Essays on Banking and the Macroeconomic Effects of Financial Intermediation

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Dedication

To my wife Ana, my son Adrian, and my parents Irma and Jose, who made this possible.

Abstract

This dissertation consists of three chapters which are focused on banking topics. In the first one, I provide a review of the banking literature. I discuss several of the main contributions to the understanding of financial intermediation and banking, from both theoretical and empirical perspectives. From this literature review, I conclude that most papers have not taken into consideration the role of banking heterogeneity to explain how banks make their capital decisions and how banks reacted to the financial crisis of 2007-08. This is the foundation for the next two chapters, where I link too-big-to-fail policies to the issue of banking heterogeneity.

Chapter 2 is focused on answering the question of why did so many relatively big banks in the United States fail during the 2007-2008 financial crisis. I use a competitive industry equilibrium model that links Too-Big-To-Fail (TBTF) policies to the low risk-weighted capital ratios of big banks in order to offer an explanation. A big bank can benefit from a bailout during bad times, so it maintains small capital buffers. However, if there is a systemic crisis that worsens the bad state of the economy, the government will not be able to help the big bank and the big bank will not have enough equity to absorb the losses on its own. Calibration of the model shows that approximately one in ten recessions will become a systemic crisis. This low probability helps explain why big banks do not increase their equity levels themselves.

Finally, Chapter 3 expands several of those ideas to a macroeconomic context. I study how bank capital affected bank lending during the past financial crisis in the United States. I argue in this paper that small banks amplified the recession through a bank capital channel and that TBTF policies helped the economy avoid a deeper recession by reducing the negative effects of this channel in the case of big banks. In my model, when the banking sector is hit with a negative systemic shock, small banks contract their lending during the recession. However, big banks' equity is protected by TBTF policies, so they do not have to contract their lending as much. This helps explain the banks' heterogeneous responses to the recent financial crisis. I find that there are small benefits to the overall economy from the use of TBTF policies, but there

are important wealth redistribution consequences. In particular, households are worse off because they have to bear the costs of the TBTF policies.

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Chapter 1

Financial Intermediation and Banking: A Literature Review

1.1 Financial Intermediation

There have been several seminal contributions to the understanding of financial intermediaries and their effect on the economy, such as Diamond and Dybvig (1983), Bernanke and Gertler (1995), Bernanke et al. (1999), Kiyotaki and Moore (1997), Hölmstrom and Tirole (1997), Carlstrom and Fuerst (1997) and Bernanke and Gertler (1989).

Early on in the literature, Bernanke and Gertler (1995) highlighted the fact that monetary policy works through credit markets to affect GDP and prices. This complemented the traditional view of monetary policy shocks affecting short-term interest rates, which influenced the cost of capital and ultimately, spending on durable goods (such as housing or firm equipment). This cost-of-capital effect was not enough to explain changes in aggregate spending, the effect of monetary policy on long term assets or the timing of the impacts. The key insight is that monetary policy's effects on interest rates are amplified by endogenous changes in the difference between the cost of funds raised externally and those created internally, called the external finance premium. This reflected the existence of frictions in credit markets.

Bernanke and Gertler (1989), Kiyotaki and Moore (1997) and Bernanke et al. (1999) use an agency problem between the borrowers and lenders to endogenize financial market frictions. This framework implies that the less of the borrower's net worth is invested in a particular project, the more the incentive for the borrower to go against the interests of the lender. These types of agency problems are only relevant when the Modigliani - Miller theorem doesn't hold.[1] This leads to the so called "financial accelerator", in which good states help reinforce firms balance sheets, who then are capable of borrowing more. This reinforces the initial improvement of the economy and links the financial and real sectors. In particular, Bernanke et al. (1999) show that credit-market frictions are useful to explain cyclical fluctuations by amplifying real and nominal shocks and they represent findings from the empirical literature.

As Brunnermeier and Sannikov (2014) mention, these models allow for persistence of temporary shocks on the equity of leveraged agents, since it takes time to restore the equity. Moreover, financial frictions amplify the shocks, not only through leverage, but also through prices. This helps explain why relatively small shocks can have serious consequences for the economy.

However, as Kocherlakota et al. (2000) argue, the ability of these initial models to generate enough amplification of shocks to be consistent with the data is not robust to changes in parameters. Nevertheless, credit constraints can in theory be the mechanism to propagate cycle fluctuations that are persistent and pronounced. Brunnermeier and Sannikov (2014) overcome this criticism by not making recovery certain after a shock, unlike Bernanke et al. (1999) and Kiyotaki and Moore (1997). In this framework, a negative shock creates the possibility of further price decreases, so the length of the negative shocks is stochastic. This increases the amplification and persistence of negative shocks.

Another seminal paper in the understanding of financial intermediation is Hölmstrom and Tirole (1997). In their framework, there is moral hazard on two fronts. Intermediaries are in charge of monitoring firms to reduce the firms' incentive to decrease the probability of success of their investments in order to gain a private benefit (shirking). However, monitoring is privately costly. Thus, how much money the intermediary can receive from other investors (called uninformed in the model because they do not have access to monitoring technology) depends on how much of its own resources are invested as well. This setup allows for the analysis of capital tightening (such as credit crunches, collateral squeezes or savings squeezes), which shows that capital tightening

[1] Modigliani and Miller (1958)

affects poorly capitalized firms the most but that interest rates and the intensity of monitoring depend on the composition of capital for the projects.

Recently, Jermann and Quadrini (2012) also studied the effects of credit constraints of firms, but focusing on shocks originating on the financial sector itself, rather than coming from the real economy. They document the procyclicality of equity payouts and countercyclicality of debt payouts for nonfinancial corporate firms. This helps motivate a model in which financial shocks affect real and financial variables. The authors find that financial frictions and shocks that impact nonfinancial borrowers are important to the understanding of business cycles and especially fluctuations in labor. Moreover, downturns are represented as a contraction of the firms' financing conditions, which contributed to the past recessions of 1990, 2001 and 2008.

Brunnermeier et al. (2012) provide a survey of the literature of financial frictions from a macroeconomic perspective. Some of the topics discussed are credit rationing, demand for liquid assets, liquidity insurance and monitoring. They conclude that financial institutions can reduce frictions in the economy, but they also generate fragility and can increase volatility in prices.

1.2 Understanding the Role of the Financial Sector and Banks in the 2008-09 Crisis

An important point to highlight is that most of the earlier literature was focused on nonfinancial borrowers. After the recent financial crisis, the financial intermediation is no longer studied as only a propagator of real shocks. Many recent papers have considered shocks that originate in the financial sector, such as Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Kiyotaki and Moore (2012), and Del Negro et al. (2010).

In addition, many of the models discussed in the previous section, like Bernanke et al. (1999) and more recently Iacoviello (2005), have credit and collateral requirements that allow the amplification of macroeconomic shocks. However, these do not model explicit financial intermediaries such as banks. In fact, Adrian et al. (2010) argue that before the crisis, standard models of monetary policy used by central banks did not incorporate the banking sector sufficiently. The main friction was price stickiness and banks were limited to channels of monetary policy.

More recent literature has given especial attention to banks, as the recent financial crisis highlighted the importance of the banking sector in the economy. Gertler and Kiyotaki (2010), Goodfriend and McCallum (2007), Christiano et al. (2010), Gertler et al. (2012), Gerali et al. (2010) and Iacoviello (2015) model banks explicitly as decision making agents in the economy.

In particular, Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) explicitly model the frictions in the financial intermediation sector to better understand the mechanisms that were in place during the crisis that started in late 2007. Gertler and Kiyotaki (2010) argue that during a crisis, financial firms not only have less funds coming from depositors, but also from each other through wholesale markets. Thus, the agency problem also affects their ability to borrow in the interbank market, which is transmitted to the real economy through reductions in the lending to nonfinancial businesses. This is a departure from the traditional view of runs, as in Diamond and Dybvig (1983), where the people withdrew their deposits. Instead, this model incorporates frictions in the interbank market which are closer to what happened during the financial crisis, as argued by Duffie (2010).

Building on Gertler and Kiyotaki (2010), Gertler and Karadi (2011) develop a model to understand unconventional monetary policy tools used by the Federal Reserve after the start of the sub-prime crisis. Previous models of monetary policy such as Christiano et al. (2005) and Smets and Wouters (2007) did not incorporate the necessary financial market frictions to be able to address the Great Recession.

Gertler et al. (2012) extend this work to explain why banks held such risky balance sheets that left them vulnerable. They do this by incorporating the option to issue outside equity. This means that the banks can choose their liability structure and decide the optimal trade-off between short term debt and equity. The presence of direct central bank lending that mitigates the impact of the crisis makes the banks hold lower buffers of outside equity to absorb financial shocks.

Gerali et al. (2010) model banking intermediation to understand better the transmission of monetary shocks and credit market shocks to the real economy. They introduce an imperfectly competitive banking sector and financial frictions into a DSGE model. Balance sheet constraints serve as the link between capital and the supply of loans. The main conclusion is that shocks that were originated from the banking sector had the biggest impact on the 2008 downturn for the Euro Area. In addition, sticky bank rates reduce the effect of monetary policy on the economy.

Another paper that studies monetary policy is Goodfriend and McCallum (2007). They include a demand for money for transactions affects the financial accelerator. Increases in the supply of collateral created by higher asset prices also expand the demand for collateral, because agents take money loans from banks to spend more. In addition, their model features a banking attenuator, which implies that expansionary monetary policy also increases the demand for bank deposits and thus raises the external finance premium.

A further contribution to the monetary DSGE modeling is made by Christiano et al. (2010), with respect to the role of banking in the financial crisis. Their model incorporates the fact that changes in credit supply are a vital channel that allows market risk to become systemic. After estimating the model using Bayesian techniques, they find that financial factors, such as bank liquidity constraints and shocks that change market risk expectations, are primarily responsible for the recent crisis in both the Euro Area and the US. This conclusion is even stronger for the US case. Also, they find that if the Federal Reserve had started a policy of monetary easing sooner than it did, it would have assisted in stabilizing the economy.

Meh and Moran (2010) highlight the important role bank capital has as a link between banks' balance sheets and the economy. Several previous models have ignored the fact that lending depends on banks' capital positions. In their framework, bank capital magnifies the effects of shocks on output, investment and inflation, whereas bank capital shocks create important reductions in GDP and investment. There is a double moral hazard problem, as in Hölmstrom and Tirole (1997). First, investors cannot monitor entrepreneurs' projects, so they delegate this task to banks. However, banks may not monitor sufficiently, since this activity is costly and private. This implies that the final risk is in the hands of the investors, unless there is bank capital invested as well in the projects. In addition, there is a similar problem between entrepreneurs and the banks, where the net worth of the entrepreneurs mitigates the moral hazard. Within this framework, when the economy has more bank capital, it can better withstand negative shocks.

Departing from the monetary modeling focus of the previous papers, Iacoviello (2015) is instead centered around understanding the role of banking during the Great Recession. The model expands the work in Iacoviello (2005) and includes a redistribution shock from banks to households that represents the defaults on mortgage loans experienced during this period. In addition, it features a bank capital channel, where losses force banks to generate a credit crunch which amplifies the shocks to the real economy. The model shows that bank losses can have deep and enduring effects on business cycles.

1.3 Maturity Transformation

One of the key aspects of banking that has received attention is its role in the maturity transformation process of financial intermediation. Adrian et al. (2010) use a different framework from the standard DSGE used in the literature to show that banks drive the financial cycle because of their influence on the pricing of risk. In this setup, changes in the supply of credit are due to bank risk-taking and the market risk premium. In addition, they argue that short-term interest rates are important not only because of their role determining long-term interest rates, but also because they set the term spread, and thus the net interest margin and capital of the banks.

A more macroeconomic perspective is taken in Andreasen et al. (2013), in which a general equilibrium model is created to understand the role of banks in maturity transformations. Most of the models assume that both deposits and loans are one-period. However, banks often rely on short-term deposits to finance long-term investments. This has implications for business cycle dynamics. In particular, this dampens the consumption and investment responses to technological shocks. Also, the model shows that the average deposit rate is less persistent than the average loan rate, which is in line with U.S. corporate bond data. This complements the previous findings of Gambacorta and Mistrulli (2004) and Van den Heuvel et al. (2006) in terms of the effects of bank's maturity transformation on the transmission of monetary policy shocks.

Kiley and Sim (2011) discuss the risks involved in this process. There is short-term funding risk paired with long-term investments. When capital markets are not frictionless, this funding risk may cause expensive recapitalizations and fire sales. This implies that uncertainty forces risk-neutral financial intermediaries to behave as risk-averse ones. These institutions might react to uncertainty by reducing exposures and letting go of good investments. In aggregate, this tightens the credit supply and affects the economy negatively. Thus, the balance sheet condition of intermediaries can be a key element in explaining asset prices and GDP.

1.4 Recent Empirical Studies of Financial Intermediation and Banking

As Brunnermeier and Krishnamurthy (2014) point out, there are many difficulties in studying financial risks and exposures. For example, before the financial crisis, little attention was given to banks' macroeconomic risk exposures. In addition, the data previously reported by banks was not sufficient in many important aspects to understand not only systemic risk in the economy, but also individual bank exposures and conditions. There is a need to better monitor the risks of systemically important financial intermediaries, measure underlying risk factors of financial intermediaries, determine the liquidity of banks' balance sheets, figure out the leverage of banks and better report changes in the supply of new bank loans.

Geanakoplos and Pedersen (2012) argue that it is important to monitor leverage on new loans because this reflects current credit conditions, not leverage on all loans or average loan-to-value ratios across all loans as it is now. It is necessary to account for leverage at origination of current loans, leverage on new loans and updated leverage on existing loans that incorporates changes in collateral and amortizations. These measurements will be useful in understanding the buildup of systemic risk, monitoring vulnerabilities and detecting asset pricing bubbles.

Bassett et al. (2011) analyze banking in particular. They explain that changes in the outstanding stock of bank loans are a noisy signal of a bank's loan supply decisions because they include other forms of intermediation activities, such as loan purchases, loan sales, etc. There needs to be more information on the flow of loan originations and other factors that affect the outstanding amount, besides charge-offs. There is also a need for more information on credit lines, which are accounts off the balance sheet, to be able to monitor accurately a banks' lending capacity during recessions. They suggest the collection of information on credit that separates commitment versus no commitment clauses, credit to new customers, changes in credit flows due to banks' decisions and trades of credit products.

Despite these difficulties assessing banks' information, there have been many empirical studies on banking and its role in the 2008-2009 crisis. For instance, papers with a focus on bank lending data are Ivashina and Scharfstein (2010) and Gilchrist and Zakrajšek (2012a). Other papers have studied bank loans using data reported to their regulators, such as Bassett et al. (2014), and Ciccarelli et al. (2014).

Ivashina and Scharfstein (2010) show that there were considerable drops in new loans to large borrowers during the financial crisis. In addition, after the collapse of Lehman Brothers in September 2008, short-term bank creditors did not allow banks to roll over their short term debt as easily. At the same time, there was another run by borrowers, who drew down their credit lines.

On the other hand, Gilchrist and Zakrajšek (2012a) find that banks reduce their off-balance-sheet credit exposure by cutting unused loan commitments as an immediate reaction to problems in financial markets. After some time comes the scaling down of loans outstanding. Moreover, they find that increases in the excess bond premium (which is an indicator of problems in financial markets analyzed in Gilchrist and Zakrajšek (2012b)) preceded reductions in bank lending and can be used as an early indicator of changes in credit supply conditions.

Bassett et al. (2014) use the Federal Reserve's Loan Officer Opinion Survey on Bank Lending Practices (SLOOS) to study banks' responses to the crisis. They use bank-level responses instead of aggregates to better understand how credit supply responded to the shocks during this period. This is helpful because often the same elements that affect the supply of loans also affect the demand, so this dataset is helpful in disentangling demand from supply in the bank credit market. Their results show that more firms reported a tightening of their lending standards than a reduction in loan demand. With this information, they create an indicator of credit supply. In addition, after introducing macroeconomic and bank-specific controls that also influence loan demand, they show that this negative shock to the indicator resulted in important reductions in output and borrowing capacity of households and firms.

Another study in the same vein is Ciccarelli et al. (2014). Their objective is to understand better the credit channel, as defined by Bernanke and Gertler (1995). They use the U.S. Senior Loan Officer Survey as well as the Euro area Bank Lending Survey to quantify the channels that link monetary policy with business cycles through credit markets for both. They compare the cost of capital channel to the broad credit channel, composed of the non-financial borrower balance sheet channel and the bank balance sheet channel. The results point to the bank lending and cost of capital channels being the most important for corporate and mortgage loans in the Euro area, while in the US, monetary policy shocks are transmitted primarily through the firm balance sheet channel.

Bank level survey information is also used as part of the motivation for Gerali et al. (2010). The authors show that both in the US and Euro area, banks' credit standards for firms and households were tightened considerably. This confirms again the importance of banks in current financial systems and the economy in general.

More broadly, Adrian et al. (2012) discuss many financial features of the crisis. They argue that the recent recession was mainly due to negative shocks in the supply of bank loans and other intermediaries, instead of the demand side of credit being the main cause. This reinforces the conclusions about the importance of supply side shocks to intermediated credit for understanding financial frictions, as explained by Kashyap et al. (1993). Another important conclusion is that bond financing increased to compensate the decline in bank loans for the firms who had access to capital markets. However, credit spreads increased for both types of credit. Finally, they mention two important characteristics of the banking industry: the procyclicality of bank leverage and the stickiness of bank equity.

1.5 Banking Regulation

Another area that has been greatly studied in the past years is banking regulation. However, this is not a new topic. Dewatripont and Tirole (1994) highlight the importance given to solvency in the regulation of financial intermediaries. They argue that capital capital adequacy ratios and external interventions in case of insolvency by debtholders can be used to optimally regulate banks by insulating banks from macroeconomic shocks. They also link the savings and loans (S&L) crisis of the 80's in the United

States to problems in the framework of banking regulations. Many of the issues raised in that book are still relevant today, such as the lack of information and free-riding on the side of debtholders.

However, bank capital is not only accumulated to satisfy financial regulations. Diamond and Rajan (2000) argue that bank capital matters for bank safety, to reduce banks cost of refinancing and to extract repayment from its borrowers (or to liquidate them). In addition, an optimal capital structure takes into consideration the cost of lower liquidity creation.

Hellmann et al. (2000) point out that the existence of deposit insurance schemes create the gambling on resurrection problem. This implies that banks choose risky investments that pay considerable profits if they succeed and the loses are absorbed by the depositors if they fail. With deposit insurance, depositors are less incentivized to monitor the banks. Bank capital requirements can reduce the gambling issue by assuring that there is bank equity at stake as well. On the other hand, since these requirements reduce banks' franchise values, they can also encourage this behavior. In addition, the authors focus on financial liberalization as a source of banking fragility. More competition reduces expected future profits and increases the moral hazard problems discussed previously. Capital requirements can reduce this negative outcome, but deposit-rate (such as deposit-rate ceilings) controls are needed in order to reach Pareto-efficient outcomes. Other alternative instruments could also be used, such as asset-class restrictions and direct supervision.

