (0.161)	0.200 (0.151)	-4.615 (12.54)
LEV	-30.56 (42.40)	69.14** (19.50)	6.957 (6.252)	-3.499 (12.41)	3.457 (11.63)	380.2 (963.9)
LIQ	11.38 (21.16)	27.69** (9.731)	-0.440 (3.121)	-1.104 (6.192)	-1.544 (5.804)	-32.57 (481.1)
LEV $\times$ LIQ	77.58 (395.5)	-674.3*** (181.9)	-14.89 (58.32)	131.6 (115.7)	116.7 (108.5)	-222.1 (8990.9)
$\sigma_{\text{S\&P500}_t}$	1.774** (0.623)	-0.279 (0.286)	-0.0170 (0.0918)	0.347 (0.182)	0.330 (0.171)	47.44** (14.16)
$\sigma_{\text{S\&P500}_{(t-1)}}$	-1.179 (0.650)	0.0987 (0.299)	0.0896 (0.0958)	-0.368 (0.190)	-0.278 (0.178)	-12.94 (14.77)
_cons	-8.416 (6.175)	-5.299 (2.840)	1.594 (0.911)	-6.369** (1.807)	-4.776** (1.694)	192.4 (140.4)
$N$	40	40	40	40	40	40
$R^2$	0.291	0.521	0.173	0.338	0.335	0.308
adj. $R^2$	0.079	0.378	-0.075	0.139	0.135	0.100
rmse	1.428	0.657	0.211	0.418	0.392	32.46

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.7: Fixed Effects Regression for the Risk of Government ABC Institutions with Interaction Term

The results show that for the market risk  $\beta_M$ , the interaction term is significant. Furthermore, the Wald test suggests that the increase in  $R^2$  from 0.302 to 0.521 is significant., which means that the interaction term is relevant for the analysis. First the introduction of this interaction term does not impact the relevance of the LIQ variable but changes its sign and also makes the LEV variable relevant. The size of the interaction term is  $-674.3$ . The interaction suggests that market discipline is triggered by both leverage and liquidity, but the combined effect is much stronger than each individual effect.

**Investment Bank** This sample is large enough to potentially find a significant relation ( $N = 144$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.143 (0.484)	-0.211 (0.482)	0.0156 (0.0180)	-0.0476 (0.0337)	-0.0320 (0.0331)	-1.319 (1.187)
$\log(\text{Capital})$	-0.557 (0.999)	1.009 (0.996)	-0.102** (0.0371)	-0.0648 (0.0695)	-0.166* (0.0684)	1.259 (2.453)
LEV	-20.16* (8.052)	8.806 (8.021)	0.505 (0.299)	0.0228 (0.560)	0.528 (0.551)	-0.180 (19.76)
LIQ	-1.116 (3.236)	0.822 (3.224)	0.0284 (0.120)	-0.554* (0.225)	-0.525* (0.222)	-4.640 (7.942)
$\sigma_{\text{S\&P500}_t}$	2.371 (1.344)	-1.893 (1.338)	0.0127 (0.0499)	0.239* (0.0935)	0.251** (0.0920)	0.00706 (3.297)
$\sigma_{\text{S\&P500}(t-1)}$	1.443 (1.337)	-0.508 (1.332)	0.00946 (0.0496)	0.202* (0.0930)	0.212* (0.0915)	-0.304 (3.281)
_cons	22.68* (9.278)	-15.48 (9.243)	0.877* (0.344)	-0.551 (0.646)	0.326 (0.635)	8.204 (22.77)
$N$	144	144	144	144	144	144
$R^2$	0.091	0.036	0.085	0.192	0.234	0.013
adj. $R^2$	-0.120	-0.188	-0.128	0.004	0.056	-0.217
rmse	6.096	6.073	0.226	0.424	0.417	14.96

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.8: Fixed Effects Regression for the Risk of Investment Banks

The amount of capital of an investment bank is significantly negatively correlated with firm-specific and total risk. In this case this test promotes the view of capital only as a risk buffer. Leverage is also significantly negatively correlated with the interest rate risk, with a very large  $\beta$ . This promotes the idea that investment banks are not good at managing interest rate risk.

Finally, balance sheet liquidity (LIQ) is also significantly negatively correlated with systematic and total risk. The more liquid assets are on the balance sheet, the less risky the company.

Overall, investment banks seem to have only negative risk relations with the risk measures chosen by this study.

This is the same regression with an interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0809 (0.484)	-0.283 (0.481)	0.0131 (0.0179)	-0.0484 (0.0339)	-0.0353 (0.0332)	-1.407 (1.194)
$\log(\text{Capital})$	-0.397 (1.002)	1.194 (0.996)	-0.0951* (0.0372)	-0.0626 (0.0703)	-0.158* (0.0688)	1.484 (2.473)
LEV	-27.14** (9.491)	0.705 (9.427)	0.219 (0.352)	-0.0712 (0.666)	0.148 (0.652)	-10.04 (23.42)
LIQ	-10.05 (7.248)	-9.543 (7.199)	-0.337 (0.269)	-0.674 (0.508)	-1.011* (0.498)	-17.26 (17.88)
LEV $\times$ LIQ	14.75 (10.72)	17.11 (10.65)	0.604 (0.397)	0.199 (0.752)	0.802 (0.736)	20.84 (26.44)
$\sigma_{\text{S\&P500}_t}$	2.105 (1.352)	-2.201 (1.343)	0.00185 (0.0501)	0.235* (0.0948)	0.237* (0.0929)	-0.368 (3.337)
$\sigma_{\text{S\&P500}_{(t-1)}}$	1.392 (1.332)	-0.568 (1.323)	0.00736 (0.0494)	0.202* (0.0934)	0.209* (0.0915)	-0.376 (3.287)
_cons	23.09* (9.247)	-15.01 (9.185)	0.894* (0.343)	-0.546 (0.649)	0.348 (0.635)	8.777 (22.82)
$N$	144	144	144	144	144	144
$R^2$	0.106	0.058	0.103	0.193	0.242	0.018
adj. $R^2$	-0.112	-0.172	-0.115	-0.004	0.057	-0.221
rmse	6.073	6.032	0.225	0.426	0.417	14.98

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.9: Fixed Effects Regression for the Risk of Investment Banks with Interaction Term

The interaction term is not significant, suggesting that this interaction is not relevant to the analysis.

**Pure ABC Institutions** This sample is large enough to potentially find a significant relation ( $N = 488$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.154 (0.127)	0.0354 (0.124)	-0.00577 (0.00564)	0.00640 (0.0119)	0.000624 (0.0115)	-0.730 (1.489)
$\log(\text{Capital})$	-0.192 (0.376)	0.904* (0.368)	-0.0650*** (0.0167)	0.0317 (0.0353)	-0.0333 (0.0342)	9.014* (4.426)
LEV	-0.0526 (2.019)	0.641 (1.976)	0.0116 (0.0899)	0.0227 (0.190)	0.0344 (0.183)	31.50 (23.76)
LIQ	-0.505*** (0.125)	0.272* (0.122)	-0.00253 (0.00556)	-0.00315 (0.0117)	-0.00568 (0.0113)	-0.612 (1.470)
$\sigma_{\text{S\&P500}t}$	-0.445 (0.560)	0.921 (0.548)	0.0365 (0.0249)	0.0935 (0.0526)	0.130* (0.0509)	6.670 (6.615)
$\sigma_{\text{S\&P500}(t-1)}$	0.629 (0.598)	-0.410 (0.585)	0.0370 (0.0266)	0.157** (0.0561)	0.194*** (0.0543)	10.01 (7.032)
_cons	2.083 (2.781)	-2.292 (2.722)	0.889*** (0.124)	-1.754*** (0.261)	-0.864*** (0.253)	42.97 (32.80)
$N$	488	488	488	488	488	482
$R^2$	0.054	0.037	0.055	0.059	0.092	0.029
adj. $R^2$	-0.179	-0.200	-0.176	-0.172	-0.131	-0.213
rmse	4.550	4.454	0.203	0.427	0.413	53.35

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.10: Fixed Effects Regression for the Risk of Pure ABC Institutions

Capital is significantly positively correlated with market and bankruptcy risk and significantly negatively correlated with firm-specific risk. This finding is in keeping with the theory mentioned in Section 6.5.2, that even if capital buffers risk on a firm level, it increases risk from a market perspective.

Balance sheet liquidity is significantly positively correlated with market risk and significantly negatively correlated with interest rate risk. The mix can be explained as sufficient liquid assets on a balance sheet help reduce losses from unexpected interest rate moves, but is seen by the market as a nonproductive use of assets.

Even if all pure ABC institutions have similar access to liquidity, their business models can be very different. This study therefore examines their breakdown in more detail. This will provide new insight into the ways ABC institutions differ in dealing with risk under the same liquidity situation.

This is the same regression with an interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.155 (0.127)	0.0345 (0.124)	-0.00572 (0.00564)	0.00628 (0.0119)	0.000562 (0.0115)	-0.718 (1.490)
$\log(\text{Capital})$	-0.154 (0.378)	0.937* (0.370)	-0.0669*** (0.0168)	0.0357 (0.0355)	-0.0312 (0.0344)	8.696 (4.453)
LEV	0.174 (2.032)	0.836 (1.990)	0.000329 (0.0905)	0.0470 (0.191)	0.0473 (0.185)	29.67 (23.93)
LIQ	-3.356 (2.889)	-2.185 (2.829)	0.140 (0.129)	-0.309 (0.271)	-0.169 (0.263)	22.79 (34.08)
LEV $\times$ LIQ	2.899 (2.935)	2.499 (2.874)	-0.145 (0.131)	0.311 (0.275)	0.166 (0.267)	-23.79 (34.60)
$\sigma_{\text{S\&P500}t}$	-0.425 (0.560)	0.938 (0.549)	0.0355 (0.0249)	0.0956 (0.0526)	0.131* (0.0509)	6.536 (6.623)
$\sigma_{\text{S\&P500}(t-1)}$	0.625 (0.598)	-0.413 (0.585)	0.0371 (0.0266)	0.157** (0.0561)	0.194*** (0.0544)	10.02 (7.036)
_cons	2.241 (2.785)	-2.155 (2.727)	0.881*** (0.124)	-1.737*** (0.261)	-0.855*** (0.253)	41.70 (32.88)
$N$	488	488	488	488	488	482
$R^2$	0.056	0.038	0.058	0.062	0.093	0.030
adj. $R^2$	-0.179	-0.201	-0.176	-0.171	-0.133	-0.215
rmse	4.550	4.455	0.203	0.427	0.414	53.39

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.11: Fixed Effects Regression for the Risk of Pure ABC Institutions with Interaction Term

The interaction term is not significant. Thus, this interaction is not relevant to the analysis.



**Risk by Pure ABC Types**

This set of fixed effects regressions is run on the full set of each type of pure ABC institutions, individually.

**Credit Card Issuers** This sample is not large enough to potentially find a significant relation ( $N = 26$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0720 (0.606)	0.835 (0.474)	-0.0148 (0.0176)	0.0599 (0.0747)	0.0451 (0.0868)	-1.329 (7.029)
$\log(\text{Capital})$	0.796 (0.585)	0.585 (0.457)	-0.0197 (0.0170)	0.0254 (0.0720)	0.00569 (0.0838)	-2.617 (6.783)
LEV	-4.522 (3.726)	-2.190 (2.913)	0.0896 (0.108)	0.464 (0.459)	0.554 (0.534)	-22.34 (43.22)
LIQ	0.836 (1.420)	1.258 (1.110)	-0.0118 (0.0413)	-0.0240 (0.175)	-0.0358 (0.203)	-9.051 (16.47)
$\sigma_{S\&P500_t}$	2.700* (1.046)	-1.925* (0.818)	0.0351 (0.0304)	0.395** (0.129)	0.431* (0.150)	-5.812 (12.13)
$\sigma_{S\&P500_{(t-1)}}$	-1.150 (1.008)	1.013 (0.788)	0.0795* (0.0293)	0.516*** (0.124)	0.595*** (0.144)	10.32 (11.69)
_cons	0.915 (5.156)	-6.439 (4.031)	0.665*** (0.150)	0.479 (0.635)	1.144 (0.739)	80.19 (59.81)
$N$	26	26	26	26	26	26
$R^2$	0.381	0.479	0.619	0.819	0.812	0.086
adj. $R^2$	0.032	0.186	0.405	0.718	0.706	-0.428
rmse	1.585	1.240	0.0461	0.195	0.227	18.39

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.12: Fixed Effects Regression for the Risk of Credit Card Issuers

There is no significant correlation, which can be explained by the sample's small size.

**Sales Financing** This sample is large enough to potentially find a significant relation ( $N = 137$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0464 (0.280)	0.0889 (0.296)	-0.00281 (0.0127)	-0.0185 (0.0261)	-0.0213 (0.0228)	0.624 (2.640)
$\log(\text{Capital})$	0.382 (0.890)	1.156 (0.941)	-0.157*** (0.0404)	0.177* (0.0831)	0.0204 (0.0726)	12.45 (8.406)
LEV	4.196 (4.711)	2.617 (4.983)	-0.0432 (0.214)	0.186 (0.440)	0.143 (0.384)	23.15 (44.50)
LIQ	-0.502** (0.161)	0.215 (0.170)	-0.00504 (0.00730)	-0.00107 (0.0150)	-0.00611 (0.0131)	-0.526 (1.520)
$\sigma_{\text{S\&P500}t}$	0.592 (1.184)	2.236 (1.252)	0.0520 (0.0537)	0.120 (0.111)	0.172 (0.0966)	15.04 (11.18)
$\sigma_{\text{S\&P500}(t-1)}$	0.110 (1.260)	-1.468 (1.333)	0.0682 (0.0572)	0.165 (0.118)	0.233* (0.103)	8.915 (11.90)
_cons	-0.275 (6.096)	-3.553 (6.448)	1.536*** (0.277)	-2.309*** (0.569)	-0.773 (0.498)	64.78 (57.58)
$N$	137	137	137	137	137	137
$R^2$	0.091	0.066	0.159	0.104	0.139	0.061
adj. $R^2$	-0.144	-0.177	-0.059	-0.129	-0.084	-0.182
rmse	5.249	5.552	0.238	0.490	0.428	49.59

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.13: Fixed Effects Regression for the Risk of Sales Financing Firms

Capital is significantly positively correlated with systematic risk and significantly negatively correlated with firm-specific risk. Balance sheet liquidity is also significantly negatively correlated with the interest rate risk. Those results are consistent with the overall behavior of pure ABC institutions (see Section 6.5.2).

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0488 (0.283)	0.0566 (0.298)	-0.00156 (0.0128)	-0.0236 (0.0261)	-0.0252 (0.0229)	0.585 (2.672)
$\log(\text{Capital})$	0.380 (0.894)	1.177 (0.942)	-0.158*** (0.0405)	0.181* (0.0825)	0.0229 (0.0723)	12.47 (8.448)
LEV	4.124 (4.851)	3.619 (5.112)	-0.0821 (0.219)	0.344 (0.448)	0.262 (0.392)	24.36 (45.82)
LIQ	-0.0887 (6.066)	-5.490 (6.393)	0.217 (0.274)	-0.902 (0.560)	-0.686 (0.491)	-7.423 (57.30)
LEV $\times$ LIQ	-0.418 (6.138)	5.775 (6.468)	-0.224 (0.278)	0.912 (0.566)	0.688 (0.496)	6.981 (57.98)
$\sigma_{S\&P500_t}$	0.578 (1.205)	2.418 (1.270)	0.0449 (0.0545)	0.149 (0.111)	0.194* (0.0975)	15.26 (11.38)
$\sigma_{S\&P500_{(t-1)}}$	0.113 (1.267)	-1.513 (1.335)	0.0700 (0.0573)	0.158 (0.117)	0.228* (0.102)	8.861 (11.97)
_cons	-0.344 (6.206)	-2.605 (6.541)	1.499*** (0.281)	-2.159*** (0.573)	-0.660 (0.502)	65.93 (58.62)
$N$	137	137	137	137	137	137
$R^2$	0.091	0.072	0.164	0.125	0.154	0.061
adj. $R^2$	-0.155	-0.179	-0.062	-0.112	-0.075	-0.193
rmse	5.274	5.558	0.239	0.487	0.427	49.81

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.14: Fixed Effects Regression for the Risk of Sales Financing Firms with Interaction Term

The interaction term is not significant. Therefore, this interaction is not relevant to the analysis.

