Abstract

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The role played by financial intermediaries and banks in modern economies is undeniably critical. However, explaining their importance in a theoretical general equilibrium framework presents some challenges. If firms and households have unrestricted access to complete financial markets, then at the competitive equilibrium banks make zero profits and the size and composition of the bank's balance sheet have no impact on the other economic agents. Imperfections in credit markets are key then to explain the unique role of banks when compared to alternative financing methods. The first chapter studies some of these financial frictions focusing on how can they introduce a specific need for bank financing as opposed to alternative methods. This study carries out a macroeconomics general equilibrium analysis of this topic, taking into account the feedback between firms' financing and investment decisions. Having established the relevance of bank financing for economic outcomes, the second chapter is devoted to study how bank lending can become a transmission channel of aggregate shocks to the rest of the economy. It particularly focuses on the role played by bank capital requirements, the most important banking regulation, as a financial accelerator mechanism in a model of real business cycles. Banks becomes more capital constrained during recessions as they suffer more loan losses that erode their equity, and this results in a reduction in loan supply which in turn worsens the severity of the recession. Bank-loan dependent firms suffer the most and aggregate investment and production fall. Following this line of research, the third chapter investigates yet another mechanism by which bank lending can become a transmission channel of aggregate shocks. This one hinges on the pricing of loans by banks and its variation over the business cycle. Price-cost margins can be seen as a wedge in credit markets that produce deadweight losses for the economy.

Countercyclical price-cost margins uncover a financial accelerator mechanism by which deadweight losses are more severe during recessions. This is an empirical study in which the countercyclical behavior of price-cost margins in the US commercial banking sector is carefully documented.

Essays on the Macroeconomics of Banking

by

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A María Pía, por todo.

A Agustín.

A mis padres, Julio y María.

To María Pía, for everything.

To Agustín.

To my parents, Julio and María.

Biography

Roger Aliaga Díaz was born in Córdoba, Argentina, on April 6, 1974, where he lived before moving to the US in 2000.

He completed his secondary education at La Salle school in 1991 and his B.A. in Economics in Universidad Nacional de Córdoba, Argentina in 1997. As an undergraduate student he was a Teaching Assistant for Principles of Macroeconomics and he also joined the Institute for Economic Studies of Fundación Mediterránea, Argentina as a Junior Researcher. In that position he gained experience in applied economic research methods and participated in several research projects on public policy.

After four years working as a policy analyst he decided to pursue graduate studies in the US. In 2001 he earned a M.A. in Economics from Duke University, where he took courses in Advanced Macroeconomics, Stochastic Macroeconomics and Econometrics. In 2002 he joined the doctoral program at North Carolina State University and he specialized in Macroeconomics and Banking. As a Ph.D. student he was instructor for several undergraduate Macroeconomics courses at NC State University, he was Teaching Assistant at the Fuqua School of Business, Duke University and Research Assistant at the Sanford Institute of Public Policy, Duke University. Before graduating, he presented his dissertation research in several professional conferences and universities.

Roger Aliaga Díaz is married and has one son.

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Table of Contents

List of Figures

List of Tables

Introduction

Explaining the importance of financial intermediation by banks in a theoretical general equilibrium framework presents some challenges. A representative agent world with perfectly competitive banks and firms leads to a redundant role for banks. That is, if firms and households have unrestricted access to perfect financial markets, then at the competitive equilibrium banks make zero profits and the size and composition of the bank's balance sheet have no impact on the other economic agents (Freixas and Rochett, 1997). Under those circumstances, households are completely indifferent between demand deposits and securities and similarly firms are indifferent between bank loans and securities. This is an analogue to Modigliani-Miller theorem of irrelevance of financial decisions.

Imperfections in credit markets are key then to explain the unique role of banks when compared to alternative financing methods[1]. Traditionally, the existence of banks has been justified by the presence of certain transaction costs in the financial markets. By pooling a large number of financial operations banks can save in these costs by exploiting economies of scale or economies of scope associated to a certain transaction technology. However, as described by Freixas and Rochett (1997), the technological advances in telecomunications and computers as well as the development of sophisticated finan-

[1]The other alternative would be to relax the assumption of perfectly competitive banking firms, but this avenue is not explored here.

cial instruments would certainly reduce any kind of transaction costs making these arguments weaker.

In this context, a different kind of imperfection in credit markets is needed to explain the existence of banks. Informational imperfections in credit contracts are the cornerstone of modern theoretical banking literature. This is a different type of transaction costs that can be partially overcome by financial intermediaries. If we think on the financial contract as a principal-agent problem in which the lender delegates the task of maximizing the returns of a given investment to the borrower, then asymmetric information between the parties will clearly reduce the efficiency with which funds are reallocated from saving to investment. The distinctive role of banks arises from the monitoring technology operated by them that allows them to screen borrowers in a context of adverse selection, to prevent opportunistic behavior of borrowers in a moral hazard setting or to audit borrowers who fails to meet contractual obligations as in the so-called costly state verification setting.

The first chapter studies the issue of existence of banks. The goal is to study why, from the perspective of firms' financing decisions, bank credit and bond financing are only imperfect substitutes with each other. In a setting of costly state verification of financial contracts, banks are endowed with a financial intermediation technology that allow them to overcome this informational asymmetry. However, banks are heavily regulated and they also must pay costs related to the production of financial services, and all this makes intermediation costly to borrowers. Thus, in an environment of heterogenous firms, the costly intermediation of banks may outweigh any informational advantage for firms with lower degrees of risk (i.e. lower probability of going bankrupt). Safer firms will use direct financing while riskier ones will find it cheaper to use bank credit.

Although the issue of coexistence of bank lending and bond financing has been already studied in the "microeconomics of banking" literature, this study carries out a macroeconomics general equilibrium analysis of this topic. The choice of financing method depends not only on firms' characteristics but also on the size and expected return of the investment projects they need to finance. Moreover, this choice determines in turn the cost of funding for firms and thus it affects their investment decisions. Thus, there is a feedback between firms' financing and investment decisions. Those micro partial equilibrium models neglect these feedback by assuming investment projects of exogenously given size and return.

The development of the asymmetric information paradigm in relation to financial contracts also suggested new links between the financial and the real sector of the economy. Although money has traditionally played a key role in this relationship because of its effects on the aggregate price level and inflation, that does not necessarily neglect the existence of other type of connections. The literature on the "credit channel" of monetary policy stresses the role played by credit markets and the importance of distinguishing among different type of financial assets such as bank lending versus public debt or internal versus external financing. This literature builds on the micro literature on imperfect information in financial markets by embedding its main insights into a general equilibrium macroeconomic framework. The idea is to show how credit market imperfections can affect the response of the economy to monetary policy shocks and to assess how these shocks are propagated throughout the economy and over time.

The second chapter studies a particular channel by which the availability of bank credit responds to macro aggregate shocks rather than to monetary policy shocks. Macroeconomic shocks (such as total factor productivity shocks) affect the supply of bank loans due to a particular type of imperfection in credit markets which is bank capital requirements. It has been argued that bank capital requirements are responsible for the so-called "credit crunch" phenomenon by which capital constrained banks must cut back on lending as a way to meet the minimum capital requirements. Moreover, if banks becomes more capital constrained during recessions as they suffer more loan losses that erode their equity, then the resulting reduction in loan supply will worsen the severity of the recession. Bank-loan dependent firms, that use bank credit in order to finance either investment projects or working capital needs, will delay investment spending or cut on production. This fall in investment and production adds to the normal slow down in these macro aggregates during any recession. Thus, bank capital requirements reinforces the downturn of the cycle creating a financial accelerator effect.

The third chapter studies yet another different channel by which the supply of bank credit depends on the state of the economy. This one hinges on the pricing of loans by banks and the behavior of price-cost margins for commercial banks over the business cycle. Price-cost margins can be seen as a wedge in credit markets arising due to some kind of inefficiency such as non-competitive behavior, distortive taxation or regulations. This inefficiency produces deadweight losses for the economy that translates into less funding available to bank-loan dependent firms. Thus, if price-cost margins vary endogenously in response to aggregate shocks, their variation becomes an additional channel through which such shocks can affect economic activity.

This chapter is an empirical study of the cyclical behavior of price-cost margins in the US commercial banking sector for the period 1979-2005. We find robust evidence for counter-cyclical margins even after controlling for suggested explanations for that behavior, such as monetary policy and credit risk. With price-cost margins in the market for credit being countercyclical according to our results, a financial accelerator seems to be operating in the American economy. In bad times, countercyclical margins make credit become more expensive relative to economies where margins behave differently.

Chapter 1

Investment Financing and Coexistence of Bonds and Bank Loans in General Equilibrium

1.1 Introduction

The topic of investment financing has been extensively studied, both at a theoretical and at a empirical level, by several literatures in economics. The modern banking literature has traditionally studied the financing decisions of the firms in the context of partial equilibrium models. This literature is developed in the informational asymmetries paradigm and strongly relies on several results of the literature on financial contracts under imperfect information. The themes in these papers range from giving a justification for the exitance of banks to explaining the coexistence of bank credit with direct financing. A seminal study is Leland and Pyle (1977) model of capital markets with adverse selection in which financial intermediaries arise as a coalition of borrowers that can lower the informational cost of capital (which they should bear by self-financing part of the project) by diversifying risk of their projects. Diamond (1984) first advanced the idea of delegated monitoring as a theory of financial intermediation by suggesting that banks have a comparative advantage in those monitoring activities compared to other lenders. This monitoring role refers in fact to many activities banks can undertake. For example, monitoring could mean screening projects in an adverse selection environment, it could mean to prevent opportunistic behavior by the borrower as in Holmstrom and Tirole (1997) or finally could mean verifying firm's cash flow as in Diamond (1984), Townsend (1979) or Gale and Hellwig (1985).

An important branch of this banking literature is less centered on the "uniqueness of bank loans" and instead tries to explain the coexistence of bank credit and direct financing by studying the choice of alternative financing methods by firms. One type of models is based on moral hazard, which prevents firms without enough assets from obtaining direct finance. In Holmstrom and Tirole (1997) only wealthy firms have enough assets to self-finance part the project by an amount enough to signal their are trustworthy so that they can receive direct financing from investors. So, if firm's assets are not enough to receive credit directly in the financial markets then they must turn to bank loans. However, bank loans are more expensive compared to direct financing because banks operate a costly monitoring technology. In that case, the moral hazard problem is solved through the costly monitoring undertaken by the bank. Diamond (1991) extends the previous model to two periods and he shows that firms can build a reputation in period 1 that allows them to overcome the moral hazard problem and get direct financing in period 2. Other papers studying the coexistence of bank lending and public debt are Diamond (1997), Besanko and Kanatas (1993), Repullo and Suarez (1995) and Boot and Thakor (1995) among others.

However, all these papers study banks and credit markets through partial equilibrium analysis. That is, they study the determinants of the demand and supply for credit as well as the informational imperfections in the financial contracts without paying attention to the real effects of the choice of financing methods by firms. In general, this models assume that firms' credit needs arise from investment projects of a given size and return. By neglecting a general equilibrium analysis these papers cannot understand how the financial decision of firms affects the capital accumulation process and how that in turn feedbacks on the choice of financing method.

A large literature on macroeconomic effects of credit market frictions has emerged after Bernanke and Gertler (1989) paper on the general equilibrium analysis of agency costs. This literature overcame the challenge of embedding the partial equilibrium models of credit contracts under imperfect information described above within a general equilibrium macro model[1]. Other papers on firms' investment decisions with financial frictions are Bernanke and Gertler (1995); Bernanke, Gertler and Gilchrist (1996, 1999) Carlstrom and Fuerst (1997) among others. These papers usually concentrate in the choice between internal and external financing and its effects on firms investment decisions. However, they do not address the issue of firm's optimal choice among different sources of external funding, such as publicly traded debt versus intermediated lending.

This paper is a modest attempt to fill the gap left between those two literatures. A general equilibrium dynamic model in continuous-time featuring both endogenous investment and financing decisions of firms is set and solved. Micro-foundations for firms' financing decisions are provided, however the the choice of alternative financing methods is limited to only external financing: corporate bonds and bank loans. Internal financing is restricted to firm's working capital needs including depreciation of capital, but firms has

[1] This was a complicated task, since representative-agent models would be useless because in those models no lending actually takes place. Incorporating heterogeneity among agents in a tractable general equilibrium model is difficult.

no decision over it.

The paper studies the transitional dynamics and steady-states resulting from changes in the banks' cost of intermediation and from technology shocks. At an empirical level, many testable implications can be derived from the model's response to these changes. The qualitative response of the endogenous variables: output, consumption, investment, and external financing are all in line with generally accepted facts found in the business cycles with financial frictions literature. Some of the main results of the model are also in line with the empirical evidence in the banking literature: bond financing is found in relatively safe firms whereas bank financing is the main source of funding in riskier firms; firms switch out of bank loans into commercial paper when bank spreads increase (Bolton and Freixas, 2000); and bank loans and private placements are highly procyclical while bond financing and commercial paper issues are quite countercyclical (Cantillo and Wright, 2000).