Repullo (2004) continues with this line of research by studying the effects of capital requirements on banks' risk-taking behavior in an imperfectly-competitive setting, where there is a safe asset and a risky one. The safe asset has a higher expected return, but the risky one provides a larger payout if successful. Imperfect competition in the deposit market is modeled as spatial competition using the circular model of Salop (1979). When the cost of capital is higher than the return of the safe asset, capital requirements guarantee the existence of an equilibrium in which the bank chooses to invest in the safe asset. In the model, increases in capital requirements reduce the equilibrium deposit rates so that the franchise values do not change, eliminating the negative effect of capital requirements discussed in Hellmann et al. (2000).

Besides the theoretical properties of bank capital on banks' behavior, the literature has also focused on the implications of the banking regulatory framework set forth by the Basel Committee on Banking Supervision (BCBS). The Basel Accords have been the cornerstone of modern banking regulation. The first set of guidelines, Basel Committee on Banking Supervision (1988), proposed minimum capital requirements for banks. Later on, the Basel Committee on Banking Supervision (2004) was design to address the lack of sensitivity to risk of the previous accord. However, the financial crisis of 2008 highlighted many weaknesses that needed to be addressed. Thus, a new standard, Basel Committee on Banking Supervision (2010), was introduced to complement the previous framework.

There have been many papers that incorporate thee Basel Accords in the analysis of banking topics. Van den Heuvel (2002) points out a weakness in previous studies of monetary economics, which is the lack of attention to bank equity. In this work, Basel Accord I capital requirements are incorporated in order to analyze the impact of these regulations on bank lending and the response of the banking sector to monetary policies. The model shows that bank capital matters for lending decisions even if the capital requirement is not binding in that period. In addition, there is a bank capital channel that links monetary policy to the supply of bank loans by its effect on bank capital. This channel relies on the capital adequacy of banks and the capital distribution across banks.

The first Basel Accord required a ratio of capital to risk-weighted assets of at least 8%. However, since most of the business loans had a weight of 100% in the denominator, this 8% represented a risk-insensitve requirement for banks. That is why Basel II was created. This new standard provided banks with different methods of estimating their capital requirements given their risk exposure. This new framework allows banks to use two different approaches to determine their capital requirements. The standardized approach uses external ratings to modify the risk weights of Basel I, whereas the internal ratings based approach enables banks to determine their capital charges after estimating their own probabilities of default and loss given default.

Repullo and Suarez (2004) study the implications of Basel II. Under a perfectly competitive loan market, loan default rates are modeled according to the single risk factor model used for the internal ratings based (IRB) approach . The main conclusion is that firms with relatively low risk will get lower rates from banks that adopt the IRB approach, whereas risky firms will avoid higher loan rates by borrowing from banks using the less risk-sensitive standardized approach. In addition, the authors find that the IRB charges are too high from a welfare perspective and that changing from Basel I to Basel II would only affect the volume of risk lending, which would expand.

The literature has also been concerned with the procyclical effects created by Basel II. This issue was discussed in Repullo and Suarez (2008). The banking regulations that followed Basel II can amplify business cycle fluctuations, since they make bank reduce their lending during recessions. The probability of default and loss given default measures increase during crises. Thus, under the IRB approach of Basel II, capital requirements are raised and this in turn could cause a decrease in the credit supply. Using a model that features relationship banking and limits to the access of equity markets, the authors find that Basel II leads to banks having buffers that range from 2% in recessions to 5% during booms. Despite having these buffers, recessions still contract the supply of credit. However, Basel II greatly reduces the probabilities of bank failures, when compared to Basel I and no capital requirement regulation. Thus, despite the business cycle implications, Basel II benefits the economy by safeguarding the long-term solvency of the banks.

Kashyap and Stein (2004) also pointed to the procyclicality of Basel II. They argue that risk-based capital requirements can reduce pricing distortions in the different loan categories and reduce the incentives for regulatory capital arbitrage. However, they can increase business-cycle fluctuations. Basel II has a single time-invariant risk curve, which links measures of credit risk to capital charges, which is inefficient from a social planner's perspective. In addition, simulations show that this regulation can produce a large degree of cyclical variation, which depends on the credit-risk models used to estimate the parameters required for the IRB approach. The authors also suggest including conditions for the reduction of capital requirements during recessions can reduce regulators discretion during times of crisis when banks are not able to meet the capital requirements.

Another area that has been studied is the welfare implications of capital requirements. Van den Heuvel (2008) includes the liquidity creation role of banks and the moral hazard generated by deposit insurance. Capital requirements reduce the problem of moral hazard, but are costly to society because they diminish the banks' ability to produce of liquidity. This model studies the interaction between two of the pillars of Basel II, the capital adequacy requirements and banking supervision. A low welfare cost of capital ratios would mean that there is no need to incur high supervision costs, whereas high welfare cost of capital adequacy ratios would imply a need for more supervision and compliance. Using the 8% capital ratio (tier 1 plus tier 2 equity over risk weighted assets) required by the original Basel Accord, the results are a permanent loss in consumption between 0.1% to 1%. Thus, the author concludes that the target of 8% is too high.

However, there is no consensus in the literature. For example, Begenau (2014) finds that the optimal Tier-1 capital ratio by itself should be 14%. This result is based on the assumption that households value safe and liquid assets, which banks provide as bank debt, more as they become scarcer. The justification is that bank debt has a safety and liquidity premium. Thus, higher capital requirements that reduce the supply of bank debt can increase lending because interest rates on bank debt are reduced through a general equilibrium effect. Thus, the banks' funding costs decrease and they are able to expand their supply of credit. In addition, the model shows that higher capital requirements also reduce volatility in the economy and increase total output and consumption.

As mentioned previously, the financial crisis that started in late 2007 evidenced many problems with the regulation based on Basel II. Thus, Basel III was created not to supersede the previous accord but to improve it on many dimensions. Besides reinforcing the microprudential or bank-level regulation, a focus on macroprudential or system-wide was added. This new layer is design to reduce systemic risks across the banking industry and their procyclical amplification.[2] . With respect to the changes in capital requirements, there are now stringent requirements for the quality of capital and an increase to a minimum of 4.5% of common equity Tier 1 to risk weighted capital. In addition, there is a capital conservation buffer of 2.5% and a countercyclical buffer ranging from 0% to 2.5% that is activated when regulators detect a perilous build up of systematic risk. Another important measure is the requirement of 1% to 2.5% applied to global systemically important financial institutions, given their weight in the financial system. There are also changes in the risk coverage regulation, additional leverage

[2] `http://www.bis.org/bcbs/basel3.htm`

requirements and new liquidity standards, among other policies.[3]

Although Basel III is still in its implementation phase, which is expected to continue until 2019, there have been some contributions to the literature that try to assess its impact. Slovik and Cournède (2011) estimate the medium-term impact of Basel III on GDP growth for the United States, Euro area and Japan. They find that on average, GDP growth is reduced by 0.05 percent to 0.15 percent per year over a five-year period. This is due to the fact that higher capital requirements lead to increases in lending spreads. These results are consistent with other estimates, such as the one done by the Macroeconomic Assessment Group of the Financial Stability Board and the Basel Committee on Banking Supervision. However, the authors argue that these estimates do not include monetary policy changes that could offset this impact on the economy.

Other papers have incorporated some of the Basel III framework into their analysis of the banking sector. For example, De Nicolò et al. (2012) use capital requirements and a liquidity coverage ratio that is now mandatory under Basel III. In this paper, the authors evaluate the possibility of using taxation to influence banks' risk-taking and to pay for the resolution costs of the crises[4] . The authors find that under mild capital requirements, bank efficiency and social welfare are higher than under no regulation. Raising the capital requirements to higher levels offsets those gains and does not reduce the default risk. This finding points to an inverted-U-shaped function between bank lending, efficiency, welfare and the level of bank-specific capital requirements. On the other hand, liquidity requirements not only diminish bank lending, efficiency and social value, but also destroy the benefits of low capital requirements when working in conjunction. Finally, an increase in corporate income taxes also reduces lending, bank efficiency and social value and these effects are worsened if the tax is on non-deposit short-term liabilities.

There have also been studies that compare Basel III to its predecessors. Repullo and Suarez (2013) continue their research on procyclicality and capital regulation extending the discussion to include Basel III's framework. The authors consider Basel III to be a compromise between the microprudential perspective on protecting the health of individual banks and the macroprundential one, concerned about the consequences of

[3] `http://www.bis.org/bcbs/basel3/b3summarytable.pdf`

[4] This can be seen as Pigouvian taxation that forces the banks to incorporate the negative externalities created by bank failures

banks' decisions on the aggregate economy. The existence of the capital preservation buffer and countercyclical buffer helps build up capital during booms which can be used during crises to reduce the inherent procyclicality of Basel II's regulation. This is viewed as a move in the correct direction.

Finally, Angeloni and Faia (2013) provide some insights into how the recent financial crisis changed the perception of the roles of financial regulation and monetary policy and how Basel III deals with those issues. The previous microprudential view assumed that by assuring the solvency of individual banks, the financial system as a whole would be stable. This meant that monetary policy did not need to incorporate financial issues and could focus only on inflation. The crisis has shown that individual capital requirements are not a sufficient condition for the stability of the financial system and monetary policy should be concerned about systemic risks in the financial sector, as it influences its risk-taking behavior. The authors find that in a general equilibrium model that includes financial fragility monetary expansions and positive productivity shocks increase bank leverage and risk. Regulation similar to Basel II then amplifies how GDP and inflation respond, and reduces welfare. However, anti-cyclical buffers, as in Basel III, offset those effects.

1.6 Too-Big-to-Fail policies

The importance of Too-Big-To-Fail (TBTF) polices has been recognized before by the literature. For example, Boyd and Gertler (1994) link the existence of TBTF polices with the poor performance of large banks. The authors argue that this explains the banking troubles of the 80s in the United States. The authors argue that TBTF policies subsidized risk-taking, which made banks more vulnerable to the negative shocks that occurred during that period. In addition, the capital crunch of 1990 and 1991 could be attributed mainly to large banks.

In Begenau (2014), the TBTF policies were modeled to incorporate factors such as asset size, leverage and risk taking of banks, which increase the amount of the transfer given to the banks. This is a subsidy that prevents defaults in equilibrium and removes default risk from the pricing of deposits, which lowers the debt financing costs of banks. In addition, the functional form allows for complementarity between risk-taking behavior and the choice of leverage. This reflects the idea that highly leveraged banks have more incentives to take on extra risk, because the loss is limited to the small amount of equity at stake whereas the upside is not shared with the debtholders.

Ennis and Malek (2005) propose a simple model to understand the influence of TBTF policies on banks' decisions. The authors argue that TBTF policies have two effects. The first is a size distortion in the banking sector. These types of policies incentivize banks to become big and benefit from the insurance TBTF policies create because they internalize that the bigger their size, the greater the probability of being bailed out. The second is a risk distortion that worsens the moral hazard created by the existence of deposit insurance schemes. Moreover, these two distortions are complementary in the sense that bigger banks make riskier investments to benefit more from the TBTF policies.

Bianchi (2012) also discusses a TBTF policy, questioning how the expectation of bailouts affects the financial sector's stability. In a non-linear DSGE model, credit frictions are used to generate financial crises. The focus is on the linkages between ex-post bailouts in credit markets and the accumulation of ex-ante risk. There is an optimal level of bailouts (around two percentage points of GDP while a credit crunch occurs) that is found by considering the trade-off between risk-taking and relaxing balance sheet constraints during a crisis. However, this systemic insurance should be accompanied by macroprudential policies during booms to reduce the incentives for building up risk. This is because from an ex-ante view, bailouts can generate externalities by reducing the cost of borrowing below the social cost. Results show that while the optimal bailout makes credit crunches happen more frequently, output during crunches is reduced by considerably less. Moreover, lack of prudential policies can increase the rate of credit crunches and deepen the financial crises.

Another strand of the literature centers around the moral hazard consequences of bailouts and overall TBTF policies. For example, Farhi and Tirole (2012) and Chari and Kehoe (2013) show how bailouts can increase financial fragility, which highlights the importance of ex-ante financial regulation.

In particular, Farhi and Tirole (2012) model how bank leverage and maturity mismatch are affected by bailouts and the optimal regulation under those conditions. The authors find that the monetary authority provides too much liquidity in the time-consistent outcome. This reinforces the need for regulation that is ex-ante macro-prudential, in the sense that individual banks solvency should be complemented by considering the overall transformation activities of the banking industry. In addition, optimal regulation does not require breaking up big banks, but instead imposing liquidity requirements to reduce their maturity mismatch and their correlated risk. Also, current loose interest-rate policies make future crises more likely as they signal the central bank's accommodating position and generate new maturity mismatches. Finally, an optimal bailout is based on interest-rate policies and only uses transfers when the crisis affects a large share of banks. This is because interest-rate policies benefit banks that actually face borrowing restrictions, whereas transfers support banks that do not need to or should not refinance.

On the other hand, Jeanne and Korinek (2013) show that there can be efficient bailouts. In their work, they question the "Greenspan doctrine" which represented the idea that ex-post interventions are better than ex-ante, because the latter are too costly and unpredictable. The authors find that it is generally optimal to use both types of policies. In addition, there is no time inconsistency problem for ex-post interventions (such as fiscal bailouts or monetary stimulus) if the appropriate ex-ante macroprudential policies are in place (like the use of maximum loan-to-value ratios or financial regulation). Finally, the model shows that it is not efficient to create a bailout fund to finance ex-post interventions. It is better to use new resources that do not come from the borrowing sector because borrowers react to the bailout fund by borrowing more (Ricardian equivalence).

1.7 Banking Heterogeneity

Clearly, TBTF policies have had a vital role in the banking sector and thus in the economy. As Stern and Feldman (2004) warned, this issue has become more problematic over time. Thus, the need to understand who gets to be bailed out is key for comprehending the impact of such policies. However, many models include TBTF policies that apply to banks in general, modeling their impact as a bailout on the overall financial system. Therefore, it is important to recognize the heterogeneity in the banking sector, not only because of its link to the TBTF policies, but also because it has an effect on the dynamics of the banking sector.

A first issue to consider is what dimension of bank heterogeneity should be the main focus. TBTF policies indicate that size is the main issue, but in reality they are designed to target systemically important institutions. Ennis and Malek (2005) mention that systemic importance is not necessarily the same as the size of a bank. For example, an agent that performs a vital activity for financial markets could be considered as systemically important, despite not being big in terms of its assets. In addition, other institutions, besides banks, can also be considered systemically important. However, the easiest variable work with is the size of the balance sheet, so most of the focus in the literature and economic policies is concentrated on banks' balance sheets. Moreover, big banks provide many services to the financial system, so they are considered systemically important.

Understanding the current size distribution is an important element of the analysis. Ennis (2001) argues that the Riegle-Neal Interstate Banking And Branching Efficiency Act, which passed in September 1994, and the Gramm-Leach-Bliley Financial Services Modernization Act, passed in November 1999, are key for understanding the size distribution of banks since they removed interstate branching restrictions and impediments to horizontal and vertical integration for firms in the financial services industries, respectively. These changes helped speed up the concentration process for banks, supporting the idea that these restrictions were responsible for the large number of banks in the United States. In Canada, where such constraints were not imposed, there are few small banks with many branches across the country. This also serves as evidence of the role of those branching and integration restrictions in creating a distribution of numerous small banks in the United States. From a theoretical perspective, trade-offs between capital rations and operating costs, product differentiation and corporate governance issues can justify the existence of a non-degenerate distribution of bank sizes, but in practice, the trend is towards a more concentrated banking industry.

Thus, in order to understand the banking sector, it is important to recognize the significant heterogeneity that exists, where the top four banks represent almost 50 percent of the asset distribution and there are thousands of tiny banks still in existence. However, most of the literature has treated banking as a homogeneous sector that can be modeled with a representative agent or as a friction.

One of the papers that does include the heterogeneity of banking is Corbae and D'Erasmo (2013). This paper studies the link between market structure in the banking sector and the banks' risk-taking decisions. In particular, it models banking heterogeneity by assuming three classes of banks: national, regional and fringe. This represents the top 10 banks, top 1 percent of banks (excluding the first 10) and the bottom 99 percent, respectively. This classification is due to the empirical evidence that identifies significant differences in the behavior of these three groups in terms of variables such as loan returns and volatility and net interest margins. In addition, several measures, such as the Lerner Index or the net interest margins, are show to argue that the banking industry is not perfectly competitive. This is modeled via a Stackelberg game between banks, where the big banks take advantage of their position and move first. The model is able to generate an endogenous bank size distribution and features procyclical supply of loans and entry rates, and countercyclical interest rates, bank failure rates, and returns on loans. The model is then used for counterfactual experiments. Reductions in the competition level lowers bank exit and TBTF policies allow big banks to provide more loans in risky states of nature, whereas small banks reduce their exposure, thereby reducing the overall loan market.

Corbae and D'Erasmo (2014) is based on the previous model but focuses on the issue of capital requirements. In this model, banks are able to hold securities and borrow from the interbank market in case of deposit shortfalls. There is an incentive to participate in the interbank market because there are liquidity shocks that reduce the amount of deposits banks have access to. Similarly to the previous paper, there is heterogeneity in the banking industry, which is represented by a big bank and a fringe of small banks. The model is in line with empirical evidence presented by the business cycle literature and the work of transmission effects of monetary policy through banks of Kashyap and Stein (2000). The model is also used to assess the changes proposed by Basel III. In particular, the increase in capital requirements from 4% to 6% is studied. This higher requirement reduces exist rates of small banks and the banking sector becomes more concentrated. To meet the higher capital requirements, there is a reduction in loan supply and a corresponding increase in loan interest rates. Basel III also encourages the use of countercyclical buffers up to 2% of risk-based Tier 1 capital. The model predicts this will have an increase in the holding of securities, thereby reducing the amount of loans offered. This in turn reduces their profits and reduces bank entry, similar to the increase in capital requirements.

This literature review has highlighted the various areas of research in banking topics. However, there has been few attempts to try to bring together TBTF policies, banking heterogeneity and the recent financial crisis. Thus, in the following two chapters, these strands of the literature are studied in conjunction to try to contribute to the current understanding of banking topics.