**Consumer Lending** This sample is not large enough to potentially find a significant relation ( $N = 35$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0784 (0.383)	0.502 (0.384)	-0.00825 (0.0366)	-0.103 (0.0631)	-0.111 (0.0697)	-12.29 (15.98)
$\log(\text{Capital})$	1.590 (1.381)	0.569 (1.384)	0.122 (0.132)	-0.404 (0.228)	-0.281 (0.251)	65.98 (57.61)
LEV	-8.581 (9.326)	-3.593 (9.349)	-0.897 (0.892)	2.658 (1.536)	1.761 (1.696)	-244.3 (389.0)
LIQ	2.513 (3.365)	3.272 (3.373)	0.0487 (0.322)	-0.949 (0.554)	-0.900 (0.612)	86.63 (140.4)
$\sigma_{\text{S\&P500}_t}$	-0.0922 (0.931)	0.250 (0.933)	-0.0490 (0.0890)	0.0720 (0.153)	0.0231 (0.169)	31.58 (38.84)
$\sigma_{\text{S\&P500}_{(t-1)}}$	-0.191 (1.264)	0.286 (1.267)	0.0405 (0.121)	0.438* (0.208)	0.478 (0.230)	22.04 (52.73)
_cons	-5.545 (7.371)	-0.343 (7.389)	-0.0754 (0.705)	0.772 (1.214)	0.697 (1.340)	29.79 (307.5)
$N$	35	35	35	35	35	35
$R^2$	0.086	0.201	0.121	0.287	0.276	0.236
adj. $R^2$	-0.636	-0.429	-0.572	-0.276	-0.295	-0.367
rmse	1.712	1.716	0.164	0.282	0.311	71.41

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.15: Fixed Effects Regression for the Risk of Consumer Lending Firms

There is no significant correlation, which can be explained by the sample's small size.

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.151 (0.394)	0.472 (0.402)	-0.00572 (0.0384)	-0.0822 (0.0621)	-0.0879 (0.0683)	-14.43 (16.61)
$\log(\text{Capital})$	1.273 (1.433)	0.699 (1.463)	0.111 (0.140)	-0.493* (0.226)	-0.381 (0.249)	75.30 (60.44)
LEV	-6.363 (9.698)	-4.501 (9.900)	-0.820 (0.945)	3.281* (1.529)	2.461 (1.683)	-309.4 (409.1)
LIQ	-3.083 (7.113)	5.563 (7.261)	-0.146 (0.693)	-2.519* (1.121)	-2.665* (1.234)	251.1 (300.0)
LEV $\times$ LIQ	9.256 (10.35)	-3.790 (10.56)	0.322 (1.009)	2.598 (1.631)	2.920 (1.796)	-272.0 (436.5)
$\sigma_{S\&P500_t}$	-0.243 (0.951)	0.312 (0.971)	-0.0542 (0.0927)	0.0298 (0.150)	-0.0244 (0.165)	36.00 (40.11)
$\sigma_{S\&P500_{(t-1)}}$	0.147 (1.326)	0.148 (1.353)	0.0523 (0.129)	0.533* (0.209)	0.585* (0.230)	12.12 (55.92)
_cons	-4.434 (7.513)	-0.798 (7.670)	-0.0368 (0.732)	1.084 (1.184)	1.047 (1.304)	-2.842 (316.9)
$N$	35	35	35	35	35	35
$R^2$	0.125	0.207	0.126	0.375	0.369	0.252
adj. $R^2$	-0.653	-0.498	-0.651	-0.181	-0.192	-0.413
rmse	1.721	1.757	0.168	0.271	0.299	72.58

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.16: Fixed Effects Regression for the Risk of Consumer Lending Firms with Interaction Term

The interaction term is not significant, meaning that this interaction is not relevant to the analysis.

**Real Estate Credit** This sample is just large enough to potentially find a significant relation ( $N = 94$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.339 (0.226)	0.0790 (0.245)	0.00590 (0.00910)	0.0285 (0.0204)	0.0344 (0.0179)	-0.856 (0.752)
$\log(\text{Capital})$	0.384 (0.934)	1.132 (1.016)	-0.0831* (0.0377)	0.0326 (0.0847)	-0.0505 (0.0740)	4.687 (3.143)
LEV	-2.054 (5.303)	-0.844 (5.767)	-0.492* (0.214)	0.0521 (0.481)	-0.440 (0.420)	60.64** (18.19)
LIQ	0.469 (0.987)	1.533 (1.073)	0.0472 (0.0398)	-0.0697 (0.0894)	-0.0226 (0.0782)	-13.32 (7.350)
$\sigma_{\text{S\&P500}_t}$	-3.063* (1.387)	1.730 (1.509)	0.0238 (0.0560)	-0.0153 (0.126)	0.00851 (0.110)	3.301 (4.632)
$\sigma_{\text{S\&P500}_{(t-1)}}$	2.891 (1.584)	0.176 (1.722)	-0.0241 (0.0639)	0.125 (0.144)	0.101 (0.126)	-3.164 (5.295)
_cons	-2.015 (7.608)	1.395 (8.273)	0.843** (0.307)	-2.201** (0.690)	-1.358* (0.603)	-13.83 (25.52)
$N$	94	94	94	94	94	93
$R^2$	0.109	0.099	0.157	0.074	0.103	0.190
adj. $R^2$	-0.255	-0.270	-0.188	-0.304	-0.264	-0.146
rmse	4.907	5.336	0.198	0.445	0.389	16.36

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.17: Fixed Effects Regression for the Risk of Real Estate Credit Firms

Capital is significantly negatively correlated with firm-specific risk. There may not be any other significant correlations because of the sample's size. These results are consistent with the overall behavior of pure ABC institutions (see Section 6.5.2).

The variable LEV is significantly negatively correlated with firm-specific risk. The fact that LEV is significantly positively correlated with bankruptcy is difficult to explain except by the bad quality of the Z-score measure.

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.314 (0.214)	0.0882 (0.246)	0.00537 (0.00903)	0.0299 (0.0201)	0.0353 (0.0178)	-0.856 (0.759)
$\log(\text{Capital})$	1.345 (0.943)	1.478 (1.084)	-0.103* (0.0398)	0.0883 (0.0887)	-0.0151 (0.0785)	4.682 (3.347)
LEV	-6.678 (5.261)	-2.509 (6.051)	-0.395 (0.222)	-0.216 (0.495)	-0.611 (0.438)	60.67** (19.69)
LIQ	-22.81** (7.976)	-6.844 (9.173)	0.538 (0.337)	-1.420 (0.751)	-0.882 (0.664)	-13.20 (28.38)
LEV $\times$ LIQ	24.96** (8.492)	8.981 (9.766)	-0.526 (0.359)	1.447 (0.799)	0.921 (0.707)	-0.135 (31.61)
$\sigma_{\text{S\&P500}_t}$	-3.383* (1.318)	1.615 (1.516)	0.0305 (0.0557)	-0.0338 (0.124)	-0.00327 (0.110)	3.303 (4.693)
$\sigma_{\text{S\&P500}_{(t-1)}}$	3.698* (1.524)	0.466 (1.753)	-0.0411 (0.0644)	0.172 (0.143)	0.131 (0.127)	-3.169 (5.457)
_cons	-1.714 (7.203)	1.504 (8.284)	0.837** (0.304)	-2.183** (0.678)	-1.347* (0.600)	-13.83 (25.73)
$N$	94	94	94	94	94	93
$R^2$	0.214	0.111	0.184	0.119	0.126	0.190
adj. $R^2$	-0.125	-0.272	-0.167	-0.261	-0.251	-0.164
rmse	4.646	5.343	0.196	0.437	0.387	16.49

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.18: Fixed Effects Regression for the Risk of Real Estate Credit Firms with Interaction Term

For the interest rate risk  $\beta_I$ , the interaction term is significant. After performing a Wald test we can see that the increase in  $R^2$  from 0.109 to 0.214 is also significant. Thus, this interaction term is relevant for the analysis. The introduction of this interaction term does make the LIQ variable relevant. This analysis suggests that liquidity is relevant mainly in conjunction with leverage and not on its own.

**All Other Non-Depository Credit Intermediation** This sample is just large enough to potentially find a significant relation ( $N = 93$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.00159 (0.231)	-0.238 (0.231)	-0.0128 (0.0164)	-0.00233 (0.0278)	-0.0151 (0.0320)	-1.050 (3.893)
$\log(\text{Capital})$	0.125 (0.852)	1.133 (0.853)	-0.0134 (0.0606)	-0.0214 (0.102)	-0.0348 (0.118)	-4.600 (14.70)
LEV	-8.801 (4.772)	3.764 (4.773)	0.117 (0.339)	-0.360 (0.574)	-0.243 (0.661)	54.88 (79.56)
LIQ	1.749 (1.792)	-1.536 (1.792)	-0.0324 (0.127)	0.305 (0.215)	0.272 (0.248)	21.71 (30.27)
$\sigma_{\text{S\&P500}_t}$	-1.250 (0.968)	-0.450 (0.968)	0.0746 (0.0688)	0.0234 (0.116)	0.0980 (0.134)	12.30 (16.57)
$\sigma_{\text{S\&P500}_{(t-1)}}$	1.065 (1.057)	0.358 (1.057)	0.00428 (0.0751)	0.353** (0.127)	0.357* (0.146)	-13.87 (17.62)
_cons	2.448 (5.097)	-5.836 (5.098)	0.568 (0.362)	-0.860 (0.613)	-0.293 (0.706)	41.30 (88.56)
$N$	93	93	93	93	93	90
$R^2$	0.070	0.071	0.027	0.165	0.152	0.048
adj. $R^2$	-0.172	-0.170	-0.226	-0.053	-0.069	-0.211
rmse	3.280	3.281	0.233	0.395	0.454	54.50

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.19: Fixed Effects Regression for the Risk of Other Non-Depository Credit Intermediation

There is no significant relation, possibly because the sample is not large enough.



This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	0.0137 (0.240)	-0.172 (0.238)	-0.0168 (0.0169)	-0.00246 (0.0288)	-0.0192 (0.0332)	-1.603 (4.022)
$\log(\text{Capital})$	0.164 (0.877)	1.346 (0.869)	-0.0261 (0.0619)	-0.0218 (0.106)	-0.0479 (0.121)	-7.359 (15.48)
LEV	-8.655 (4.852)	4.568 (4.809)	0.0686 (0.343)	-0.361 (0.584)	-0.293 (0.671)	46.89 (81.07)
LIQ	-1.774 (16.65)	-20.83 (16.51)	1.119 (1.176)	0.343 (2.004)	1.462 (2.303)	200.4 (303.7)
LEV $\times$ LIQ	3.891 (18.28)	21.31 (18.12)	-1.272 (1.291)	-0.0421 (2.200)	-1.314 (2.529)	-196.0 (331.4)
$\sigma_{\text{S\&P500}_t}$	-1.233 (0.978)	-0.360 (0.969)	0.0692 (0.0690)	0.0232 (0.118)	0.0925 (0.135)	11.59 (16.70)
$\sigma_{\text{S\&P500}_{(t-1)}}$	1.062 (1.064)	0.342 (1.054)	0.00521 (0.0751)	0.353** (0.128)	0.358* (0.147)	-13.65 (17.71)
_cons	2.388 (5.138)	-6.166 (5.093)	0.587 (0.363)	-0.860 (0.618)	-0.272 (0.711)	48.66 (89.84)
$N$	93	93	93	93	93	90
$R^2$	0.071	0.089	0.040	0.165	0.155	0.053
adj. $R^2$	-0.187	-0.164	-0.227	-0.067	-0.080	-0.222
rmse	3.302	3.273	0.233	0.397	0.457	54.75

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.20: Fixed Effects Regression for the Risk of Other Non-Depository Credit Intermediation with Interaction Term

The interaction term is not significant. In conclusion, this interaction is not relevant to the analysis.

**Portfolio Management** This sample is just large enough to potentially find a significant relation ( $N = 101$ ).

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.0854 (1.022)	0.630 (0.833)	-0.0153 (0.0299)	0.0870 (0.0799)	0.0717 (0.0827)	-2.099 (14.91)
$\log(\text{Capital})$	-0.613 (0.966)	0.555 (0.787)	-0.0171 (0.0282)	-0.0233 (0.0756)	-0.0404 (0.0782)	7.010 (14.08)
LEV	4.498 (6.470)	-3.912 (5.270)	0.0494 (0.189)	-0.372 (0.506)	-0.323 (0.523)	33.14 (95.27)
LIQ	-2.337*** (0.657)	0.0849 (0.535)	0.0151 (0.0192)	0.00248 (0.0514)	0.0176 (0.0531)	2.138 (9.581)
$\sigma_{S\&P500_t}$	-0.170 (1.402)	-0.0431 (1.142)	0.0231 (0.0410)	0.154 (0.110)	0.177 (0.113)	-4.511 (20.42)
$\sigma_{S\&P500_{(t-1)}}$	0.109 (1.396)	0.0370 (1.137)	0.0346 (0.0408)	-0.105 (0.109)	-0.0702 (0.113)	35.87 (20.34)
_cons	3.693 (7.489)	0.771 (6.099)	0.531* (0.219)	-2.052*** (0.586)	-1.521* (0.606)	89.11 (109.2)
$N$	101	101	101	101	101	100
$R^2$	0.153	0.014	0.036	0.045	0.047	0.055
adj. $R^2$	-0.085	-0.264	-0.236	-0.224	-0.222	-0.215
rmse	5.234	4.263	0.153	0.409	0.423	76.18

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.21: Fixed Effects Regression for the Risk of Portfolio Management Firms

Balance sheet liquidity is significantly negatively correlated with interest rate risk. This finding is consistent with the fact that private equity risk is mainly related to unexpected interest rate moves. These results are also consistent with the overall behavior of pure ABC institutions (see Section 6.5.2).

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\beta_I$	$\beta_M$	Firm	Systematic	Total	Z-Score
SHORT	-0.121 (1.094)	0.929 (0.886)	-0.00567 (0.0318)	0.0630 (0.0852)	0.0574 (0.0884)	-8.601 (15.81)
$\log(\text{Capital})$	-0.633 (0.995)	0.723 (0.805)	-0.0116 (0.0289)	-0.0368 (0.0775)	-0.0485 (0.0804)	3.347 (14.37)
LEV	4.687 (6.803)	-5.493 (5.506)	-0.00179 (0.198)	-0.245 (0.530)	-0.247 (0.549)	67.76 (99.24)
LIQ	-1.775 (5.892)	-4.614 (4.768)	-0.137 (0.171)	0.380 (0.459)	0.243 (0.476)	103.9 (84.99)
LEV $\times$ LIQ	-0.585 (6.096)	4.893 (4.934)	0.158 (0.177)	-0.393 (0.475)	-0.234 (0.492)	-106.0 (87.93)
$\sigma_{\text{S\&P500}_t}$	-0.155 (1.420)	-0.167 (1.149)	0.0191 (0.0413)	0.164 (0.111)	0.183 (0.115)	-1.805 (20.48)
$\sigma_{\text{S\&P500}_{(t-1)}}$	0.122 (1.412)	-0.0703 (1.143)	0.0311 (0.0410)	-0.0962 (0.110)	-0.0650 (0.114)	38.18 (20.37)
_cons	3.667 (7.541)	0.989 (6.104)	0.538* (0.219)	-2.070*** (0.587)	-1.532* (0.609)	84.24 (109.0)
$N$	101	101	101	101	101	100
$R^2$	0.154	0.026	0.045	0.054	0.050	0.073
adj. $R^2$	-0.099	-0.264	-0.240	-0.229	-0.234	-0.208
rmse	5.268	4.264	0.153	0.410	0.425	75.96

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.22: Fixed Effects Regression for the Risk of Portfolio Management Firms with Interaction Term

The interaction term is not significant, meaning that this interaction is not relevant to the analysis.

### 6.5.3 Conclusions about ABC Institution Risk

From the point of view of firm-specific risk, measures of risk function as one would expect. From a larger perspective, however, the picture is more complex. Since government ABC institutions not to seem to deliver the maturity transfer expected, they should be excluded from further investigation. Investment banks and pure ABC institutions seem to have very similar risk profiles, even though their liquidity access and business models are different. Even pure ABC institutions whose business models are very different have, overall, very similar risk profiles.

## 6.6 ABC Institution Market Discipline

After examining ABC institution risk, this study looks at how market discipline can punish badly managed ABC institutions. This section quickly reviews the literature on market discipline before looking at how it can be applied to ABC institutions. It finishes by formulating a testable hypothesis of market discipline.

### 6.6.1 Market Discipline

Peria & Schmukler (2001) ask the topical question “Do depositors punish banks for bad behavior?”

The common discipline mechanism, developed for banks, assumes that the market (stockholders, large credit owners, etc.) and depositors take action against banks that take on too much risk. The effect of such actions is a cost increase for risky institutions (Berger 1991); for example, when stakeholders withdraw their deposits or interest rates increase. A review of empirical work on the topic is available in Flannery (1998).