1.2 A Model of Firms' Financing Decisions

After clearly stating the assumptions required for the model, this section addresses the firm's financing decisions. In the next section I show how firms' financing decisions and their investment decisions are both endogenous outcomes of the dynamic optimization problem for the firm.

There are three agents in the economy: households, firms and financial intermediaries (hereafter I simply call them banks).

The production sector of the economy is composed of a large number of firms of different types. Firm's type is represented by an index $p_k \in \{p_1, \ldots, p_N\}, p_1 < \ldots < p_N < 1$. Index p_k could be interpreted as the probability of a firm of that type exiting the market (i.e. bankruptcy) at a given moment of time. By appealing to the law of large numbers we can say that this is exactly the proportion of each type of firms that die at each moment of time.

The number of firms of each type is exogenously given in the model and the distribution of firms across types do not depend on the states of nature of the economy. The goal of this study is not to trace down how financial frictions affect the economy wide distribution of firm sizes, but rather to analyze how different type of borrowers choose the two alternative financing methods based on their own characteristics.

Thus, I assume that there is the same number of firms of each type p, say P, and this is constant over time.[2]. With $\sum_{i=1}^{N} p_i P$ firms going out of business at each moment of time, the assumption is that there are $\sum_{i=1}^{N} p_i P$ new firms entering the economy. Without lost of generality we can normalize P to 1.

In case of bankruptcy, firms pay the factors of production and the remainder of the firms' assets is completely transferred to the new firms entering the market. That is, new firms start out with the same capital stock of the pP dying firms. This assumption is added for the sake of simplicity to avoid introducing some kind of secondary market where existing capital is traded among firms.

All firms produce the same good, no matter what type they are. Also,

[2]Instead of assuming a constant mass of firms for each risk type, I could have assumed some skewed normal distribution, where the mass of firms is clustered around high risk firms. Although this would be nice in terms of making the model consistent with the data it would not add much to the comparative statics analysis carried out here

their production technology features decreasing returns to scale (DRS). This assumption is necessary to prevent the case of the lowest risk type of firms (i.e p_1) to drive the others out of business by undercutting prices [3]. DRS technology is justified by the presence of a factor of production in fixed supply, such as managerial talent. I will assume that the total endowment of managerial talent is equally distributed among the N firm types. Thus, managerial talent is a specific factor for a given firm's type. Now, within each firm class the fixed factor will be allocated among the P firms competitively. Thus, the rent earned by this factor will be equal to the difference between the firm's output and the payment to the other inputs, i.e. capital.

Firms in this economy need to borrow in order to finance new investment projects and to replace depreciated capital. They can borrow directly by issuing corporate bonds or they can sign a loan contract with a bank. The choice of financing source will depend critically on the considerations that follow next.

First, both the distribution of firms and the firms' types are fully observed by all the agents in the model. Thus there is no adverse selection problem in financial contracts signed between firms and their lenders. However there is an informational friction in the model: as in Townsend (1979) and Gale and Hellwig (1985) it is costly to verify the firm's cash flow. Specifically, agents cannot observe freely which firm in particular has truly gone bankrupt among the firms of each type that claim to be in that state of nature. That is, a firm could fallaciously claim that it has fallen into bankruptcy, and due

[3] With CRS, the lowest p firm that is charged the lowest risk premium would incur in lower marginal costs than the rest. Thus, this firm could undercut prices driving the other firms out of business.

to limited liability it can just default on its debt. Since there is no reputation issues in the model, this firm could continue operating normally after that.

Second, there is a transaction cost in public debt financing that depends on the borrower's characteristics and on the size of the issue. The specification of this finance cost is similar to that one assumed in Gomes (2001). In that paper, the cost function is zero if no external financing is required and positive and increasing when the firm uses debt. Based on evidence presented in several empirical studies, Gomes (2001) justifies these transaction costs in underwriting fees and other flotation costs associated to new issues of public debt. Also Smith (2002) includes underwriting fees in bond financing and equity issuance in her model. Based on empirical evidence presented by Altinciliç and Hansen (2000) and Lee, Lockhead, Ritter and Zhao (1996), this author includes transaction costs per unit of loan that are increasing in the size of the issue but that are decreasing in the size of the firm.

Third, as regards intermediated lending, I assume that banks are endowed with an information technology that puts them at an advantage respect to any other type of lender. Because of this technology there is no information asymmetries in the bank loan contract. By lending to a firm the bank can extract all the information needed in order to observe at no cost the firm's cash flow in any state of nature. One way to interpret this assumption is that, after default, banks reorganize firms more efficiently than bondholders.

There are many models in the literature stressing the reorganization role of banks. In Bolton and Freixas (2000), for example, banks provide flexible financing as opposed to the case of bondholders who would liquidate the firm as soon as it enters in default. Under bond financing the firm is always liquidated following default. Liquidation is inefficient and thus costly if the firm is a good one. In their model, good firms can have problems to meet interest payments in the short-run, although they are guaranteed to obtain positive profits in the long run. Liquidating this type of firms is inefficient. With bank lending, default and bankruptcy will not give rise to inefficient liquidation. The bank, endowed with superior information and with greater ability to restructure its loans, will choose to liquidate only bad firms. Thus bank lending dominates bond financing in terms of expected bankruptcy costs.

Also Cantillo and Wright (2000) focus on the reorganization ability of banks as opposed to bondholders. In their model, banks have lower verification costs than bondholders. They relate these verification costs to delays in workouts after default. They mention some empirical papers showing that both private and court-administered workouts are quite prolonged. Thus if investment generates substandard returns in the interim, then these delays are costly. However, in their paper they mention additional evidence showing that the cost associated to private reorganization is half of the cost corresponding to court-administered ones. They discuss further evidence showing that companies who use bank debt are more likely to reorganize privately (i.e. faster and cheaper) than firms who use publicly traded debt.

Another alternative consistent with the information advantage of banks compared to bondholders, is the existence of a unique verification technology that features economies of scale in the volume of funds audited. If banks are big in relation to the size of the projects financed then it is natural to think that banks exhaust these scale economies driving the average verification costs close to zero. This will not be the case for small scale bondholders who can finance just a fraction of a single project. Bondholders cannot cluster in larger groups and exploit the economies of scale because of free-riding problems. This framework is close to Diamond (1984).

Although banks are assumed to have and informational advantage respect to other lenders, the cost of bank loans may be higher than the cost of direct debt. When banks give out loans they incur in intermediation costs that makes the opportunity cost of capital rise over those of bondholders. In general, there exist several reasons why this extra cost arises. For instance, the cost of certain banking regulations such as reserve requirements or capital adequacy ratios will be reflected in interest rate on loans that are higher than the marginal cost of funds.[4] Administrative costs, such as payments to inputs in the production process for banking services is another way to justify this intermediation cost (see Oviedo (2003)). This corresponds to the intermediation approach to banking, in which banks use traditional inputs (i.e. labor, physical and human capital) plus financial capital (i.e. deposits) to produce loans. The wedge between the price of the loan and the cost of the financial capital is the administrative cost associated to intermediation.

In this paper, I do not plan to fully model one of these stories. That is, I do not attempt to provide micro-foundations to the cost of bank loans. Rather, I will simply assume that bank intermediation is costly, and this cost represents a deadweight loss to the economy. In my model, the cost will be paid by the borrower. However in a general equilibrium setting the cost will be actually borne both by households and firms.[5]

[4]The cost of reserve requirements is given by the interest payments to depositors for the part of the funds held as reserves, while the cost of bank capital requirements arises from the fact that rising bank equity may be more costly than bank deposits.

[5]Admittedly, not building a model consistent with one of these stories as described above is a weakness of this paper. This is, however, a necessary simplification in order to get closed form solutions for the differential equations characterizing the macroeconomic equilibrium.

Summarizing, banks observe the firms' cash flow at no cost and they charge risk-adjusted interest rate $i^L = f(r^d, p)$, where r^d is the interest rate paid on deposits, p is the probability of default. In addition, the firm pays a constant cost c^L per unit of loan at the moment of signing the credit contract[6].

In order to avoid dealing with uncertainty in the model, it is necessary to assume that banks can achieve perfect diversification of their portfolio of assets. The assumption is that each bank is big enough so that it lends to a large number of firms of a given type. Under these conditions, the firm's type will indicate exactly the proportion of non performing loans in each bank's assets portfolio (i.e. law of large numbers).

Of course, under this assumption the role of banks in the economy is not only information processing but also risk pooling[7]. However, this perfect diversification assumption will be also needed for the case of bondholders below. The goal of this assumption is just to avoid dealing with uncertainty in the model economy. Thus, risk pooling is not the distinctive feature of banks in this model. Rather, the main difference is their ability to process information efficiently.

[6]The assumption that the intermediation cost c^L is paid at the moment of getting the loan is a matter of convenience. This way, the cost will be comparable to the financial frictions arising in bond financing. Treating financial costs this way will prove to be key in order to solve the dynamic model. This will make the costs observationally equivalent to the case of adjustment cost to investment and therefore I will be able to apply standard solution procedures. I do not see that the main conclusions would be affected if intermediation costs were modelled as interest rate spread. In this case I would not be able to apply standard optimal control problem procedures though.

[7]This is a role that cannot be attributed solely to banks. Any other type of financial intermediary such as insurance companies or mutual funds typically perform the same kind of risk pooling.

As regards households, there is no heterogeneity among them. The representative household is risk-averse. It holds its wealth in the form of two type of financial assets: bank deposits and corporate bonds. Households are the owners of both firms and banks, and thus they receive their profits.

Households, in their role of debtholders of the firm's issues, cannot freely observe the firm's cash flow in every state of nature. They are not endowed with the same information processing technology of banks. Thus, it is costly for the economy to have them to learn the firm's cash flow in the event of default. As it will be explained below, this cost represents the time and effort uninformed lenders should spend in the verification activity. This is a pure waste. This is modelled as the resources spent in the information transferring activities that could be otherwise used for consumption or investment.

As of who will "pay" for this information cost, I assume that firms will. However, in a general equilibrium setting interest rates is an endogenous variable so the burden of the financial friction will be actually borne both by households and by firms. The cost consists of an origination cost that the firm must pay upfront at the moment of issuing the bonds. The idea is that p-firm will pay its expected bankruptcy cost $p\varphi$, where φ is the constant verification cost per unit of loan.

As it was stated above, there is also a transaction cost per unit loan associated with bond issues that will be also paid by the firm. Based on empirical evidence the form of this cost depend on the amount borrowed by the firm but also it depends on the size of the firm.

Empirical evidence on this cost can be found by looking at the underwriting fees paid upfront by the firm at the moment of issuing the securities (Smith, 2002). Lee, Lockhead, Ritter and Zhao (1996) estimate that this cost is around 2-3% for the case of corporate bonds. Smith (2002) mentions the fact that marketing cost associated to the issue includes 'road shows' aimed at selling the project to the public. Their goal is to release all the information that potential lenders need to know as well as to show them what are the firm's prospects if the investment project being promoted is effectively undertaken.

Altinkiliç and Hansen (2000) estimate marginal spreads paid in firm underwritten seasoned common stock offerings and straight bond offerings. The spread is the compensation paid to the underwriter for selling the firm's issue, as a percent of the capital raised. Based on empirical and anecdotal evidence, they work under the assumption that investment-banking competition is enough to ensure that underwriter fees represent just the cost of underwriting the offer. They obtain the result that the spread increases with the size of the issue and with the firm risk, conditional on the size of the firm.

The conventional wisdom is that there are important economies of scale in security issuance. For example, Gomes (2001) uses for the finance cost in his model evidence presented by Smith (1977). According to this evidence flotation costs in new issues as a fraction of the amount raised are decreasing in the size of the issue. However, Altinciliç and Hansen (2000) maintain that this evidence is misleading and is generated by the fact that larger firms, which tend to have larger issues, have lower monitoring, certification and marketing costs per dollar of new capital than do smaller firms, which tend to have smaller issues.

The economies of scale view requires the existence of important fixed costs associated to the security issue. In contrast, underwriting theories suggest that issuer's spread should be U-shaped. Initially, fixed cost causes scale economies, but as the issue size increases diseconomies of scale emerge due to the presence of placement costs. Placement costs increase because finding more buyers willing to buy the offer at the offer price becomes increasingly difficult. Also, diminishing returns in service production fuel the diseconomies of scale. After an empirical estimation they find: 1) underwriters' fixed costs are not large; they are just 6.5% of underwriting fees for stocks and 10.4% for bonds. Small fixed costs are not consistent with the economies of scale view. 2) marginal spreads are increasing in the size of the issue, with smaller firms facing steeper marginal schedules. 3) Spreads are U-shaped due to the interaction of small fix costs with rising average costs. However, higher quality issues (bigger firms or less risky firms according to S&P) pay lower spreads. 4) 35% of equity issues are in the region of diseconomies of scale while 30% of bond issues are in this region. This result is a bit disappointing, but we have to take into account that an additional 36% of issuers would fall in the diseconomies of scale part if they increased the issue by 25%.