Chapter 2

Too Big to Fail: Implications for the Capital Decision of Big Banks

2.1 Introduction

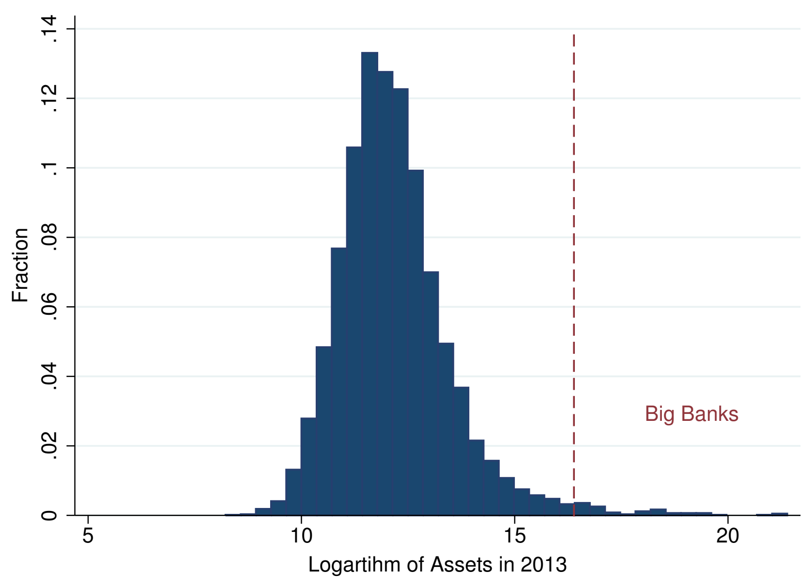
The recent financial crisis has pointed out many weaknesses in the way banks were being regulated. In the present paper, I add to this discussion by highlighting another dimension to the problem: the interaction among too big to fail (TBTF) policies, the capital decisions of big banks, and the presence of systemic shocks to the economy in the United States.

2.1.1 "Big" versus "Small" Banks

First of all, I differentiate the behavior of small and big banks. Most of the literature treats banking as a homogeneous sector, but in reality it is a highly concentrated industry with important disparities. As Corbae and D'Erasmo (2014) and Corbae and D'Erasmo (2013) point out, banks in the top one percent of the asset distribution differ substantially from the ones in the bottom 99 percent in terms of returns, variability of returns, share of the deposit and loan markets, cost structure, balance sheet items, etc. In addition, Ennis (2001) compares theories that attempt to explain bank size heterogeneity and mentions that the ones that state that the existence of small banks is not a transitory situation but an equilibrium outcome match the data better.

Using the asset distribution to create size categories for banks can lead to some issues. For example, a decrease in the number of banks can cause a ”small” bank to be now classified as ”big”, without the bank having altered their asset level at all. Thus, in this paper, I define small banks as the ones whose assets are lower than 0.05 percent of the current year's GDP and big banks as the ones with assets bigger than or equal to that benchmark. Although it is an arbitrary number, given the distribution of banks' assets with many outliers on the right side, it is robust to small changes. Using our sample from the years 1992 to 2014, this means that on average 1.58 percent of banks are considered big each year.[1] Figure 2.1 shows the application of this criterion for the year 2013.

Figure 2.1: Representation of the criterion for big banks



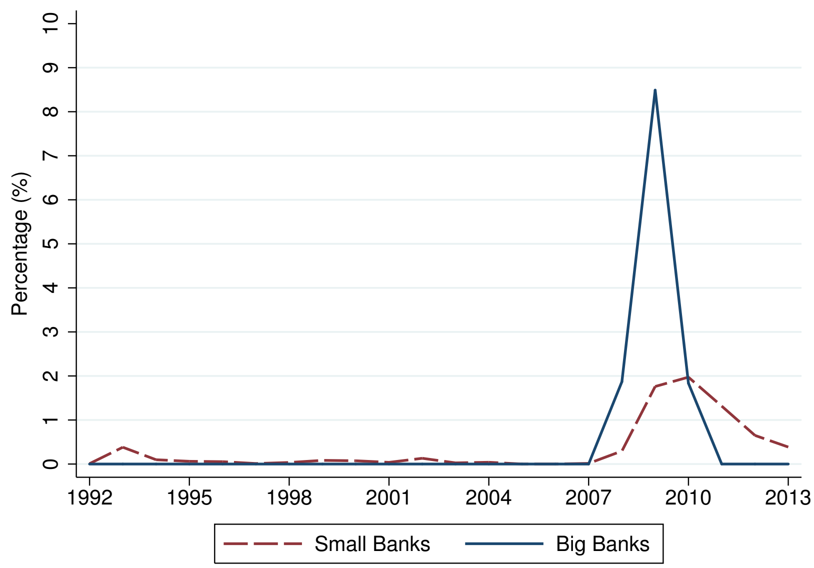
Source: Federal Deposit Insurance Corporation

[1] These categories are also consistent in the sense that there is little movement from small to big banks and vice versa.

2.1.2 Exit Rates

With this definition of size in mind, the key fact I try to explain is why so many of the big banks failed in the past financial crisis. Figure 2.2 shows that in 2008, 1.87 percent of big banks failed. This increased to 8.49 percent in 2009 and then went back again to 1.83 percent in 2010. In absolute terms, that represents only 13 banks in total exiting the industry, but in terms of their class, these are high exit rates. In contrast, during those three years, 122, 132 and 84 small banks exited, but that only represented 1.76 percent, 1.97 percent and 1.32 percent of all the small banks respectively.

Figure 2.2: Exit rates for big and small banks



Source: Federal Deposit Insurance Corporation

2.1.3 Risk Weighted Capital Ratios

The main hypothesis of this paper links the exit behavior of big banks to the low levels of equity that they held during the period prior to the financial crisis.

As Van den Heuvel (2008) mentions, capital requirements are the cornerstone of modern bank regulation and vital for the capital structure of US banks. Moreover, Zhu (2008) highlights the role of bank capital regulation on the soundness, risk taking behavior, and competitiveness of banks.

However, it is not the case that banks fail because they are very close to the regulatory requirements. As Elizalde and Repullo (2007), Zhu (2008), and Van den Heuvel (2008) point out, capital requirements are not binding for most banks.

Repullo (2013) notes that the banking literature has many models where banks do not have holdings of capital bigger than the minimum to operate, so models that generate the buffers endogenously help explain better the bank's decision making. In the data we can observe that there is a buffer-stock behavior, which might be interpreted as banks reducing the probability that an adverse shock makes them fall below the required level of capital or other types of contingencies like regulatory penalties. Thus, the question is why big banks held too little additional capital[2] .

When analyzing capital adequacy ratios, there are several indicators that regulators follow. I will focus on the Tier 1 risk-based capital ratio[3] . As Hanson et al. (2011) state, this has been the measure financial authorities' focus on when evaluating a bank's ability to cushion potential losses. This is because Tier 1 capital is of higher "quality" in terms of easing the recapitalization process and reducing the debt overhang problem faced by banks, as studied by Myers (1977).

Figure 2.3 shows the evolution of the average risk weighted capital ratios for big and small[4] banks weighted by the assets of each type[5] . Following current Federal Deposit

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[2] Elizalde and Repullo (2007) use the definitions of regulatory capital (limit set by regulation), economic capital (chosen by banks without any regulatory constraints) and actual capital (set by the bank in presence of regulation). Therefore, the concept of capital buffer could be understood as the difference between actual and regulatory capital.

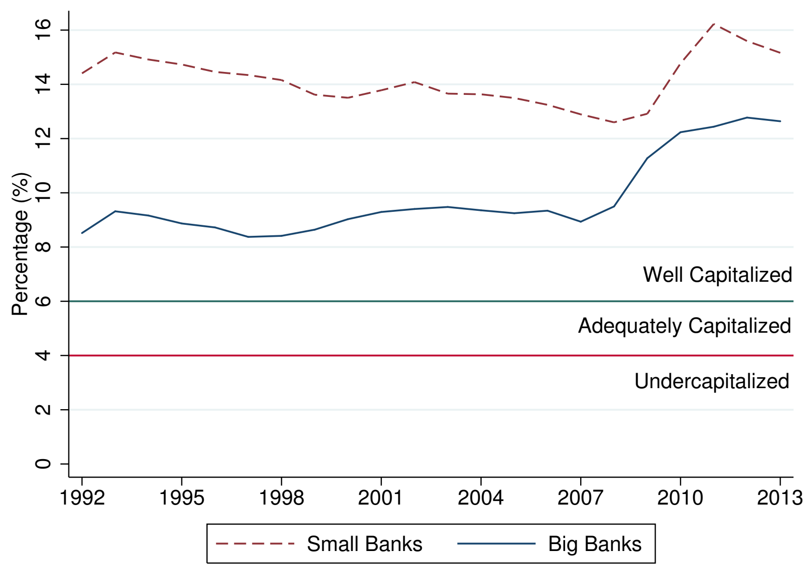
[3] Following the Federal Deposit Insurance Corporation (FDIC), this ratio is defined as the tier 1 capital divided by the risk weighted assets. Tier 1 includes mainly common stock and retained earnings with preferred stocks being part of the additional tier 1 capital (`https://www.fdic.gov/regulations/resources/director/RegCapIntFinalRule.pdf`). Risk-weighted assets are calculated by multipliying each asset class by some weights determined by the financial regulator. For example, exposures to gold would receive a weight of zero, whereas consumer loans and credit cards have a weight of 100 percent (`https://www.fdic.gov/news/news/financial/2012/fil12027.pdf`).

[4] Some observations corresponding to small banks have been removed since they had zero interest incomes during the period. These banks also have extreme values of the risk weighted capital ratio. This is due to having assets close to zero. If they were included, there would be a bigger value for the years 2010 and 2011.

[5] Each observation represents the last quarter of the year. The sample period starts at 1992:Q4 even though the FDICIA regulation that implemented the first Basel Accord (which was published in 1988) was not fully enforced until January 1, 1993 (Getter (2012)). However, since the changes had been gradually introduced and banks were fully aware of the end goals, it would be expected that banks

Insurance Corporation (FDIC) regulations[6] , a bank is considered to be undercapitalized if its tier 1 risk-weighted capital ratio is below 4 percent, adequately capitalized if it is above 4 percent, and well capitalized if it is above or equal to 6 percent.

Figure 2.3: Differences in the Risk Weighted Capital Ratios



Source: Federal Deposit Insurance Corporation

A first conclusion one might derive is that the regulatory constraints imposed under Basel I and II were too low to protect the banking industry from a severe financial crisis. Hanson et al. (2011) sum up the findings of many papers by stating that the regulation that was in place before the recent financial crisis was focused only on microprudential concerns. Thus, the main goal was on avoiding bank defaults, but not on the health of the financial system. This would be reasonable if the failure of an individual bank was due to idiosyncratic causes. However, if the trouble comes from a systemic source, then the economy is unprepared to handle the risk.

Moreover, it is clear from the graph that big banks hold less capital relative to their risk-weighted assets than small ones. However, they are considerably above the 6

had done much of the necessary modifications by the last quarter of 1992.

[6] `https://www.fdic.gov/regulations/laws/rules/`

percent requirement, so they were considered as well capitalized. Allen et al. (2011) also notice that even though banks held capital above the regulatory minimum, this was not enough to prevent the recent financial crisis.

2.1.4 Capital Buffers

The next question then is why did big banks hold so little in terms of equity to assure their own survival? Regulations concerning low levels of equity relative to assets also incentivize banks to accumulate buffers. For example, once the bank has been classified as undercapitalized, it has to submit a capital restoration plan and face additional constraints imposed by the FDIC. The result is an incentive to avoid ever falling below certain limits, so they generate buffers above what regulation requires.

Moreover, Elizalde and Repullo (2007) find that the threat of closure for undercapitalized banks is key in generating capital buffers. This element has a greater impact than factors related to market discipline (approximated by changes in the coverage of deposit insurance) in their model. This conclusion is supported by the empirical findings of Aggarwal and Jacques (2001). Another explanation is given by Allen et al. (2011), who created a model where one important explanation for the existence of the positive capital buffer is market discipline coming from the asset side.

Nevertheless, according to Stein (2012), banks have strong incentives to operate with relatively small capital buffers. In this model, banks do not take into consideration the indirect costs of having debt. For example, if they are forced into a fire sale, they reduce the value of the assets other banks hold in common. By simply taking advantage of the cheaper source of finance, their debt levels are not socially optimal. This behavior contributes to the fragility of the financial system.

Kashyap et al. (2010) argue that banks choose low buffer levels because they face high levels of competition. In the financial industry, there are limited ways to gain a competitive advantage, so they rely more on the deposits, which cost less than equity. Moreover, with the existence of deposit insurance, depositors do not force banks to minimize their risk of default. Every bank becomes a perfect substitute for most depositors, who are below the maximum coverage of the insurance, so banks do not compete on the basis of their balance sheet strength.

It is also important to highlight the differences between the big and small banks' capital decisions. Why do big banks choose to hold smaller buffers? Part of the explanation is that big banks can diversify their risks better, so they believe that they do not need to build more equity to reduce their probability of failures. However, as the crisis showed, this effect was not enough to prevent the high rate of failure. Hanson et al. (2011), point out that larger banks face a higher degree of competition for the biggest customers. Therefore, they hold low levels of costly equity to finance their loans to offer cheaper rates to attract this type of client.

Zhu (2008) compares the trade-off between one-period gains (efficiency) versus future franchise value (safety). For small banks, focusing on the first objective leads to high leverage and high default risk resulting in a future franchise value cost that is too high. However, as equity increases, banks can assign more weight into current-period gains without increasing their probability of default substantially. This process continues until the safety concern outweighs the efficiency again and we have a "U-shaped" equity over assets ratios. He also finds that part of the difference in the capital held by banks of different sizes is due to the risk-sensitive capital standard. Compared to a flat rate, this creates an incentive for small banks to hold more capital than big banks, which are less risky.

2.1.5 Too Big to Fail

In this paper, I highlight the role of too big to fail (TBTF) policies as a key ingredient to understand why big banks held relatively small capital buffers. As Ennis and Malek (2005) note, too big to fail is not a completely clear term since it is not only related to the amount of assets a bank has, but can also refer to other institutions or even entities that perform a vital activity for the financial markets, regardless of their size. In this paper, I take their approach and only focus on banks with a significant level of assets. As stated in the beginning, I define a big bank as one that has assets bigger that 0.05% of the current year's GDP.

Stern and Feldman (2004) claim the higher levels of concentration and the increased intricacy of banking operations as reasons for the existence of TBTF banks. The first means that the impact of a default spreads more through the economy since the bank has more deposits and gives more loans and the fact that there are fewer other institutions to seamlessly cover the void left. The second deals with regulation. The fast changes and invention of new products in the financial world means the laws and policies become quickly outdated and the government has to further compete with the private sector for the best employees.

As Ennis and Malek (2005) make clear, deposit insurance and failure-resolution policies make the TBTF issue even more complex. The literature has made very clear the increase in the moral hazard issue that deposit insurance policies create. Moreover, the existence of special clauses for systemic risk cases signals to the market that the government will help big banks.

TBTF is not a recent issue for financial regulation. Boyd and Gertler (1994) pointed out early on that by looking at some measures of performance (such as loan charge-off rates and variance of return on assets) and size, the TBTF problem was key in understanding the financial troubles of the 1980's. They mention that the failure of Continental Illinois Bank in 1984 made it clear that big banks could count on TBTF policies. Ennis (2001) reviews many of the Acts and regulatory changes that explain the evolution of the size distribution of banks in the United States. Moreover, O'hara and Shaw (1990) use an event study methodology and find that after the Comptroller of the Currency announced that some banks were TBTF (which implied complete insurance for their deposits) in September 1984, the equity value of these banks increased and there were negative effects for the shareholders of the ones not included. They also argue that this is not an isolated event, since the handling of the savings and loans crisis had similar results.

Having TBTF policies generate many distortions in the banking sector. Clearly, as Dewatripont and Tirole (1994) study, they worsen the moral hazard problem that is at the core of banking activity. Ennis and Malek (2005) argue that these policies also create size and risk distortions, which complement each other. This means that under these policies, banks have an incentive to become big and take on more risk. Acharya and Yorulmazer (2007) show that there is also an incentive for banks to correlate the risks of their investments. They show that if one bank can buy out another, this creates an incentive to reduce their correlation. However, if they both are bailed out when they fail and this is worth more than the value of one bank buying the other, banks will maximize their correlation.

Moreover, besides the direct problems caused by these policies, there are also externalities. As Chari and Kehoe (2013) emphasize, individual firms do not take into consideration the cost on other firms of having high debt levels. The more high debt firms there are, the bigger the cost of the bailout, and thus, the ones that do not need it, will have to face a higher level of taxes. This logic applied to the current case means that big banks do not internalize the cost they impose on the rest of the economy when they choose to hold little equity.

It is clear that there are many negative effects of holding TBTF policies that bail out big banks. However, the economic and political consequences generate huge pressure on governments to rescue big banks. As Chari and Kehoe (2013) demonstrate, there is a lack of commitment issue that leads to a time-inconsistency problem. This issue has also been studied by many others such as Farhi and Tirole (2012), Ennis and Keister (2009) and Gertler et al. (2012), who find that if banks believe that they will be bailed out, they will act accordingly and thus make rescues optimal.

In the model presented here, the effect of TBTF is a reduction in the equity levels that big banks have to hold. Since banks know they have access to bailouts most of the time they need them, they have little incentive to worry about their survival. This is consistent with figure 2.3. As soon as big banks realized that the government would not bail everyone out, they dramatically raised their capital levels. Small banks also increased their capital, but only to levels it had reached before, and quickly reduced them. However, big banks increased their ratios to amounts not seen in previous decades and maintained their levels there.

2.2 Model

2.2.1 Main Assumptions

The model is based on the competitive industry equilibrium framework of Corbae and D'Erasmo (2013) and Corbae and D'Erasmo (2014)[7] . However, the model in this paper differs in many substantial dimensions. Most importantly, equity is the key

[7] They use the static models of Boyd and De Nicolo (2005) and Allen et al. (2011) to generate a dynamic model of the banking industry. They combine the Markov perfect industry equilibrium concept of Ericson and Pakes (1995) with the competitive fringe idea of Gowrisankaran and Holmes (2004) in order to generate an endogenous distribution of banks.

variable to answer the question addressed in the introduction. Thus, I do not include securities or other borrowing (such as fed funds) decisions and make equity a decision variable. Banks have to manage their equity holdings to absorb the losses they suffer and cannot refinance afterwards or use their securities as collateral. Moreover, the interaction between the big and small banks is assumed to be competitive to simplify the analysis.

Time is discrete and there are two types of banks, big and small, which are risk neutral. In terms of their balance sheet, each individual bank chooses how many loans to give, how many deposits to accept and how much equity to hold. Each loan and deposit is worth one unit and they expire after one period. This last assumption simplifies the problem by not dealing with maturity mismatch issues that generate liquidity risk[8] as in Mankart et al. (2014) and reduces the number of stock variables to track. Table 2.1 presents the simplified balance sheet of each bank.