The bank literature considers the yield on deposit to be a response to bank risk, as in Cook & Spellman (1994), while other studies consider it to be the degree or change in deposits (Goldberg & Hudgins 1996, Calomiris & Wilson 2004). Park & Peristiani (1998) and Peria & Schmukler (2001) view market discipline using both approaches.

Even if ABC institutions do not have deposit, they use the wholesale market to replace liquidity. So financial institutions like banks or money market funds are providing liquidity to ABC institutions using unsecured or secured loans (repo/reverse repo). Therefore, those agents providing liquidity to ABC institutions can punish them in case of bad behavior.

Market discipline is more convincing for ABC institutions than for banks, because the institutions that provide them with liquidity have strong financial skills and a high level of information, especially compared to most depositors for banks. A feature that affects banks but not ABC institutions is the state guarantee, simplifying the analysis. However, the limited reporting obligations of ABC institutions do not allow us to obtain data on the interest rates charged. From a regulatory perspective, if one were to consider ABC institutions as banks, market discipline corresponds to Pillar 3 of Basel II (Elizalde 2007).

In summary, market discipline has been extensively studied for banks in the US and throughout the world, but not for ABC institutions. Our initial assumption is that ABC institutions behave very similarly to banks. Therefore one should observe significant market discipline punishing risky ABC institutions; which leads to the following research question:

When ABC institutions take on too much risk, does the market discipline them by limiting their liquidity access?

### **6.6.2 ABC Institution Deposit Equivalents**

Banks use deposits to access liquidity, and depositors discipline risky banks by removing their borrowings. How ABC institutions access liquidity is critical in the differentiation of ABC institutions (Section 6.2).

Like banks, ABC institution have stakeholders that provide them with liquidity through short-term loans using the repo and money markets. Money market transactions are short-term loans that are accounted for as such under current liabilities; repo market transactions, however, are accounted for within accounts payable. Since one knows where in the balance sheet of ABC institutions to obtain the information that reflects access to liquidity, one should be able to

determine that liquidity access for ABC institutions is comparable to deposits for banks<sup>10</sup>.

### 6.6.3 ABC Institution Fundamentals

To maintain consistency with current research on bank market discipline, the determinant uses of (Peria & Schumkler 2001) are kept, that is, leverage, return on assets, liquidity, and total assets. Although the interest rate levels that liquidity providers impose on ABC institutions is desirable, these data are not accessible.

#### Leverage

The amount of debt in relation to available assets is a significant and visible source of risk for any company. In the case of ABC institutions, given that their assets are mostly illiquid, leverage is a source of risk that must be accounted for.

In the case where a liquidity provider reacts to this measure of risk — the leverage — the less capital exists in relation to total assets, the riskier the institution.

#### Return on Assets

Return on assets (ROA) indicates how profitable a company is relative to its total assets. It gives an idea of how efficient management is at using the company's assets to generate earnings.

#### Liquidity

One of the main challenges in the loan business is to adequately fund low-liquidity loans. If funding liquidity dries up, the loan institution may not be able to meet their contractual financial commitments. In banking theory, an institution that does not meet its liquidity commitments will cause its customer to leave, leading to a bank run. Like banks, ABC institutions can fall victim to runs on the ABC, as happened to Bear Stearns and Lehman Brothers.

A firm's balance sheet liquidity can be measured by examining its liquid assets with respect to total assets. The issue with this metric is that it does not take into account liquidity transfer from assets to liability, and, in the case of ABC institutions, liquidity transfer is central to this

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<sup>10</sup>A study of the contribution of money market versus repo market as a contribution for ABC institution liquidity could make an interesting study.

study. A more precise metric for liquidity is the ratio of liquid assets to total liability. As an added benefit, this measure removes any volatility due to equity.

### **Interaction, Controls and Limits**

As discussed in section 6.3.2, the same level of liquidity can be assessed very differently in terms of risk, depending on the level of the leverage. This is the reason why I will not only look at liquidity risk and leverage risk in isolation but in conjunction. This will be done by the introduction of an interaction term between liquidity and leverage in the statistical analysis.

The analyses must be controlled for total assets and the growth of total assets of institutions. The first control is total asset size, since short-term loans are more readily given to large institutions than to small ones, the rationale being that large institutions have more funding choices with which to fulfill their financial commitments. Controlling for total asset growth is critical to avoid taking into account extension of the asset base as an increase in accessible liquidity.

This methodology assumes that agents outside of the institution mainly decide liquidity. The approach is similar to the methodology used by, for example, (Peria & Schmukler 2001), who examine market discipline by comparing liquidity access with other elements in the balance sheet. The issue is that the liquidity measure — short-term debt and accounts payable in the case of ABC institutions — is a section of the balance sheet and this liquidity measure is compared with parts of the balance sheet. Thus, there is an element of collinearity between the measure of bad behavior of an institution and the liquidity measure used here. This must be kept in mind in the interpretation of the empirical results.

#### **6.6.4 Testable Hypothesis**

In the following, I investigate the question “When ABC institutions take on too much risk, does the market discipline them by limiting their liquidity access?”

The test of market discipline is whether the estimates of bank fundamentals are individually or jointly correlated: If there is no market discipline, liquidity growth should be uncorrelated with ABC institutions’ characteristics.

To summarize, the relation between liquidity access growth and company attributes is as follows:

$$\Delta\text{Liquidity} = F(\text{Leverage, Return on Asset, Liquidity, Asset, } \Delta\text{Asset}, \dots) \quad (6.8)$$

## 6.7 Market Discipline Data and Variable

This section examines the data used to measure the dependent and independent variables of the testable hypothesis. It describes the database from which the data are obtained and how the dependent and independent variables are calculated.

### 6.7.1 Data

The data are from the balance sheets and market data of US corporations collected by Compustat. The balance sheet data correspond to annual data from 1990 to 2006. The stock price data are monthly for the same period, which allows the calculation of the annual standard deviations for each stock price and the Standard & Poor's (S&P) 500 index.

The North American Industry Classification System (NAICS) is used to select ABC institutions in Compustat, since most are under code 5222 (Nondepository Credit Intermediation). ABC institutions are then categorized into three types: government ABC institutions, investment banks, and pure ABC institutions. One change in category is made, however, moving Citibank from the consumer lending business to the investment bank business. Data points where capital is not available or below \$1 million are eliminated.<sup>11</sup>

### 6.7.2 The Dependent Variable: Liquidity Access

As a proxy for liquidity access, this study uses the debt portion of current liability and adds accounts payable. Debt in current liability accounts for money market transactions, and accounts payable reflect repo transactions on the balance sheet:

$$\text{Liquidity Access} = \text{Debt in Current Liability} + \text{Account Payable} \quad (6.9)$$

<sup>11</sup>The data used in this section are the same are used in section 6.3.2.



Liquidity access growth across time  $\Delta$  (Liquidity Access) is the dependent variable.

### 6.7.3 Independent Variables: Institution Fundamentals

Leverage is calculated as

$$\text{LEV} = \frac{\text{Capital}}{\text{Total Assets}} \quad (6.10)$$

where Capital is the balance sheet's total assets minus total liability.

Return on asset, ROA, is defined as

$$\text{ROA} = \frac{\text{Earnings before Interest and Tax}}{\text{Total Assets}} \quad (6.11)$$

One expects ROA to be positively correlated with liquidity access, since the higher the value of ROA, the more efficient the use of assets.

Balance sheet liquidity, LIQ, is defined as

$$\text{LIQ} = \frac{\text{Liquid Assets}}{\text{Total Liability}} \quad (6.12)$$

One expects LIQ to be positively correlated with liquidity access, since the higher the value of LIQ, the higher the amount of liquid assets on the balance sheet.

## 6.8 Market Discipline Results

The relation between institution liquidity access, ABC institution fundamentals, and control variables is estimated for panel data over the period 1990–2006, using OLS analysis and then a fixed effects regression. This section ends with a summary of ABC institution discipline findings. I will keep the same regression notation than for the 'ABC Institution Risk Results' in section 6.5.

### 6.8.1 Liquidity Growth and Balance Sheet Determinants

To examine market discipline for ABC institutions, leverage (LEV), return on assets (ROA), and balance sheet liquidity (LIQ) are used as a proxy for ABC institution risk determinants. These

elements should be significantly correlated with liquidity access, with  $\beta$  individually or jointly different from zero. In the case of no market discipline, liquidity growth should be uncorrelated with ABC institution risk characteristics.

It must be noted that this study compares only data from balance sheets, so the risk of collinearity is strong. To avoid this collinearity, similar work on bank market discipline uses the interest rate charged, but this information is not available.<sup>12</sup> Even if this practice is used by others in the literature (Peria & Schmukler 2001), this study needs to find ways of mitigating the risk of collinearity. The right choice of control can help. Large organizations obtain loans more easily than smaller ones, so it is important to control for the overall size of organizations, that is, total assets. When an institution is growing, its needs for liquidity will mechanically grow; therefore one needs to control for this by using total asset growth.

Even though the data used, given the data available, are to some extent collinear, I believe that, with the controls chosen, this study provides interesting insights into the market discipline of ABC institutions.

### 6.8.2 OLS Analysis

The relation between liquidity growth, return on assets, liquidity, and other control variables is first estimated using the following OLS regression over the period 1990–2006:

$$\begin{aligned} \Delta(\text{Liquidity Access}_{it}) = & \beta_0 + \beta_1 \text{LEV}_{i(t-1)} + \beta_2 \text{ROA}_{i(t-1)} + \beta_3 \text{LIQ}_{i(t-1)} \\ & + \beta_4 \text{Asset}_{i(t-1)} + \beta_5 \text{Asset Growth}_{i(t-1)} + u_{it} \end{aligned} \quad (6.13)$$

where  $\text{LEV}_{it}$ ,  $\text{ROA}_{it}$ ,  $\text{LIQ}_{it}$ ,  $\text{Asset}_{it}$ , and  $\text{Asset Growth}_{it}$  are the time-variant regressors,  $(\beta_i)_{i \in [0,5]}$  are the standard regression coefficients, and  $u_{it}$  is the error term.

#### All ABC Institutions

As a first step, this section includes all types of ABC institutions and runs an OLS regression.

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<sup>12</sup>I am in the process of securing Credit default swap data that would be a good reflection of the interest rate charged by the main dealers for ABC companies.

	(1)	(2)
	All ABC	All ABC
LEV	3.706 (2.849)	3.648 (3.014)
ROA	-1.228 (3.842)	-1.637 (3.972)
LIQ	0.618 (1.886)	1.204 (2.099)
Asset	-0.119 (0.119)	-0.111 (0.112)
Asset Growth	1.363 (1.534)	1.357 (1.536)
Govt		0 (.)
IB		-2.544 (1.939)
Pure ABC		-1.459 (2.288)
_cons	1.209 (1.553)	2.694 (2.223)
$N$	1149	1149
$R^2$	0.036	0.037
adj. $R^2$	0.031	0.031
rmse	15.54	15.54

Standard errors in parentheses  
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.23: OLS Regression for the Discipline of All ABC Institutions

The  $\beta$  are positive overall, even if no relation is statistically significant. Each  $\beta$  is also different from zero.

**ABC Institutions by Categories**

This section runs the OLS regression for each category of ABC institution individually, that is, government ABC institutions, investment banks, and pure ABC institutions.

	(1)	(2)	(3)
	Govt	IB	Pure ABC
LEV	136.2*** (2.729)	1.026 (0.628)	1.954 (2.830)
ROA	25.54 (14.38)	0.564* (0.265)	-0.806 (4.736)
LIQ	-3.559 (2.137)	-0.341 (0.428)	2.548 (2.269)
Asset	0.0668 (0.0873)	0.0311 (0.0223)	-0.208 (0.148)
Asset Growth	-3.509*** (0.194)	1.067*** (0.190)	1.327 (1.551)
_cons	-6.493*** (1.374)	-0.381 (0.236)	2.237 (1.681)
<i>N</i>	59	197	893
<i>R</i> <sup>2</sup>	0.992	0.476	0.032
adj. <i>R</i> <sup>2</sup>	0.991	0.462	0.027
rmse	1.389	0.651	17.24

Standard errors in parentheses  
 \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.24: OLS Regression for the Discipline of ABC Institutions by Categories

In this case we see a positive and statistically significant relation for government ABC institutions and investment banks. Government ABC institutions have a strong, positively statistically significant relation with leverage. Investment banks have a positive statistically significant relation with return on assets. These two elements are consistent with the hypothesis of market discipline.

**Pure ABC Institutions**

Here the regression is carried out only for each type of pure ABC institution individually, that is, credit card issuers, sales financing institutions, consumer lenders, real estate credit institutions, portfolio management institutions, and all other types.

	(1)	(2)	(3)	(4)	(5)	(6)
	Credit card	Sales	Consumer	Real Estate	Portfolio	All Other
LEV	-2.658 (9.229)	10.22 (9.762)	1.119 (1.722)	-31.91 (29.37)	0.0461 (3.403)	-3.083 (2.261)
ROA	-65.00** (19.91)	-3.897 (8.059)	-2.009 (2.454)	-16.81 (53.30)	-10.72 (7.496)	-9.557 (7.461)
LIQ	-16.54 (20.53)	-0.177 (1.754)	7.581 (6.662)	187.3* (89.32)	6.586 (5.171)	1.514 (1.659)
Asset	-2.192 (1.138)	0.295 (0.406)	0.0592 (0.114)	3.065 (2.643)	-0.479 (0.466)	-0.479* (0.240)
Asset Growth	20.10*** (2.655)	4.182 (3.692)	0.269 (0.433)	-0.0399 (0.647)	13.90 (7.400)	3.341* (1.489)
_cons	20.41 (13.06)	-3.985 (5.038)	-0.482 (1.245)	-19.95 (13.21)	-0.174 (5.225)	5.729 (2.914)
<i>N</i>	27	343	114	70	153	176
<i>R</i> <sup>2</sup>	0.905	0.079	0.074	0.110	0.575	0.147
adj. <i>R</i> <sup>2</sup>	0.882	0.065	0.031	0.040	0.561	0.121
rmse	5.662	8.424	2.616	42.31	16.96	4.947

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.25: OLS Regression for the Discipline of Pure ABC Institutions

In this case there is a non-zero statistically significant relation for credit card and real estate companies. The OLS analysis is interesting but considers a heterogeneous sample without enough specificity for each individual institution.

### 6.8.3 Fixed Effects Analysis

The relation between liquidity growth, return on assets, liquidity, and other control variables is first estimated using the following panel fixed effects regression over the period 1990–2006:

$$\begin{aligned} \Delta(\text{Liquidity Access}_{it}) = & \beta_0 + \beta_1 \text{LEV}_{i(t-1)} + \beta_2 \text{ROA}_{i(t-1)} + \beta_3 \text{LIQ}_{i(t-1)} \\ & + \beta_4 \text{Asset}_{i(t-1)} + \beta_5 \text{Asset Growth}_{i(t-1)} + \gamma Z_i + \alpha_i + u_{it} \end{aligned} \quad (6.14)$$

where  $\text{LEV}_{it}$ ,  $\text{ROA}_{it}$ ,  $\text{LIQ}_{it}$ ,  $\text{Asset}_{it}$ , and  $\text{Asset Growth}_{it}$  are the time-variant regressors,  $(\beta_i)_{i \in [0,5]}$  are the standard regression coefficients,  $Z_i$  is the time-invariant regressor,  $\alpha_i$  is the unobserved individual effect, and  $u_{it}$  is the error term.

**All ABC Institutions**

As a first step, a fixed effects regression is run on all the ABC institutions and for each ABC category.

	(1)	(2)	(3)	(4)
	All	Govt	IB	Pure ABC
LEV	18.55*** (4.469)	129.9*** (4.191)	3.393*** (0.571)	12.47* (5.396)
ROA	-2.982 (5.554)	5.534 (19.26)	-0.150 (0.321)	-1.222 (7.642)
LIQ	7.587 (5.794)	-8.411** (2.581)	-1.221** (0.462)	13.28 (7.346)
Asset	-0.787 (0.665)	-0.576* (0.275)	0.00979 (0.0514)	-0.603 (0.881)
Asset Growth	2.295*** (0.337)	-3.967*** (0.267)	1.045*** (0.0845)	2.330*** (0.384)
_cons	0.974 (5.631)	2.151 (3.835)	-0.411 (0.499)	0.0486 (7.052)
<i>N</i>	1149	59	197	893
<i>R</i> <sup>2</sup>	0.073	0.994	0.539	0.063
adj. <i>R</i> <sup>2</sup>	-0.042	0.993	0.469	-0.056
rmse	15.46	1.248	0.511	17.23

Standard errors in parentheses  
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.26: Fixed Effects Regression for the Discipline of All ABC Institutions

The  $\beta$  values are individually or jointly not equal to zero. Leverage (LEV) is significantly positively correlated with all types of ABC institutions, as expected. Balance sheet liquidity (LIQ) is significantly negatively correlated with government ABC institutions and investment banks. These findings are still consistent with market discipline, even if the sign of the  $\beta$  values is opposite to that expected. Liquidity regulator guaranties—for government institutions and the largest investment banks<sup>13</sup>—that provide liquidity when needed can explain why the market punishes those institutions that carry too many liquid assets on their balance sheets.