To summarize, bondholders will charge $i^b = f(r^b, p)$ for the loan to a type p firm, where r^b is the opportunity cost of capital to the bondholders and p is a "credit risk premium"[8]. Firms must also pay at the moment of selling the issue an origination payment composed of the expected bankruptcy costs, $p\varphi$, plus a transaction cost per unit of loan of the form $\phi(\frac{I}{K})$, where $\frac{I}{K}$ is the firm's investment rate and $\phi'(.) > 0$.

As in the case of banks, we need to assume perfect diversification in order to avoid uncertainty. Households are atomistic units though, so we cannot invoke risk pooling. Rather we should think in a setting in which

[8]This "risk premium" does not refer to the compensation for the risk-aversion of the lender, but rather it corresponds to an interest rate spread between the cost of funds and the price of loans which is a compensation for credit risk

households own quota parts of mutual funds who undertakes the risk pooling function. Of course, the reason why the mutual fund and the bank are different institutions is that the latter operates under perfect information. At the same time, there is no intermediation costs associated to the activities of the mutual fund.

With the elements of the model introduced so far, I can discuss informally how a firm makes its financial decisions. Given its type p, each firm will decide to fund its investment projects by borrowing from the lender that is the cheapest. On the one hand, both banks and bondholders charge the risk premium p, once they observe it. On the other, households portfolio optimal decisions will lead to $r^d = r^b$ in equilibrium. Thus, firms will just compare $\vartheta(p, \frac{I}{K}) \equiv p\varphi + \phi(\frac{I}{K})$ and c^L to decide which source is the cheapest.

As it is depicted in Figure 1, $\vartheta(p, \frac{I}{K})$ is increasing with the firm's risk[9]. As a result, firms of type $p < p^*$ will use bond financing and those of type $p > p^*$ will use bank lending.

1.3 The Dynamic General Equilibrium Model

1.3.1 Households

The setting is one of infinitely lived representative households that maximize utility on consumption goods. Households are endowed with a fixed amount of managerial talent. Thus, this factor of production is supplied inelastically to the firms and total endowment in the economy is normalized to 1. Moreover, $\frac{1}{N}$ of the endowment is supplied inelastically to each type of firm.

[9] I assume further that $\vartheta(p_1, \frac{I}{K}) < c^L < \vartheta(p_N, \frac{I}{K})$, which simply means to take as given the fact that bond financing and bank lending do coexist in the real world.

Households make their saving decisions through allocating resources between two assets: corporate bonds issued by firms (B) and bank deposits (D).

$$\begin{aligned} \max_{\{\alpha,C\}} \quad & \textstyle\int_0^\infty \quad U(C)e^{-\rho t}dt \\ C + \dot{a} \quad & \leq \quad \sum_{i=1}^{N} w_i + (a-E)[\alpha r^d + (1-\alpha)r^b] + \pi^{bank} + \pi^{firm} \qquad (1.1) \\ a \quad & = \quad D + B + E \\ C \quad & \geq \quad 0 \end{aligned}$$

where

D = bank deposits.

B = corporate bonds [10]

E = equity holdings (fixed over time).

C = consumption.

ρ = rate of time preference.

w_i = payment to the fixed factor by type p_i firms.

α = share bank deposits on total assets (net of equity holdings).

As regards the budget constraint (1), individuals will never find it optimal to satisfy this restriction with strict inequality because it will be advantageous to increase C in order to raise the current flow of utility or to increase

[10] Due to the assumption on perfect diversification achieved through risk pooling by the mutual fund the risk premium p does not enter in the budget constraint.

asset holdings a to raise the future flows of utility (Barro and Sala-I-Martin, 1995). Note also that restriction $C \geq 0$ will never be binding if marginal utility of consumption tends to infinity as C goes to zero[11].

Firms' profits and banks' profits both enter the household budget constraint because they own these companies. Here I simply assume that there is neither issue of new stock nor retained earnings, thus household equity holdings will be constant over time. This is no problem for the case of banks, which neither default nor they loose money.

For the case of firms' equity, I assume again that households own quota parts of a mutual fund. The mutual fund holds firms' stock but it can diversify away any risk by spreading its asset holdings over a large number of firms. Although there is a proportion p of firms of each type going bankrupt, there is also a number pP of new firms at every moment of time. Thus, equity holding are also constant for the case of firms.

The solution to the optimization problem can be framed in the context of an optimal control problem. The Hamiltonian function and the FOCs are:

$$H = e^{-\rho t}\Big[U(C) + \lambda\Big(\sum_{i=1}^{N} w_i + (a-E)[\alpha r^d + (1-\alpha)r^b] + \pi^{bank} + \pi^{firm} - C\Big)\Big]$$

$$H_C = U'(C) - \lambda = 0 \tag{1.2}$$

$$H_\alpha = \lambda(a-E)(r^d - r^b) = 0 \quad \Rightarrow \quad r^d = r^b \tag{1.3}$$

$$H_a = -\dot{\mu}, \qquad \mu = \lambda e^{-\rho t} \quad \Rightarrow \quad \dot{\lambda} = \lambda\{\rho - [\alpha r^d + (1-\alpha)r^b]\} \tag{1.4}$$

[11] This is the case for many utility functions. For example, Cobb-Douglas utility, CRRA family and its particular case of logarithmic utility functions.

1.3.2 Banks

Banks are perfectly competitive, so they take as given the interest rate on the loans supplied to each type of firm $l(p_k)$ and on the deposits demanded D. Banks receive interest payments on the loans outstanding and they pay interest for the balances held by households at the bank. Bank's problem is a static one, so:

$$\max_{l(p),D} \pi^{bank} = \sum_{p=p_1}^{p_N} (1-p)i^L l(p) - pl(p) - r^d D$$

$$\sum_{p=p_1}^{p_N} l(p) + E^{bank} = D$$

Thus the pricing equation corresponding to the type p borrower would be,

$$i^L = \frac{r^d + p}{1-p} \tag{1.5}$$

Thus, the bank will never make loses. Since it can perfectly observe firms' types it can charge them the fair risk premium p. The bank will perfectly pool risk eliminating any source of uncertainty.

1.3.3 Firms

Firms are price takers. Firms make production, investment and financing decisions. Their goal is to maximize the present value of the stream of cash flows paid to the stockholders discounted at the market interest rate. However, the discount rate must also reflect the firm's probability of bankruptcy given by its type p.

1.3.3.1 No Financial Frictions in Bond Financing

In the case of no information asymmetries in the financial market and no transaction cost for bond issues, type p firm's problem is:

$$\max_{\{iv(p),\iota(p)\}} v(0,p) = \int_0^\infty z(t,p)\{AF[k(p)] - w(p) - \\ - i^L l(p) - i^b b(p) - iv(p)[1+\iota(p)c^L] + \dot{b}(p) + \dot{l}(p)\}dt$$

$$\begin{aligned}
\dot{k}(p) &= iv(p) - \delta k(p) && (1.6)\\
\dot{l}(p) &= \iota(p)iv(p) - \delta\beta k(p) && (1.7)\\
\dot{b}(p) &= \Big(1-\iota(p)\Big)iv(p) - \delta(1-\beta)k(p) && (1.8)\\
i^L &= \frac{r^d + p}{1-p} && (1.9)\\
i^b &= \frac{r^b + p}{1-p} && (1.10)\\
\lim_{t\to\infty} & \quad k(p)z(t,p) \leq 0 && (1.11)\\
k(0,p) &= e(p) + l(0,p) + b(0,p) && (1.12)
\end{aligned}$$

where

$z(t,p) = \exp\Big(-\int_0^t[\alpha r^d + (1-\alpha)r^b + p]dt\Big)$, i.e. discount factor

$k(p)$ = type p firm's capital

$w(p)$ = rent paid to the manager

$\iota(p)$ = 1 if bank lending is cheaper than bond financing, and 0 otherwise (binary variable)

$iv(p)$ = type p firm's gross investment

$l(p)$ = bank loans outstanding

$b(p)$ = bonds outstanding

$e(p)$ = type p firm's equity

$\beta = \frac{l(p)}{l(p)+b(p)}$

c^L = upfront administrative cost in bank loan financing

$k(0,p)$ = type p firm's initial capital stock [12].

The production technology $AF(k)$ has the usual properties: $AF_k > 0$; $AF_{kk} < 0$ and Inada conditions hold. A is an index for the economy wide technology level. Both capital and managerial talent are inputs in the production process, but the latter exists in fixed supply. Thus, the production function features DRS. Managerial talent has not been explicitly included in the production function, but the assumption is that each firm needs at least $\frac{1}{PN}$ to operate.

Equations of motion for bonds and bank loans (i.e. $\dot{b}$ and $\dot{l}$) arise from the assumption that gross investment is entirely financed through external resources. Retained earnings or stock issuing are ruled out from the set of available financing methods. Either bank loans or bond financing are used,

[12] Because of the assumption of perfect diversification in equity and debt holdings, the initial value of the state variables (including capital) in the problem for the Pp new firms is equal to the current value of these same variables for the existing $(1-p)P$ firms. In this way, the aggregate capital stock of the economy does not change because of entry and exit of firms.

whatever is the cheapest (i.e. $\iota(p)$ takes values 0 or 1). For the total debt stock not to grow in steady-state, I assume that at each moment of time a fraction of the stock of debt (equal to the depreciation rate) is paid back to the lender [13].

Equations $i^j = \frac{r^j+p}{1-p}$, with $j = L, b$ are simply the participation constraints for banks and the mutual fund (in representation of bondholders) respectively.

The Hamiltonian function is

$$H = z(t)[AF(k) - w - i^L l - i^b b - iv\iota c^L - \delta k + q(iv - \delta k)] \tag{1.13}$$

And FOCs to this problem are

$$\begin{aligned} H_{iv} &= q - \iota c^L = 0 \\ H_k &= -\dot{\mu} \quad \mu = z(t)q \\ &\Rightarrow \quad AF_k - \delta - \frac{r+p}{1-p} - \delta q = [\alpha r^d + (1-\alpha) r^b + p]q - \dot{q} \end{aligned}$$

where firms take as given the fact that no arbitrage condition for households (3) implies that $r^d = r^b \equiv r$. Since, under perfect information, bank lending is

[13] A different alternative could be just to assume that net investment is financed with debt while depreciation is paid out of the firm's cash flow at every moment of time. In fact, if there were no financial frictions there would be no difference between these two schemes. However, as I will show later, when there are costs of issuing debt then the two settings differ in that only the former gives a continuous function for the adjustment cost to investment. With the alternative setting there would be a discontinuity in that function at the steady state value of investment, since it would jump discontinuously to zero. Thus the marginal condition for capital could not be derived.

always more expensive than bond financing, all firms (of any type) will choose $\iota(p) = 0$ always. Thus, the necessary condition for an optimum reduces to the usual expression for a static firm's problem

$$AF_k - \delta = \frac{r + p}{1 - p} \tag{1.14}$$

1.3.3.2 Costly State Verification

Following Freixas and Rochet (1997), I will characterize the contract between the borrower and the lender in the case in which the firm's cash flows is not observable to the bondholders. Using the revelation principle, the contract can be described by a repayment function, $R(\tilde{f})$, where $\tilde{f}$ is the firm's cash flow as reported by the borrower (i.e. $f \equiv AF(k) - w$), an auditing rule, identified by a set S of reports of the borrower for which the lender undertakes and audit, and a penalty function $P(f, \tilde{f})$, specifying an additional transfer from the borrower to the lender after the audit in case in which $\tilde{f} \neq f$.

The set of incentive compatible contracts for which truthful reporting $\tilde{f} = f$ is a dominant strategy for the firm is given by

$$\begin{array}{cccc} \forall \tilde{f} & \textit{not in} & S & R(\tilde{f}) = R \\ \forall \tilde{f} & \in & S & R(\tilde{f}) \leq R \end{array}$$

and $P(\tilde{f}, f) = 0$ for $\tilde{f} = f$, and $\rightarrow \infty$ otherwise.

Thus, there is no incentive to untruthful reporting neither in the auditing region (because the penalty function is big enough) nor in the no auditing region (because the repayment is independent from the report).

The next step is to select the efficient incentive compatible debt contract. Given that both firms and the mutual fund (in representation for the bondholders) are risk neutral, the optimal contract is obtained by maximizing the expected repayment given a fixed probability of a costly audit. Given that the repayment is constant in the no audit region, the optimal contract is:

$$\begin{array}{cccc} \forall\tilde{f} & \textit{not in} & S & R(\tilde{f}) = R \\ \forall\tilde{f} & \in & S & R(\tilde{f}) = f \end{array}$$

and $S = \{\tilde{f}|\tilde{f} < R\}$ and $P(\tilde{f}, f) = 0$ for $\tilde{f} = f$, and $\rightarrow \infty$ otherwise.

This corresponds to the standard debt contract, by which under limited liability and bankruptcy laws, the firms will be inspected and its assets seized in case of default. In my model, the auditing rule is given by the singleton $\tilde{f} = 0$, and the repayment function is $R(0) = 0$ while the constant repayment (per unit of loan) in the no audit region is $R = i^b$. I assume that auditing firms costs φ per unit of loan and that this cost is actually paid by the firms [14]. Of course, firms must pay in advance (i.e. at the moment of getting the loan) according to their probability of default. That is, when the P type-p firms are given a loan each will be charged φp, so that $Pp\varphi$ will amount exactly to the verification costs associated to the pP defaulting firms.