Table 2.1: Simplified Balance Sheet

Assets	Liabilities
Loans (l)	Deposits (d)
	Equity (E)

Banks face a capital requirement to hold a minimum amount of equity over their risk-weighted assets. Similarly to Van den Heuvel (2008)[9] , loans are the only type of asset in the model and they have a weight of 100 percent, so banks need a level of equity that is bigger than or equal to ϕ times the loans given in the current period.[10]

[8] Shin (2009) and Duffie (2010) argue that wholesale funding runs (creditors are unwilling to roll over their short term loans) were an important component in the troubles of many financial institutions, even big ones such as Northern Rock, Bear Stearns and Lehman Brothers.

[9] It that model, there is also a choice for the level of riskiness of the loans. However, given the assumptions of the convexity of the risk, Van den Heuvel states a sufficient condition for banks always choosing the safest possible loans. A similar argument could be used here to claim that banks cannot choose any additional diversifiable risk, since it is not compensated by the market and they are left with the best alternative possible.

[10] Elizalde and Repullo (2007) develop a model in which they include the single-risk factor model of Vasicek (2002) that is used for determining the capital required under the internal ratings based approach of Basel II. Switching from the standard regulation to the internal ratings based approach requires a bank to meet many requirements, like having a specialized modeling unit, so small banks do

To meet the capital requirement and to assure their franchise value, banks raise new capital at the beginning of each period which increases their accumulated equity. However, they cannot recapitalize after profits are known at the end of the period as in the models of Repullo (2013) and Repullo and Suarez (2013), which assume that there are capital market imperfections that prevent banks from raising new capital. In contrast, Cooley and Quadrini (2001) model issuing new equity to cover losses as a linear function cost. In the present model, it is assumed to be prohibitively costly. This more extreme assumption can be thought of representing a crisis, where the available funds are limited.

This assumption is also consistent with the debt overhand issue studied by Myers (1977). If the bank has too much debt to pay off, it will not raise new capital even if it will finance profitable projects that would reduce its burden. This is because those investments would only benefit current debt holders. Moreover, raising capital might be seen as a signal that the bank is in trouble. As in Myers and Majluf (1984), issuing equity might be seen as a signal that managers believe it is overvalued, so this would reduce the stock price. Finally, Hanson et al. (2011) mention that banks prefer to reduce their lending instead of raising new equity. This behavior is particularly noticeable when a crisis has started and investors are less willing to recapitalize a bank.

In order to focus more on the equity and asset decisions, the deposits are simplified. This is similar to Zhu (2008) in which the model does not take into consideration competition for deposits. The elasticity of deposit supply is assumed to be infinite, depositors are risk neutral and their reservation return is the risk-free rate. Van den Heuvel et al. (2006) also has a model where there is perfect access to deposits. This assumption allows us to center in the banks' lending behavior[11] , without taking into consideration the deposit effects. Every period, banks can accept deposits up to a certain capacity constraint given exogenously to each type of bank.

In contrast to the model in Zhu (2008), here there is a deposit insurance that covers perfectly all deposits. Thus, deposit rates do not need to include a risk premium based

not have access to it. To use this approach, a bank needs to estimate their loan's probability of default, the loss given default, the exposure to systematic risk and include the confidence level that the regulator imposes (capital required to cover losses due to loan defaults with this probability).

[11] The macroeconomic implications of bank lending are referred to as the bank lending channel, developed in Bernanke and Blinder (1988) and in Kashyap and Stein (1994) among others.

on their probability of default. This helps generate the moral hazard faced by banks. This problem arises because if the results are negative enough that the equity cannot cover all the losses, the remainder is paid by the deposit insurance fund. Therefore increasing the investment in risky assets improves the return to shareholders if the results are good, while not worsening them if they are bad. The deposit insurance creates a situation similar to a put option.

This is especially revleant when the bank is in stressful situations (like facing a recession with small capital reserves), since the probability that the equity can cover the losses is lower. This creates a pervasive incentive to take on as much risk as possible, since the probability of defaulting is already high. However, having this deposit insurance has positive effects for the economy. Diamond and Dybvig (1983) build a model where banks provide liquidity and panic induced bank runs can occur. They show that deposit insurance can prevent runs, which are socially undesirable. In this case, illiquidity of assets is the reason for having banks in the economy and the possibility of runs.

With respect to the TBTF policies, I model them similarly to what Boyd and Gertler (1994) described. The focus is to shelter big banks from loan losses. Although not explicitly stated in the model, it can be thought of as direct subsidies or generous discount window services. It is key to highlight that the bailouts only benefit big banks. The probability of receiving the transfer depends on the state of the economy and if the bank will be below the regulatory minimum or not. Moreover, each time the economy enters into a bad state, there is a probability μ that the recession becomes a "systemic crisis" for banks. If this happens, the government will not bailout the bank. This reflects the fact that the government will also be hit by the crisis, so their resources will be lowered. Also, since it is systemic, the government cannot help every single big bank, so it will let some go out of business.

Finally, the model also features borrowers' decision making processes. As in Corbae and D'Erasmo (2014), borrowers are risk neutral and every period they receive a shock that determines their outside option to requesting a loan, which is private information. This helps generate more uncertainty on the banks, so they cannot perfectly predict the demand for loans and gives it a negative slope. Also, there is a risk-shifting effect. If banks charge a higher interest rate, borrowers will choose an investment R that promises a higher return but faces higher risk. Both the probability of success and the return borrowers get are affected by an aggregate shock that determines if the economy is in a good or bad state.

The timing of the decisions is as follows.

1. Banks start each period with their accumulated level of equity (E), information about the previous period's aggregate productivity shock (z) and knowledge about the current number of banks ζ_t.

2. Borrowers draw their opportunity cost (ω).

3. Banks choose how many unit loans (l) to extend, how many deposits (d) to accept and how much new equity (e) to raise. Borrowers choose their investment technology (R).

4. This period's aggregate productivity shock (z') and the individual borrower's probability of success shocks are realized.

5. Entry and exit decisions are made.

2.2.2 Banks' Problems

Each incumbent bank's problem is similar to the model presented by Zhu (2008). The incumbent small bank's problem consists of choosing loans l, deposits d and new equity e to maximize the expected discounted value of dividends.

The value of the bank at the start of each period is given by

$$V^s(E,\zeta,z) = \max_{l\geq 0, d\in[0,\lambda^s], e\geq 0} \beta E_{z'|z} W^s(l,d,e,E,\zeta,z') \tag{2.1}$$

s.t.

$$E + d \geq l \tag{2.2}$$

$$E \geq \phi l \tag{2.3}$$

where $W^s(l,d,e,E,\zeta,z')$ reflects the value at the end of the period. Equation 2.2 shows the balance sheet restriction. A bank cannot have assets that are bigger than their liabilities. However, a bank can choose to have a lower level of loans than its available funds if, for example, it is close to violating the capital restriction (given by equation 2.3). ϕ is a parameter set by the regulators to protect banks from losses.

The value at the end of the period depends on the continuing ($x = 0$) versus exiting ($x = 1$) decision, as depicted in the following equation.

$$W^s(l, d, e, E, \zeta, z') = \max_{x \in \{0,1\}} \left[v^{s,x=0}(l, d, e, E, \zeta, z'), v^{s,x=1}(l, d, e, E, \zeta, z') \right] \tag{2.4}$$

If the bank chooses to stay, they get this periods dividends plus the continuation value, both of which occur at the end of the period.

$$v^{s,x=0}(l, d, e, E, \zeta, z') = \left\{ D^s(l, d, e, \zeta, z') + V^s(E', \zeta', z') \right\} \tag{2.5}$$

s.t.

$$\begin{aligned} D^s(l, d, e, \zeta, z) &= \max\{\pi^s(l, d, e, \zeta, z'), 0\} && (2.6) \\ E' &= E + e + \min\{\pi^s(l, d, e, \zeta, z'), 0\} \geq 0 && (2.7) \\ \zeta' &= H(z, z', \zeta) && (2.8) \end{aligned}$$

Dividends $D^s(l, d, e, \zeta, z)$ are bounded by zero because of the assumption of no re-capitalization made in the previous section.

Equation 2.7 shows the evolution of the accumulated equity at the end of the period. It takes into consideration the accumulated equity at the start, plus the new equity raised minus the losses experienced. The min operator represents the fact that in this model there is no reinvestment of utilities in the bank.

It is important to highlight that this equation represents the loss absorption role of equity in the model. The imposition of it being bigger or equal to zero is also part of the regulation of the banking sector. As Elizalde and Repullo (2007) mention, there are two main regulation instruments in the U.S. banking system. The first one is the minimum capital requirements a bank must hold, represented by equation 2.3. Second is the prompt corrective action (PCA) provisions of the Federal Deposit Insurance Corporation Improvement Act (FDICIA), which allows the government to close a bank if at the end of a period it is considered undercapitalized. In this case, I consider reaching a level of zero grounds for closing the bank.

The third restriction corresponds to the evolution of the cross-sectional bank size distribution. This gives the new industry distribution. The number of banks entering and exiting is determined endogenously in equilibrium.

Profits are given by

$$\begin{aligned}\pi^s(l,d,e,\zeta,z') &= \left\{p(R,z')(1+r^L)+(1-p(R,z'))(1-\lambda)-c^s\right\}l \\ &\quad -(1+r^d)d-(1+\epsilon)e-\kappa^s \end{aligned} \tag{2.9}$$

$p(R,z')$ represents the probability of failure for a borrower's project. This depends on the investment choice R and the aggregate shock to the economy z' that is realized at the end of the period. If the project is successful, the bank earns $1+r^L$ and if it fails, it gets back $1-\lambda$ which is what is left of the investment. λ represents the loss given default parameter.

There are also marginal costs to loans given by c^s. Furthermore, banks have to pay interests on deposits r^d. If the bank wants to raise more capital, it has to pay a cost of ϵ per unit of new equity. Finally, there are fixed costs to operate, given by κ^s.

On the other hand, if the bank chooses to exit, their value is

$$v^{s,x=1}(l,E,\zeta,z') = \max\left\{(1-\tau)(\pi^s(l,d,e,\zeta,z')+E'),0\right\} \tag{2.10}$$

There is limited liability, so the value is bounded by zero. This is a key element in generating the moral hazard problem for banks. Moreover, there are liquidation costs given by the parameter τ. At the end of the period, banks get the accumulated equity net of the profits, minus the τ percentage that is lost in the liquidation process.

The small bank entrant's problem consists of raising equity to enter, given the current amount of banks and the aggregate shock to the economy.

$$V^{s,e}(\zeta,z) = \max_{E'} \beta\left\{-E'+E_{z'|z}V(E',\zeta',z')\right\}-\Psi^s \tag{2.11}$$

Ψ^s represents the entry cost.

For a big bank, the problems are similar, except for the differences in the indexed parameters and the existence of the TBTF policy. First of all, the concept of being big in this model is having a higher deposit constraint, which is given by $\lambda^b > \lambda^s$. This implies that a big bank has more funds to increase their loans. Implicitly, by giving more loans, a big bank is also better diversified from the individual shocks of each borrower, since they are independent.

The key difference is the TBTF policy $\theta(\mu, l, e, E; \phi)$. The idea is that this function determines whether or not a bank will have its obligations dealt with by the government. If this function is one, this means that the losses have to be all absorbed by the bank's equity. However, if it is zero, the bank's equity is not changed.

$$E' = E + e + (1 - \theta(\mu, l, e, E; \phi)) \min\{\pi^b(l, d, e, \zeta, z'), 0\} \geq 0 \tag{2.12}$$

The bail-out policy has the following distribution:

$$\theta(\mu, l, e, E; \phi) = \begin{cases} 0 & \mu = 1 \text{ } or \text{ } (E + e + \min\{\pi^b(\cdot), 0\})/l > \phi \\ 1 & o.w. \end{cases} \tag{2.13}$$

In order for the TBTF policy to be deactivated, it has to be the case that either there is a systemic shock present or the bank can absorb the shock with its equity and still be above the required risk-weighted capital ratio.

The idea is that this shock worsens the bad state of the economy. The systemic shock μ follows a Bernoulli distribution with mean $\bar{\mu}$ conditional on $z = z_g$ and is 0 otherwise. This represents the fact that the government has fewer resources during the crisis and there are many big banks who need help, so the government cannot help all of them.

2.2.3 Borrowers' Problem

The individual borrower's problem is represented by the following maximization

$$v(r^L, z) = \max_R E_{z'|z} \left[p(R, z')(z'R - r^L) \right] \tag{2.14}$$

A borrower will choose the investment R such that it exceeds the cost of taking out the loan r^L. This return is also affected by the state of the economy.

However, the higher the level of R, the lower the probability of success. This represents the risk-reward investment decision. This probability is also affected by the aggregate shock, with the good state increasing the chance of success and the bad one decreasing it.

Total loan demand is given by the number of borrowers who find it profitable to ask for a loan. There are N borrowers who compare the optimal value of getting the loan $v(r^L, z)$ to their opportunity cost drawn from the distribution Ω.

$$L^d(r^L, z) = N \int_{\underline{\omega}}^{\overline{\omega}} 1_{\{v(r^L,z)\geq\omega\}} d\Omega(\omega) \tag{2.15}$$

2.2.4 Equilibrium

Given the regulatory parameter ϕ, a Competitive Industry Equilibrium consists of the functions v, R representing borrower behavior, $V^i, l^i, d^i, E^{i\prime}, x^i$ representing bank behavior for small and big banks $i \in s, b$, an interest rate r^L charged for loans, an industry state (number of banks) ζ, and a mass of entrants M such that

- Given r^L, v and R solve the borrower's problem.
- Given the loan demand, $V^i, l^i, d^i, E^{i\prime}$, and x^i satisfy the banks' problems.
- The free entry condition is met $V^e(z) = 0$.
- The law of motion for the industry state ζ is consistent with entry, exit and equity decision rules.
- r^L clears the loan market.

2.3 Calibration

In order to solve the model, I use the algorithm proposed by Corbae and D'Erasmo (2014), which is based on the work of Krusell and Smith (1998). The following calibration is based on Corbae and D'Erasmo (2014) as well.

The stochastic process for the borrower's outside option $\Omega(\omega)$ is an uniform distribution over $[\underline{\omega}, \overline{\omega}]$. For the stochastic process of each of the borrowers' projects, an additional variable y is defined. Let $y = \alpha z' + (1-\alpha)\epsilon_e - bR^\nu$, where $\epsilon_e \in N(\mu_\epsilon, \sigma_\epsilon^2)$ which is i.i.d. across agents. The probability of success is then given by the probability of $y > 0$. Thus, $p(R, z') = \Phi\left(\frac{\alpha z' - bR^\nu}{(1-\alpha)}\right)$. Finally $F(z', z)$ is constructed using NBER recession data. An indicator function takes the value of one if two or more quarters in any given year are labeled as a recession. Then, the positive values of the indicator are associated with the bad states of the economy z_b and the other observations with the good state z_g. A transition matrix is calculated using the maximum likelihood estimator.

Table 2.2: Parameters Calibrated to Corbae and D'Erasmo (2014)

Parameters		Value
Failure dist. mean	μ_e	-0.85
Failure dist. volatility	σ_e	0.059
Agg. shock weight	α	1.62%
Success prob. coeff.	b	3.773 %
Success prob. elast.	ν	0.784
Agg. shock in bad state	z_b	0.969
Marginal cost b	c^b	1.62%
Marginal cost s	c^s	1.60%
Transition	$F(z_g, z_g)$	0.86
Transition	$F(z_b, z_b)$	0.43

The following parameters are also calibrated.

Table 2.3: Parameters Calibrated Other Sources

Parameters		Value	Source
Mass of borrowers	N	1	Normalization
Agg. shock in good state	z_g	1	Normalization
Min. reservation value	$\underline{\omega}$	0	Normalization
Deposits big banks	λ^b	0.62	Share of deposits of big banks
Capital requirement	ϕ	6%	Basel II - FRB
Deposit rate	r^d	0.85%	Int. Expense
Loss given default	λ	22%	Charge-off rate
Discount	β	0.95	Zhu (2008)
New-Equity premium	ϵ	30%	Zhu (2008)

In this case, I am using six percent as the regulatory value since big banks are not in risk of becoming undercapitalized. Also, both types of banks are on average considerably above this value, as shown in the introduction.

To simplify the problem, only one big bank is modeled. This becomes a representative big bank. The big bank entrant problem then becomes as follows. If there is one big bank active, the cost of entry is infinite and if there is no big bank in the economy, the mass of potential entrants is just one. Therefore, no calibration is needed to find the fixed cost for big banks.

The remaining parameters are estimated by Simulated Method of Moments. The moments chosen are presented in the following table.

Table 2.4: Moments

Moments	Data	Model
Default freq.	2.33%	2.92 %
Fixed cost over loans - big	1.08%	2.44 %
Fixed cost over loans - small	2.29%	3.10 %
Entry rate for small banks	1.49%	1.06 %
Exit rate for small banks	0.36%	1.04%
Equity to asset ratio - big	9.70 %	6.76 %
Equity to asset ratio - small	14.59%	12.15 %

Table 2.5: Estimated Parameters

Parameters		Value
Mean systemic shock	$\bar{\mu}$	0.104
Max. reservation value	$\overline{\omega}$	0.452
Liquidation cost	τ	0.588
Fixed cost - big	κ^b	0.230
Fixed cost - small	κ^s	0.004
Entry cost - small	Ψ^s	0.010

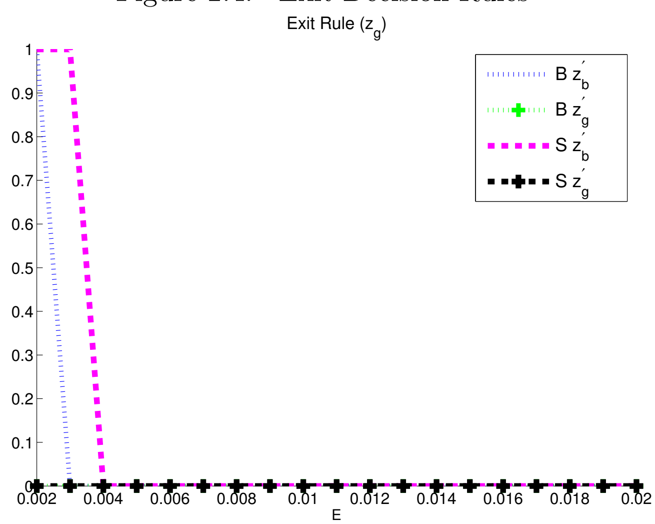
The key parameter is the mean of the systemic shock. This means that about one in ten recessions becomes a systemic crisis. The low probability of not having bailouts contributes to the big bank's decision of not raising equity to levels that would allow them to survive the crisis.

2.4 Results

On this section, I highlight the main results of the model. First of all, I present the two key decision rules that develop the intuition of the model.