<sup>13</sup>This is the case even if those guarantees are explicitly not in the regulation, since each time Freddie Mac, Fannie Mae, and even Goldman Sachs had a problem, the government bailed them out.

As we cannot assume that liquidity provision will be constant over time, I also investigate the pattern of liquidity across time, testing for time-fixed effects.

First it is interesting to note that “Real Estate Credit” is the only category of ABC institutions that reject the null hypothesis, which means that all years’ coefficients are jointly equal to zero, therefore no time fixed-effects are needed. I have then used the ABC institutions, for each ABC category, to obtain the time-fixed effect.



	(1) All	(2) Govt	(3) IB	(4) Pure ABC
LEV	19.73*** (4.708)	123.9*** (4.602)	3.161*** (0.614)	14.12* (5.681)
ROA	-4.235 (5.707)	-25.46 (22.41)	-0.0270 (0.373)	-4.130 (7.764)
LIQ	7.560 (5.826)	-6.903** (2.434)	-1.216* (0.491)	14.96* (7.404)
Asset	-0.349 (1.009)	-1.188 (0.730)	-0.104 (0.103)	0.147 (1.256)
Asset Growth	2.329*** (0.343)	-4.217*** (0.283)	1.045*** (0.0976)	2.376*** (0.390)
1992	-0.109 (3.449)	-0.192 (1.000)	-0.390 (0.359)	-1.674 (3.903)
1993	0.673 (3.365)	0.944 (1.253)	-0.541 (0.326)	-0.875 (3.911)
1994	-0.408 (3.262)	0.240 (1.261)	-0.202 (0.291)	-2.576 (3.944)
1995	7.840* (3.145)	0.798 (1.251)	-0.292 (0.277)	8.460* (3.908)
1996	0.946 (3.048)	0.960 (1.250)	-0.242 (0.269)	-0.949 (3.941)
1997	1.071 (2.937)	0.701 (1.328)	-0.0455 (0.259)	-0.766 (3.858)
1998	1.515 (2.788)	0.840 (1.472)	-0.130 (0.244)	-0.365 (3.805)
1999	-0.380 (2.673)	1.765 (1.671)	-0.257 (0.235)	-3.018 (3.783)
2000	2.274 (2.593)	2.312 (1.841)	-0.237 (0.220)	0.335 (3.831)
2001	5.970* (2.561)	2.374 (1.938)	-0.122 (0.208)	5.402 (3.921)
2002	0.648 (2.502)	2.810 (2.080)	-0.211 (0.207)	-1.884 (3.942)
2003	1.338 (2.470)	1.872 (2.217)	-0.133 (0.211)	-0.991 (3.945)
2004	0.873 (2.395)	1.174 (2.351)	-0.213 (0.198)	-1.640 (4.015)
2005	-0.329 (2.378)	-0.434 (2.356)	0.223 (0.193)	-3.061 (4.266)
2006	0 (.)	-0.180 (2.290)	0 (.)	-2.681 (4.309)
_cons	-4.094 (9.330)	9.415 (6.657)	0.833 (1.093)	-5.196 (9.160)
N	1149	59	197	893
R <sup>2</sup>	0.093	0.997	0.569	0.090
adj. R <sup>2</sup>	-0.036	0.996	0.455	-0.046
rmse	15.41	0.977	0.518	17.14

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

Table 6.27: Time-Fixed Effects Regression for the Discipline of All ABC Institutions

I now add the interaction term  $LEV \times LIQ$  to see if it improves the results.

	(1) All	(2) Govt	(3) IB	(4) Pure ABC
LEV	20.00*** (5.618)	130.5*** (3.855)	3.295*** (0.719)	11.79 (6.833)
ROA	-2.923 (5.558)	8.130 (17.72)	-0.151 (0.322)	-1.262 (7.651)
LIQ	10.45 (8.876)	15.07 (7.721)	-1.325* (0.656)	11.78 (11.86)
Asset	-0.773 (0.666)	-0.572* (0.253)	0.00849 (0.0519)	-0.604 (0.882)
LEV $\times$ LIQ	-6.982 (16.37)	-470.9** (147.4)	0.391 (1.732)	3.304 (20.49)
Asset Growth	2.287*** (0.338)	-3.761*** (0.254)	1.048*** (0.0858)	2.334*** (0.384)
_cons	0.429 (5.776)	1.625 (3.528)	-0.379 (0.520)	0.275 (7.195)
$N$	1149	59	197	893
$R^2$	0.073	0.995	0.539	0.063
adj. $R^2$	-0.043	0.994	0.466	-0.058
rmse	15.47	1.146	0.513	17.24

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.28: Fixed Effects Regression for the Discipline of All ABC Institutions with Interaction Term

We can see that for government ABCs the interaction term is significant. The Wald test further shows that the increase in  $R^2$  from 0.994 to 0.995 is significant. First, the introduction of this interaction term changes the sign and the relevance of the LIQ variable, so it seems that the liquidity in itself is not a factor for the liquidity provider to change their behavior. Instead, it is the combined effect of leverage and liquidity that triggers market discipline.

**Pure ABC Institutions**

Here the fixed effects regression is carried out only on each type of pure ABC institution, individually, that is, credit card issuers, sales financing institutions, consumer lending institutions, real estate credit institutions, portfolio management institutions, and all other types.

	(1)	(2)	(3)	(4)	(5)	(6)
	Credit card	Sales	Consumer	Real Estate	Portfolio	All Other
LEV	0.343 (17.35)	15.07** (5.024)	3.109 (2.380)	-30.89 (49.14)	5.156 (10.09)	1.145 (4.733)
ROA	-62.14*** (15.15)	-1.411 (7.880)	-42.76*** (7.677)	-127.6 (95.13)	-6.904 (10.45)	-14.89 (9.047)
LIQ	-15.30 (25.32)	7.427 (6.093)	-4.412 (4.076)	175.6* (80.65)	9.318 (11.49)	8.273 (6.777)
Asset	-1.961 (1.695)	0.202 (0.796)	0.00952 (0.407)	-5.720 (9.504)	0.719 (1.863)	-0.186 (0.732)
Asset Growth	20.53*** (3.238)	4.688** (1.517)	2.133* (0.905)	-0.871 (1.587)	14.62*** (1.034)	3.827*** (1.046)
_cons	17.05 (16.87)	-5.321 (6.819)	3.632 (2.780)	34.09 (61.86)	-12.19 (13.96)	2.002 (5.455)
<i>N</i>	27	343	114	70	153	176
<i>R</i> <sup>2</sup>	0.896	0.086	0.290	0.125	0.611	0.146
adj. <i>R</i> <sup>2</sup>	0.849	-0.018	0.173	-0.078	0.538	0.010
rmse	6.020	8.512	2.152	43.22	16.91	4.849

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.29: Fixed Effects Regression for the Discipline of Pure ABC Institutions

In the individual examination of each pure ABC type, the sample for credit card companies is very small,  $N = 27$ , as is the sample for real estate companies,  $N = 70$ .

The  $\beta$  values are individually or jointly not equal to zero for each type of pure ABC institution. Liquidity growth is significantly correlated with credit card, sales financing, consumer loan, and real estate institutions, but no significant correlation is found with private equity (portfolio) or any of the other non-depository institutions. Liquidity growth is significantly positively correlated with leverage for sales financing institutions and with balance sheet liquidity with real

estate institutions, as expected. The reason why liquidity growth is significantly negatively correlated with return on assets for credit card companies and consumer lending institutions is not clear.

This is the same regression than previously, but with the additional interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
	Credit card	Sales	Consumer	Real Estate	Portfolio	All Other
LEV	19.20 (16.92)	9.198 (6.140)	5.590* (2.794)	-38.44 (92.58)	6.657 (15.04)	0.0384 (5.061)
ROA	-67.26*** (13.43)	-2.320 (7.877)	-46.36*** (7.913)	-126.2 (97.05)	-6.764 (10.54)	-14.83 (9.066)
LIQ	36.21 (30.08)	-5.777 (10.03)	1.518 (5.398)	163.1 (152.8)	11.76 (21.46)	3.071 (10.72)
Asset	-1.286 (1.509)	0.360 (0.800)	0.0462 (0.404)	-5.735 (9.590)	0.713 (1.871)	-0.173 (0.734)
LEV × LIQ	-158.3* (62.41)	30.48 (18.43)	-18.58 (11.22)	37.04 (383.4)	-4.653 (34.46)	10.26 (16.37)
Asset Growth	19.80*** (2.852)	4.651** (1.513)	1.917* (0.906)	-0.807 (1.732)	14.62*** (1.038)	3.817*** (1.049)
_cons	6.808 (15.33)	-5.018 (6.802)	3.111 (2.774)	35.67 (64.51)	-12.99 (15.23)	2.254 (5.481)
<i>N</i>	27	343	114	70	153	176
<i>R</i> <sup>2</sup>	0.924	0.094	0.310	0.126	0.611	0.148
adj. <i>R</i> <sup>2</sup>	0.884	-0.012	0.188	-0.097	0.535	0.006
rmse	5.277	8.488	2.133	43.61	16.98	4.859

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6.30: Fixed Effects Regression for the Discipline of Pure ABC Institutions with Interaction Term

For credit card companies, the interaction term is significant. The Wald test shows that the increase in  $R^2$  from 0.896 to 0.924 is significant. The introduction of this interaction term does not change the sign or the relevance of the ROA variable. The interaction term provides additional information that on individually, leverage or liquidity do not trigger market discipline, while the combined effect of leverage and liquidity does.

#### 6.8.4 Discipline Conclusion

Market discipline is critical in showing that ABC institutions present similar constraints as banks, since it determines whether ABC institutions have industry self-control.

This section's findings are consistent with the market discipline of ABC institutions. The claim that badly run ABC institutions are punished is more credible than in the case of banks, since ABC institution liquidity providers are elaborate institutions such as commercial or investment banks, money market funds, hedge fund, and so forth. Market discipline is determined to be quite homogeneous across ABC institutions. The main issue with the results of this study is the fact that it could not use the second measure of market discipline, that is, interest rates.

The good news, however, is that the fundamental model of ABC institutions is similar in terms of self-control to that of banks. This finding goes against claims (for example Roubini (2008)) that this part of the shadow banking system is based on unbalanced mechanism. It seems that with some additional regulation, ABC institutions could become a part of healthy lending industry.

### 6.9 Conclusion

The assumption behind this work is that ABC institutions function like banks, even if they do not have deposits. To investigate this assumption, this study adapts tools commonly used to analyze bank risk and market discipline. It finds that, putting aside government-backed institutions, ABC institutions do in many ways behave like banks in term of risk and market discipline.

Since ABC institutions are similar to banks, they probably hold some level of systemic risk. In one aspect, banks are riskier than ABC institutions, since they hold deposits that, if destroyed, can have high social costs. If an ABC institution fails, it cost its stakeholders, but the general public is not directly affected. The FDIC should therefore not be involved with ABC institutions. Aside from this albeit important aspect, ABC institutions do hold systemic risk, in the sense that they facilitate large amounts of credit flow in the economy and any disruption of this flow would hurt business. A more specific issue with ABC institutions is that their significance

for the economy is new and their contributions to the economy did not draw much attention before 2007. (Torres & Zumbun 2010) report what the US Federal Reserve Chairman, Ben S. Bernanke, said about the systemic risk of lenders outside the banking system:

The Fed chairman blamed the runs on a regulatory structure that didn't encompass lenders working outside the banking system or place enough emphasis "on the detection of systemic risks." (Torres & Zumbun 2010)

One of the issues raised in this work is the lack of data on ABC institutions and the impossibility to examining them as well as one can examine banks. I then join the International Monetary Fund (International Monetary Fund 2011) in calling for the regulatory disclosure of ABC institutions. This would be useful for analyzing all aspects of ABC institutions' systemic risks, and the results of this work could have been improved had rates charged data been accessible.

The next logical research step is to compare the sustainability of banks and ABC institutions by analyzing the status of each institution after the 2007 crisis, but this is left for future work.





## Chapter 7

# Conclusion

This thesis investigates the demand and supply sides of the recent credit expansion. The three main results are as follows: (1) Household real estate debt has quantifiable drawbacks. (2) A link exists between the prices of asset collateral of bank loans and macroeconomic credit risk. (3) There is empirical evidence that asset-based credit (ABC) institutions behave like banks in term of risk and discipline. I reflect on each of these findings in turn before discussing the overarching effects of credit expansion on financial stability.

### 7.1 Drawbacks of High Household Debt

Due to financial liberalization that translated into easier access to credit, compounded by low inflation and low borrowing rates, household borrowing has grown considerably in many countries over the past two decades (Debelle 2004). These recent high levels of household debt are generally seen as a potential macroeconomic risk, and Debelle finds that they heighten household sensitivity to shocks to interest rates and incomes.

On the other hand, the existence of debt collateralized by real estate is studied in the literature mainly for its positive aspects. For example, the relaxation of collateral constraints for households is found to bring positive macroeconomic stabilization benefits (Campbell & Hercowitz 2005). Campbell & Hercowitz show that the “relaxation of collateral constraints can explain a large fraction of the actual volatility decline in hours worked, output, household debt” and that the relaxation of collateral constraints contributes to macroeconomic stability. This is reflected

in the empirical literature, where Greenspan & Kennedy (2008) show that the existence of real estate collateral can make households more resilient to limited productivity shocks.

Governments around the world have been encouraging households to buy real estate assets leading then to take on large amounts of real estate-backed debt — like the Community Reinvestment Act in the USA. This work proposes arguments that lessen the benefits from household debt collateralized by real estate. This is achieved by specifically examining financial stability issues caused by similarly high levels of debt. This study extends von Peter's (2009) model by allowing households to commit to large amounts of asset-backed debt. In the case of a large productivity shock—the kind that wipes out the loss buffer that constitutes the corporate sector—the monetary contraction is exacerbated, and household debt above a certain level can hasten bank capital erosion.

From a regulatory perspective, this is a call to limit household debt levels related to real estate. A target level can be defined quantitatively as the level where, even in the case of a large productivity shock, household debt does not hasten bank capital erosion. An interesting area for future research, there are several methods of capping the quantity of household debt. For example, interest rate levels can be changed, even if this method is difficult to implement, since so many other factors must be included in setting interest rates. Another method would be to increase the cost of buying real estate assets through tax treatments, as in eliminating the interest tax rebate or increasing taxes on real estate purchases. Finally, one could restrict access to real estate ownership to a very specific section of the population, but this policy can only work on the repartitioning of real estate ownership and not its overall level.

From an investor's perspective, this contribution can be useful to define what role household debt has on the fragility of a financial system. For a given household's real estate debt burden, what is the impact of a productivity shock on the financial system? In this case, the UK financial system is a good potential candidate for the implementation of the numerical model developed in Chapter 3. In late 2011, the UK government was providing as much help to the financial system as they could, and it is currently a good time to apply the underlying correction predicted by this model. The investor view that the Chapter 3 model support is that a correction is about

to happened in the UK financial system. There are a number of ways to implement this view, from taking a short position in sterling, a long position in UK Eurobonds—UK bonds paying in a currency other than sterling—or a short position in a UK-based financial firm. The main issue with this implementation is, of course, timing. . .

## 7.2 Asset Price Involvement in Macroprudential Policy

Whether or not to focus on asset prices has been a long debate in the field of macroeconomic and central banking. This work focuses on assets that comprise the collateral of large quantities of loans. Collateral assets have a macroeconomic standing that other assets do not. Their specificity lies in the fact that their price moves can lead to financial instability.

I build a model that uncovers the relation between the collateral assets of bank loans and financial stability. The depreciation of collateral loan asset prices can lead to a financial crisis through the erosion of bank capital. Such crises are costly, given that they diminish social welfare. This is consistent with the empirical literature, where Adalid & Detken (2007) find that the price of asset residential property helps explain the depth of post-boom recessions. This can explain why the aftermath cost of the dot-com bubble—equity fueled—was less harmful than that of the subprime bubble—debt fueled.