In this setting, type p firm's problem is:

[14] In a general equilibrium setting this does not mean the φ is actually borne by the firm.

$$\max_{\{iv(p),\iota(p)\}} v(0,p) = \int_0^\infty z(t,p)\{AF[k(p)] - w(p) - i^L l(p) - i^b b(p) - $$
$$- iv(p)[1 + \iota(p)c^L + (1-\iota(p))p\varphi] + \dot{b}(p) + \dot{l}(p)\}dt$$

$$\begin{aligned}
\dot{k}(p) &= iv(p) - \delta k(p) && (1.15)\\
\dot{l}(p) &= \iota(p)iv(p) - \delta\beta k(p) && (1.16)\\
\dot{b}(p) &= \Big(1-\iota(p)\Big)iv(p) - \delta(1-\beta)k(p) && (1.17)\\
i^L &= \frac{r^d + p}{1-p} && (1.18)\\
i^b &= \frac{r^b + p}{1-p} && (1.19)\\
\lim_{t\to\infty} k(p)z(t,p) &\leq 0 && (1.20)\\
k(0,p) &= e(p) + l(0,p) + b(0,p) && (1.21)
\end{aligned}$$

The Hamiltonian function is

$$H = z(t)\big[AF(k) - w - (r^d+p)l - (r^b+p)b - iv[\iota c^L + (1-\iota)p\varphi] - \delta k + q(iv - \delta k)\big] \quad (1.22)$$

Where we have made use of the approximation $i^j \approx (r^j + p)$, for $j = d, b$[15].

[15] Adding 1 both sides of the equation: $1+i = \frac{1-p+r+p}{1-p} \rightarrow e^i = e^{r+p} \rightarrow (1+i) \approx (1+r+p)$. Although this is reasonable only for p small enough, the scope of the qualitative analysis is not limited by this assumption. Since the approximation is just a monotonic transformation of the actual function i^j the qualitative conclusions will not be affected if we use $(r^j + p)$ instead of i^j.

FOCs to this problem are

$$\begin{aligned}
H_{iv} &= q - \iota c^L - (1-\iota)p\varphi = 0 \\
H_k &= -\dot{\mu} \quad \mu = z(t)q \\
&\Rightarrow \quad AF_k - \delta - (r+p) - \delta q = [\alpha r^d + (1-\alpha)r^b + p]q - \dot{q} \\
\frac{\Delta H}{\Delta \iota} &= -c^L + p\varphi \geq 0
\end{aligned} \tag{1.23}$$

Thus, I need to assume $p_1\varphi < c^L < p_N\varphi$. The only justification for these assumptions is that this will guarantee coexistence of bond financing with bank lending. Since I am not interested in the case of only one type of financial instrument I will make the assumptions necessary for the model to be consistent with the empirical fact of coexistence of both methods.

Since the marginal value of capital q is constant over time, the optimization problem for the firm is essentially a static one. The marginal optimality condition for capital is

$$AF_k = (r+p+\delta)[1 + \iota c^L + (1-\iota)p\varphi] \tag{1.24}$$

1.3.3.3 Transaction Costs in Bond Financing

Following Gomes (2001), Smith (2002) and Altinciliç and Hansen (2000) I include loan elastic financial frictions. As it was discussed above, the empirical evidence shows that underwriting fees per unit loan are increasing in the size of the issue conditional on the size of the firm. Thus the origination payment per unit of loan will be increasing in the investment rate $\frac{iv}{k}$ and the financial frictions in the model will work as standard adjustment cost to investment. Thus, transaction cost is $\phi(\frac{iv}{k})$, with $\phi'(.) > 0$. Without loss of generality I further assume $\phi''(.) = 0$.

Adding this financial friction to the contract described in the previous two sections, we can now outline the dynamic problem for the firm.

$$
\begin{aligned}
\max_{\{iv(p),\iota(p)\}} v(0,p) &= \int_0^\infty z(t,p)\{AF[k(p)] - w(p) - (r^d+p)l(p) - (r^b+p)b(p) - \\
&- iv(p)[1+\iota(p)c^L + (1-\iota(p))\vartheta(p,\frac{iv}{k})] + \dot{b}(p) + \dot{l}(p)\}dt \\
s.t. & \\
\dot{k}(p) &= iv(p) - \delta k(p) \\
\dot{l}(p) &= \iota(p)iv(p) - \delta\beta k(p) \\
\dot{b}(p) &= \Big(1-\iota(p)\Big)iv(p) - \delta(1-\beta)k(p) \\
\lim_{t\to\infty} & \quad k(p)z(t,p) \leq 0 \\
k(0,p) &= e(p) + l(0,p) + b(0,p)
\end{aligned}
$$

Where $\vartheta(p,\frac{iv}{k}) \equiv \phi(\frac{iv}{k}) + p\varphi$, with $\vartheta_1(.) > 0$ and $\vartheta_2(.) > 0$. Without loss of generality we can assume $\vartheta_{22}(.) = 0$.

As it was explained above, the formulation for the equations of motion for bonds and bank loans implies that the adjustment cost to the investment function is continuous as long as gross investment is positive. Thus an implicit assumption of the model is that investment is irreversible. And I say that it is an assumption because I am not including a constraint of the form $iv(p) \geq 0$. As usual, this can be justified if we limit the analysis of the dynamics to a neighborhood of the steady state, in which $iv = \delta k$.

The Hamiltonian is

$$H = z(t)\{AF(k) - w - (r^d + p)l - (r^b + p)b - iv[\iota c^L + (1-\iota)\vartheta(\frac{iv}{k})] - \delta k + q(iv - \delta k)\} \tag{1.25}$$

The FOCs to the optimal control problem for type p firms are

$$\begin{aligned}
H_{iv} &= q - \iota c^L - (1-\iota)\vartheta(x) - (1 - \iota(p*))x\vartheta'(x) = 0 && (1.26)\\
H_k &= -\dot{\mu}; \quad \mu = z(t)q \\
\Rightarrow & \quad AF_k + (1-\iota)x^2\vartheta'(x) - [\beta r^d + (1-\beta)r^b + p] - \delta - \delta q = \\
& \quad = [\alpha r^d + (1-\alpha)r^b + p]q - \dot{q} && (1.27)\\
\frac{\Delta H}{\Delta \iota} &= -c^L + \vartheta(x) \geq 0 && (1.28)
\end{aligned}$$

Where $x \equiv \frac{iv}{k}$.

1.4 Decentralized Economy Equilibrium

In order to solve for the decentralized economy problem we must impose market clearing conditions for assets

$$\begin{aligned}
a - E - D &= \sum_{p=p_1}^{p_N} b(p) \\
D + E &= \sum_{p=p_1}^{p_N} l(p)
\end{aligned}$$

And for shares of stock,

$$E = E^{bank} + E^{firms} = (\sum_{p=p_1}^{p_N} l(p) - D) + \sum_{p=p_1}^{p_N} [k(p) - l(p) - b(p)] \qquad (1.29)$$

As regards the market for goods, the resource constraint is

$$C \quad + \quad \sum_{p=p_1}^{p_N} iv(p)[1 + \iota(p)c^L + (1 - \iota(p))\vartheta(x)] = \sum_{p=p_1}^{p_N} AF(k(p))$$

Following Abel and Blanchard (1983), we can define a variable $y \equiv (1+q)\lambda$, which is the marginal value of capital in marginal utility units. Then,

$$\dot{y} = \lambda\dot{q} + (1+q)\dot{\lambda} \qquad (1.30)$$

solving for $\dot{q}$ and replacing in (27)

$$\lambda[AF_k + (1 - \iota(p))x^2\vartheta'(x)] = \lambda[r + p + \delta](1+q) - \dot{y} + (1+q)\dot{\lambda} \qquad (1.31)$$

where we have use household FOC (3) to get only one interest rate r. Adding 1 in both sides of (26) and multiplying by λ we get

$$y \equiv \lambda(1+q) = \lambda[1 + \underbrace{\iota(p)c^L + (1 - \iota(p))\vartheta(x)}_{\gamma(x)} + \underbrace{(1 - \iota(p))x\vartheta'(x)}_{x\gamma'(x)}] \qquad (1.32)$$

And define $\Gamma(x) \equiv 1 + \gamma(x) + x\gamma'(x)$.

We can use (32) to eliminate y in (31). In order to eliminate $\dot{y}$, I have first to derive (32) respect to time

$$\dot{y} = U''(C)\Gamma(x)[AF_k - x(1+\gamma(x))]\dot{k} - [U''(C)k\Gamma(x)^2 - U'(C)\Gamma'(x)]\dot{x} \quad (1.33)$$

Plugging this into (31) we get

$$U'(C)[AF_k + x^2\gamma'(x)] = [r + p + \delta]U'(C)\Gamma(x) + U'(C)\Gamma(x)(\rho - r) - \quad (1.34)$$
$$- U''(C)\Gamma(x)[AF_k - x(1+\gamma(x))]\dot{k} + [U''(C)k\Gamma(x)^2 - U'(C)\Gamma'(x)]\dot{x}$$

and rearranging

$$A_1\dot{x} = A_2 + A_3\dot{k} \quad (1.35)$$

With

$$A_1 \equiv [\Gamma'(x) - \frac{U''(C)}{U'(C)}\Gamma(x)^2 k] > 0 \quad (1.36)$$
$$A_2 \equiv [(\rho + \delta + p)\Gamma(x) - AF_k - x^2\gamma'(x)] \quad (1.37)$$
$$A_3 \equiv -\frac{U''(C)}{U'(C)}\Gamma(x)[AF_k - x(1+\gamma(x))] \quad (1.38)$$

And restating the equation of motion for $k(p)$

$$\dot{k} = k(x - \delta) \quad (1.39)$$

System (35) and (39) can be used to derive the steady state and characterize the dynamics of the problem in terms of k and x.

Following Abel and Blanchard (1983), the locus $\dot{x}$ can be figured out by analyzing loci $A_2 = 0$ and $A_3 = 0$. These loci and their signs for each value of x and k are shown in Figure 2. The format is (sign, locus number). By inspecting (35) it is easy to see that $\dot{x} = 0$ locus must go through the areas where loci A_2 and A_3 have opposite signs if we are above $\dot{k} = 0$ locus (i.e. where $\dot{k} > 0$); and it must go through the area where A loci have the same sign below the $\dot{k} = 0$ locus (where $\dot{k} < 0$).

Finally, the arrows show the signs for $\dot{k}$ and $\dot{x}$ in each area of the graph. There is saddle point equilibrium at the crossing of these loci. The stable arm of this equilibrium is depicted in the graph as a dashed line.

By inspecting loci A_2 and A_3, one can derive the distribution of the steady-state capital stock across firm types. Note, that the model obtains endogenously the result that firm size is inversely related to the firm risk. The bottom panel in Figure 2 is a rough description of how the economy's capital stock is distributed among firm types. The kink in the line is due to the fact that the wedge introduced by the financial frictions changes asymmetrically as we move toward each of the extremes of the horizontal axe. As one moves toward $p = p_1$, the cost of financing decreases for two reasons: 1) because p falls and 2) because $\vartheta'(p) > 0$ and $\vartheta'(k) < 0$. However, as one moves toward $p = p_N$, cost of financing increases at a lower rate.

This is one testable implication of the model: firm's capital stock is more sensitive to the firm's risk when investment is financed through bonds as compared to bank lending.

1.4.1 A change in Banks' Intermediation Cost

In this section I put the model to work. The idea is to keep track over time of the evolution of aggregate variables after the model economy is hit by unexpected permanent shocks. First, I will analyze the case of an exogenous change in banks intermediation cost. This development could be associated to a policy shock affecting bank efficiency in intermediation[16]. In the next section I will study the case of a permanent unexpected productivity shock.

Suppose that c^L increases permanently; from the definition for $\Gamma(x)$ is easy to see that:

$$\frac{\partial \gamma(x)}{\partial c^L} \geq 0 \quad ; \qquad \frac{\partial \gamma'(x)}{\partial c^L} = 0$$
$$\frac{\partial \Gamma(x)}{\partial c^L} = \frac{\partial \gamma(x)}{\partial c^L} \geq 0 \quad ; \qquad \frac{\partial \Gamma'(x)}{\partial c^L} = \frac{\partial \gamma'(x)}{\partial c^L} = 0$$

Therefore, A_2 and A_3 loci can also be signed after a change in c^L, for the derivatives evaluated at $A_2 = 0$ and $A_3 = 0$ respectively.

$$\begin{aligned} \frac{\partial A_2}{\partial c^L} &= (\rho + \delta + p)\frac{\partial \Gamma(x)}{\partial c^L} \geq 0 \\ \frac{\partial A_3}{\partial c^L} &= \frac{U''(C)}{U'(C)}\Gamma(x)x\frac{\partial \gamma(x)}{\partial c^L} \leq 0 \end{aligned}$$

These signs imply that after an increase in c^L, both loci will shift to the left and thus $\dot{x} = 0$ locus will also shift. Figure 3 below shows the effect of

[16] At this point no explanation can be given for such a change in the intermediation costs. The idea is, in my future research, to relate this to monetary policy changes or to a type of financial accelerator by which the cost of certain regulations (such as capital adequacy ratios) changes over the business cycle.

an unexpected permanent increase in c^L for all firm types that used to finance investment through bank loans. From equation (28) it is clear that p^* has increased after the change in c^L, so some of these firms still use bank lending financing (i.e. $p > p^*$) and some others now use bond financing. On the right panel, the time paths followed by x, investment, capital and consumption are plotted.