Figure 2.4 show the exit decision rule for big and small banks starting from a good period (z_g) in the economy. It is clear that neither of the two types will default if the following period is also good. However, for very low values of accumulated equity, both will consider to exit. Small banks have lower franchise values, so they will also consider exit with more accumulated equity than big banks.

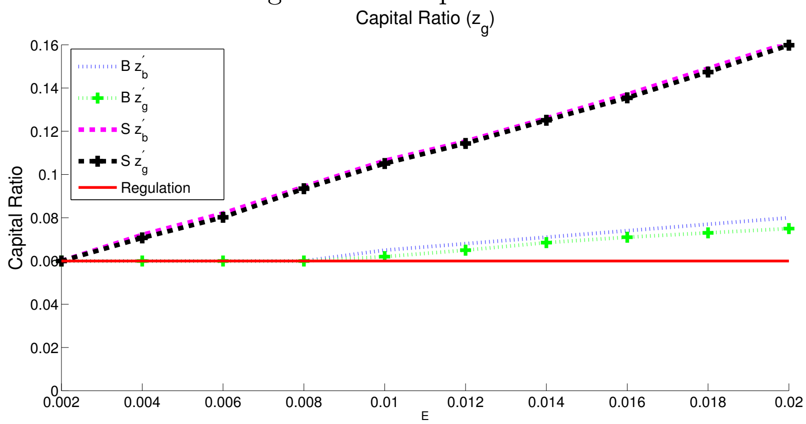
Figure 2.4: Exit Decision Rules



The next figure presents the capital ratio for the two types of banks, again starting from a good period. Big banks take advantage of their position by accumulating less equity in cases where the next period is either good or bad. Small banks do not change their behavior much if the future the economy is in a good state or not, but big banks do have a small difference. This figure resembles the findings of figure 2.3.

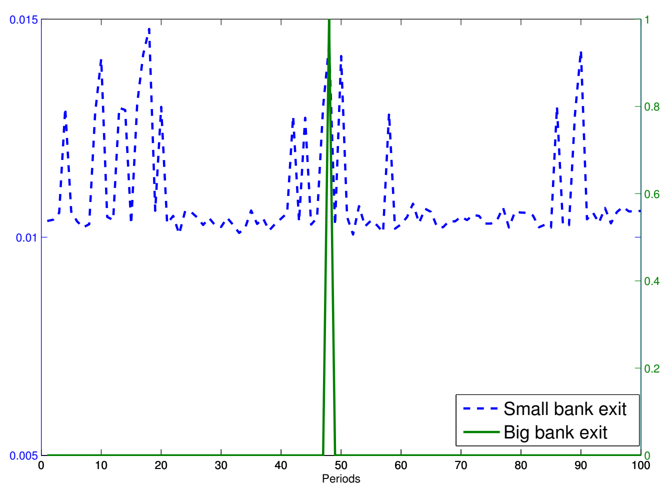
Finally, I present the results of a simulation of the last 100 periods of a 500 period run. There are 18 recessions in this sample and only one of them became a systemic crisis. The right hand side of the y axis represents the rates for the big bank and the left hand side, for the small banks. Exit rates rise with the occurrence of negative shocks

Figure 2.5: Capital Ratio



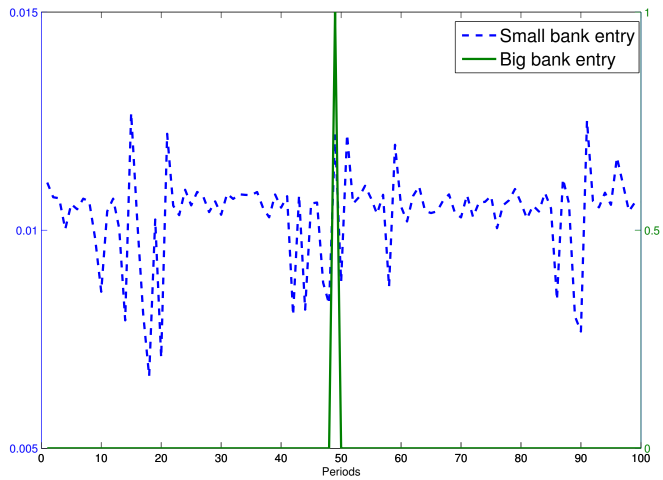
to the economy. The exit rate of small banks does not change drastically with the the systemic crisis since in the model, this only affects directly big banks.

Figure 2.6: Simulated Exit Rates



Since there is only one big bank, the exit rate is 100 percent when it leaves. However, as it can be seen in figure 2.7, the next period right after the exit, a new big bank enters. This is because the franchise value of a big bank is high. Therefore, even if the number of big banks was not restricted to one, there would be an increase in the entry rate of both types of banks after the exit of a big bank.

Figure 2.7: Simulated Entry Rates



2.5 Concluding Remarks

In this paper, I have tried to answer the question of why so many big banks exited during the recent financial crisis. The data shows a link between being big and holding significantly lower levels of risk-weighted capital than small banks. I propose that an important element to explain this behavior is that big banks rely on bailouts from TBTF policies to save on accumulating expensive equity.

However, if the economy experiences a systemic shock, the government is not going to be able to save all of them. Therefore, big banks are left vulnerable because they have accumulated too little capital to survive the systemic crisis on their own. The calibrated model shows that approximately one in ten recessions will become systemic, so banks do not take the necessary precautions because the probability of occurrence is low.

As stated in the introduction, big banks do not fail because they are close to the regulatory limits. They generate buffers to avoid being close to these imposed constraints. Thus, a clear policy would be to increase the limits high enough to help most banks survive even a systemic crisis. Moreover, as Chari and Kehoe (2013) mention, regulation that limits debt level also alleviates the externalities created by the lack of commitment of the government with respect to its bailout policy.

This view is supported by Hanson et al. (2011), who find that the regulatory minimum that exists is not enough. Using estimations from the IMF (2010) report, they calculate that the minimum ratio of equity to assets should be 15 percent to have endured the recent financial crisis. However, this is considerably higher than the current requirements, which are based on microprudential considerations. Moreover, they argue that the effects of increasing the equity level would not be significant, since the risk premium it has would decline as leverage decreases. This effect is shown empirically to hold in Kashyap et al. (2010). Moreover, in the model of Begenau (2014), the capital requirement has to be set as high as 14% to maximize welfare.

On the other hand, Van den Heuvel (2008) finds that there is a large welfare cost of imposing capital requirements, which is comprised of a permanent loss in consumption between 0.1% and 1%. He stated that the already low levels of bank failures could be achieved by increasing supervision spending and having lower levels of capital requirements. However, this view does not consider macroprudential concerns.

Therefore, this paper brings arguments in favor of the implementation of Basel III (Basel Committee on Banking Supervision (2010)) rules by the US Department of Treasury, Federal Reserve System, and the Federal Deposit Insurance Corporation.[12]

The increase to a minimum of six percent for the risk-weighted capital ratio and the inclusion of a capital conservation buffer and a countercyclical buffers[13] are key elements to better protect big banks to face systemic crises and force them not to rely on TBTF policies.

[12] FDIC 2012-08-30 proposed rule

[13] The capital conservation buffer adds 2.5 percent to the risk-weighted capital ratio buffer and the countercyclical buffer can add up to another 2.5 percent during times of high credit growth.

Chapter 3

Banking Heterogeneity and the Bank Capital Channel in the Great Recession

3.1 Introduction

The Great Recession has incentivized the exploration of banking issues and the influence banks have on the economy as a whole. However, most of the literature on banking has taken banking as a homogeneous sector, an implied element, or a friction. In this paper, I model banks explicitly and propose that banking heterogeneity is a key element in the discussion of the recent crisis.

Linked to this banking heterogeneity is the Too-Big-To-Fail (TBTF) set of policies. These are aimed at safekeeping banks that are considered to be of systemic importance. In the previous chapter, I argued that these policies were vital to understanding the banking sector's dynamics. In that paper, I modeled the negative side of TBTF policies, which is the moral hazard they create by allowing big banks to hold less equity than they would have without them.[1]

[1] Other works that highlight the moral hazard issue are Dewatripont and Tirole (1994) and Stern and Feldman (2004). Time inconsistency problems are studied in Chari and Kehoe (2013) and Farhi and Tirole (2012).

Now, I extend this line of research to a general equilibrium model to see the macroeconomic effects of TBTF policies during the Great Recession. The objective of this paper is to analyze the effectiveness of TBTF policies in reducing the impact of a negative banking shock of the economy and the welfare implications this creates. In other words, I want to evaluate whether TBTF policies helped soften this negative shock and who were positively and negatively affected by them, taken as given the existence of the TBTF policies.

The main framework for this model is based on Iacoviello (2005) and Iacoviello (2015), which allows the study of banking behavior in detail and the role of collateral and other frictions. I extend this basis to include banking heterogeneity, combining it with TBTF policies and making the banking capital channel explicit. There are five distinct representative agents: 1. A patient household that works and makes deposits. 2. An impatient household, which works and borrows from both types of bankers, big and small. 3. An entrepreneur that produces and borrows from bankers. 4. A big banker, who decides how much to lend, how many deposits to accept and how much equity to accumulate. In addition, they have a TBTF policy that protects them from losses. 5. A small banker, who faces the same problem as the big banker, but who cannot rely on the TBTF policy.

In my model, the mechanism works through the bank capital channel, which has been studied before by Van den Heuvel et al. (2006), Gambacorta and Mistrulli (2004) and Meh and Moran (2010). The basic idea is that bankers, both small and big, suffer a negative shock on their profits. Small bankers have to contract their assets in order to meet capital requirements and reduce exposure to further loses. Big bankers, on the other hand, are protected by TBTF policies, so they are able to sustain higher asset levels and not contract as much. This in turn helps the economy to recover sooner, which has a positive effect on small banks and firms. However, households have to bear the cost of financing the TBTF transfer.

After estimating the model with Bayesian techniques, I find that the economy is not as negatively affected under TBTF system from a negative shock to the bankers' profits, compared to a counterfactual case where there are no policies to protect big banks. This does not mean TBTF policies are always desirable, since they induce moral hazard issues. However, once instated, they work through a bank capital channel to help the recovery of the economy. With respect to welfare, big banks are the main beneficiaries, along with firms and to a lesser degree small banks, whereas households are worse off in general. Even though they will benefit from the quicker improvement of the economy, they have to face the direct cost of supporting the big banker through the period of losses. The patient household is not as affected as the impatient. Even though the impatient household benefits from the relaxing of the collateral constraint, the amount of the lump-sum transfer they have to pay affects them more because they receive a smaller share of the wages.

The rest of the paper is structured as follows. Part 2 mentions many strands of the literature I combine in this paper. Part 3 describes some important definitions and the relevant empirical motivation. Then, part 4 discusses the model and its main assumptions. Afterwards, part 5 goes through the estimation and the main results. Finally, in part 6 I provide some concluding remarks.

3.2 Motivation

3.2.1 Main Definitions

In order to explain the motivation, I shall first define some relevant concepts. This section is similar to the one in the first chapter, as the initial motivation is shared by both. The first definition is that of the Tier 1 risk-weighted capital ratio or risk-based capital ratio (RBCR)[2] .

$$RBCR = \frac{Tier\ 1}{Risk - Weighted\ Assets} \tag{3.1}$$

This is one of the measures that financial regulators observe to assess the strength of a bank. Moreover, this ratio is linked to the capital requirements set by the Bank for International Settlements (BIS) in the now called Basel II agreement (Basel Committee on Banking Supervision (2004)).

[2] According to the Federal Deposit Insurance Corporation (FDIC) implementation, tier 1 includes common stock and retained earnings, whereas preferred stocks being part of the additional tier 1 capital (https://www.fdic.gov/regulations/resources/director/RegCapIntFinalRule.pdf). Moreover, risk-weighted assets are the result of the multiplication of the bank's asset classes by weights that represent their riskiness. (https://www.fdic.gov/news/news/financial/2012/fil12027.pdf).

As Angeloni and Faia (2013) mention, the objective of these requirements is to guarantee a certain degree of individual bank solvency. However, this does not protect the financial system as a whole from systemic disturbances, as the Great Recession proved. Hanson et al. (2011) mention this focus on protecting banks from idiosyncratic shocks was motivated by microprudential concerns, which did not take into account the interconnections of financial agents and their influence on the economy.

Moreover, there have been many discussions with respect to the implementation of Basel II. Many have argued that these regulations have had pro-cyclical consequences (ex. Kashyap and Stein (2004) and Repullo and Suarez (2013)). Others have argued about what the optimal level the required RBCR should be (see Van den Heuvel (2008) and Begenau (2014)).

Many of these concerns have been addressed in the newest revision of the Basel Accord, called Basel III (Basel Committee on Banking Supervision (2010)). For instance, the inclusion of a capital conservation buffer and a discretionary counter-cyclical buffer help mitigate many of the issues experienced by the banking industry. However, this paper is concerned with a time period before these new set of policies were included (1992 to 2014), so the main focus in terms of understanding the data and modeling this constraint is based on the Basel II framework.

A second important consideration is what should be considered as a big bank.[3] The real objective is to identify what banks are of systemic importance to the economy. However, there is no clear definition of what can be considered as systemically important, since it may involve many different dimensions. For example, a bank that provides a unique and vital service to the financial industry can be considered systemic. On the other hand, a bank that is interconnected with many other financial institutions and producing firms could also be considered systemic. Therefore, size in terms of assets is usually used as a proxy. The idea is that variables such as interconnectedness and specialization of services are positively correlated with size.

Next, there is the problem of establishing a cuttoff point in the asset distribution to classify big and small banks. For instance, Corbae and D'Erasmo (2013) classify banks as Top 10, Top 1% (excluding those included in the first category) and Bottom 99%.

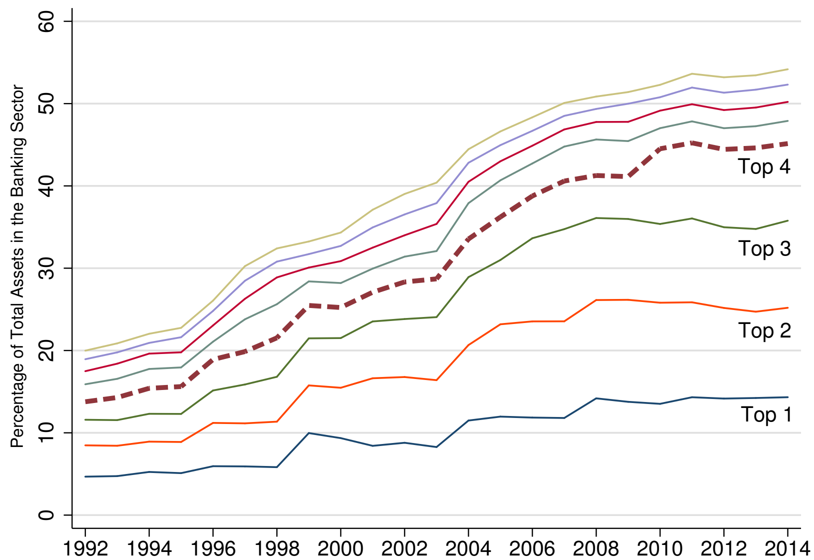
[3] There is an important distinction between investment and commercial banks, but since the financial crisis, the biggest investment banks either disappeared, were absorbed by commercial banks or incorporated as commercial banks. Thus, the distinction between the two is less relevant.

There is an advantage to use a fixed number of banks, because this does not depends on changes in the asset distribution. On the other hand, Duffie (2010) talks about major dealer banks, which are financial firms that act as intermediaries between securities markets and over-the-counter derivatives, usually providing wholesale financial services. In this paper, I define big banks as the top four in terms of total assets. This is not a static category, as the individual banks that are considered big have changed over time, though most of them remain the same for long periods of the sample used. Currently, the top four spots correspond to JP Morgan Chase, Bank of America, Wells Fargo and Citibank.

There are several reasons for choosing this particular criteria. Mainly, as I will point out in the TBTF policy section, these four banks benefited greatly from this policy. In addition, each of the four banks represent much more to the cumulative asset distribution than the following ones. In other words, the marginal contribution to the total from the fifth bank and afterwards is not as meaningful. This can be observed in Figure 3.1. The gain from going from the fourth bank to the fifth is considerably less than that of the third bank to the fourth. From the figure, it seems this trend is likely to continue, which suggests a consolidation of the banking industry and make the top four banks even more relevant.

Finally, for the analysis, I wanted to have two economically meaningful groups. For example, using the top 100 banks as the big banks would mean that the small banks represent less than 1% of the total assets in the banking sector. Moreover, in order to avoid arguing that the big banks have access to different technologies or markets, I include considerably big banks in the small bank group. For instance, the 5th, 6th and so on banks are included in the small bank group, so it would be difficult to argue that they do not have the same technology and access as the 4th bank.

Figure 3.1: Top Banks According to their Assets

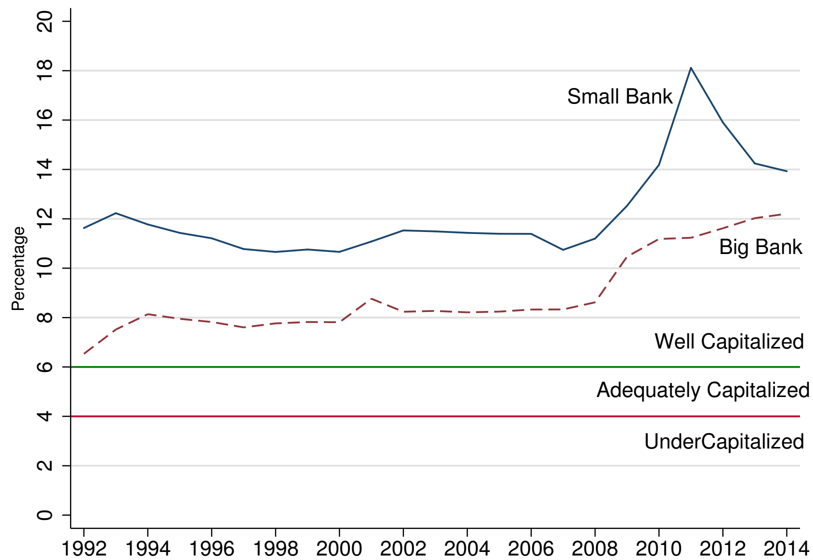


Source: Federal Deposit Insurance Corporation

3.2.2 Banking Heterogeneity

With these definitions in mind, the following graph shows the behavior between the so called big and small banks during the recent crisis. Figure 3.2 shows the asset-weighted average response of the risk-based capital ratio variable for the two groups. As can be seen, both big and small banks responded by increasing this ratio above the previous levels in the sample period.