From a financial stability perspective, this thesis proposes the new argument that, in the specific case where a particular asset is the collateral of a large amount of debt, it is useful to prick an asset price bubble. This work can thus extend the academic literature on defining how asset valuation distortion can hurt financial stability, as in (Adrian & Shin 2010*b*). It would be beneficial for central bankers to regularly monitor the value of assets when these are collateral for large amounts of debt. This approach can be used to monitor for potential asset price bubbles. For example, according to Zumbrun (2011), the Federal Reserve Bank of Kansas City is worried about the price levels of farmland. Is the steep increase in farmland prices linked to the supply and demand of farm products or is it the result of debt-fueled speculation? If the former, there is no financial stability issue, whereas if the latter, then the situation should be monitored as a possible financial stability risk. This can be the basis for future work.

The focus on the collateral assets of bank loans can also help in determining a warning indicator of costly asset bubbles, which would be a useful extension of the signaling approach developed by Alessi & Detken (2009). The signaling approach to detecting costly asset bubbles is used by Borio & Drehmann (2009), who admit that the statistical criteria used in their work were “fuzzy.” The specificity of the collateral assets of bank loans can thus help in choosing a rational and precise signal.

This is of obvious interest to investors, since it would be an additional indicator of whether or not an economy is on the verge of a costly financial crisis due to an asset bubble. As unethical as it can be, costly financial crises can generate extremely high profits for those who know how to speculate. Zuckerman (2009) describes how in the summer of 2007 hedge fund manager John Paulson earned more than \$15 billion for his firm on a few subprime deals.

Another contribution of this work is that it can help implement financial stability risk monitoring, since such risk can be formulated as a derivative pricing problem. I show that it is possible to reformulate the specific risk linked to bank collateral assets as a relation between the overall leverage of the banking system and an option on asset price inflation. It is then possible to complement existing capital requirement monitoring techniques by using the now mature field of derivative pricing. This proposal is in line with the work of Jarrow (2007) and Das (2007), who promote the use of modern risk management to complement existing methods of evaluating financial stability risk. The main improvements this method provides is it takes into account credit crunch feedback risk, tail risk, and allows for a forward-looking approach.

From a macroprudential perspective, the model developed in Chapter 4 is a new tool to numerically evaluate the elements of asset price risk. From an investor perspective, it is a numerical tool that can estimate the risk of a financial system failing. Such option pricing can be used to evaluate the value of a put option on the UK financial industry due to the overvaluation of UK real estate.

### **7.3 ABC Institutions: A Positive Development**

Lending institutions that do not hold deposit are ABC institutions. Instead of deposits, ABC institutions use the wholesale market for their liquidity needs, mainly through the repo market, where they pledge assets for cash loans. From an academic perspective, however, ABC institutions are not, strictly speaking, banks, even if they fulfill a similar role.

This thesis examines ABC institutions from a number of perspectives: I first investigate them descriptively, and then I examine their liquidity creation, the specific risk they hold, and how market discipline applies to them. In most ways ABC institutions behave like banks: They generate liquidity, even if it is less than that of banks; they suffer, overall, from the same types of risk as banks; but they are more sensitive to market discipline than banks.

These institutions comprise a relatively new area of academic research. Pozsar et al. (2010) conduct an survey of ABC institutions, or “nonbanks,” as the authors call them. To study liquidity creation, I use the methodology developed by Berger & Bouwman (2009). Concerning both ABC risk and market discipline, I use similar methodologies as those developed for bank risk, as in (Angbazo 1997) and (Peria & Schmukler 2001), respectively.

From a systemic perspective, ABC institutions have one systemic risk less than traditional banks, that is, deposits. The social cost of an ABC institution failing is, from the perspective of the depositor, lower. On the other hand, as far as can be determined in this work, ABC institutions are under the same kinds of risks as banks. Another positive aspect of ABC institutions is the fact that the market discipline—according to our empirical results—is active; moreover, liquidity providers for ABC institutions are sophisticated investors, making the market discipline argument more convincing for ABC institutions than for banks. This means that, from a microeconomic perspective, ABC institutions have real incentives to behave well.

Mandatory regulatory disclosure allows the right level of data to be available to monitor banks. The main issue in applying bank risk and discipline techniques to ABC institutions is that their data are far less available. A regulatory call for more transparency would allow better risk monitoring of ABC institutions. This can be implemented through mandatory disclosure regulations

similar to those applied to banks and would help detect bad behavior at the micro- and macroeconomic levels.

Another area for future research is to examine the implications of “too big to fail” ABC institutions. While there is no direct risk related with deposits, ABC institutions can independently or jointly create economical costs sufficiently large to qualify as ‘too big to fail. The first idea is that some ABC institutions, such as Lehman Brothers, were “too interconnected to fail.” The fact that Lehman Brothers was allowed to fail disrupted the credit market so badly that it probably should not have been allowed to happen. On a macro level, it is not unimaginable that under some situations the entire ABC institution system could lose its funding from the wholesale market. The specifics of such a situation would be a very exciting future work.

Finally, from an investor perspective, the dynamics developed in this work can provide an edge in evaluating the share prices of ABC institutions. From a risk perspective, this study provides a good description of the specificity of ABC institution risk, but, more interestingly, the discipline findings allow an investor to be more precise in evaluating shares. This works in two ways: Bad management is punished by the market, so an investor witnessing bad management can be confident that it will soon be reflected in the share price. On the other hand, given that market discipline is active, it should reduce noise in the share price.

## 7.4 Financial Stability: New Relevance for Macroeconomics

The credit expansion of the last two or three decades has tested the limits of the amount of credit that can be safely held, especially by households. It also led to the development of debt securitization and the emergence of new types of lenders. The private sector has demonstrated great ability to adapt to and generate profits from this credit expansion, even if it is obvious now how unsustainable these profits were. The credit landscape has changed but the regulatory environment has not kept pace, and the cost of not implementing adequate regulation can be very high.

One reason for the resistance to changes in financial regulation may be that the focus has been microprudential, while the very idea of macroprudential regulation was not generally accepted. This has changed, since there is now a consensus on the need for robust macroprudential regulation. From an academic perspective, this is an extremely promising area for research and theory development, but the most rewarding aspect is that it can be a meaningful contribution for policy and practice, to be used as a basis for future regulation in the new world environment.

From an investor's perspective, there are now very few investment opportunities that do not involve an important macroeconomic dimension. The great majority of firms depend on the financial stability of the country in which they operate—directly, to be able to function, and indirectly, since a depressed financial system translates into a poor business environment. Historically, financial stability has not been a concern for investors in the developed world, but nowadays it is a key part of any investment decision.

At the national level, financial stability used to be an issue only for developing countries, but it now impacts most of the developed world and even countries known for their stability, such as Germany. The financial press now speaks of the “German auction disaster,” as in Dobson (2011), since 35% of 10-year German bonds offered for sale failed<sup>1</sup> on November 23, 2011. Given the financial stability concerns of most euro countries, financial stability is at the heart of the euro's survival.

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<sup>1</sup>At the same time, the size of hedge on German debt exposure through the credit default swap market is around US\$19.9 billion (Alloway & Oakley 2011).

Justified concern about the financial stability of the new world order provides new relevance to macroeconomic research.



# Appendix A

## Very Small Dictionary

This section will define the unusual word or specific credit derivative vocabulary to help the non-specialist reader.

*ABC*: Asset Based Credit, financial institution generating credit from asset instead from deposit.

*ABS*: Asset Backed Security, is a simple securities debt with a asset as collateral.

*ABX*: The ABX is a credit derivative swap contract that pools lists of exposures to mortgage backed securities.

*CDO*: Collateralized Debt Obligations, allows the restructuring in tranches of any kind of initial debt. For example this can be applied to corporate or mortgage debt.

*CDS*: Credit Default Swaps, this is insurance on specific debt, in case of default this contract pays a pre-determined amount.

*corporate bonds*: a company issues debt that pays fixed or floating coupons.

*MBS*: Mortgages Backed Security, this type of Asset Backed Security (ABS) is back using household mortgages. It is common to also use the term MBS for credit card or automobile debt backed security.



## Appendix B

# Macroeconomic Impact of Household Debt

### B.1 Lemmas' Proof

This section is the proof of two technical lemmas that are needed in chapter 3.

#### B.1.1 Proof of Lemma (3.3.1): Effect of a Productivity Shock on Household Consumption

**Lemma 3.3.1** *The productivity shock has the following effects on household consumption:*

1. Household consumption  $S_t$  increases compared with time  $t - 1$ , i.e.  $S_t > S$
2. Household consumption  $S_{t+1}$  falls compared with time  $t - 1$ , i.e.  $S_{t+1} < S$

Rearranging (3.19) describes the new steady state  $p_{t+1}$ :

$$q_t = (1 - \tau) \frac{\alpha y}{H^l} \sum_{i=1}^{+\infty} \frac{p_{t+i}}{R^i} \Rightarrow q_t H^l = (1 - \tau) \frac{\alpha p_{t+1} y}{R - 1}$$

Differentiating with (3.16) yields:

$$\delta(\tau) = \tau p_{t+1} + 1 - p_{t+1} \tag{B.1}$$

as the initial price  $p = 1$ .

Thus, it is possible to rearrange (3.20) to be with (3.14) If we take the first lines of (3.20) and (B.1) and by remarking that  $RqH^I = qH^I + (R - 1)qH^I$  we can eliminate the  $p_t$ . Then to eliminate the  $K$  we can use (3.16) to get

$$S_t = S + q\delta(\tau)H^I + \lambda_b \quad (\text{B.2})$$

This treats the first part of Lemma (3.3.1). The overspending in  $t$  due to the asset price depreciation and the household asset loss has an impact at  $t + 1$ .

At time  $t + 1$ , the form of the equation is the same as at the steady state, so we see that this model can reach a new steady state at  $t + 1$ . To demonstrate this, we observe a derived equation for households and by using (3.6) it is possible to see that

$$\sum_{i=0}^{+\infty} \frac{S_{t+i}}{R^i} = RD$$

But using the fact that  $t + 1$  is a new steady state we also have

$$\sum_{i=0}^{+\infty} \frac{S_{t+i}}{R^i} = S_t + \frac{S_{t+1}}{(R-1)} = RD$$

we obtain by difference

$$S_{t+1} - S = -(R-1)(S_t - S) \quad (\text{B.3})$$

given that  $S_t > S$  this proves the second part of Lemma (3.3.1) i.e.  $S_{t+1} < S$ .

### B.1.2 Proof of Lemma (3.3.2): Effect of a Productivity Shock on Asset Price

**Lemma 3.3.2** *The productivity shock has the following effects on prices:*

1. Asset price  $p_t$  falls compared with time  $t - 1$ , i.e.  $p_t < p$
2. Asset price  $p_{t+1}$  increases compared with time  $t - 1$ , i.e.  $p_{t+1} > p$

By rewriting (3.15) as  $p = 1 = p_t$

$$p_{t+i} = \left( \frac{S_{t+i}}{S} \right)^{\frac{\gamma}{\gamma-1}} \quad \forall i \geq 0 \quad (\text{B.4})$$

This equation holds for the period  $[t - 1, t]$ . This formula works for  $i > 0$  as we have set  $p = p_{t-1} = 1$  and because the system is reaching a new steady state at  $t + 1$ .

We wish to understand the behavior of  $\delta(\tau)$  and  $p_t(\tau)$ . To do this, we examine  $p_{t+1}(\tau)$ . We can introduce (B.4) into (3.21), then use the fact that  $K = \alpha\gamma/R = S$  (we use the way the bank capital has been created). We then obtain:

$$p_{t+1} = (1 - R[1 - (1 - \tau)p_{t+1}])^{\frac{\gamma}{\gamma-1}}$$

This equation defines the solution function  $p_{t+1}(\tau)$ . It is evident that  $p_{t+1}(0) = 1$  for any  $\gamma$ , then  $\delta(0) = 0$  and  $p_t(0) = 1$  the rest of the variables remain stable. We have unity of the solution for  $\gamma < 1$ . Then it is possible to derive the  $p_{t+1}(\tau)$

$$p'_{t+1}(\tau) = \frac{p_{t+1}}{(1 - \tau) + \frac{1-\gamma}{\gamma} p_{t+1}^{-1/\gamma}} > 0$$

so we have  $p'_{t+1}(\tau) > 0 \forall \tau \in [0, 1]$ .

Then, using (B.1) it is possible to deduce that  $\delta'(\tau) > 0$ . Now, using (B.2) and given the fact that  $S_t > S$  as  $\delta'(\tau) > 0$  and  $\lambda_b \geq 0$  we have that  $p_{t+1} \geq 0$ . Then, using (B.4) it is evident that  $p'_t(\tau) < 0$ .

One of the specificities of this model is the fact that most impacts are short lived and deflation, for example, lasts only for the time  $t$ . It is clear that  $S_t > S$  then using (B.3) we get  $S_{t+1} < S$ . Finally we can use (B.4) to get  $p_t(\tau) < 1$  and  $p_{t+1}(\tau) > 1$ .



## Appendix C

# Asset Price Involvement in Macro-prudential Policy

### C.1 Appropriate Probability Density

The famous lognormal probability density is at the core of the model used in the private sector to price options. Given the time frame and the scope of the bank leverage analysis, an investigation of alternative risk metrics is necessary.

#### C.1.1 Is the Normal Distribution Adapted?

The normal distribution is used almost exclusively in the fields of econometrics and statistics. The first reason is that normal distribution is very easy to use, but another reason is the fact that the classical version of the central limit theorem (Lindeberg–Lévy) gives the false impression that any distribution can be approximated by the normal distribution. In fact, a given probability distribution approximated by the normal distribution can be very wrong in the short run if, for example, the phenomenon in question exhibits jumps.

Thurner et al. (2009) show that the very existence of leverage in an economy creates long tails and clustered volatility. Given that a large share of economic agents, mainly banks, are leveraged, it would not be wise to use a normal distribution. Aït-Sahalia & Jacod (2009) find empirical evidence of infinitely active jumps in index and stock quotations.

This is why long-tailed density distributions are investigated. For this, one needs to introduce the concept of  $\alpha$ -stable random variables and to see how the central limit theorem can be generalized.

### $\alpha$ -Stable Random Variable

To start, the concept of an  $\alpha$ -stable random variable needs to be defined.

A random variable  $X$  is called a stable random variable (or is said to have a stable distribution) if  $(X_n)_{n \in \mathbb{N}^*}$  is a family of independent variables with the same distribution as  $X$  and there exist constants  $a_n > 0$  and  $b_n$  such that

$$\sum_{i=1}^n X_i = a_n X + b_n$$

has the same distribution as  $X$ . It is then possible to prove (Feller (1971), Theorem VI.1.1) that, necessarily,

$$a_n = n^{1/\alpha}$$

for some  $\alpha \in ]0, 2]$ .

### Generalized Central Limit Theorem

The main motivation for most econometricians and financial professionals to use the normal probability density is the classical central limit theorem (Lindeberg–Lévy). The generalized central limit theorem limits the use of the normal density distribution.

The Lindeberg–Lévy central limit theorem says that that the normalized sum of independent, identical terms with a finite variance converges to a normal distribution. Take the  $(X_n)_{n \in \mathbb{N}}$  independent, identically distributed random variables with mean  $\mu$  and variance  $\sigma^2$ . The classical central limit theorem states that the sample mean  $\bar{X}_n = \frac{1}{n} \sum_{i=1}^n X_i$  has

$$\frac{\bar{X}_n - \mu}{\sigma \sqrt{n}} \longrightarrow Z \sim N(0, 1) \text{ as } n \rightarrow +\infty$$



To match the notation in what follows, rewrite this as

$$a_n \frac{1}{n} \sum_{i=1}^n X_i - b_n \longrightarrow Z \sim N(0, 1) \text{ as } n \rightarrow +\infty$$

where  $a_n = 1/(\sigma \sqrt{n})$  and  $b_n = \sqrt{n} \mu / \sigma$ .

The generalized central limit theorem allows one to drop the finite variance assumption.

**Generalized Central Limit Theorem:** A non-degenerate random variable  $Z$  is  $\alpha$  stable for some  $\alpha \in ]0, 2]$  if and only if there is an independent, identically distributed sequence of random variables  $(X_n)_{n \in \mathbb{N}}$  and constant  $a_n \in \mathbb{R}^+$  and  $b_n \in \mathbb{R}$  with

$$a_n \frac{1}{n} \sum_{i=1}^n X_i - b_n \longrightarrow Z \text{ as } n \rightarrow +\infty$$

This theorem opens up new areas of research for economists. To understand the full extent of the generalized central limit theorem, one needs to take a step back and look at Lévy processes. This allow one to examine specific applications for asset pricing and finally determine how the CGMY model is most appropriate for this study. One then sees how the CGMY model can be used to numerically calculate option prices for this research. Finally, I present the Matlab code used for this numerical implementation.