The paths for investment and consumption can be easily derived from the phase diagram. Since steady state investment is $iv^* = \delta k^*$, the new steady state level is lower than before the policy change. During the transition, k decreases while investment decreases at a lower rate, so that x increases after the initial negative shock.

For consumption, Abel and Blanchard (1983) use iso-consumption lines derived from the resource constraint, $\sum_{p=p_1}^{p_N} AF(k(p)) - \sum_{p=p_1}^{p_N} iv(p)[1+\iota(p)c^L + (1-\iota(p))\vartheta(x)] =$ constant C. Again, since the aggregate variables are just increasing monotonic transformations of the individual firm's counterparts, we can analyze the qualitative response of aggregate consumption by looking to type-p firm phase diagram. So, for a type-p firm $AF(k) - kx[1+\gamma(x)] = \overline{C}$. These lines have the shape of and inverted U, with a maximum at the combination of x and k for which $A_3 = 0$.[17] Of course, the iso-consumption curves increase in value as we move to the southeast.[18]. Therefore, after the change in c_L consumption will immediately jump, from C_0 to C_1' in the graph. In fact, that change is composed by two parts: first, C decreases from C_0 to C_0' due to the fact that $\frac{\partial\gamma(x)}{\partial c^L} > 0$; second, C increases from C_0' to C_1' due to the fall

[17]From (38) we see that $A_3 = 0$ implies that $AF_k - x[1+\gamma(x)] = 0 \Rightarrow \frac{dx}{dk}_{d\overline{C}=0} = 0$.

[18]For a given amount of capital, less investment (i.e. lower x) implies more consumption; and for a given investment rate, more capital implies more production and more consumption

in x. The net result of these two instantaneous changes is ambiguous though. For the remaining of the transition, as x increases, consumption falls smoothly toward the new steady state. To see that the new steady state level will be lower than before we can differentiate the economy's resource constraint for $dx = 0$:

$$\frac{dC}{dk} = [AF_k - x(1 + \gamma(x))] > 0$$

since $A_3 > 0$ in the steady state.

The distribution of capital across firm types will also changes after the increase in the cost of bank lending. Since transaction costs have risen for firms that either switched to bond financing or that still use bank lending, the distribution becomes more skewed toward lower p firms. This is shown in Figure 4 where the original distribution of capital (dashed line) is compared against the new distribution (solid line) after the change in the intermediation cost. Thus, one prediction of the model is that the variance of firms' sizes across types decreases as the cost of bank credit goes up.

1.4.2 Productivity shocks with financial frictions

The second exercise consists of studying the problem dynamics after an unexpected permanent productivity shock. From the expressions for A_2 and A_3 above

$$\begin{aligned} \frac{A_2}{A}|_{A_2=0} &= -F_k < 0 \\ \frac{A_3}{A}|_{A_3=0} &= -\frac{U''(C)}{U'(C)}\Gamma(x)F_k > 0 \end{aligned}$$

The sign of the derivatives implies that, after a positive unexpected permanent productivity shock, both loci will shift to the right. Thus, C, k and iv would all increase and their time profiles will look just like the negative to the ones shown in Figure 3.

As regards the distribution of capital across firm types it also changes in this case. The change in the steady state level of capital is given by the horizontal shift of the A_2 locus, which is equal to $-F_k$. Thus, the shift will be smaller for low p type of firms. Figure 5 compares the original distribution of capital (dashed line) with the one that arises after the unexpected productivity shock (solid line).

Frictionless Economy

A more interesting exercise is to compare the system dynamics with the one corresponding to a frictionless environment. If there were no financial transaction costs of any sort, the differential equations describing the system would be given by (40) and (41)[19].

$$\bar{A}_1 \dot{x} = \bar{A}_2 + \bar{A}_3 \dot{k} \tag{1.40}$$

$$\dot{k} = k(x - \delta) \tag{1.41}$$

with

[19] Check appendix for the solution of frictionless economy.

$$\begin{aligned}\bar{A}_1 &= -\frac{U''}{U'}k \\ \bar{A}_2 &= (\rho+\delta+p) - AF_k \\ \bar{A}_3 &= -\frac{U''}{U'}(AF_k - x)\end{aligned}$$

The over-line is used to distinguish each variable from its counterpart in the original system.

First, comparing $\bar{A}_2$ locus to A_2 we can see that for the same value of k and x, $A_2 > \bar{A}_2$. Since in steady state $x = \delta$, and for the total factor productivity indices $A = \bar{A}$

$$A_2 = (\rho+\delta+p)\Gamma(\delta) - \delta^2\gamma'(\delta) - AF_k >$$
$$(\rho+\delta+p)\Gamma(\delta) - (\rho+\delta)\delta\gamma'(\delta) - AF_k > (\rho+\delta+p) - AF_k = \bar{A}_2$$

Thus, ceteris paribus, steady state k must be lower in the economy with financial frictions.

Now, in order to compare the dynamics of the two systems, suppose that initially $\bar{A} < A$ such that $A_2 = \bar{A}_2$. In that case steady state capital stocks will be equal to each other in the beginning. Now, after a TFP shock an increase in the steady state level of k in each case will be given by

$$\frac{dk}{dA} = \frac{F_k}{-AF_{kk}} > 0 \quad \text{and} \quad \frac{dk}{d\bar{A}} = \frac{F_k}{-\bar{A}F_{kk}} > 0$$

under the usual decreasing marginal productivity to capital assumption. Thus, for a given shock $\frac{\partial k}{\partial A} < \frac{\partial k}{\partial \bar{A}}$.

Second, plugging (38) into (34) and (41) into (40) we can do

$$\frac{\dot{\bar{x}}\bar{A}_1 - \bar{A}_2}{\bar{A}_3} = \frac{\dot{x}A_1 - A_2}{A_3}$$
$$\dot{\bar{x}} = \frac{\bar{A}_3}{A_3}\frac{A_1}{\bar{A}_1}\dot{x} - \frac{\bar{A}_3}{A_3}\frac{A_2}{\bar{A}_1} + \frac{\bar{A}_2}{\bar{A}_1}$$

Both, $\dot{x}$ and $\dot{\bar{x}}$ are negative after the productivity shock, but unfortunately we cannot see unambiguously which one is lower. Since

$$A_3 = \Gamma(x)\bar{A}_3 + \frac{U''}{U'}\Gamma(x)x\gamma(x)$$

we cannot see if $\frac{\bar{A}_3}{A_3}$ is higher or lower than one. However, there is no ambiguities other than this. That is, suppose $\frac{\bar{A}_3}{A_3} \approx 1$ which is reasonable, then it is easy to show that $\frac{A_1}{\bar{A}_1} > 1$ and $\bar{A}_2 < A_2 < 0$. In that case $\dot{\bar{x}} < \dot{x} < 0$.

Therefore, on the one hand we have $\frac{dk}{dA} < \frac{dk}{d\bar{A}}$ from a comparative static point of view (i.e. with $\dot{x} = 0$ and $\dot{k} = 0$) and, on the other, $\dot{\bar{x}} < \dot{x}$ for any point during the transition, including the stable arm. With all this information we can draw the time profile for x, k and iv in each case as depicted in Figure 6 (bold lines correspond to the dynamics of the system with financial frictions).

The left top panel of the graph shows $x < \bar{x}$ up to certain point of the transition and after that $x > \bar{x}$. In fact, this is just one possibility, the other being $x < \bar{x}$ during the whole transition period. The value of x at each point in time will in turn affect the dynamics of capital.

With $x < \bar{x}$, we will have $0 < \dot{k} < \dot{\bar{k}}$ (remember $\dot{k} = k(x - \delta)$) and k will be lower than $\bar{k}$ always. Finally, investment under financial frictions must also be lower during the transition, but it must be increasing at a lower rate for the case depicted in the graph. After a positive productivity shock, investment jumps and keeps increasing toward the new steady state level. Since the presence of transactions costs make investment financing more expensive in terms of resources diverted from consumption, it is optimal from the point of view of consumption smoothing to invest at a lower rate during more time than in the frictionless environment case.

As regards investment financing, we can see from (28) that p^* will temporarily decrease while $x(p)$ is above steady state and then it will return to its original level. Once again this is in line with empirical evidence showing that bond financing is countercyclical while bank lending is procyclical.

1.5 Concluding Remarks and Directions for Future Research

This paper develops a dynamic general equilibrium model of investment financing and it explains the coexistence of two alternative sources of external funding: bonds and bank loans. The setting and assumptions of the model are all in line with the main stylized facts of financial markets. Its distinct feature respect to the usual partial equilibrium models in this literature is that it takes into account the fact that financing choices and investment decisions are two endogenous outcomes in the optimization problem of firms.

Following Abel and Blanchard (1983) I can derive the system of differential equations describing the steady-state and transitional dynamics of the model. In steady-state, and due to the informational frictions in credit markets, more risky firms prefer to use bank lending while less risky ones can overcome better the informational cost associated with the use of public debt.

The model generates an endogenous steady-state distribution of the capital stock across firms, with larger firms being the less risky ones.

As regards the analysis of the transitional dynamics which is characterized by a phase diagram, it is based on two exercises:

An unexpected positive permanent shock to banks' intermediation cost. This affects directly the financing decisions of firms: riskier firms that usually find it cheaper to use bank lending now switch to bond financing. The phase diagrams characterizing the model solution suggest how this, in turn, will impact on the firm's investment decisions. The higher costs associated with the informational imperfections of credit markets raise the cost of capital for these firms and thus investment decreases. As capital accumulation slows down, production and consumption fall permanently. As regards firm size, investment decreases only in those firms using bank lending so the distribution of capital across firms becomes more skewed toward less risky firms.

An unexpected positive permanent shock to total factor productivity. This affects on impact the investment decisions of the firm. Since the productivity of capital increases all firms in the economy invest more and output and consumption both increase. The model allows studying the second round effects of this shock on firms' financing decisions. With informational frictions in corporate bond markets being a convex function of the amount borrowed, many firms switch to bank lending. As regards firm size, since the effect of a given TFP shock on smaller riskier firms is stronger than in larger safer ones, the distribution of capital across firms becomes less skewed toward the latter.

One interesting direction worth exploring after these results are obtained would be to inter-relate these two effects to explain certain features of the business cycle that standard stochastic models cannot match. Typically, business cycle models with no frictions in credit markets fail to predict persistence and amplitude of output fluctuations. Increased persistence in the cycles would be obtained if the effects of the shocks on investment and financing decisions by firms reinforce with each other producing a financial accelerator. For example, if cost c^L were a function of the TFP index A (i.e. $c^L(A)$), then productivity shocks would affect the intermediation costs for banks. In order to get a financial accelerator $\frac{\partial c^L(A)}{\partial A} < 0$ would be needed.

A very well known financial accelerator study is Bernanke and Gertler (1989) paper on agency costs, net worth and business cycles[20]. However, we could also argue that it is not only the fluctuations in borrowers net worth what triggers this change in the cost of bank credit but also it is something else on the lender's side, such as a change in the structure of the banking industry over the cycle. For example, a negative productivity shock would trigger a decrease in the demand for bank credit, which in turn would increase the unit cost of the loans. This could occur for example if the banking industry behaved as a colluding oligopoly of the type described in Rotemberg and Saloner (1986). Banks could sustain above competitive profits because of the threat of reverting to competition when a single bank does not cooperate. The point in that model is that such oligopoly finds collusion easier to carry out when their demand is

[20]Because of the informational asymmetries between borrowers and lenders, the optimal financial contract entails deadweight losses relative to the first-best perfect information case. These agency costs will be lower the greater the level of collateralizable net worth of the potential borrower. Thus, periods of financial distress, during which asset prices are low and thus net worth is low, are also times of high agency costs.

relatively low. Thus, after a reduction in demand for credit, and under certain conditions, banks would increase the degree of collusion (and hence profits) by increasing the interest rate spread.

Following Blum and Hellwig (1995), certain existing banking regulations can also work as a financial accelerator in a model where bank lending has real effects. In their model, when bad times arise, a higher proportion of firms go bankrupt than during normal times. Therefore the fraction of non performing loans in banks' assets portfolio increases and banks' equity falls. If there exists a capital adequacy regulation, and if for some reason it is costly to raise more funds, banks will adjust the size of their assets portfolio. They will limit the amount of loans to the maximum allowed by the regulation. Thus, it is not only loan demand falling after a negative productivity shock but also the supply shrinking due to the regulation imposed to banks.

A distinct feature of this financial accelerator, as opposed to those in the Bernanke and Gertler (1989) tradition, is that it derives from lender's characteristics rather than from borrower's characteristics. That is, regulation or industry structure affects directly the decisions by the suppliers of credit. Bernanke and Gertler's explanation instead hinges more on borrower's net worth when credit contracts requires collateral and asset prices fluctuate over the business cycle.