Figure 3.2: Risk Weighted Capital Ratios



Source: Federal Deposit Insurance Corporation

However, the key issue is that the reason for the increase in both cases is quite different. Table 3.1 shows the rate of change of the elements of the ratio. For small banks, the increase came from a larger reduction in the denominator (the risk-weighted assets), rather than an increase in the numerator (Tier 1). This means that small banks had to contract their assets more than the losses in equity that they experienced in order to make their equity proportionally larger. In contrast, the source of the increase in the ratio for big banks is the opposite. Big banks did not suffer great equity losses, even though their growth rate did steadily diminish somewhat during this period. Thus, they did not have to contract their assets. In other words, the increase in their risk-weighted capital ratio was mainly due to an increase in the numerator, instead of a decrease in the numerator of the same magnitude as in the small banks.[4]

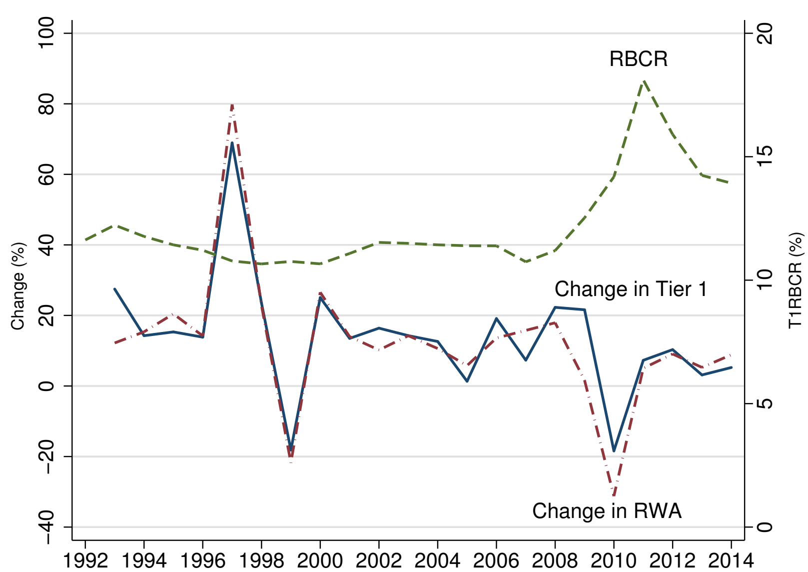
[4] Since I am using accounting information, the losses appear on 2010 because of the lag and timing used in the presentation of the losses.

Table 3.1: Changes in Equity and Assets

	Small Bank		Big Bank	
	Tier 1	RWA	Tier 1	RWA
2006	19.1	13.6	15.0	13.8
2007	7.3	15.8	14.3	14.4
2008	22.3	17.9	11.6	8.0
2009	21.6	1.6	15.1	-3.9
2010	-18.4	-31.2	7.1	1.6
2011	7.3	5.0	7.5	6.0
2012	10.3	9.1	4.2	0.7
2013	3.1	5.3	12.0	7.3
2014	5.2	8.9	11.0	9.5

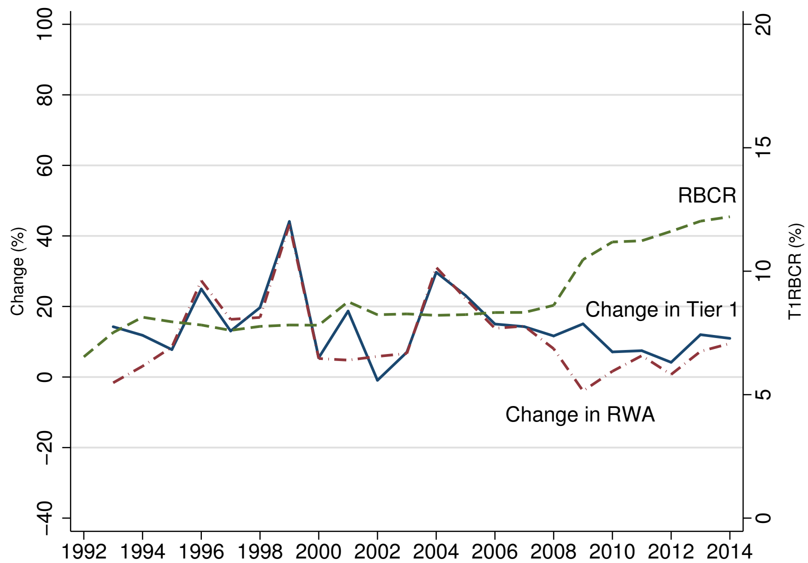
This can be illustrated as well by comparing these rates of change (measured in the left y-axis) against the ratio itself (measured in the right x-axis) for the last quarter of each year for the small bank in Figure 3.3 and for the big bank in Figure 3.4.

Figure 3.3: Tier 1 and Risk-Weighted Assets for Small Bank average



Source: Federal Deposit Insurance Corporation

Figure 3.4: Tier 1 and Risk-Weighted Assets for Big Bank average



Source: Federal Deposit Insurance Corporation

It is important to mention that this difference is not due to the type of technology or diversification of the portfolio. These are asset-weighted averages, so it includes and gives more importance to part of the top banks in the distribution. Thus, it is hard to argue that banks ranked from five to twenty in the small bank average had considerably different technologies or asset types than the top four. Another possibility is that this result was driven by many small banks failing. However, the small banks that went out of business had relatively small amounts of assets, so their effect is not considerable in the asset-weighted average. Finally, this result is also not mainly driven by changes in the composition of the bank's portfolio, ie. a switch from risky assets to less risky assets. Although there were shifts in the assets, this result holds as well when using total assets instead of risk-weighted assets.

I propose in this paper that this is linked to the existence of TBTF policies that favor the biggest banks in the economy. Moreover, while some of the banks considered as small did receive help of this type, if one of the top four would have needed more help, it would have the priority because of its systemic importance. This will be discussed in greater detail in the next section. This creates an expectation that is built into their behavior and how the market perceives them. The implicit guarantee of bailouts acts as a real protection.

In this paper, I do not model the rationale for this type of insurance. Usually this has relied on arguments like reducing the financial fragility, similar to the idea of deposit insurance, covered early in the literature by Diamond and Dybvig (1983). However, as noted earlier, the costs in terms of excessive risk-taking are important to consider.

3.2.3 Too-Big-To-Fail Policies

There is a vast literature studying the sources of fragility in the banking sector and the role of safety nets for it (see for example Rochet (2009) and Dewatripont et al. (2010) for a current perspective). However, this past financial crisis was meaningful in terms of the scale of the interventions and the varied types of policies deployed to deal with the banking sector and the economy in general.

Also, the government was not only focused on the financial markets, but also allocated resources to help kick start the economy. Taking into consideration the stimulus packages, the United States government poured $2.8 trillion into the economy, according to CBO estimates in 2010.

Table 3.2: Total Government Interventions during the Financial Crisis

Program	Billions of US Dollars
2010 Tax cuts	858
Stimulus (Obama)	787
TARP	700
Stimulus (Bush)	168
Other programs	162
Fannie Mae & Freddie Mac	151

Source: Congressional Budget Office (CBO)

Thus, the policy tools used during this period included more than just interventions in financial markets. What is particularly relevant to financial institutions is the Troubled Asset Relief Program (TARP) and the money invested in Fannie Mae and Freddie Mac.

The TARP was established by the Emergency Economic Stabilization Act of 2008 and later on was reduced to $475 billion, with the DoddFrank Wall Street Reform and Consumer Protection Act of 2010. The TARP itself can be divided into different beneficiaries. As Table 3.3 shows, auto companies and government programs were also part of the set of policies.

In order to focus on the policies that affected the financial system and, in particular, banking, we need to take a look at the programs involved in the TARP. The Capital Purchase Program (CPP) or Healthy Bank Program currently accounts for $205 billion. This was the main policy tool used to benefit banks. It worked through a preferred stock and equity warrant purchase[5] . In addition, to provide additional resources to Citibank and Bank of America, the Targeted Investment Program (TIP) was created. This accounted for an extra $40 billion. However, banks benefited from other programs as well.

Table 3.3: TARP Breakdown (as of 2015)

Beneficiary	Billions of US Dollars
Banks and other Financial Institutions	245.0
Auto Companies	79.7
AIG	67.8
Toxic Asset Purchases	18.6
Making Home Affordable	11.7
State Housing Programs	5.51
Others	0.4

Source: Source: U.S. Department of the Treasury

Besides the fact that there was a particular program to help two of the four banks I have grouped in the big bank category, the CPP primarily benefited the largest banks.

[5] See United States Government Accountability Office (2008).

Table 3.4: Amount Committed by CPP

Beneficiary	Billions of US Dollars
Bank of America	25.0
Citigroup	25.0
JPMorgan Chase	25.0
Wells Fargo	25.0
Goldman Sachs	10.0
Morgan Stanley	10.0
PNC Financial Services	7.6
U.S. Bancorp	6.6
SunTrust	4.9
Capital One Financial Corp.	3.6
Other institutions in the CPP (not only banks)	62.0

Source: Source: U.S. Department of the Treasury

Clearly, big banks were not the only ones to benefit from the programs. However, the data suggests that they were the main beneficiaries. In fact, the existence of TIP suggests that if the biggest banks needed more resources, they would have obtained them. Thus, the TBTF policies do not mean that only big banks get government help, but highlights that they are certainly the priority.

This is further confirmed when we take a look at the combined programs CPP and TIP for banks. Even when compared to their total asset levels, the amounts of the bailouts where proportionally bigger for the top four versus most of the smaller banks.

Table 3.5: CPP and TIP including Subsidiaries (billions USD)

Beneficiary	CPP	TIP
Bank of America	26.7	20.0
Citigroup	25.6	20.0
JPMorgan Chase	27.1	0
Wells Fargo	26.9	0
Goldman Sachs	10.0	0
Morgan Stanley	10.0	0
PNC Financial Services	7.6	0
U.S. Bancorp	6.7	0
SunTrust	4.9	0
Capital One Financial Corp.	3.6	0
Other Banks	53.0	0

Source: Source: U.S. Department of the Treasury

Several aspects of the TARP program are being studied. For example, Wilson (2012) argues that purchases of toxic mortgages and common stock from problematic banks are the most efficient way to bail out a bank suffering from debt overhang, whereas preferred stock recapitalizations are the least efficient. Veronesi and Zingales (2010) claim that the government interventions during the crisis were a net positive for the economy, by reducing the probability of bankruptcy of banks. Finally, it is worth mentioning that the U.S. government has actually turned a profit from the TARP and the Fannie and Freddie bailout. As of Oct. 21, 2015, it had made \$64.5 billion in profits[6] and many of the financial institutions paid the loans before their deadlines. Wilson and Wu (2012) find that executive pay restrictions and high levels of CEO compensation in 2008 were responsible for banks being more likely to exit TARP earlier.[7]

However, this is not the only source of support for the financial sector. As Acharya et al. (2009) argue, public interventions during the financial crisis can be classified into liquidity provision and bailouts or rescue packages. The first set of policies were handled by the Federal Reserve from August 2007 and included tools like open market operations, discount window, Term Auction Facility, Commercial Paper Funding Facility,

[6] https://projects.propublica.org/bailout/main/summary

[7] Goldman Sachs and Morgan Stanley both announced on September 22, 2008 that they would become traditional bank holding companies, with commercial banking operations.

etc.[8] However, these policies were not enough to stop the gradual worsening of the economy, and as argued by the authors, liquidity provision is not meant to solve a systemic solvency crisis. Thus, the center of this paper is on the bailout policies discussed previously.

The objective of the U.S. Treasury department was to strength of the balance sheet of financial institutions and their recapitalization. So, a key question is how to model all the programs discussed. In this paper, I model an equity injection that simplifies the analysis of the policies. It addresses the objectives of those programs, which are to solidify the financial position of the banks.

3.3 Model

The model is based on Iacoviello (2005) and Iacoviello (2015) with the inclusion of banking heterogeneity, a TBTF policy and an explicit equity accumulation decision. There are five infinitively lived different agents in the model: a patient household, an impatient household, an entrepreneur, a big banker, and a small banker. Each of them are of equal measure and will be represented by a representative agent of their type.[9]

Patient households supply work, demand housing, and deposit in the banks. Impatient households offer labor, demand housing, and get loans from the banks. They have a collateral constraint based on their housing stock for each bank. This generates a role for the small banker in equilibrium. The impatient household will always borrow as much as possible, so the big banker cannot completely cover the market. The same mechanism be in place for the entrepreneur's problem. They also face two collateral constraints, but these will depend on their capital stock. This is an important modeling contribution, as most models would have trouble explaining the existence of two banks that perform the same services in equilibrium. Other papers usually rely on

[8] The Federal Deposit Insurance Corporation (FDIC) also contributed by handling a loan guarantee scheme in which it guaranteed new issues of senior unsecured debt up to a maturity of three years for banks.

[9] Other formulations of the model have included only four agents. One option is to give the capital accumulation decision to the patient household. However, after a negative banking profit shock, it simply substitutes deposits for capital, which goes against the desired results. Thus, an additional constraint is needed to prevent this from happening. On the other hand, by eliminating the impatient household, I lose the connection to the housing market, so the results would be less relevant to the Great Recession.

relationship banking to explain this issue, so this is a distinct way of modeling banking heterogeneity.[10]

In addition, both types of households have to bear equally the burden of financing the TBTF policy. Thus, the government runs a balanced budget and acts as a transferring mechanism between the households and the big banker.

The entrepreneur produces, accumulates productive physical capital, hires labor for each type of household, and also demands loans from the banks. As mentioned before, the entrepreneur has two different collateral constraints, but based on the stock of capital it has accumulated.

Finally, there are the big and small bankers. These bankers provide loans, accept deposits, and accumulate equity to meet the capital requirements and balance sheet constraint. However, big bankers also have the TBTF policy. Furthermore, there is no growing in the sense that a small banker cannot become a big banker.[11]

3.3.1 Patient Household

The patient household's problem is as follows:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_P^t \left[\varepsilon_t^S \left(\log(C_t^P) + \varepsilon_t^H \gamma_H \log(H_t^P)\right) + \gamma_N \log(1 - N_t^P)\right] \tag{3.2}$$

subject to

$$C_t^P + q_t \Delta H_t^P + D_t = R_t^D D_{t-1} + W_t^P N_t^P - T_t \tag{3.3}$$

In the model, the patient household consumes C_t^P, values and accumulates housing H_t^P and works N_t^P, which provides them with a wage W_t^P, but generates disutility. ε_t^S represents an aggregate demand shock, which affects both consumption and housing, whereas ε_t^H is a shock to housing demand.

[10] See Boot (2000) for a survey on the relationship banking literature.

[11] As Wheelock (2011) note, the consolidation process in the banking industry accelerated during the past financial crisis. In the context of this model, this reinforces the idea that big bankers were in a better economic position than small bankers during this period. However, this paper does not address the concentration in the banking industry. Furthermore, there is doubt that there are economic benefits of this clustering process, since some empirical papers find no significant overall gains from bank mergers, see Houston and Ryngaert (1994).

The patient household also pays q_t if it wants to increase its stock of housing. It can also deposit D_t and get a return of R_t^D.[12] It does not differentiate between banks when making the deposit, since both offer the same rate. The logic behind this assumption is that policies like the Deposit Insurance Fund allow individuals to disregard the risk levels of the banks when considering where to deposit their money.[13]

Finally, the patient household has to pay T_t, which is a lump sum that will be transferred to the big bank in case of negative systemic financial shocks.

3.3.2 Impatient Household

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_I^t \left[\varepsilon_t^S \left(\log(C_t^I) + \varepsilon_t^H \gamma_H \log(H_t^I)\right) + \gamma_N \log(1 - N_t^I)\right] \tag{3.4}$$

subject to

$$C_t^I + q_t \Delta H_t^I + R_t^{IB} L_{t-1}^{IB} + R_t^{IS} L_{t-1}^{IS} = L_t^{IB} + L_t^{IS} + W_t^I N_t^I - T_t \tag{3.5}$$

$$L_t^{IB} \leq \varepsilon_t^L \theta^I \psi_I \mathbb{E}_t \left(\frac{q_{t+1}}{R_{t+1}^{IB}} H_t^I \right) \tag{3.6}$$

$$L_t^{IS} \leq \varepsilon_t^L (1 - \theta^I) \psi_I \mathbb{E}_t \left(\frac{q_{t+1}}{R_{t+1}^{IS}} H_t^I \right) \tag{3.7}$$

Similar to the patient household, the impatient household consumes C_t^I, demands housing H_t^I and works N_t^I. Moreover, they face the same shocks to preferences (ε_t^S) and to housing (ε_t^H).

Their budget constraint shows that they pay the same price q_t for their housing purchases as the patient household. They receive W_t^I from their labor and have to pay the same tax as the patient household T_t.

[12] Theoretically, the patient household could demand loans as well, however, to simplify the notation of the model, I will include only the deposit decision for the patient household and the demand for loans from the impatient household and entrepreneur.

[13] In general, this would mean that there is no need to risk-adjust the deposit rates paid by banks by the probability of going out of business. In my model, there is no exit decision by the banks, but their solvency could be measured by their equity levels and it could be extended to include risk-return portfolio decisions.

The main difference is that their discount factor β_t^I is low enough to make them want to borrow, instead of deposit. They have access to a line of credit from the big banker L_t^{IB} at a rate of R_t^{IB} and one from the small banker L_t^{IS} at a rate of R_t^{IS}. It is important to notice that, unlike the deposits, I allow the interest rates to be different. Since the impatient household is going to borrow as much as it can, the two bankers are not competing. Each of them will have all of its supply demanded, so they are free to charge different interest rates. Corbae and D'Erasmo (2013) provide evidence that shows that banking is not a competitive industry, supporting this assumption.

It uses its stock of housing as collateral to secure its borrowing. It cannot use the same collateral for both bankers, so there is a proportion of θ^I for the big banker and $1 - \theta^I$ for the small banker. ψ_I represents the loan-to-value ratio, which determines how much of the collateral is valued for granting the loan. Finally, there are shocks to these two collateral constraints, given by ε_t^L. These represent changes in the valuation of their housing.

3.3.3 Entrepreneur

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_E^t \left[\log\left(C_t^E\right)\right] \tag{3.8}$$

subject to

$$C_t^E + K_t + R_t^{EB} L_{t-1}^{EB} + R_t^{ES} L_{t-1}^{ES} = Y_t - W_t^P N_t^P - W_t^I N_t^I + L_t^{EB} + L_t^{ES} + (1-\delta) K_{t-1} \tag{3.9}$$

$$L_t^{EB} \leq \theta^E \psi_E K_t \tag{3.10}$$

$$L_t^{ES} \leq (1-\theta^E) \psi_E K_t \tag{3.11}$$

where

$$Y_t = \varepsilon_t^Z \left(K_{t-1}\right)^{\alpha} \left[(N_t^P)^{\mu} (N_t^I)^{(1-\mu)}\right]^{1-\alpha} \tag{3.12}$$

The representative entrepreneur[14] consumes C_t^E, accumulates physical capital K_t and takes on loans from big banks and small banks, L_t^{EB} and L_t^{ES} respectively. The entrepreneur pays R_t^{EB} and R_t^{ES} for such loans to the big banker and small banker and is subject to collateral constraints, similar to the impatient household. Moreover, he is also impatient to the point of using all the credit lines given. The difference is that he uses his productive capital as the collateralized asset.