### C.1.2 Lévy Processes

Lévy processes can be understood as a generalization of the widely known Wiener process. A comprehensive overview of Lévy processes is found in Prabhu (1980), Barndorff-Nielsen, Mikosch & Resnick (2001), or Kyprianou (2006), and for more specific applications on option pricing, one can refer to Kyprianou, Schoutens & Wilmott (2005). Papapantoleon (2006) is used as a survey guide for Lévy processes.

#### Definition of a Lévy Process

Let  $(\Omega, \mathcal{F}, \mathbf{F}, P)$  be a filtered probability space, where  $F = F_T$  and the adapted filtration  $\mathbf{F} = (F_t)_{t \in [0, T]}$  for a given  $T \in [0, +\infty]$ , which is the (possibly infinite) time horizon.

A càdlàg<sup>1</sup> function adapted, real-valued stochastic process  $L = (L_t)_{0 \leq t \leq T}$  with  $L_0 = 0$  almost surely is called a Lévy process if the following conditions are satisfied:

1.  $L$  has *independent increments*, that is,  $L_t - L_s$  is independent of  $F_s$  for any  $0 \leq s < t \leq T$ .
2.  $L$  has *stationary increments*, that is, for any  $0 \leq s, t \leq T$ , the distribution of  $L_{t+s}$  does not depend on  $t$ .
3.  $L$  is *stochastically continuous*, that is, for every  $0 \leq t \leq T$  and  $\epsilon > 0$ ,  $\lim_{s \rightarrow t} P(|L_t - L_s| > \epsilon) = 0$ .

One notes that the Wiener and Poisson processes are particular cases of the Lévy process. It is also interesting that the sum of a Wiener and a Poisson process is also a Lévy process.

### Characterization of a Lévy Process: The Lévy–Khintchine Formula

The law  $P_X$  of a random variable  $X$  is infinitely divisible if and only if there exists a triplet  $(b, c, \nu)$ , with  $b \in \mathbb{R}$ ,  $c \in \mathbb{R}^+$ , and a measure satisfying  $\nu(\{0\}) = 0$  and  $\int_{\mathbb{R}} (1 \wedge |x|^2) \nu dx < +\infty$ , such that

$$E(e^{iuX}) = \exp \left[ ibu - \frac{u^2 c}{2} + \int_{\mathbb{R}} (e^{iux} - 1 - iux 1_{|x| < 1}) \nu dx \right] \quad (\text{C.1})$$

The detailed proof can be found in Theorem 8.1 of Sato (1999).

### Lévy's Properties

Let  $L$  be a Lévy process with triplet  $(b, c, \nu)$ :

1. If  $\nu(\mathbb{R}) < +\infty$ , then almost all paths of  $L$  have a finite number of jumps on every compact interval. In that case, the Lévy process has finite activity.
2. If  $\nu(\mathbb{R}) = +\infty$ , then almost all paths of  $L$  have an infinite number of jumps on every compact interval. In this case, the Lévy process has infinite activity.

Proof: See Theorem 21.3 in Sato (1999).

Whether a Lévy process has finite variations or not also depends on the Lévy measure (and on the presence or absence of a Brownian part).

Let  $L$  be a Lévy process with triplet  $(b, c, \nu)$ :

<sup>1</sup>This is the French contraction of "continue à droite, limitée à gauche."

1. If  $c = 0$  and  $\int_{|x| \leq 1} |x| \nu dx < +\infty$ , then almost all paths of  $L$  have finite variations.
2. If  $c \neq 0$  or  $\int_{|x| \leq 1} |x| \nu dx = +\infty$ , then almost all paths of  $L$  have infinite variations.

Proof: See Theorem 21.9 in Sato (1999).

The traditional properties of Wiener processes that are the Itô differential have their equivalent for Lévy processes; the Lévy–Itô decomposition is found in Chapter 4 of Kyprianou (2006). Similarly, there is an equivalent of the Wiener processes’ Girsanov theorem for Lévy processes, the details of which are found in Jacod & Shiryaev (2002).<sup>2</sup>

### C.1.3 Lévy Process Applications in Asset Price Models

This section describes an asset price model driven by a Lévy process under statistical and risk-neutral measures, market incompleteness and option pricing.

#### Statistical Measures

Under statistical or real-world measures, one can model an asset price process as the exponential of a Lévy process:

$$A_t = A_0 e^{L_t}, \forall 0 \leq t \leq T$$

where  $L$  is a Lévy process with an infinitely divisible distribution. This distribution is calibrated to the data for a particular asset. The log-returns of the model have independent and stationary increments distributed—among time intervals of a specific length, for example, 1—according to an infinitely divisible distribution.

The path property of the process  $L$  is kept in the process  $A$ ; for example, if  $L$  is a pure jump Lévy process, then  $A$  will be a pure jump Lévy process. This finding is critical, since it allows one to capture the features of the distribution.

The normal distribution—used in Black & Scholes (1972)—and the Poisson distribution—used in Merton (1975)—processes are, in fact, a particular case of the Lévy processes.

---

<sup>2</sup>The full Girsanov theorem for Lévy processes is given in Theorems III.3.24, III.5.19, and III.5.35 of Jacod & Shiryaev (2002).

### Risk-Neutral Measures

Selivanov (2005) presents an in-depth discussion on the existence and unity of martingale measures for exponential Lévy models in finite and infinite time horizons and for different specifications of the no-arbitrage condition. The existence of the martingale measure is a given for a very wide range of payoff functions; however, unity is usually not a guarantee but can be secured.<sup>3</sup>

This allows one to prove the existence of a risk-neutral measure, even if unity is not guaranteed.

### European Option Pricing

The full toolkit is accessible for European option pricing. In most cases option pricing is inaccessible in closed form, and in quite a few cases the Lévy processes are also inaccessible in closed form. The way to calculate option prices is to use Fourier or Laplace transforms. The use of these transforms is particularly appropriate, since a Lévy process is defined by its explicit characteristic function, provided by the Lévy–Khintchine formula. The transform integral can then be very easily calculated for a simple payoff. This technique is not well adapted to more complex payoffs, however.

The literature on calculating option prices using Fourier or Laplace transforms is quite vast. Carr & Madan (1999) were the first to examine systematic ways of valuing options with fast Fourier transforms (FFTs). Benhamou (2000) takes a more practitioner view on specifically valuing Lévy processes with Fourier transforms. Finally, Eberlein, Glau & Papapantoleon (2010) look at the use of Fourier transforms for a very generic set of payoffs, with an emphasis on calculating the Greeks, still using Fourier transforms.

#### C.1.4 The CGMY Model

The CGMY model, developed by Carr et al. (2002), is also called the generalized tempered stable processes (see Cont & Tankov (2003) for more details).

---

<sup>3</sup>Details on how to make the martingale measure unique are given in Corcuera, Nualart & Schoutens (2005a) and Corcuera, Nualart & Schoutens (2005b)

### Choice of the CGMY Model

Models solely based on Brownian motion such as that in Black & Scholes (1972) are limited, since they do not allow for jumps or long tails. Poisson-based jump diffusion models as in Merton (1975) add a denumerable number of jumps; these models are already more realistic, but the number and amplitude of jumps are deterministic. This model is still too limited to represent known possible market behaviors.

Two of the Lévy processes used in the financial literature with a better fit to reality are the generalized hyperbolic, developed by Eberlein & Prause (1998), and the normal inverse Gaussian distribution, developed by Barndorff-Nielsen (1997). These two density distributions cover a very large scope of market behaviors. The normal inverse Gaussian distribution is a specific case of the generalized hyperbolic distribution; it fixes the heaviness of the tail. Because tail calibration is a central feature that needs to be customized, the normal inverse Gaussian distribution is excluded.

The CGMY model is best because it is stable, since it has finite moments of all orders, and it allows one to calibrate asymmetrical distributions very simply. Finally, the CGMY model allows for easy calibration of the type variation of path to be finite or infinite.

### CGMY Model Specificity

The description of the CGMY model is taken from Carr et al. (2002). The Lévy density  $k_{CGMY}(x)$  has four parameters  $(C, G, M, Y)$  given by

$$k_{CGMY}(x) = \begin{cases} C \frac{e^{-G|x|}}{|x|^{1+Y}} & \text{for } x < 0 \\ C \frac{e^{-M|x|}}{|x|^{1+Y}} & \text{for } x > 0 \end{cases}$$

where  $C > 0$ ,  $G \leq 0$ ,  $M \leq 0$ , and  $-1 < Y < 2$ . The two parameters  $G$  and  $M$  control the heaviness of the tail on the left and right sides.

Note that

- If  $-1 < Y < 0$ , the process is completely monotone, with finite activity.

- If  $0 < Y < 1$ , the process is completely monotone, with infinite activity and finite variation.
- If  $1 < Y < 2$ , the process is completely monotone, with infinite activity and infinite variation.

One notes finite activity as a process with a finite number of jumps, and infinite activity as a process with an infinite number of jumps.

The characteristic function for the infinitely divisible process with independent increments and the CGYM Lévy density is given by

$$\phi_{CGMY}(u, t; C, G, M, Y) = e^{tC\Gamma(-Y)[(M-iu)^Y \gamma M^Y + (G+iu)^Y \gamma G^Y]}$$

### CGMY Asset Prices

The CGMY model assumes that the martingale component of the movement in the logarithm of the price is given by the CGMY process. Hence, the stock price dynamics are assumed to be

$$A(t) = A(0)e^{(\mu+\omega)t + X_{CGMY}(u, t; C, G, M, Y)}$$

where  $\mu$  is the mean rate of return of the asset and  $\omega$  is a “convexity correction” defined by

$$e^{-\omega t} = \phi_{CGMY}(u, t; C, G, M, Y)$$

Then the characteristic function is

$$\phi_{\ln(A)}(u, t) = e^{iu[\ln(A_0) + (\mu + \omega)t]} \phi_{CGMY}(u; CGMY) e^{-\frac{v^2 u^2}{2}}$$

### CGMY Variance

An important feature of CGMY processes is the fact that it is possible to calculate moments of any order. Interesting information for a given CGMY model is the variance delivered by a set of

parameters  $(\nu, C, G, M, Y)$ . Carr et al. (2002) provide the variance  $\sigma_{CGMY}^2$  formula:

$$\sigma_{CGMY}^2 = \nu^2 + C\Gamma(2-Y) \left( \frac{1}{M^{2-Y}} + \frac{1}{G^{2-Y}} \right) \quad (\text{C.2})$$

### Calibration Methodology

The following methodology has been implemented to calculate put options using CGMY density distributions, but it is generic enough to be adapted to most Lévy density distributions.

The data described in Section 4.3.2 are used. The FFT is used for the CGMY density calibration. The CGMY random variable is denoted  $X$ , and  $\phi$  is its characteristic function and  $\psi$  its density function. One then has

$$\phi(u) = E(e^{iux}) = \int_{-\infty}^{\infty} e^{iux} \psi(x) dx$$

So, if one considers the Fourier transform  $\mathcal{F}$  and the inverse Fourier transform  $\mathcal{I}\mathcal{F}$ , one obtains

$$\mathcal{I}\mathcal{F}(\psi)(u) = \int_{-\infty}^{\infty} e^{iux} \psi(x) dx = \frac{1}{2\pi} \phi(u)$$

Then

$$\psi(x) = \frac{1}{2\pi} \mathcal{F}(\phi)(x)$$

Let  $Y$  denote a discrete representation of  $\psi$ , and  $y$  a representation of  $\phi$ . The integration will be carried out in  $[-L/2, L/2]$  with  $l = N/4$ , so the step in  $y$  space is 0.25. Using the discrete Fourier transform (DFT),  $\forall k \in [0, N]$ , one obtains

$$Y_k = \frac{1}{2\pi} \sum_{n=1}^N y_n e^{-2\pi i(k-1)(n-1)/N}$$

with  $\forall n \in [0, N]$

$$y_n = \phi(x_n)$$

with  $x_n \in [-L/2, L/2] \forall n \in [0, N]$ . For an integration spacing of 0.25, the density is obtained for a return spacing of  $8\pi/N$ , where  $N$  is a power of 2 used in the FFT. The value  $N = 2^{19}$  is used for the calibration.

The Matlab code related to this implementation is given in Appendix C.2.1.

### C.1.5 Put Calculation

As for the calibration above, the following methodology is implemented to calculate put options using a CGMY density, but it is generic enough to be adapted to most Lévy densities.

#### Asset Price

The following assumes the probability measure  $Q$  is a martingale measure for the asset and option prices. At time 0, a European option is calculated for some fixed expiration date  $T$ . Denote  $A_t$  as the asset at time  $t$  and  $g(\cdot)$  as the payoff function. In addition,  $r$ , the interest rate, is considered constant. Note that  $a_T = \ln(A_T)$  and its characteristic function

$$\phi_T(z) = E \left[ e^{iz a_T} \right]$$

#### The Fourier Method

The methodology used is taken from Carr & Madan (1999). Denote as  $k$  the logarithm of the strike price  $K$  and let  $P_T(k)$  be the value of a  $T$ -maturity put option with strike  $e^k$ . The risk-neutral density of the log asset price  $a_T$  is still  $\psi_T(s)$ . The characteristic function is

$$\phi_T(z) = \int_{-\infty}^{+\infty} e^{izs} \psi_T(s) ds$$

The put value  $P_T(k)$  is then related to the risk-neutral density  $\psi_T(s)$  by

$$P_T(k) = \int_{-\infty}^k e^{-rT} (e^k - e^s) \psi_T(s) ds$$

Given that  $P_T(k)$  tends to  $A_0$  as  $k$  tends to  $+\infty$ , one cannot integrate this function. Since a square-integrable function is desired, one needs to modify it and consider the modified put price  $p_T(k)$  defined by

$$p_T(k) = e^{-\alpha k} P_T(k)$$



for a given  $\alpha < 0$ . For a range of negative values of  $\alpha$ , it is expected that  $p_T(k)$  is square integrable in  $k$  over the entire real line. One can now apply the Fourier transform of  $p_T(k)$ , defined by

$$\chi_T(v) = \int_{-\infty}^{+\infty} e^{ivk} c_T(k) dk$$

One can then apply the inverse Fourier transform on  $\chi_T(v)$ :

$$P_T(k) = \frac{e^{-\alpha k}}{2\pi} \int_{-\infty}^{+\infty} e^{-ivk} \chi_T(v) dv \quad (\text{C.3})$$

Then it is possible to transform  $\chi_T(v)$  as follows:

$$\begin{aligned} \chi_T(v) &= \int_{-\infty}^{+\infty} e^{ivk} \int_{-\infty}^{+\infty} e^{\alpha k} e^{-rT} (e^k - e^s) \psi_T(s) ds dk \\ &= e^{-rT} \int_{-\infty}^{+\infty} \psi_T(s) \int_s^{+\infty} (e^{(1+\alpha)k} - e^{s+\alpha k}) e^{ivk} dk ds \\ &= e^{-rT} \int_{-\infty}^{+\infty} e^{ivk} \left( \frac{e^{(\alpha+1+iv)s}}{\alpha+iv} - \frac{e^{(\alpha+1+iv)s}}{\alpha+1+iv} \right) ds \\ &= \frac{e^{-rT} \phi_T(v - (\alpha+1)i)}{\alpha^2 + \alpha - v^2 + i(2\alpha+1)v} \end{aligned}$$

Given this explicit value for  $\chi_T(v)$ , the evaluation of the put option (C.3) is a single integral. This integral can be approximated using an FFT.

### Approximation of the Fourier Integrals by Sum

Equation (C.3) needs to be numerically integrated, and one of the advantages of using the FFT is its numerical complexity. If one notes the level of discretization  $N$ , since the polygonal approximation of the integral increases the number of calculations in  $N^2$ , the FFT increases only as  $N \ln_2(N)$ .

The FFT is an algorithm for simultaneously calculating the discrete Fourier transforms for a range of parameter values  $x$ . It transforms the origin parameter  $u$  split in  $(u_k)_{k \in [0, N]}$  with a

spacing  $\Delta u$  in  $x$  as  $(x_k)_{k \in [0, N]}$ . The relation between the two is

$$\Delta x = \frac{2\pi}{N\Delta u}$$

with  $N$  a power of 2. Given the sequence  $(Y_n)_{n \in [0, N-1]}$  of complex numbers, the FFT computes

$$w(k) = \sum_{n=1}^N e^{-\frac{2\pi i}{N}(n-1)(k-1)} x_n \text{ for } \forall k \in [1, N]$$

The calculation of  $P_T(k)$  is

$$P_T(k) = \frac{e^{-\alpha k}}{\pi} \sum_{n=1}^N e^{-i v_n k} \chi_T(v_n) \Delta x$$

I implement the additional Simpson rule weightings, as in Carr & Madan (1999), obtaining

$$P_T(k_u) = \frac{e^{-\alpha k_u}}{\pi} \sum_{n=1}^N e^{-\frac{2\pi i}{N}(n-1)(k-1)} e^{i \Delta x} \chi_T(v_n) \frac{\Delta x}{3} [3 + (-1)^n - \delta_{n-1}]$$

### Outline of the Algorithm

This is a brief summary of the steps taken in the implementation of the put option calculation.