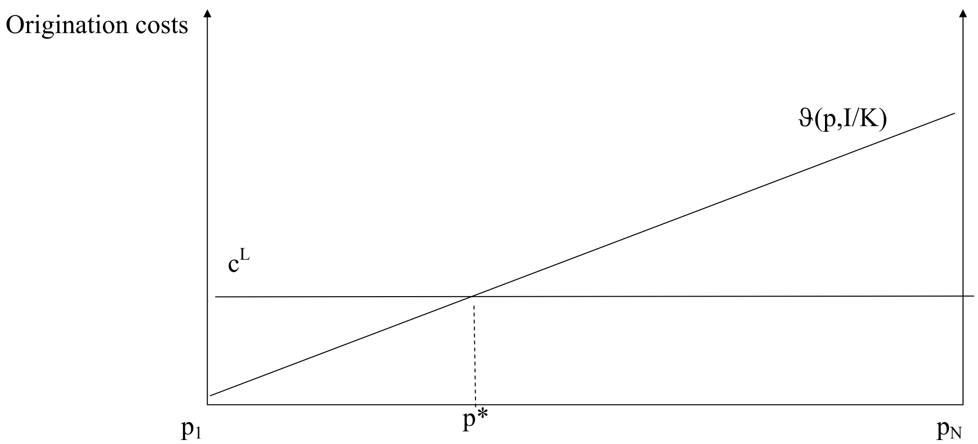

Figure 1.1: Financial decision of the firm

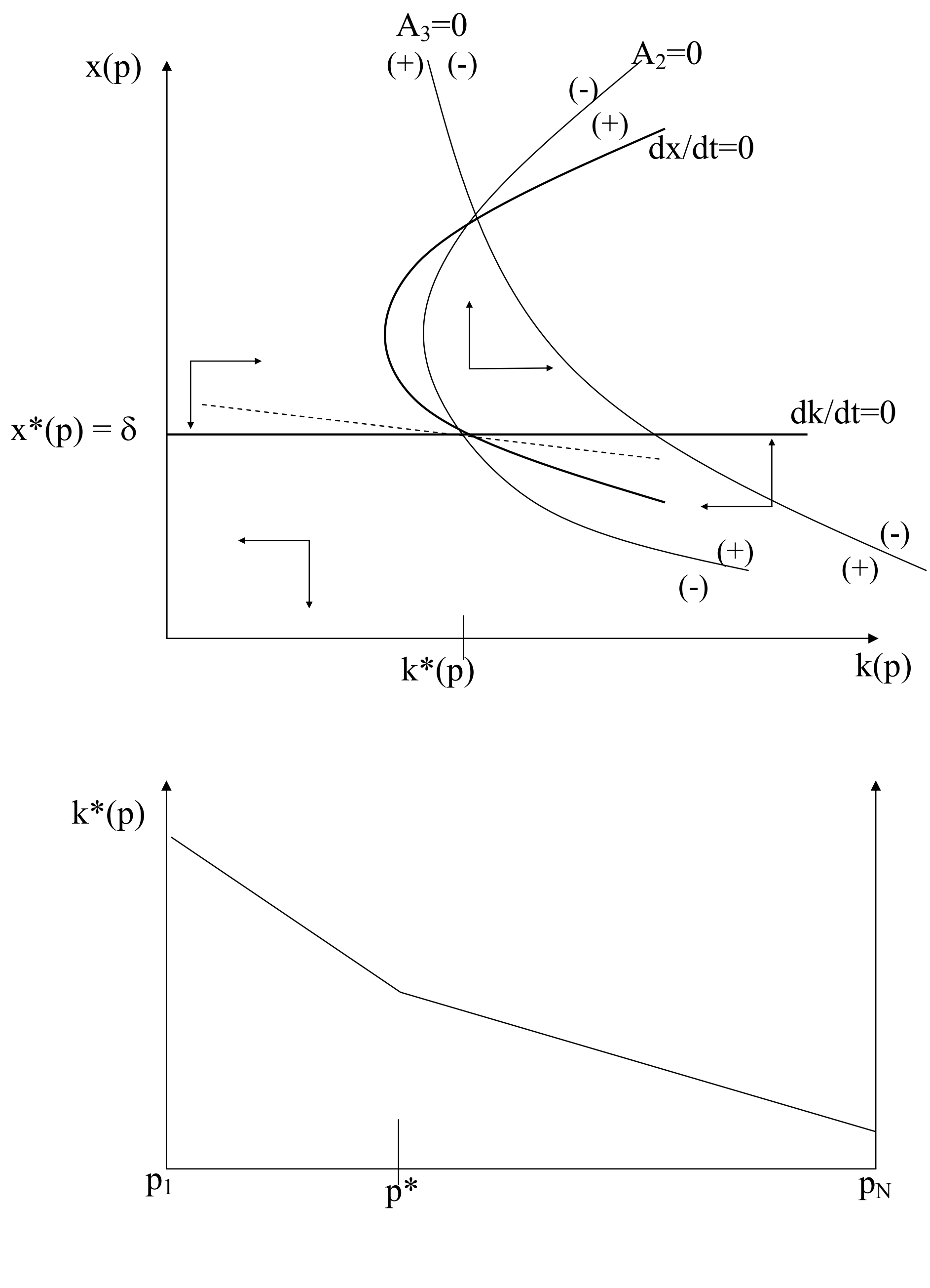

Figure 1.2: Phase Diagram and Distribution of Capital

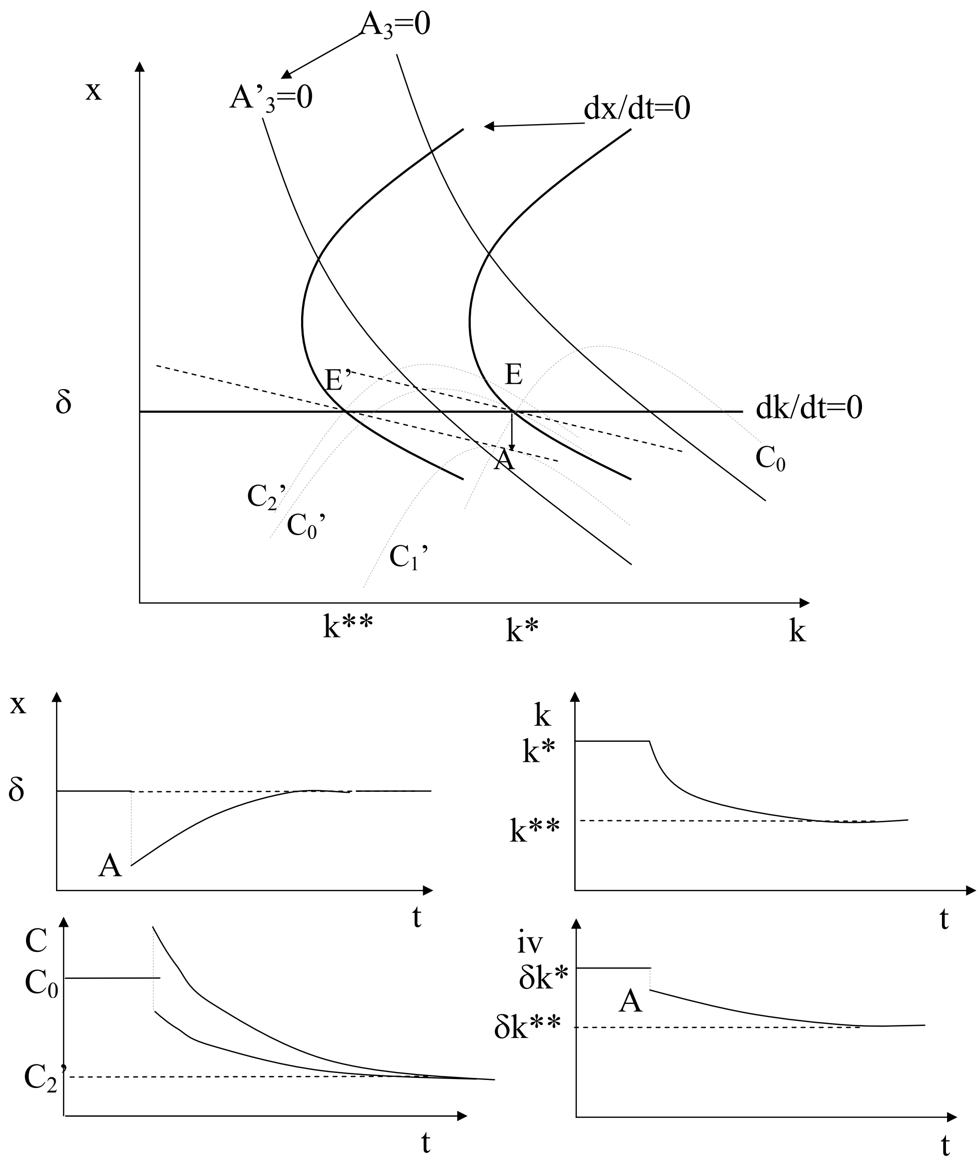

Figure 1.3: A Change In Bank's Intermediation Cost

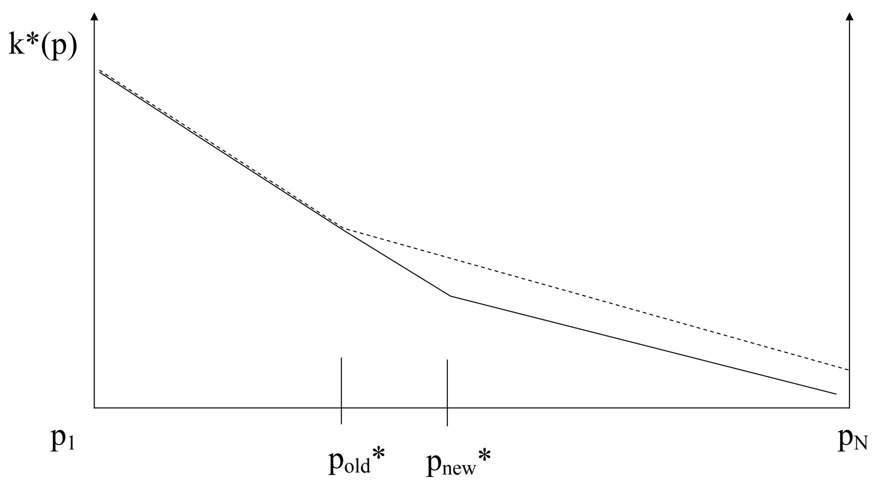

Figure 1.4: Distribution of Capital

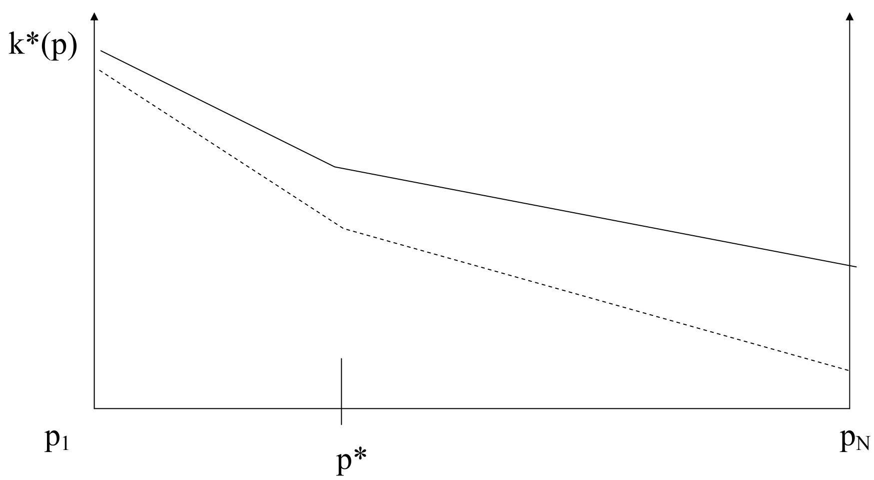

Figure 1.5: Distribution of Capital after a TFP Shock

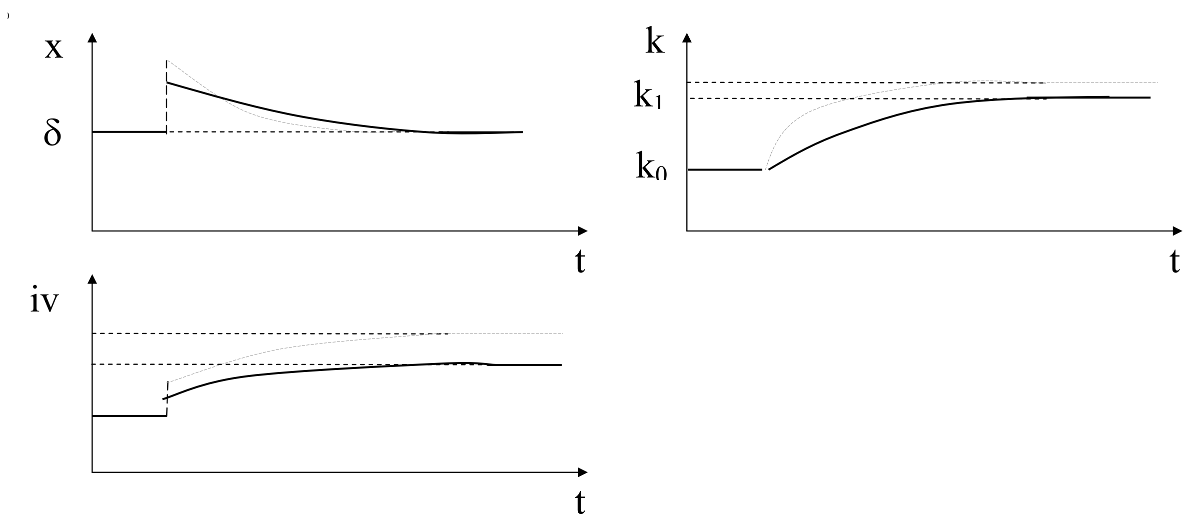

Figure 1.6: Transitional dynamics - Frictionless Economy

Chapter 2

Bank Capital Requirements, the Credit Crunch and Business Cycles

2.1 Introduction

The recessions experienced by several OECD countries around the early 1990s have been extensively studied by the banking and macroeconomics literatures. Bank equity and bank lending have been at the center of the scene in these papers, as a perceived credit crunch has been regarded as the most plausible explanation for these recessions. As loan losses and low asset prices affected bank equity, banks started to limit their lending.