He can pledge a portion θ^F of his capital to the big banker and the rest, $1 - \theta^F$, to the small banker. ψ_F is a parameter that denotes the loan-to-value ratio that sets the maximum amount of the entrepreneur's loans.

On the production side, Y_t is a Cobb-Douglas function of capital and the two types of labor.[15] α is the total capital share in the production and the μ term represents the relative size of each type of household in terms of labor. It is also subject to a productivity shock, ε_t^Z.

3.3.4 Big Banker

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_B^t \left[\log\left(C_t^B\right)\right] \tag{3.13}$$

subject to

$$\begin{aligned} & C_t^B + L_t^{IB} + L_t^{EB} + \Delta E_t^B \\ & = \pi_t^B\left(\varepsilon_t^B, L_{t-1}^{IB}, L_{t-1}^{EB}, D_{t-1}^B\right) + D_t^B + TR\left(\varepsilon_t^B, L_t^{IB}, L_t^{EB}\right) \end{aligned} \tag{3.14}$$

$$\frac{E_t^B}{\left(\chi_I L_t^{IB} + \chi_E L_t^{EB}\right)} \geq \varphi_B \tag{3.15}$$

$$E_t^B + D_t^B \geq L_t^{IB} + L_t^{EB} \tag{3.16}$$

[14] I use the denomination entrepreneur instead of firm to highlight the fact that the agent consumes and has a utility function to maximize, instead of the typical risk-neutral profit maximizing production.

[15] As Iacoviello and Neri (2010) mention, the complementarity between labor types assumption has the benefit of making the problem analytically more tractable. Moreover, they do not find that assuming substitutability between the two types provides considerably different results and it introduces unnecessary complexity between borrowing constraints and labor supply decisions. In addition, Rubio and Carrasco-Gallego (2014b) motivate this modeling choice as representing the idea that savers are older than the borrowers, so more experienced and thus more valuable in the production process.

where

$$\pi_t^B = \varepsilon_t^B \left(R_t^{IB} L_{t-1}^{IB} + R_t^{EB} L_{t-1}^{EB} \right) - R_t^D D_{t-1}^B$$

$$TR\left(\varepsilon_t^B, L_t^{IB}, L_t^{EB}\right) = \tau_1 \left(\mathbb{1}_{\varepsilon_t^B < 0} \right) \left(\chi_I L_t^{IB} + \chi_E L_t^{EB} \right)^{\tau_2} \tag{3.17}$$

The big banker consumes C_t^B and offers loans to both the impatient household L_t^{IB} and the entrepreneur L_t^{EB}, and accepts deposits D_t^B from the patient household. He also accumulates equity E^B to comply with the capital requirement given by Equation 3.15 and the balance sheet constraint given by Equation 3.16. In Equation 3.15, χ_I and χ_F represent the weights that make the denominator the risk-weighted asset level, representing the RBCR used by regulators, discussed in Section 3.

The big banker's operational profit π_t^B is given by the interest rates they collect multiplied by their loans (R_t^{IB} from the impatient household and R_t^{EB} from the entrepreneur) minus the interest rate they pay for deposits R_t^D, times the deposit level accepted.

The negative systemic shock to the financial sector is given by ε_t^B. It is systemic in the sense that it affects both bankers, big and small. This is opposed to an idiosyncratic shock that would affect each differently and would be uncorrelated between bankers.[16]

This shock reduces their income, replicating the effect of losses from their portfolio.

The second modeling contribution in this paper is the way the TBTF policy is constructed. In equation 3.17, the indicator function $\mathbb{1}_{\varepsilon_t^B < 0}$ represents the idea that these types of policies are only deployed during crisis. The banks take this into consideration, but now the policy is contingent on negative shocks to the banking sector. This tries to replicate the fact that TBTF policies had a key role during financial crisis, as the savings and loans crisis in the 80s and the recent financial crisis.[17]

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[16] This is the focus of the previous banking regulation framework, see for instance the methodology of loan portfolio valuation in Vasicek (2002).

[17] To avoid introducing discontinuities in the model, I use the logistic function.

$$\mathbb{1}_{\varepsilon_t^B < 0} \approx \left[\frac{1}{1 + e^{-2(300)\varepsilon_t^B}} \right]^8$$

In Appendix A.2, I provide an illustration of this approximation.

Moreover, it also depends on the risk-weighted portfolio. This incentivizes big banks to not contract their asset level and to increase their lending to benefit from the transfer. Without this condition, the big banker would simply consume the transfer, without investing it in lending. τ_1 determines the level of the policy and τ_2, the sensitivity of the policy to the risk-weighted asset level.[18]

3.3.5 Small Banker

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_B^t \left[\log\left(C_t^S\right)\right] \tag{3.18}$$

subject to

$$C_t^S + L_t^{IS} + L_t^{ES} + \Delta E_t^S = \pi_t^S\left(\varepsilon_t^B, L_{t-1}^{IS}, L_{t-1}^{ES}, D_{t-1}^S\right) + D_t^S \tag{3.19}$$

$$\frac{E_t^S}{\left(\chi_I L_t^{IS} + \chi_E L_t^{ES}\right)} \geq \varphi_B \tag{3.20}$$

$$E_t^S + D_t^S \geq L_t^{IS} + L_t^{ES} \tag{3.21}$$

where

$$\pi_t^S = \varepsilon_t^B\left(R_t^{IS} L_{t-1}^{IS} + R_t^{ES} L_{t-1}^{ES}\right) - R_t^D D_{t-1}^S$$

The small banker's maximization problem is similar in structure to the big banker's problem. He consumes C_t^S, extends loans to the impatient household L_t^{IS} and to the entrepreneur L_t^{ES}, accepts deposits D_t^{SB} and accumulates equity E_t^S. The small banker receives R_t^{IS} from their loans to the impatient household, R_t^{ES} from their loans to the entrepreneur, and has to pay R_t^D to the patient household for its deposits.

The small banker is subject to the same type of constraints of a capital requirement (Equation 3.20) and a balance sheet restriction (Equation 3.21). Moreover, it also experiences the negative banking shock discussed previously ε_t^B. The main difference is that the small bank does not have the TBTF policy to help out once the negative shock occurs.

[18] Begenau (2014) shows how a related type of transfer function can be considered a reduced form of a model with an explicit default choice by banks and the decision of government to bail them outs.

3.3.6 Market Clearing, Government Budget Constraint and Shocks

$$D_t^B + D_t^S = D_t \tag{3.22}$$

The deposit market clears, meaning that the amounts deposited at the big bank and small bank have to be equal to the total given by the household.

$$H_t^P + H_t^I = 1 \tag{3.23}$$

The housing market is assumed to be fixed and normalized to one in order to simplify the model and assume that price fluctuations that affect the collateral constraint are not determined by changes in the production of housing.

$$2T_t = TR\left(\varepsilon_t^B, L_t^{IB}, L_t^{FB}\right) \tag{3.24}$$

The government runs a balanced budget, so the amount collected from the households matches the sum given to the big bank.

$$\log \varepsilon_t^i = \rho_i \log \varepsilon_{t-1}^i + \zeta_t^i \quad \forall i \in \{S, H, L, Z, B\} \tag{3.25}$$

Finally, all the shocks follow an AR(1) process with persistence ρ_i. The error term ζ_t^i follows a normal distribution with mean zero and standard deviation σ^i.

3.3.7 Equilibrium

The equilibrium is an allocation of consumption $\{C_t^P, C_t^I, C_t^E, C_t^B, C_t^S\}$, housing $\{H_t^P, H_t^I\}$, labor $\{N_t^P, N_t^I\}$, deposits $\{D_t, D_t^B, D_t^S\}$, loans $\{L_t^{IB}, L_t^{IS}, L_t^{EB}, L_t^{ES}\}$, equities $\{E_t^B, E_t^S\}$, and capital $\{K_t\}$ such that given prices $\{q_t, W_t^N, W_t^I\}$ and interest rates $\{R_t^D, R_t^{IB}, R_t^{IS}, R_t^{EB}, R_t^{ES}\}$, which satisfies patient household, impatient household, entrepreneur , big banker and small banker's maximization problems, markets clear and the relevant transversality conditions are met.

3.4 Results

3.4.1 Calibration and Estimation

Since the series used for the estimation have their means removed, the model cannot estimate some of the parameters used in the model. Thus, Table 3.6 presents the calibrated parameters.

Table 3.6: Calibrated Parameters

Parameter	Value	Source
β_P	0.9925	Iacoviello (2015)
β_I	0.94	Iacoviello (2015)
β_E	0.94	Iacoviello (2015)
β_B	0.945	Iacoviello (2015)
γ_H	0.1	Iacoviello (2005)
γ_N	2	Iacoviello (2015)
α	0.3	Iacoviello (2005)
δ	0.03	Iacoviello (2005)
φ_B	0.06	Basel II Capital Regulation
ψ_I	0.9	Iacoviello (2015)
ψ_E	0.9	Iacoviello (2015)
θ^I	0.4	Proportion of Big Banks Assets to Total
θ^E	0.4	Proportion of Big Banks Assets to Total

Bayesian estimation is done following the methodology of An and Schorfheide (2007) and the model is solved using second order perturbation methods. I use quarterly data on consumption, GDP, the FHFA House Price Index, loans to individuals from the big banker, and big banker equity[19] from 1992Q2 to 2014Q4.[20] All the variables are detrended with a one-sided HP filter, a variant of the method developed by Hodrick and

[19] Consumption is represented by the Personal Consumption Expenditures (PCE) and GDP comes from the Real Gross Domestic Product. Both series were obtained from the Bureau of Economic Analysis (BEA), expressed in billions of chained (2009) dollars and seasonally adjusted at annual rates. The House Price Index is elaborated by the Federal Housing Finance Agency. Finally the loans to individuals from the big banker and big banker equity come from the Call Reports, prepared by the Federal Deposit Insurance Corporation.

[20] This period approximately reflects the duration of the Basel II framework (including the risk weighted measure) discussed in the introduction. Even though some changes related to Basel III were implemented during 2014, all banks will be required to use the Standardized Approach starting from January 1, 2015, see Basel Committee on Banking Supervision (2014).

Prescott (1997).[21]

For cases in which the value is bounded (by zero and one for this model), the Beta distribution has been used. For the rest, the Gamma distribution was applied. For the standard deviations of the shock processes, the Inverse Gamma distribution was chosen, to avoid any negative values in the range. For the means of the prior distributions for μ and the shock processes, I have followed Iacoviello (2015). For the new shock, the banking profits shock, I have followed the same values as the other shocks. For the parameters in the tier-1 RWA constraint, I chose one, since it the value assigned to the riskier asset classes. For the starting values of τ_2, I chose one as the simple level effect of the risk-weighted assets of the big banker. Finally, for τ_1, I rounded the ratio of the TARP money received by the top four banks to the total of the TARP and the Fannie Mae and Freddie Mac bailouts, which represent the financial sector.

Table 3.7 presents the first set of estimated parameters. The table shows that the economic importance in the production process of the patient households is about 0.65 (μ). With respect to the banking variables, the two parameters that govern the TBTF policy function (τ_1 and τ_2) are also relevant in the data.

In addition, the weights on the two asset classes modeled (χ_I and χ_F) show that loans to individuals have a larger weight. This implies that they require additional contributions to the banker's equity level. In that sense, it can be inferred that they are more risky to the bankers.

[21] As Pfeifer (2013) mentions, DSGE models are solved using all the information up to the current period. A two-sided HP filter mixes information from the future with current information. Therefore, it would be incorrect to use a two-sided HP filter for these types of models. The particular implementation of the one-sided HP filter is done by Meyer-Gohde (2010), based on Stock and Watson (1999). A different version of the one-sided HP filter was developed by Mehra (2004).

Table 3.7: Estimated Parameters

	Prior Distribution			Posterior Distribution		
Parameter	Density	Mean	St. Dev.	5%	Mean	95%
μ	Beta	0.70	0.10	0.610	0.654	0.692
τ_1	Gamma	0.25	0.20	0.189	0.303	0.421
τ_2	Gamma	1.00	0.20	0.695	0.906	1.116
χ_I	Gamma	1.00	0.20	0.946	1.222	1.502
χ_F	Gamma	1.00	0.20	0.990	1.097	1.212

The last set of results is related to the shock processes included in the model. Table 3.8 shows the persistence parameters and standard deviations of the five shocks. It is worth highlighting that the banking profit shock is fairly persistent ρ_B, which emphasizes the importance of addressing systemic financial crisis.

Table 3.8: Estimated Shock Processes

	Prior Distribution			Posterior Distribution		
Parameter	Density	Mean	St. Dev.	5%	Mean	95%
ρ_S	Beta	0.8	0.15	0.925	0.950	0.982
ρ_H	Beta	0.8	0.15	0.727	0.822	0.917
ρ_L	Beta	0.8	0.15	0.708	0.811	0.923
ρ_Z	Beta	0.8	0.15	0.946	0.965	0.983
ρ_B	Beta	0.8	0.15	0.848	0.906	0.952
σ_S	Inv. Gamma	0.03	0.025	0.029	0.032	0.036
σ_H	Inv. Gamma	0.03	0.025	0.031	0.085	0.139
σ_L	Inv. Gamma	0.03	0.025	0.035	0.036	0.037
σ_Z	Inv. Gamma	0.03	0.025	0.013	0.014	0.014
σ_B	Inv. Gamma	0.03	0.025	0.053	0.055	0.057

3.4.2 Impulse Response Functions

With the estimates obtained from the data, I proceed to present the impulse response functions to a one standard deviation from a negative banking shock. I first focus on this shock, since it is the motivating element of the TBTF policy and one of they key elements of the model. In particular, I will compare the current model with a counterfactual case in which there is no TBTF policy. I present the behavior of the key variables of the model in response to the other types of shocks in the Appendix A.1.

Figure 3.5 shows the reaction of GDP and the TBTF policy in the model to a negative shock to bank profits with the TBTF policy and the counterfactual case without it. As the figure illustrates, the economy under the TBTF policy is not as negatively affected from the same bank profit shock. Moreover, the TBTF policy works as intended. After the initial shock, it increases from its zero steady state, and as the shock dissipates, it is reduced back to zero. This is key to model the emergency nature of the TBTF policy.

Figure 3.5: GDP and TBTF Policy

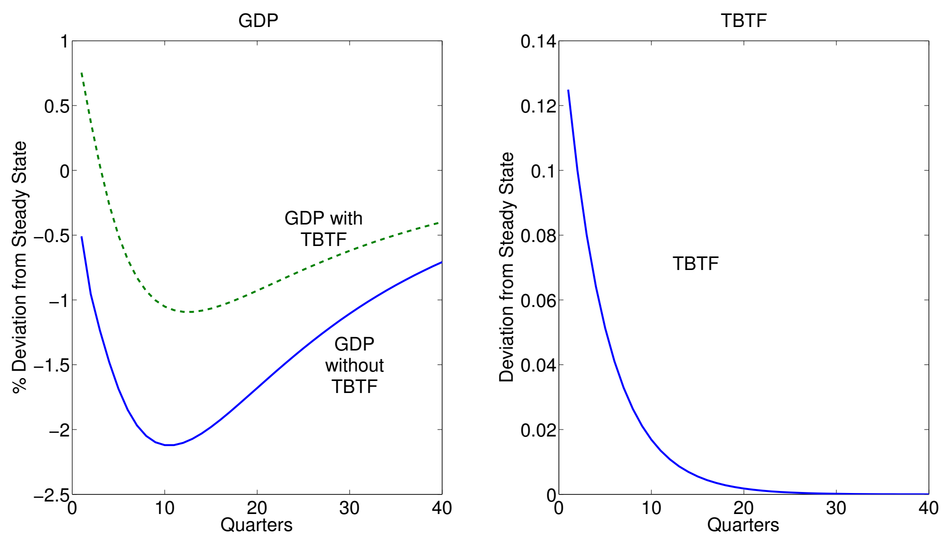
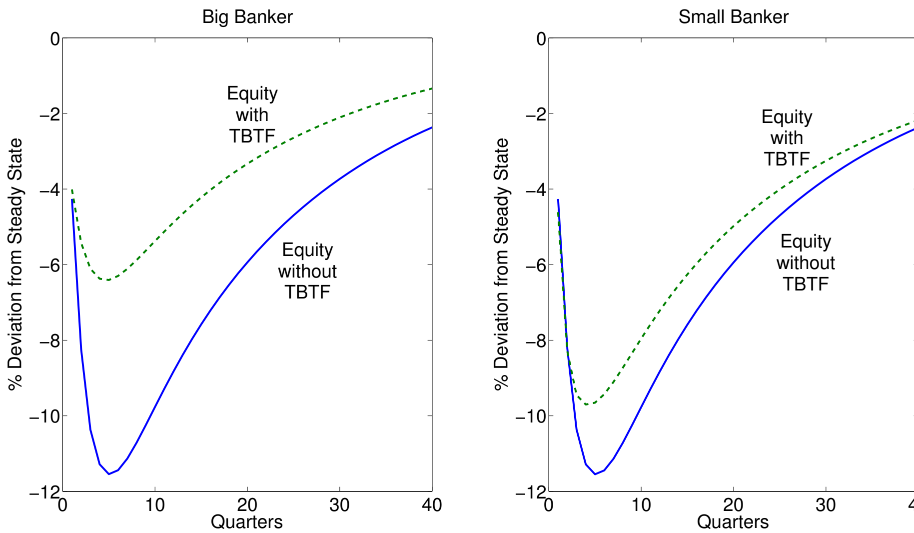


Figure 3.6 presents the behavior of the bankers' equity. The right-hand panel shows the equity response to the negative profits shock of the big banker, whereas the left-hand side corresponds to the small banker. This illustrates the workings of the mechanism explained in the introduction. Once the negative shock occurs, the big banker's equity does not suffer as much as it would have without the TBTF policy. He can use the policies' resources to cover the losses. However, the small banker has to use his equity. That explains the sharp contrast between the two agents.

Figure 3.6: Equity



Finally, Figures 3.7 and 3.8 represent the asset side reaction of the two bankers. Following the logic presented in the equity analysis, the two types of loans were reduced considerably less for the big banker under the TBTF policy. This is what prevented the economy from suffering a deeper recession, since the big banker did not have to contract its lending level in the same way the small banker did.