The steps are as follows:

- Choose the  $\alpha$ . One knows that  $\alpha < 0$  as standard and the  $1 + \alpha < 0$  so then  $\chi_T(v)$  is defined. I take  $\alpha = -10$ .
- Calculate the sequence  $(x_n)_{n \in [1, N]}$  defined by

$$x_n = e^{i \Delta x} \chi_T(v_n) \frac{\Delta x}{3} [3 + (-1)^n - \delta_{n-1}]$$

- Apply the FFT to  $(x_n)_{n \in [1, N]}$  to obtain  $w_k$  with  $k \in [-2\pi, 2\pi]$ .
- Take the real part of  $(w_k)_{k \in [-2\pi, 2\pi]}$  and apply the multiplicative factor  $\frac{e^{-\alpha k_u}}{\pi}$ .
- Interpolate the put value from the vector.

The Matlab code can be found next in Appendix C.2.

## C.2 Matlab Implementation

The following presents the exact Matlab code used in this study.

### C.2.1 Density Fitting

The following is Matlab code for the CGMY characteristic function, where a time to expiry equal to 1 is assumed:

```
function myCGMY = carCGMY(u,mu,nu,C,G,M,Y)

omega = -1.0*log(phiCGMY(-1.0*complex(0.0,1.0),1.0,C,G,M,Y));

myCGMY = exp((mu + omega -0.5*nu*nu)*complex(0.0,1.0)*u)
          * phiCGMY(u,1.0,C,G,M,Y) * exp(-nu*nu*u*u*0.5); % CGMY
```

The following is the CGMY probability density function:

```
function res = CGMYpdf(u,nu,C,G,M,Y)

P = 14;
NFFT = 2^P;
L = NFFT/4.;
RL = 8 * pi;

ugrid = linspace(-L/2., L/2., NFFT);

for j = (NFFT/2):NFFT
    z(j-(NFFT/2)+1) = carCGMY(ugrid(j),0.0,nu,C,G,M,Y);
end

for j = 1:(NFFT/2 - 1)
    z(j+(NFFT/2)+1) = carCGMY(ugrid(j),0.0,nu,C,G,M,Y);
end
```

```

results = abs(fft(z,NFFT)) / (8*pi);           % FFT

resgrid = linspace( -RL/2.0, RL/2.0, NFFT);

for j = (NFFT/2):NFFT
    orderRestutls(j-(NFFT/2)+1) = results(j);
end

for j = 1:(NFFT/2 - 1 )
    orderRestutls(j+(NFFT/2)+1) = results(j);
end

res = interp1(resgrid,orderRestutls,u);

```

### C.2.2 Put Evaluation

The following is the Matlab code for the put evaluation without feedback:

```

%% Calc Put Option with CGMY
%

function [putopt2, gbs2] = calcCGMYPut(mu, nu, C, G, M, Y, r, vol, spot, strike, expy)

P      = 16;
NFFT   = 2^P;
eta    = 0.0091;
L      = NFFT*eta;
RL     = 2.*pi/eta;
lambda = RL/NFFT;

% dumping parameter as in Carr-Madan, aa > 0 for Call, aa < 0 for Put
aa = -10.0;

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Normal Density
ugrid  = linspace(0.0,      L,      NFFT);
resgrid = linspace(-RL/2.0, RL/2.0, NFFT);

% create char fun and invert
h  = cfn(ugrid, spot, mu, nu, C, G, M, Y, expy, r, aa);
h2 = exp(i*0.5*RL*ugrid) .* h * eta;
g  = fft(h2);

g2  = real( g .* exp(-aa*resgrid) / pi);      % prices based on char fun
resBs = mybs(exp(resgrid), spot, r, vol, expy); % Black-Scholes prices

putopt2 = interp1(resgrid, g2, log(strike));
gbs2    = interp1(resgrid, resBs, log(strike));

```

The following is the Matlab code for the put evaluation with feedback:

```

%% Calc Feedback Put Option with CGMY
%
function [putopt3, gbs3] = calcCGMYFeedBackPut(mu, nu, C, G, M, Y, r, vol, spot, strike,
                                                expy, leverage)

CAR    = 0.08;

strikeLev = 1/(CAR*leverage);

if (strike > strikeLev)
    [putopt0, gbs0 ] = calcCGMYPut(mu, nu, C, G, M, Y, r, vol, spot, strike, expy);
    [putopt1, gbs1 ] = calcCGMYPut(mu, nu, C, G, M, Y, r, vol, spot, strikeLev, expy);

    putopt3 = putopt0 - putopt1 * (1-1/CAR);
    gbs3    = gbs0    - gbs1    * (1-1/CAR);
else

```

```

[putopt0, gbs0 ] = calcCGMYPut(mu, nu, C, G, M, Y, r, vol, spot, strikeLev, expy);

putopt3 = putopt0 / CAR;
gbs3    = gbs0 / CAR;
end

```

The following is the Matlab code for the miscellaneous function used by the put calculation functions:

```

%% Misc Functions

function y = mybs(x, s, r, sig, t)
% The simple Black-Scholes European put option Price
d1 = ( log(s) - log(x) + ( r + .5*sig^2 ) * t ) / sig/sqrt(t);
d2 = d1 - sig*sqrt(t);
n1 = normcdf(-d1);
n2 = normcdf(-d2);
y = x.*n2*exp(-r*t) - s*n1;

function y = cfn(th, s0, mu, nu, C, G, M, Y, t, r, aa)
% The characteristic function of the log-price
% Adjusted to incorporate the Simpson weighting scheme
th1 = th - (aa+1)*i;
f1 = exp(-r*t) * carCGMY(th1,s0,mu,nu,C,G,M,Y,t);
f2 = aa^2 + aa - (th.^2) + i*(2*aa+1)*th;
y = f1 ./ f2;
% Create Simpson's weights
N = size(th,2);
q1 = (-1).^(1:N);
q2 = eye(1,N);
S = ( 3 + q1 - q2 )/3;
y = y .* S;

```

```

function myCGMY = carCGMY(u,s0,mu,nu,C,G,M,Y,t)
% CGMY density function at a point t

omega    = -1.0*log(phiCGMY(-1.0*i,1.0,C,G,M,Y));
myCGMY3  = (log(s0) + (mu + omega -0.5*nu*nu)*t)*i*u - 0.5*nu*nu.*u.^2;
myCGMY2  = myCGMY3 + t*C*gamma(-Y) * ( (M - u*complex(0,1)).^Y
                                     + (G + u*complex(0,1)).^Y - M^Y - G^Y );
myCGMY   = exp(myCGMY2);

function myphiCGMY = phiCGMY(u,t,C,G,M,Y)
myphiCGMY = exp(t*C*gamma(-Y) * ( (M - u*complex(0,1)).^Y
                                   + (G + u*complex(0,1)).^Y - M^Y - G^Y ) ); % CGMY

```





## Appendix D

# Asset Based Credit Institutions Risk & Discipline

### D.1 STATA Code

This is the STATA code used to make to run the regression of chapter 6.

#### D.1.1 Risk STATA Code

```
* set memory 10g

clear

insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/IRmth.csv

generate fyear = real(substr(date,6,4))
generate smonth = substr(date,3,3)
generate fmonth = 0
replace fmonth = 1 if smonth == "JAN"
replace fmonth = 2 if smonth == "FEB"
replace fmonth = 3 if smonth == "MAR"
replace fmonth = 4 if smonth == "APR"
replace fmonth = 5 if smonth == "MAY"
```

```

replace fmonth = 6 if smonth == "JUN"
replace fmonth = 7 if smonth == "JUL"
replace fmonth = 8 if smonth == "AUG"
replace fmonth = 9 if smonth == "SEP"
replace fmonth = 10 if smonth == "OCT"
replace fmonth = 11 if smonth == "NOV"
replace fmonth = 12 if smonth == "DEC"

rename tcmnom_y1 oneyearTbond
rename tcmnom_y5 fiveyearTbond
rename tcmnom_y10 tenyearTbond

generate fyarmth = fyear * 100 + fmonth

drop date swaps_y10 swaps_y1 swaps_y30 swaps_y5 tcmnom_m1 tcmnom_y20 tcmnom_y30 smonth fyear
save /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/IRmth.dta

clear

insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/sandpmth.csv

generate fyear = real(substr(string(caldt,"%8.0f"),1,4))
generate fmonth = real(substr(string(caldt,"%8.0f"),5,2))
generate fyarmth = fyear * 100 + fmonth
drop caldt fyear fmonth

merge 1:1 fyarmth using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/IRmth.dta
drop if tenyearTbond == .

outsheet fyarmth spindx sprtrn oneyearTbond fiveyearTbond tenyearTbond using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/IRmth.dta

clear

insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/Indexes.csv

```

```
save /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/Indexes.dta
```

```
*****
```

```
* Load Prices
```

```
clear
```

```
insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/ABCPricemth.csv
```

```
generate fyear = real(substr(string(date,"%8.0f"),1,4))
```

```
generate fmonth = real(substr(string(date,"%8.0f"),5,2))
```

```
generate fyearmth = fyear * 100 + fmonth
```

```
drop if prc == .
```

```
drop if fyear >= 2009
```

```
merge m:1 fyearmth using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/Indexes.dta
```

```
generate mydate = monthly(string(fyear) + "m" + string(fmonth),"ym")
```

```
format mydate %tm
```

```
drop if mydate == .
```

```
* add time for rolling regression
```

```
tsset permno mydate, m
```

```
* returns
```

```
* sprtrn is the S&P 500 return from CRSP or calc one 'sp500r'
```

```
*generate sp500r = (spindx - l.spindx) / l.spindx
```

```
generate cpre = (prc - l.prc) / l.prc
```

```
generate oneyre = (oneyearthbond - l.oneyearthbond) / l.oneyearthbond
```

```
generate fivyre = (fiveyearbond - l.fiveyearbond) / l.fiveyearbond
```

```
generate tenyre = (tenyearbond - l.tenyearbond) / l.tenyearbond
```

```
generate ofyre = (oneyearthbond + fiveyearbond - l.fiveyearbond - l.oneyearthbond) / (l.fiv
```

```
generate otyre = (oneyearthbond + tenyearbond - l.tenyearbond - l.oneyearthbond) / (l.tenye
```

```
generate ftyre = (fiveyearbond + tenyearbond - 1.fiveyearbond - 1.tenyearbond) / (1.fivey
```

```
drop if cpre == .
```

```
drop if tenyre == .
```

```
* Gap in the dates
```

```
drop if permno == 10303
```

```
drop if permno == 10840
```

```
drop if permno == 10872
```

```
drop if permno == 46181
```

```
drop if permno == 63618
```

```
drop if permno == 63992
```

```
drop if permno == 76413
```

```
drop if permno == 77660
```

```
drop if permno == 82491
```

```
drop if permno == 84164
```

```
drop if permno == 87077
```

```
* Not enough dates
```

```
drop if permno == 92694
```

```
drop if permno == 90848
```

```
drop if permno == 87203
```

```
drop if permno == 86912
```

```
drop if permno == 31481
```

```
*****
```

```
* S&P 500 return taken from the exchange
```

```
rollreg cpre tenyre sprtrn mydate, move(12) stub(betas)
```

```
* S&P 500 claculated from the level
```

```
*rollreg cpre oneyre sp500r mydate, move(12) stub(betas)
```

```
drop if betas_fivyre == .
```

```
drop if fmonth != 12
```

```
rename ticker tic
```

```
outsheet fyear cusip commam tic permno exchcd cpre betas_fivyre betas_se_fivyre betas_tenyre
```

```
clear
```

```
insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasTenOut.csv
```

```
save /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasTenOut.dta
```

```
clear
```

```
insheet using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/nonDepoOut.csv
```

```
replace cusip = substr(cusip,1,strlen(cusip)-1)
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasOne
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasFiv
```

```
merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasTenC
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasOaF
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasOaT
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasFaT
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasOmF
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasOmT
```

```
*merge n:1 cusip fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/Beta/BetasFmT
```

```
generate systematic = lnreqvol - betas_rmse
```

\* Dummies for each year

```
generate dummyyear90 = 0
replace dummyyear90 = 1 if fyear == 1990
generate dummyyear91 = 0
replace dummyyear91 = 1 if fyear == 1991
generate dummyyear92 = 0
replace dummyyear92 = 1 if fyear == 1992
generate dummyyear93 = 0
replace dummyyear93 = 1 if fyear == 1993
generate dummyyear94 = 0
replace dummyyear94 = 1 if fyear == 1994
generate dummyyear95 = 0
replace dummyyear95 = 1 if fyear == 1995
generate dummyyear96 = 0
replace dummyyear96 = 1 if fyear == 1996
generate dummyyear97 = 0
replace dummyyear97 = 1 if fyear == 1997
generate dummyyear98 = 0
replace dummyyear98 = 1 if fyear == 1998
generate dummyyear99 = 0
replace dummyyear99 = 1 if fyear == 1999
generate dummyyear00 = 0
replace dummyyear00 = 1 if fyear == 2000
generate dummyyear01 = 0
replace dummyyear01 = 1 if fyear == 2001
generate dummyyear02 = 0
replace dummyyear02 = 1 if fyear == 2002
generate dummyyear03 = 0
replace dummyyear03 = 1 if fyear == 2003
generate dummyyear04 = 0
replace dummyyear04 = 1 if fyear == 2004
```

```

generate dummyyear05 = 0
replace dummyyear05 = 1 if fyear == 2005
generate dummyyear06 = 0
replace dummyyear06 = 1 if fyear == 2006

* Interaction Vars
generate shortLnkapital = short * lnkapital
generate shortKonasset = short * konasset
generate shortLiq = short * liq
generate lnkapitalKonasset = lnkapital * konasset
generate lnkapitalLiq = lnkapital * liq
generate konassetLiq = konasset * liq

* add time for fixed effect
xtset gvkey fyear
sort gvkey fyear

*****
* Fixed Effect

* For full sample
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol, fe
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol, fe
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol, fe
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol , fe
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol, fe

```

```

eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol , fe
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol3.tex, r2 ar2 se
eststo clear

* time-fixed effects
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*,
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*,
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
* We failed to reject the null that all years coefficients are jointly equal to zero therefore
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*, f
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*, f
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*, fe
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*, fe
*testparm 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol dummyyear*
* We failed to reject the null that all years coefficients are jointly equal to zero therefore
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolTimeFixedEffects
eststo clear

```



```
* For full sample with interaction terms
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model1

xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model2

xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model3

xtreg systematic l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model4

xtreg lnreqvol l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model5

xtreg zrisk l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500
eststo model6

esttab, r2 ar2 se scalar(rmse)

esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT1.tex, r2 ar2 se
eststo clear

* For Gov run ABC
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1
eststo model1

xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1
eststo model2

xtreg betas_rmse l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1
eststo model3

xtreg systematic l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1
eststo model4

xtreg lnreqvol l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1
eststo model5

xtreg zrisk l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat1 == 1,
eststo model6
```

```
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol4.tex, r2 ar2 se
eststo clear

* For Gov run ABC with interaction
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT2.tex, r2 ar2 se
eststo clear

* For IB
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat2 = 1
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat2 = 1
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat2 = 1
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat2 = 1
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat2 = 1
```

```
eststo model5
xtreg zrisk          1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol5.tex, r2 ar2
eststo clear

* For IB with interaction
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model2
xtreg betas_rmse   1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model3
xtreg systematic  1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model4
xtreg lnreqvol    1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model5
xtreg zrisk       1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT3.tex, r2 ar2
eststo clear

* For pure ABC
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dumcat3
```

```

eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat3 ==
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat3 == 1
eststo model5
xtreg zrisk l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dumcat3 == 1, f
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol6.tex, r2 ar2 se
eststo clear

* For pure ABC with interaction
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model5
xtreg zrisk l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rv
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT4.tex, r2 ar2 se
eststo clear

*****

* Credit card issuer