The credit crunch hypothesis assumes first that there is a tight link between a drop in bank equity and a reduction in bank lending[1], and second that the decline in the supply of bank credit is an independent force driving business cycles. The latter assumption can be easily rationalized by the fact that investment and production in bank-loan-dependent firms (usually small, collateral-poor firms) are determined largely by the availability of bank credit. However, for the former assumption to hold a particular mechanism is needed

[1]According to Bernanke and Lawn (1991) since this credit crunch hypothesis implies a leftward shift in bank loans supply curve explained by a shortage of bank capital it would be more correct to call it "capital crunch".

for the Modigliani-Miller theorem of irrelevance of financing decisions for the bank to be violated. In general, capital adequacy regulations requiring banks to finance a minimum share of their assets with equity can produce this result. In particular, the bank capital requirements implemented with the adoption of the 1988 Basel Accord by the G-10 countries has often been blamed for strengthening this link.[2]

In light of the new guidelines for prudential regulation of banks (also known as Basel II) put forth by the Bank of International Settlements and expected to be fully operational in the member countries around 2008, both policymakers and macroeconomists have started to look back at the existing studies on the subject.

One case that received the most scrutiny in the empirical literature was the US recession of 1990-91. The hypothesis is that the recession was originated in a credit crunch which in turn arose as a consequence of both an increase in capital requirements (after the implementation of the Basel Accord of 1988) and a drop in banks capital due to increased loan losses as the economy was entering the recession. However, the empirical literature (Bernanke and Lown, 1991; Hall, 1993; Berger and Udell, 1994; Hancock, Laing and Wilcox, 1995 and Peek and Rosengren, 1995 among many others) has not been able to reach a consensus. In general, the approach in these papers is to run a regression of bank lending growth on CA ratios plus other

[2]The guidelines for banking regulation an supervision in the Basel Accord of 1988 suggest that banks should observe a minimum ratio between their accounting capital and the risk-weighted sum of their assets. The Basel Accord not only set this capital requirement to 8% (which for several countries was significantly higher than the minimum required at that time) but also introduced consistent standards for bank capital that increased the transparency and encouraged a stricter enforcement by regulators.

controls for a cross-section of banks and to interpret a positive coefficient on bank capital as evidence of the credit crunch. The results are mixed, with some of them finding a small effect of bank capital on lending. Moreover, there are a number of problems associated to the estimation of these reduced form regressions. Identification is a concern, since the coefficients are inferred from changes in market equilibrium quantities.[3] In addition, most of these studies implicitly assume that correlation means causality (Furfine, 2000). It may be true that a decline in bank capital makes banks cut-back on lending but it is also possible that periods during which bank lending is low coincide with those when banks make large write-offs and special provisions that reduce bank capital.

A structural model of bank's behavior overcomes these limitations. Furfine (2000) argues that an important shortcoming in those studies arising from the lack of a structural model is that they cannot infer specifically the effect of an increase in capital requirements on bank lending. As a way out of this problem he carries out a structural estimation of a dynamic partial equilibrium model of banks behavior facing bank capital requirements and he finds that the increase in capital requirements (implemented between 1990 and 1992) is key at explaining the observed credit crunch in the US.

This paper proposes a dynamic, stochastic, general equilibrium (DSGE) model that can analyze the causes of the US credit crunch from a theoretical standpoint. As Furfine (2000), this is also a structural model of bank's behavior and thus it can isolate the effect of changes in capital requirements on bank lending.

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[3] Although these studies attempt to control for shifts in the demand of credit during the recession, including imperfect proxies for credit demand may not be enough.

Furthermore, this DSGE model gives a framework to evaluate an hypothesis for the US recession that Furfine's (2000) partial equilibrium analysis cannot address. Rather than focusing on the increase in capital requirements, the alternative explanation is that the effects on production and investment of an adverse macroeconomic shock (a total factor productivity shock or an aggregate demand shock) may have been reinforced by the sole existence of the capital adequacy regulation. After an adverse shock, bank profitability declines and thus bank equity decreases. Due to the rigid link between equity and lending imposed by the regulation, banks must cut-back on the supply of credit in order to meet the minimum CA ratio. This effect of the shock via bank loan supply amplifies its direct effect on production, investment and demand for credit. Thus, this banking regulation generates a "financial accelerator" of aggregate shocks.[4]

This "financial accelerator" has been discussed only informally, just as an afterthought, in the banking literature. Only Blum and Hellwig (1995) have previously carried out a formal analysis of this hypothesis in a general equilibrium setting. However, theirs is an AD-AS model with some shortcomings for an assessment of the financial accelerator. The static nature and the lack of micro foundations for the model economy are two well known criticisms of AD-AS models. The problem in this specific context is that the model cannot explain how the optimal profit-maximizing CA ratio chosen by the bank changes endogenously over the business cycle occasionally hitting the

[4]Furfine (2000) does analyze the effect of exogenous shocks to bank equity and to bank loans demand, however he cannot evaluate the "financial accelerator" that arises in general equilibrium as a total factor productivity shock affects simultaneously loan demand and bank capital.

constraint imposed by the regulation.

The computable DSGE model used here allows to study the qualitative dynamics of all macroeconomic variables, including bank variables, after a total factor productivity (TFP) shock. Optimal response functions for banks, firms and households are obtained by solving the model numerically using a finite-element method (Judd, 1991; McGrattan, 1999; Fackler, 2005). The main findings obtained from numerical simulations follow. First, banks optimal response to capital requirements under aggregate non-diversifiable risk is to accumulate excess capital (i.e. capital in excess of the minimum required) as a buffer against future shocks. Thus, banks are rarely undercapitalized or capital constrained in the stochastic steady state. This is true even when equity is a more expensive financing method than bank deposits. This is in line with the data showing that banks in general hold capital well in excess of the minimum required.[5] Second, an increase in capital requirements leads to a small reduction in bank loan supply giving some support to the credit crunch hypothesis. However, most of the adjustment on banks' balance sheets is done trough recapitalization via retention of earnings. Thus, this finding is in line with the weak evidence found in the empirical literature. Third, an adverse TFP shock (keeping capital requirements constant) also makes banks reduce loan supply. The financial accelerator effect arises clearly in the time path of the main macroeconomic variables that display both more amplitude and more persistence than in a no-regulation case. As regards banks' balance sheet adjustments after the shock, loan supply again decreases by a small amount and most of the adjustment comes from capitalization via retained

[5] The average ratio of capital to risk-weighted assets for major banks in G-10 countries was around 11% during the 1990s (BIS, 1999).

earnings. Fourth, in general equilibrium, the minimum capital requirement does not need to bind for banks' optimal response to be to pull back on their lending. This is true either for a negative TFP shock or after an increase in capital requirements. This result is noteworthy as it was previously believed that banks would cut-back on lending only as a last resort, if they were still capital constrained and retention of earnings was no longer possible.

The rest of the paper is outlined as follows. Section 2 includes a discussion of how capital requirements can produce a financial accelerator of macroeconomic fluctuations and reviews the literature related to this paper. The model is laid out in section 3. Section 4 briefly describes the numerical strategy for the model solution and presents the results from the qualitative analysis of the model dynamics. The last section concludes and outlines some directions for further research.

2.2 Capital Adequacy Regulations and Macroeconomic Shocks

Banks capital adequacy ratios have been extensively used to monitor the solvency of banking institutions. Requirements on these ratios have existed in some form for a long time. However, it was not until the 1980s that explicit capital requirements in the form of a minimum ratio of bank equity to bank assets were used as a banking regulation tool. The US was among the first countries to formally adopt these requirements in 1981 (BIS, 1999). This solvency regulation gained even more importance during the 1980s after the deregulation period in the late 1970s and early 1980s and with the Basel Accord of 1988. The Federal Deposit Insurance Corporation Improvement Act

(FDICIA) of 1991 shaped the existing regulatory regime on capital adequacy ratios in the spirit of the Basel Accord. The increase in the minimum requirements after the adoption of the Basel Accord awoke the interest of the profession on the economic implications of this banking regulation.

One of the main goals of the solvency standards introduced through the Basel Accord of 1988 was to limit the risk-taking behavior by banks (i.e. to limit 'credit risk').[6] For that purpose it was established that bank equity should not fall below 8% of the risk-weighted sum of bank assets.

In their first version the Accords did not take into account 'market risk', such as interest rate risk.[7] Amendments to the original Accords developed during the 1990s covered this gap, but the required CA ratio was not changed from its original 8% level.

However, the regulation still does not address 'aggregate risk'. Should a fixed CA requirement be strictly enforced in an environment of aggregate risk? A big challenge that still remains in the design of the regulation concerns the response of banks to a generalized under-capitalization of the sector due to adverse macroeconomic shocks, such as a wave of failures in the production

[6]Strict enforcement of minimum capital requirements should result in a reduction in bank solvency risk since bank equity works as a buffer protecting depositors from the credit risk in banks' assets portfolio. Capital adequacy regulation can also limit banks' risk taking behavior as it makes bank owners participate with their own resources, rather than just with debt, in the financing of risky assets. If a limited liability clause applies to banks, then informational asymmetries between depositors and bank owners may create a moral hazard problem as bank owners have incentives to invest in high risk-high expected return assets. A similar situation arises if there is a public deposit insurance system. In either case capital requirements may be seen as a way to decentralize the optimal incentive scheme for banks.

[7]Interest rate risk arises due to the volatility of the term structure of interest rates and the mismatch of maturities of bank assets and liabilities.

sector or a crash in stock markets. The point that this paper focuses on, and that the current regulatory regime does not address, is that the imposition of capital requirements for banks in the context of depressed economic activity may have consequences for the rest of the economy if the reduction in bank credit affects investment and production for bank loan-dependent firms.

An adverse aggregate shock that produces a wave of failures in the production sector will result in higher bankruptcy rates and lower repayment of bank loans. This will make all banks in the system experience low return realizations simultaneously. Bank equity will be affected as bank profitability decreases. Under capital requirements, banks may all run up against the regulatory constraint at the same time. If that occurs they will be left with only two courses of action: either recapitalize or cut-back on lending.

If banks cannot recapitalize all at the same time, a reduction in bank credit will occur. In turn, if firms cannot easily replace bank loans with other forms of financing, such as issuing commercial paper or bonds or retaining earnings, the negative shock will automatically propagate itself through a reduction in credit, investment and production.[8]

This idea of capital requirements working as an automatic amplifier to macroeconomic fluctuations (a "financial accelerator") has been discussed

[8]According to Blum and Hellwig (1995) these conditions are easily met. On the one hand, firms in general and banks in particular are reluctant to issue equity during bad times because of the negative inferences that may be drawn as regards their solvency. On the other hand, firms use predominantly bank lending. In the US around 60% of external financing is represented by bank loans while 30% and 2% are bond and stocks respectively, and with half the bonds and almost all the stock sold to some kind of financial intermediary (Dewatripont and Tirole, 1994). It would be very costly if not impossible for the economy to undergo a massive substitution of bank lending by other forms of financing.

only informally, just as an afterthought, by many authors (Bernanke and Lawn, 1991; Furfine, 2000; Chen, 2001; Van den Heuvel, 2003 among many others).

Blum and Hellwig (1995) study the macroeconomic implications of capital requirements in a formal setting. Their work uses an AD-AS model in which aggregate uncertainty is driven by exogenous AD shocks.[9] In their model, investment demand depends on bank loans which in turn depend on bank deposits, reserves and bank equity. They find that conditional on a binding regulatory constraint, further increases in the required CA ratio lead to a fall in lending and investment. Moreover, they find that the sensitivity of equilibrium production to demand shocks increases in the binding regulation case.