Figure 3.7: Loans to the Entrepreneur

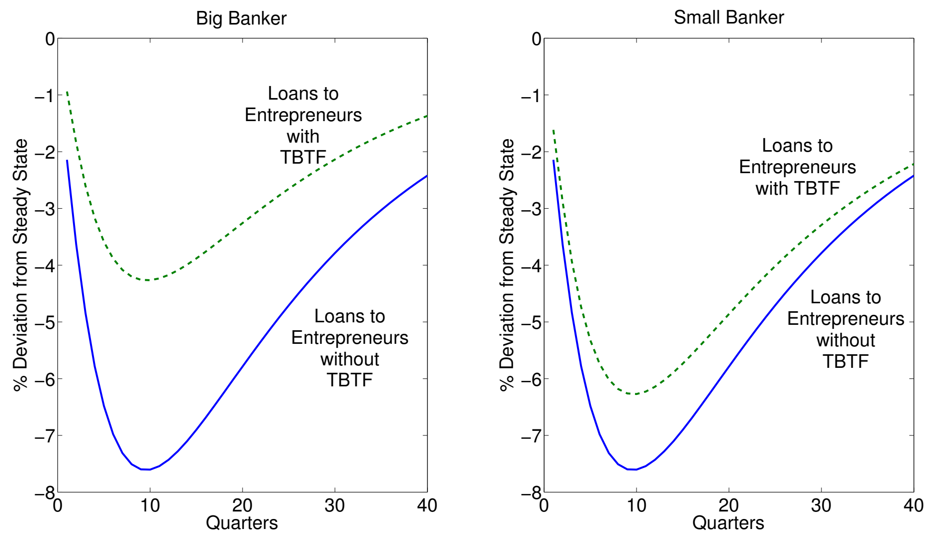
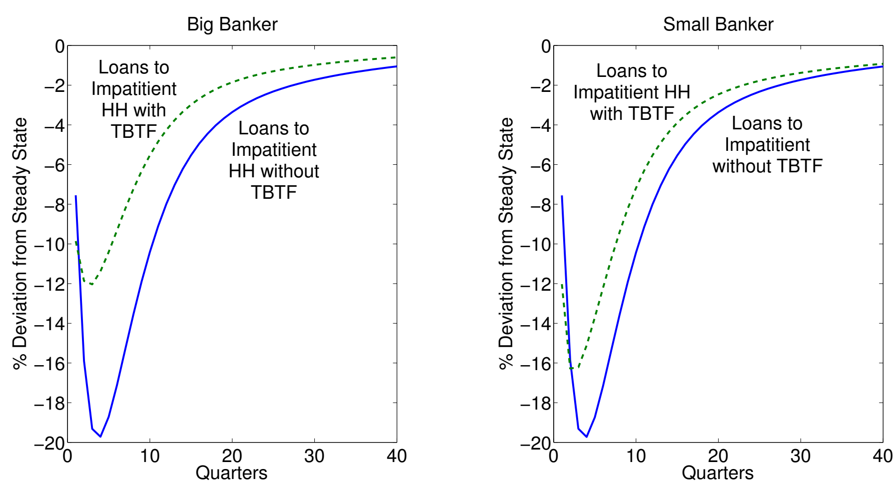


Figure 3.8: Loans to the Impatient Household



In the model, the capital and balance sheet restrictions are binding, so when the banks suffer the losses from the banking shock and their equity is reduced, they have to contract their asset levels. Under the TBTF policy, the negative shock causes the interest rates of the Big Banker to be reduced, since they receive more from the transfer the higher their assets are. In addition, the small bank is also benefited because the collateral constraints for the entrepreneur and impatient household are relaxed by the TBTF policy, so part of the benefits will spill over to them as well.

3.4.3 Welfare Analysis

Even though the TBTF policy is successful in preventing a contraction of the big banker's assets and thus helps soften the negative banking shock to the rest of the economy, there are important welfare implications. The two types of households, patient and impatient, have to pay for this policy. However, not only the big banker benefits. The entrepreneur and the small banker also benefit from the better economic conditions. Thus, we need to take into consideration each individual agent.

As mentioned by Benigno and Woodford (2012), welfare analysis in dynamic stochastic general equilibrium models can be done by solving the model using a second-order approximation. This allows the study of the welfare of different types of agents individually[22] . For each representative agent i in the model, the welfare is defined as

$$V_{i,t} \equiv \max \left[\sum_{j=0}^{\infty} \beta_i^{t+j} U_i(C_{i,t+j}, H_{i,t+j}, N_{i,t+j}) \right]$$

In the optimum,

$$V_{i,t} = U_i(C_{i,t}, H_{i,t}, N_{i,t}) + \beta_i \mathbb{E}_t V_{i,t+1}$$

In order to better understand the results, I express them in term of Consumption Equivalents,

$$CE_i = \exp\left[(1-\beta_i)\left(V_{i,\tau_1=0.303} - V_{i,\tau_1=0}\right)\right] - 1$$

comparing the benchmark case of no TBTF policy, defined by a value of $\tau_1 = 0$.

[22] This approach is used by Rubio and Carrasco-Gallego (2014a) to analyze the welfare implications of the Basel III framework.

Table 3.9: Welfare Calculations

Agent	Welfare Change	WC with Transfers
Patient	-0.22%	0.0%
Impatient	-1.13%	0.0%
Entrepreneur	1.03%	0.0%
Small Banker	1.31%	0.0%
Big Banker	1.96%	0.5%

Thus, it is clear that there are important welfare redistribution consequences of the TBTF policy. The patient household and impatient household have permanent reductions of 0.022% and 1.13% in quarterly consumption, respectively. These are significant in terms of welfare, compared to other estimates of this kind[23] . On the other extreme, the big banker is clearly the largest beneficiary of the TBTF policy. The impatient household has to pay for the policy as well, but the negative is offset partially by the reduction in the interest rates charged by the big banker. Similarly, the entrepreneur benefits from lower interest rates and also does not have to pay for the subsidy. The smaller banker benefits from the general improvement of the economy, though not as directly as the big banker, since they do not enjoy the benefits of a direct TBTF subsidy.

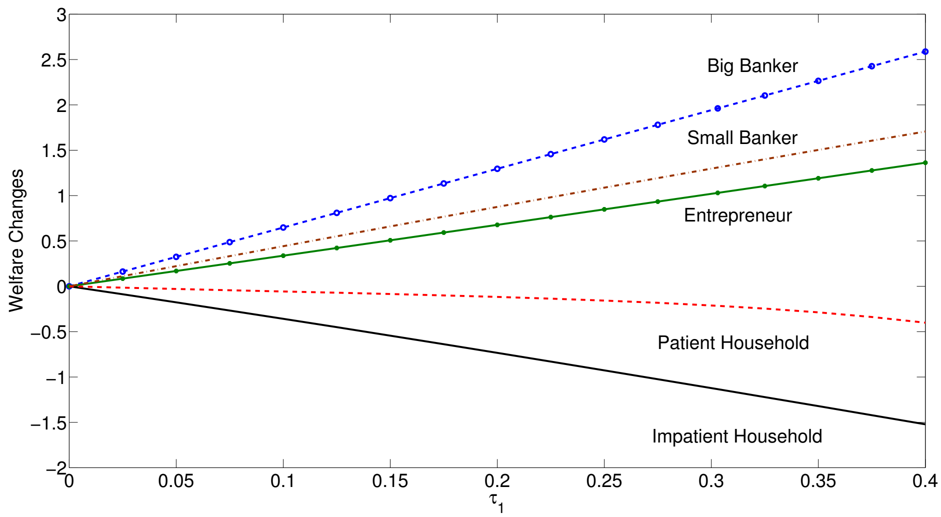
However, in order to assess the overall impact on the economy, it is important to ask if this policy could theoretically improve the situation of every agent given the appropriate transfers.[24] When considering the welfare change with lump sum transfers from the beneficiaries to the households, there is an overall Pareto-improving allocation. In this case, the two affected households are indifferent, and there is still a benefit for the big bankers. There are several possible transfer schemes, but the important point is that there is a net gain in terms of welfare to the economy.

To complement these findings, Figure 3.9 presents a sensitivity analysis to the presence of the TBTF policy. It shows that the wealth redistribution issue is important for a wide range of policy levels.

[23] See Van den Heuvel (2008) and Begenau (2014).

[24] To have a measure of the whole economy when there are different agents, Pescatori and Mendicino (2005) suggest a weighting scheme that is a function of their discount factors.

Figure 3.9: Welfare Changes



3.4.4 Historical Decomposition

Finally, I present Table 3.10, which shows the contribution of each of the smoothed shocks to the deviation of the smoothed GDP from its steady state. The decomposition is computed using the median of the posterior distribution after estimating the model.

Table 3.10: Historical Decomposition of the Shocks

Contribution to GDP	2008	2009	2010
Preferences	-1.2%	-1.7%	0.5%
Housing	-1.3%	-1.5%	0.2%
Impatient HH Borrowing	0.2%	-1.7%	-0.4%
Productivity	-0.6%	-0.5%	-0.6%
Banking Profits	-1.7%	-2.3%	-0.2%
Total	-4.6%	-7.7%	-0.5%

From this table, the contribution of the banking profits to the crisis is clear. Starting from 2008, it was a driving force in explaining the percentage deviations from the steady state of the GDP.

3.5 Concluding Remarks

In this paper, I have highlighted an important dimension in the interaction between financial institutions and the macroeconomy, which is the heterogeneity in the banking industry. This is an important contribution to the literature of financial linkages, since most models assume that the banking sector reacts uniformly.

In particular, this is vital to the understanding of banking behavior during the great recession. The data shows that small banks suffered equity loses, so they contracted their asset level in order to more than offset the reduction in their equity. Big banks, on the other hand, did not suffer equity loses to the same extent and thus did not need to diminish their lending.

The small banks response is consistent with the bank capital channel theory of financial shock transmission. In this paper, I have suggested that the difference in the big bank's reaction was due to the fact that there are implicit TBTF policies that protected big banks' equity. Through policies like the Troubled Asset Relief Program (TARP), banks improved the strength of their balance sheets. Clearly, big banks were not the only ones to benefit from such measures. However, systemically important banks were the priority.

I am able to incorporate the banking heterogeneity and the TBTF policies in a simple RBC framework. This allows a deeper understanding of the behavior of the banking sector during the 2008-2009 period. In addition, I also use the model to run a counterfactual experiment in which there is no TBTF policy. I find that the presence of this TBTF policy helped the economy soften the impact of the recession and recover more quickly. However, there are important welfare implications for the agents in my model. The big banker is clearly better off, but comes at the expense of the impatient household and patient household since they have to bear the cost of paying for the TBTF policy. The small banker and entrepreneur are benefited due to the overall improvement of the economy. Using transfers from the agents who are benefited to the ones who are affected, I am able to show that there is an overall net positive effect on the economy.

Finally, I compute a historical decomposition of the shocks in my model. I observe that the shock I used to model the losses to the financial sector contributed about a third of the deviation from the steady state of the GDP. Thus, it is a valid modeling tool from the perspective of understanding the crisis.

Even though the main result shows that the TBTF policy did help the economy, this is an ex-post result, in the sense that TBTF were already in place and had generated the moral hazard. This emphasizes the need for reforms in the banking sector to help banks deal with significant losses without the need of bailouts. The application of the Basel III framework clearly reinforces some of the weak points that were uncovered by the great recession. Higher capital requirements, the introduction of a capital conservation buffer and countercyclical buffers will help to strengthen the banking system and will reduce the impact of the bank capital channel discussed in this paper. However, the exact application of those tools and their impact on the banks will require further analysis.

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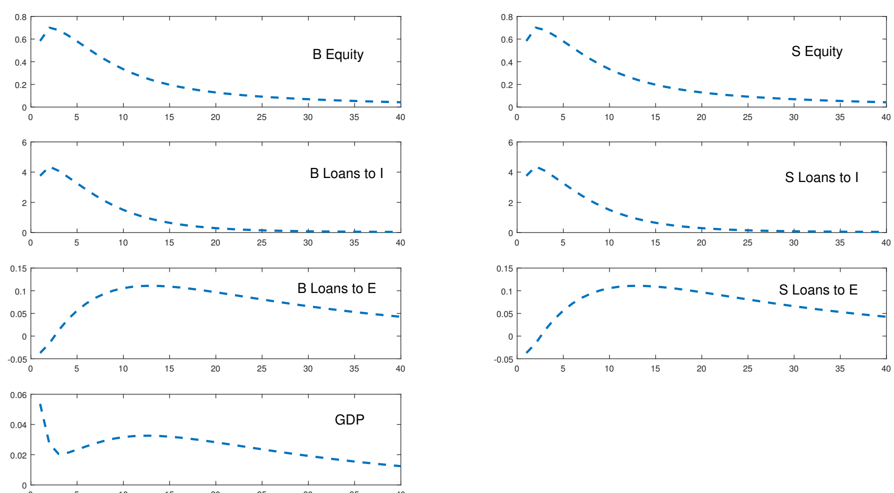
Appendix A

Appendix to Chapter 3

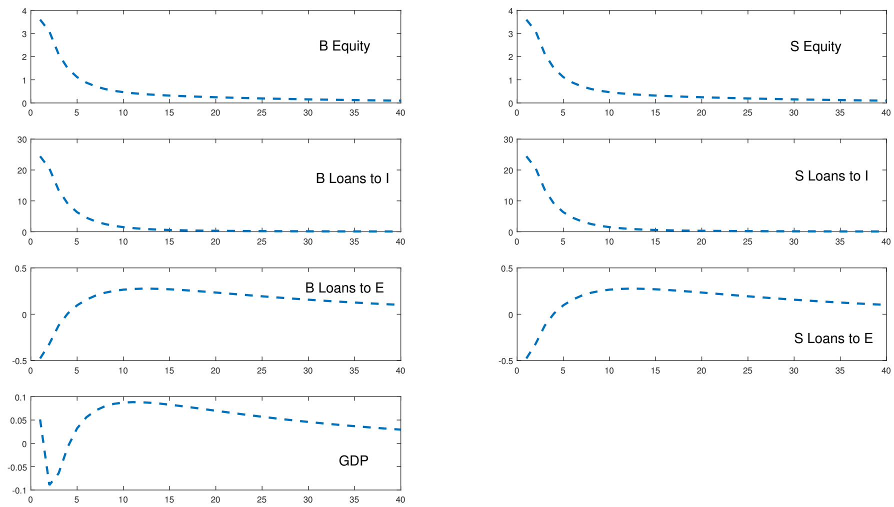
A.1 Responses of the Model to Other Shocks

Figure A.1: Response to a Positive one Standard Deviation Housing Shock ε_t^H



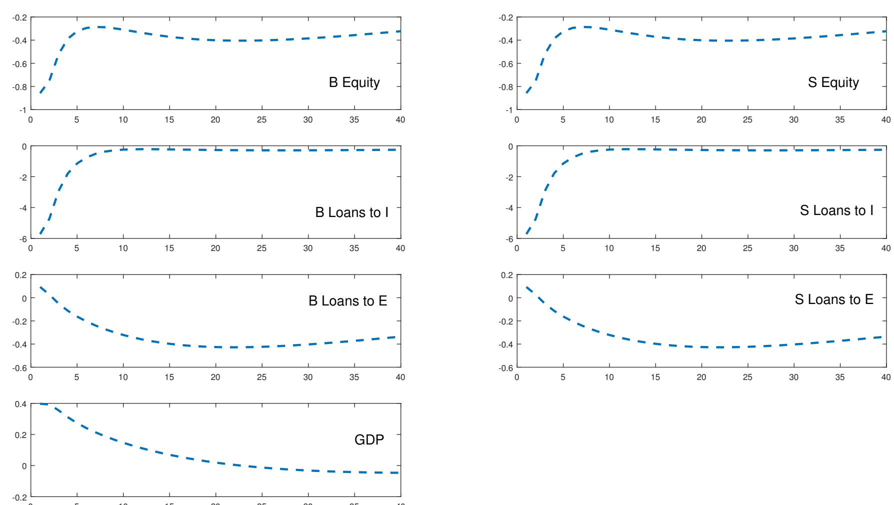
Note: Expressed in percentage deviations from the Steady State

Figure A.2: Response to a Positive one Standard Deviation LTV Shock ε_t^L



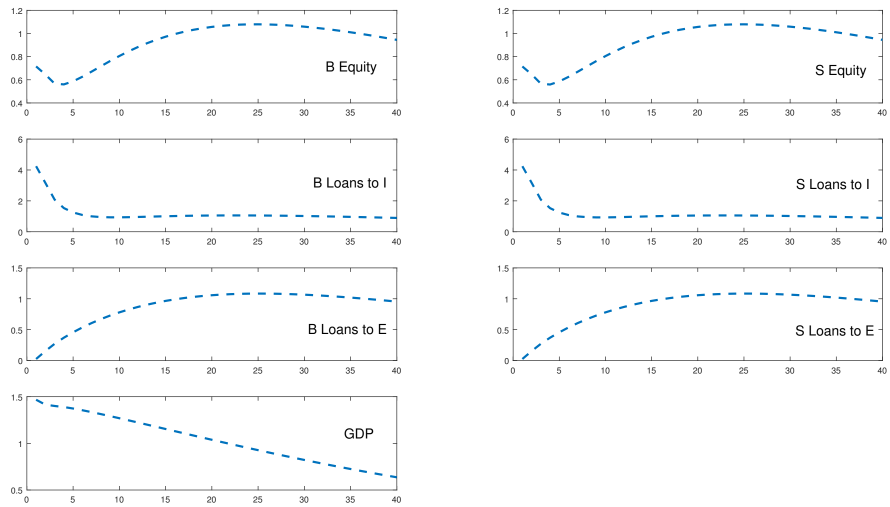
Note: Expressed in percentage deviations from the Steady State

Figure A.3: Response to a Positive one Standard Deviation Spending Shock ε_t^S



Note: Expressed in percentage deviations from the Steady State

Figure A.4: Response to a Positive one Standard Deviation Productivity Shock ε_t^Z



Note: Expressed in percentage deviations from the Steady State

A.2 Approximation of the Indicator Function

In order to avoid including discontinuities in the model, I use the logistic function to approximate the indicator function.

$$\mathbb{1}_{\varepsilon_t^B < 0} \approx \left[\frac{1}{1 + e^{-2(300)\varepsilon_t^B}} \right]^8 \tag{A.1}$$

In the exponential function, any large number fulfills the need for the steep rate of change. The logistic function by itself delivers a value of 0.5 for ε_t^B at its steady state of zero. Thus, I raise the function to the eighth power. This value makes the 0.5 closer to zero without compromising the values close to 1 by making them considerably further from one. This approximation is robust to different sets of values and the particular numbers do not affect the quantitative results significantly.

Figure A.5: Approximation of the Indicator Function