```

```
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummyc
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummyc
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummyca
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummycat
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummycat1
eststo model5
xtreg zrisk l.short l.lnkapital l.konasset l.liq l.nsp500rvol l.lnsp500rvol if dummycat1 ==
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol17.tex, r2 ar2
eststo clear

* Credit card issuer with interaction
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model5
xtreg zrisk l.short l.lnkapital l.konasset l.liq l.konassetLiq l.nsp500rvol l.lnsp500
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT5.tex, r2 ar
```

```
eststo clear
```

```
* Sales Fiancing
```

```
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model1
```

```
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model2
```

```
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model3
```

```
xtreg systematic l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model4
```

```
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model5
```

```
xtreg zrisk l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model6
```

```
esttab, r2 ar2 se scalar(rmse)
```

```
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol8.tex, r2 ar2 se scalar(rmse)
```

```
eststo clear
```

```
* Sales Fiancing with interaction
```

```
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model1
```

```
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model2
```

```
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model3
```

```
xtreg systematic l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model4
```

```
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model5
```

```
xtreg zrisk l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat2 == 1,
```

```
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT6.tex, r2 ar2
eststo clear

* Consumer Lending
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model4
xtreg lnreqvol l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model5
xtreg zrisk l.short l.lnkapital l.konasset l.liq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol9.tex, r2 ar2
eststo clear

* Consumer Lending with interaction
xtreg betas_tenyre l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model1
xtreg betas_sprtrn l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model2
xtreg betas_rmse l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model3
xtreg systematic l.short l.lnkapital l.konasset l.liq l.konassetLiq lnsp500rvol l.lnsp500rvol if dummycat3 == 0
eststo model4
```

```
xtreg lnreqvol      1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model5
xtreg zrisk        1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT7.tex, r2 ar2 se scalar(rmse)
eststo clear

* Real Estate Credit
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1
eststo model2
xtreg betas_rmse   1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1
eststo model3
xtreg systematic  1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1
eststo model4
xtreg lnreqvol    1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1
eststo model5
xtreg zrisk       1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat4 == 1,
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol10.tex, r2 ar2 se scalar(rmse)
eststo clear

* Real Estate Credit with interaction
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model2
xtreg betas_rmse   1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
```



```
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT8.tex, r2 ar2
eststo clear

* All Other nondepository credit intermediation
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummyc
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummyc
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat6
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat6 ==
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol11.tex, r2 ar2
eststo clear

* All Other nondepository credit intermediation with interaction
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model1
```

```
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500rvol
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT9.tex, r2 ar2 se scalar(rmse)
eststo clear

* Portfolio Management
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq lnsp500rvol 1.lnsp500rvol if dummycat5 == 1,
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol12.tex, r2 ar2 se scalar(rmse)
eststo clear
```

```
* Portfolio Management with interaction
xtreg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model1
xtreg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model2
xtreg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model3
xtreg systematic 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model4
xtreg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model5
xtreg zrisk 1.short 1.lnkapital 1.konasset 1.liq 1.konassetLiq lnsp500rvol 1.lnsp500
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVolIT10.tex, r2 a
eststo clear
```

```
*****
```

```
* OLS
```

```
reg betas_tenyre 1.short 1.lnkapital 1.konasset 1.liq dumcat1 dumcat2 dumcat3 lnsp500rvol 1.lnsp500
eststo model1
reg betas_sprtrn 1.short 1.lnkapital 1.konasset 1.liq dumcat1 dumcat2 dumcat3 lnsp500rvol 1.lnsp500
eststo model2
reg betas_rmse 1.short 1.lnkapital 1.konasset 1.liq dumcat1 dumcat2 dumcat3 lnsp500rvol 1.lnsp500
eststo model3
reg systematic 1.short 1.lnkapital 1.konasset 1.liq dumcat1 dumcat2 dumcat3 lnsp500rvol 1.lnsp500
eststo model4
reg lnreqvol 1.short 1.lnkapital 1.konasset 1.liq dumcat1 dumcat2 dumcat3 lnsp500rvol 1.lnsp500
```

```

eststo model5
reg zrisk l.short l.lnkapital l.konasset l.liq dumcat1 dumcat2 dumcat3 lns500rvol l.lns500r
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol1.tex, r2 ar2 se
eststo clear

reg betas_tenyre l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4
eststo model1
reg betas_sprtrn l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4
eststo model2
reg betas_rmse l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4 d
eststo model3
reg systematic l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4 d
eststo model4
reg lnreqvol l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4 dum
eststo model5
reg zrisk l.short l.lnkapital l.konasset l.liq dummycat1 dummycat2 dummycat3 dummycat4 dummyc
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCPriceVol2.tex, r2 ar2 se
eststo clear

* Credit card issuer                dummycat1
* Sales Fiancing                    dummycat2
* Consumer Lending                  dummycat3
* Real Estate Credit                 dummycat4
* All Other nondepository credit intermediation dummycat6
* Portfolio Management               dummycat5

```

### D.1.2 Market Discipline STATA Code

```
* set memory 1g
```

```
clear
```

```
insheet using /Users/pierre-olivierfortin/Documents/PhD_Data/compustat_data/Compustat/nonDe
```

```
duplicates drop
```

```
* set min and max date
```

```
drop if fyear <= 1989
```

```
drop if fyear >= 2007
```

```
drop if indfmt == "FS"
```

```
* merge with price vol
```

```
merge 1:1 gvkey fyear using /Users/pierre-olivierfortin/Dropbox/PhD/data/ABC/ABCPriceVol.dt
```

```
* remove naics that are not useful
```

```
* International trade Financing
```

```
drop if naics == 522293
```

```
* Miscellaneous Intermediation
```

```
drop if naics == 523910
```

```
* Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing
```

```
drop if naics == 532120
```

```
* Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing
```

```
drop if naics == 532411
```

```
* Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing
```

```
drop if naics == 532412
```

```
* Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
```

```
drop if naics == 533110
```

```
* Automotive Equipment Rental and Leasing
```

```
drop if naics == 5321
```

```
* Remove total asset that are too small
```

```
drop if at == .
```

```
drop if at < 1
```

```
* add time for fixed effect
```

```
xtset gvkey fyear
```

```
sort gvkey fyear
```

```
* deposit equivalent is Account Payable (ap) and debt in current Liability
```

```
*generate depoEq = dlc
```

```
generate depoEq = dlc + ap
```

```
generate lndepoEq = log(depoEq)
```

```
generate depoEqgrowth = ((depoEq - 1.depoEq)/1.depoEq)
```

```
generate assetGrowth = ((at - 1.at)/1.at)
```

```
generate roa = ebit/at
```

```
* Liquid Asset
```

```
generate liqAsset = che / at
```

```
generate LIQ = che / lt
```

```
generate kapital = at - lt
```

```
* avoid negative and small capital
```

```
drop if kapital <= 1.0
```

```
generate konasset = kapital / at
```

```
generate short = (che + rect - dlc - lco - ap) / ceq
```

```
* Risk Proxy 3: share volatility
```

```
* eqvol : coming for the equity file

* LOGs
generate lnkapital = ln(kapital)
generate lneqvol = ln(eqvol)
generate lnat = ln(at)
generate lnsp500vol = log(sp500vol)

* Cat Dummys

* dum Cat 1 is gov invoved
generate dumcat1 = 0
* Fannie Mae
replace dumcat1 = 1 if gvkey == 4601
* Federal Home Loan Mortgage Corp (Freddie Mac)
replace dumcat1 = 1 if gvkey == 15208
* Federal Agriculture Mortgage Company
replace dumcat1 = 1 if gvkey == 15153
* Student Loan Corp
replace dumcat1 = 1 if gvkey == 26022

* dum Cat 2 is IB
generate dumcat2 = 0
replace dumcat2 = 1 if naics == 523110 & dumcat1 == 0
* Citigroup
replace dumcat2 = 1 if gvkey == 3243 & dumcat1 == 0

* dum Cat 4 is Pure ABC
generate dumcat3 = 0
replace dumcat3 = 1 if dumcat1 == 0 & dumcat2 == 0
```

```
* Pure ABC Dummies
* Credit card issuer
generate dummycat1 = 0
replace dummycat1 = 1 if naics == 522210 & dumcat3 == 1

* Sales Fiancing
generate dummycat2 = 0
replace dummycat2 = 1 if naics == 522220 & dumcat3 == 1

* Comsuner Lending
generate dummycat3 = 0
replace dummycat3 = 1 if naics == 522291 & dumcat3 == 1

* Real Estate Credit
generate dummycat4 = 0
replace dummycat4 = 1 if naics == 522292 & dumcat3 == 1

* Portfolio Management
generate dummycat5 = 0
replace dummycat5 = 1 if naics == 523920 & dumcat3 == 1

* All Other nondepository credit intermediation
generate dummycat6 = 0
replace dummycat6 = 1 if naics == 522298 & dumcat3 == 1

* Dummies for each year
generate dummyyear90 = 0
replace dummyyear90 = 1 if fyear == 1990
generate dummyyear91 = 0
replace dummyyear91 = 1 if fyear == 1991
generate dummyyear92 = 0
replace dummyyear92 = 1 if fyear == 1992
generate dummyyear93 = 0
replace dummyyear93 = 1 if fyear == 1993
generate dummyyear94 = 0
replace dummyyear94 = 1 if fyear == 1994
```



```
generate dummyyear95 = 0
replace dummyyear95 = 1 if fyear == 1995
generate dummyyear96 = 0
replace dummyyear96 = 1 if fyear == 1996
generate dummyyear97 = 0
replace dummyyear97 = 1 if fyear == 1997
generate dummyyear98 = 0
replace dummyyear98 = 1 if fyear == 1998
generate dummyyear99 = 0
replace dummyyear99 = 1 if fyear == 1999
generate dummyyear00 = 0
replace dummyyear00 = 1 if fyear == 2000
generate dummyyear01 = 0
replace dummyyear01 = 1 if fyear == 2001
generate dummyyear02 = 0
replace dummyyear02 = 1 if fyear == 2002
generate dummyyear03 = 0
replace dummyyear03 = 1 if fyear == 2003
generate dummyyear04 = 0
replace dummyyear04 = 1 if fyear == 2004
generate dummyyear05 = 0
replace dummyyear05 = 1 if fyear == 2005
generate dummyyear06 = 0
replace dummyyear06 = 1 if fyear == 2006

* Interaction Var
generate konassetRoa = konasset * roa
generate konassetLiqAsset = konasset * liqAsset
generate konassetLnat = konasset * lnat
generate roaliqAsset = roa * liqAsset
generate roaLnat = roa * lnat
```

```

generate liqAssetLnat = liqAsset * lnat

sort gvkey fyear

*****

* OLS: vol of equity

* total
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth, r
eststo model1
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dumcat1 dumcat2 dumcat3, r
eststo model2
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDiscipline1.tex, r2 ar2 se
eststo clear

* All by cat
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat1 == 1, r
eststo model1
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat2 == 1, r
eststo model2
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat3 == 1, r
eststo model3
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDiscipline2.tex, r2 ar2 se
eststo clear

* Credit card issuer
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat1 == 1 & dumcat3 == 1, r
eststo model1

* Sales Fiancing

```

```

reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat2 == 1 & dumcat3
eststo model2
* Consumer Lending
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat3 == 1 & dumcat3
eststo model3
* Real Estate Credit
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat4 == 1 & dumcat3
eststo model4
* Portfolio Management
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat5 == 1 & dumcat3
eststo model5
* All Other nondepository credit intermediation
reg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat6 == 1 & dumcat3
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDiscipline3.tex, r2 ar2 se
eststo clear

*****

* time-fixed effects

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*, fe
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat1 ==
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat2 ==
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat3 ==

```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* Credit card issuer
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat1 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* Sales Fiancing
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat2 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* Consumer Lending
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat3 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* Real Estate Credit
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat4 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* No time fixed effect
```

```
* Portfolio Management
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat5 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* All Other nondepository credit intermediation
```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dummycat6 ==
```

```
testparm l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*
```

```
* All
```

```
xi: xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear*, fe
```

```
eststo model1
```

```
* Gov
```

```
xi: xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat1 ==
```

```
eststo model2
```

```

* IB
xi: xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat2
eststo model3

* Pure ABC
xi: xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth dummyyear* if dumcat3
eststo model4

esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDisciplineTFE.tex, r2
eststo clear

*****

* Fixed Effect

* All
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth, fe
eststo model1

* Gov
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat1 == 1, fe
eststo model2

* IB
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat2 == 1, fe
eststo model3

* Pure ABC
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dumcat3 == 1, fe
eststo model4

esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDiscipline4.tex, r2 ar
eststo clear

* Credit card issuer

```

```

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat1 == 1 & dumcat3
eststo model1
* Sales Fiancing
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat2 == 1 & dumcat3
eststo model2
* Consumer Lending
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat3 == 1 & dumcat3
eststo model3
* Real Estate Credit
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat4 == 1 & dumcat3
eststo model4
* Portfolio Management
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat5 == 1 & dumcat3
eststo model5
* All Other nondepository credit intermediation
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat assetGrowth if dummycat6 == 1 & dumcat3
eststo model6
esttab, r2 ar2 se scalar(rmse)
esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDiscipline5.tex, r2 ar2
eststo clear

*****

* Interaction

* All
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth, fe
eststo model1
* Gov
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dumca
eststo model2
* IB

```

```
xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model3

* Pure ABC

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model4

esttab, r2 ar2 se scalar(rmse)

esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDisciplineInterAll.tex
eststo clear

ivprobit depoEqgrowth l.roa l.lnat assetGrowth (l.konassetLiqAsset = l.liqAsset l.konasset)

* Credit card issuer

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model1

* Sales Fiancing

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model2

* Consumer Lending

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model3

* Real Estate Credit

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model4

* Portfolio Management

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model5

* All Other nondepository credit intermediation

xtreg depoEqgrowth l.konasset l.roa l.liqAsset l.lnat l.konassetLiqAsset assetGrowth if dum
eststo model6

esttab, r2 ar2 se scalar(rmse)

esttab using /Users/pierre-olivierfortin/Dropbox/PhD/Thesis/stata/ABCDisciplineInterPure.tex
```

eststo clear



# Appendix E

## Notes

### E.1 Paul Pierre Lévy



Figure E.1: Paul Lévy (1926)

Processes with independent and stationary increments are named ‘Lévy processes’ after the French mathematician Paul Pierre Lévy (1886-1971). He made the connection with infinitely divisible laws, characterized by their distributions (Lévy-Khintchine), and described their path structure (Lévy-Itô decomposition). He was one of the founding fathers of the theory of stochas-

tic processes and made a major contribution to the field of probability theory in general. He contributed to the study of Gaussian processes, the law of large numbers, the central limit theorem, stable laws and infinity divisible laws.

Lévy's background makes him an interesting subject of study. Some information about Paul Lévy can be found in his autobiography, written in French, (Lévy 1970) and in Ullmo (1972) or in English in Loève (1973).

Paul Lévy was an established professor, first at the prestigious *École des Mines* and later at the *École Polytechnique*. He received numerous honors as he was *Commandeur de la Légion d'Honneur* and a member of the French Science Academy.

In addition, Lévy he was the incarnation of the individualistic researcher. He preferred to research alone, concentrating on problems that interested him, and worked on them without external assistance. He read very little research literature and almost never went to international conferences. He also was published very little. His research methods concentrated mainly on re-discovering known results, and often discovering important results without giving them the exposure they deserved.

His methods yielded highly original work compared with other research. His theorizing was a precursor of Functional Analysis and he developed several fundamental concepts of Probability Theory.

Lévy taught Analysis at l'École Polytechnique for 39 years where he set deep print in few generations of French mathematicians. Laurent Schwartz who followed Lévy at l'École Polytechnique, who discovered the now common concept of distribution, was also his student and son in law<sup>1</sup>.

Because of his working methods and informal style of research<sup>2</sup>, he was almost unknown during his lifetime; and it is only because of the success of one of his disciples Michel Loève in Berkeley

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<sup>1</sup>Laurent Schwartz wrote a very interesting and personal necrology see Schwartz (1973).

<sup>2</sup>France is the birth country of Nicolas Bourbaki; an imaginary mathematician that invented nothing aside from formalizing and rewording the works of others.

that Lévy attained recognition in the world and then in France.

Benoît Mandelbrot (Mandelbrot 1973) was also a student and self-proclaimed disciple of Paul Lévy.

## **E.2 Historical Note on the Font Used**

This thesis uses the font named ‘Garamond’. Garamond is the name given to a group of serif typefaces named after the punch-cutter Claude Garamond (c. 1480-1561). A biography of Claude Garamond was compiled by O’Day (1940).

This font rose to prominence in the 1540s, initially as a Greek typeface. The creation was commissioned by the French king, François I. The French court later adopted Garamond’s Roman typeface for printing which influenced font uses across France and Western Europe. For more details on use of this font in the history of book publishing see Amert (2005).



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