However, to my knowledge, the literature still lacks a theoretical analysis of this issue using a computable DSGE model. Furfine (2000) and Van den Heuvel (2003) also have dynamic stochastic models of a representative bank under capital requirements and they provide interesting insights on the effects of this regulation on banks' optimal behavior. However theirs are partial equilibrium models with neither production nor capital accumulation. Thus, the financial accelerator as described above cannot arise as an equilibrium result. For this, it is key that the demand for bank credit as well as bank loan losses both change *endogenously* with economic conditions. For this to happen it is necessary to have a bank-loan-dependent production sector that picks up these two features. Firms borrow less during recessions and at the same time they

[9]As it was mentioned above, the problem of a AD-AS model to evaluate the financial accelerator is that it cannot explain how the optimal profit-maximizing CA ratio chosen by the bank changes over the business cycle occasionally hitting the constraint imposed by the regulation.

default more on outstanding loans. In addition, capital accumulation increases the persistence of the effects of the macroeconomic shock on production and investment.

The model in this paper draws from Aiyagari and Gertler (1998). They use a dynamic model to explain why asset prices in stock markets tend to decrease below their fundamental values. Theirs is an augmented Lucas-Tree model that includes a trader firm who uses leverage plus equity to finance investments in risky securities. However, this trader firm is limited in the amount of debt it can use.[10] A key assumption in their model is that issuing equity is not a possibility for the traders (or banks) and thus the best way they can recapitalize after an adverse shock is through retained earnings (i.e. driving down dividend payments to their owners to zero if possible). Moreover, because there is no benefit from using leverage in their model, they obtain the result that the trader (or bank) ends up using all-equity financing. In order to avoid this unrealistic long-run prediction, they suggest the introduction of some kind of benefit from holding debt (or bank deposits). Following this line of reasoning Van den Heuvel (2003) simply introduces a tax on corporate profits with interest payments on debt being exempt. This exemption constitutes a benefit of being leveraged.

This paper builds on Aiyagari and Gertler (1998) and Van den Heuvel (2003) models by adding capital accumulation, a production sector and endogenous default on loans in a general equilibrium setting. As explained above all these features are essential in order for the model to endogenously produce a financial accelerator.

[10] The trader behaves in exactly the same way as a bank who uses leverage and equity to finance risky loans and is limited by the regulatory constraint.

The idea of a financial accelerator is also related to the literature on agency costs that amplify business cycles (Bernanke and Gertler (1989), Carlstrom and Fuerst (1997) and Holmstrom and Tirole (1997) among many others). In these models the financial accelerator operates through changes in borrowers' balance sheets.[11] Holmstrom and Tirole (1997) add a financial intermediary that, due to agency problems, it is constrained by its own capital in the amount of credit it can supply. By considering changes in firms' collateral and changes in intermediary capital they can disentangle a balance sheet channel from a lending channel. This study deals only with a lending channel.[12]

2.3 The Model

2.3.1 Banks

Banks are competitive and they maximize their market value given by the expected present discounted value of the future stream of dividend pay-

[11] In Bernanke and Gertler (1989) informational asymmetries translate into agency costs that make external financing more expensive than internal sources. Borrowers' collateral can reduce these agency costs. The accelerator effect arises during a recession, as the deterioration of firms balance sheets worsen the agency problem increasing the cost of external financing right when internal sources decline and firms are forced to use external sources.

[12] The main difference with Holmstrom and Tirole (1997) is in the reason why fluctuations in bank capital affect the volume of credit. In their model the link between bank capital and bank lending is the result of market-determined capital adequacy ratios that arise due to the agency problems between investors and intermediaries. In this model the tight link between bank capital and bank credit arises from the capital adequacy ratio exogenously imposed by the regulator.

ments to their owners. Households are the owners of banks.[13] Since households pay income tax on bank dividends (say $\Delta_t \phi(\Delta_t)$, where Δ_t are dividends and $\phi(\Delta_t)$ is the tax rate), banks internalize this in its objective function. Due to the progressivity in the personal income tax $\phi'(.) > 0$ is assumed.

One key assumption in the banks' problems is that there is no issue of bank shares ($s_t = \bar{s}$), where s_t is the stock of bank shares.[14] This is a sensible assumption since banks are likely to be concerned about the inferences that depositors can draw as regards their solvency when issuing shares in face of a negative shock. Aiyagari and Gertler (1998) and van den Heuvel (2003) also use this assumption. Explicitly modelling a story about why is difficult for banks to issue shares during a recession would be beyond the scope of this study. Instead, we prefer to stick to the simpler yet more extreme assumption of no issuing. This assumption, however, does not mean the bank has no decision over its equity (e_t). Still the bank can decide on capitalization via retention of earnings (RE_t).

Therefore, banks maximize the present value of the expected stream of dividend payments (net of taxes) discounted at the owners intertemporal marginal rate of substitution (q_t) by choosing optimal dividend payout policy and retention of earning (RE_t). [15]

[13] The representative bank's objective can be derived from first principles by solving forward the pricing equation for bank shares derived in the households problem. From FOCs for households problem it can be shown that the price of bank shares is determined by the expected after-tax gross rate of return on shares discounted at the households intertemporal marginal rate of substitution.

[14] For simplicity we normalize $\bar{s}$ to 1.

[15] Given the constraints of the optimization problems and the state variables, the choice of RE_t and Δ_t pin down the optimal plans for equity (e_{t+1}), demand deposits (D_{t+1}) and

$$\max_{\{\Delta_t, RE_t\}} E_0 \sum_{t=0}^{\infty} \prod_{j=0}^{t} q_j \Delta_t \Big(1 - \phi(\Delta_t)\Big) \qquad q_j = \beta \frac{u_c(c_j, l_j)}{u_c(c_{j-1}, l_{j-1})} \qquad q_0 = 1 \quad s.t.$$

$$i_t L_t + \pi_t^{firm} = r_t D_t + \Delta_t + RE_t + T_t \tag{2.1}$$

$$e_{t+1} = RE_t + e_t \tag{2.2}$$

$$\Delta_t \geq 0 \tag{2.3}$$

$$L_{t+1} = D_{t+1} + e_{t+1} \tag{2.4}$$

$$T_t = \tau(i_t L_t + \pi_t^{firm} - r_t D_t) \tag{2.5}$$

$$e_{t+1} \geq \gamma L_{t+1} \tag{2.6}$$

Equation (1) define the sources (left-hand side) and uses (right-hand side) of funds respectively. Since by assumption firms only source of financing is bank lending, the bank is the only claimholder of the firm and thus it earns the firm's profits (π^{firm}). The bank also receives interest income from outstanding loans ($i_t L_t$). The uses of bank's cash flow are interest payments on outstanding deposits ($r_t D_t$), dividends payments (Δ_t), retained earnings (RE_t) and corporate income tax (T_t). Equation (2) is the law of motion for bank equity. The non-negativity constraint on dividends in equation (3) can be viewed as an upper limit on retained earnings. Since by assumption banks cannot issue equity, the only way they can change the stock of equity is through dividend policy. Negative dividends would in fact operate as if the bank issued equity, so the non-negativity constraint on dividends is introduced to eliminate this possibility. Equation (4) corresponds to the bank's balance sheet constraint. Equation (5) describes the corporate income tax. As in Van

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bank loans (L_{t+1}).

den Heuvel (2003) banks are subject to a tax on accounting profits. This implies that interest payments on debt are exempt from the tax which in turn determines a tax-advantage of using debt rather than equity to finance loans. Profit maximizing banks balance this benefit against the capital regulation-related cost of using more debt (i.e. less equity). Thus, this guarantees that the bank problem is stationary and that the financial structure will not drift toward an only-equity financing steady state (see Aiyagari and Gertler, 1998).

Finally, the inequality in (6) represents the regulation which indicates that bank equity cannot be less than a certain proportion (γ) of bank lending.[16] The presence of this constraint breaks down the Modigliani-Miller theorem for the bank leaving the door open for real shocks that undermine the bank's capital position to also affect its lending behavior. This inequality constraint is also responsible for turning the bank's problem into a dynamic one. If there were no capital regulation, banks would prefer to hold no equity due to tax exemption on interest payments. From the equation of motion for bank equity it is clear that the only intertemporal problem for the bank is the choice between dividend payments and retained earnings. So, without equity banks would never choose to retain earnings and thus the bank optimization problem would become a static one.

[16] Modelling the capital regulation as an inequality constraint corresponds to a little restrictive assumption of no bank ever being undercapitalized. However, since the time period for the model is a year it is reasonable to think that the regulator would not allow a bank to remain undercapitalized during that period of time. In fact the FDICIA of 1991 mandates a set of actions that undercapitalized banks must follow to immediately meet capital requirements such as stopping the distribution of dividends, limiting new loans and submitting a capital restoration plan. Banks deemed as critically undercapitalized face receivership within 90 days (Van den Heuvel, 2003).

This explains why in spite of being a dynamic optimization problem there are no law of motions for bank loans and bank deposits. The bank problem is dynamic only respect to equity and its corresponding law of motion is given by equation (2). As regards deposits and loans, the competitive bank will intermediate all the funds needed at the ongoing market interest rate. That is, the demand for deposits and the supply for loans are instantaneously determined and are perfectly elastic (as if the bank problem was static). Figure 1 describes the problem of the bank. Households saving schedule (i.e. supply curve of deposits) and firms' credit demand curve are the two dynamic objects that in equilibrium pin down the amount of funds intermediated as a function of the states. The only exception to this explanation happens when the capital regulation constraint binds, in which case the supply of bank loans becomes vertical at the level of $\frac{e}{\gamma}$. The figure displays two possibilities, one in which the regulation does bind ($L^2 = \frac{e^2}{\gamma}$) and one in which it does not ($L^* < \frac{e^1}{\gamma}$).

The bank's budget constraint can be obtained by combining the equality restrictions (1),(2),(4) and (5):

$$\Delta_t = \Big[(1-\tau)(1+i_t)+\tau\Big]L_t - \Big[(1+r_t)(1-\tau)+\tau\Big]D_t - L_{t+1} + D_{t+1} + (1-\tau)\pi_t^{firm} \tag{2.7}$$

Solving the dynamic programming problem, the following FOCs are derived

$$\Delta_t \eta_t = 0 \tag{2.8}$$

$$\Big[(1-\gamma)L_{t+1} - D_{t+1}\Big]\mu_t = 0 \tag{2.9}$$

$$\begin{aligned}\Big(w(\Delta_t) + \eta_t\Big) - (1-\gamma)\mu_t &= \Big[(1-\tau)(1+i_{t+1}) + \tau\Big] \times \\ &\quad E_t\Big[q_{t+1}\Big(w(\Delta_{t+1}) + \eta_{t+1}\Big)\Big]\end{aligned} \tag{2.10}$$

$$\begin{aligned}\Big(w(\Delta_t) + \eta_t\Big) - \mu_t &= \Big[(1-\tau)(1+r_{t+1}) + \tau\Big] \times \\ &\quad E_t\Big[q_{t+1}\Big(w(\Delta_{t+1}) + \eta_{t+1}\Big)\Big]\end{aligned} \tag{2.11}$$

where $w(\Delta_t) \equiv \Big[1 - \phi(\Delta_t) - \Delta_t\phi'(.)\Big]$.

Equations (8) and (9) are the two complementarity conditions for the dividends and regulatory constraints respectively (η_t and μ_t are the shadow values corresponding to those constraints). Euler equations (10) and (11) describe the optimal intertemporal decisions of the bank as regards loans and deposits respectively. Equation (10) shows that banks balance the marginal cost of an additional unit of loans against the expected marginal benefit discounted at the market interest rate. Equation (11) equates the marginal benefit of one unit of deposits against the expected marginal cost.

Subtracting (11) from (10), we get the following expression for the bank interest rate spread:

$$\gamma\mu_t = (1-\tau)(i_{t+1} - r_{t+1})E_t\Big[q_{t+1}\Big(w(\Delta_{t+1}) + \eta_{t+1}\Big)\Big]$$

The existence of the capital regulation can result in a positive interest rate spread. With no regulation ($\gamma = 0$), there would be no spread. The interest rate spread also depends on whether the capital requirement is binding (i.e. $\mu > 0$) or not.

In the deterministic steady-state it is clear that a binding capital regulation leads to a positive spread.[17] It can be shown that in the deterministic steady-state:

$$i(1-\tau) = r(1-\tau)(1-\gamma) + r\gamma \Rightarrow i > r; \qquad \tau, \gamma > 0$$

This equation states that the after-tax rate of return on bank investments equals the weighted sum of interest payments on deposits net of the tax exemption ($r(1-\tau)$) plus the dividend rate paid to stockholders (equal to r). The weights given by γ define the financing structure of the bank. This equation therefore shows that the spread arises as the wedge introduced in the bank loan market by the corporate income tax weighted by the CA ratio. In other words, the spread results from shifting to both borrowers and depositors the burden of the corporate income tax that corresponds to the part of the loans that must be financed with equity rather than with deposits according to the regulation.[18]

In order to see why the spread is zero when the capital requirement is not binding, it is necessary first to understand how the model works over the

[17] In the deterministic steady-state the capital regulation always binds.

[18] Competitive banks must shift the burden of the tax both to deposit holders and to borrowers in order not to make losses. The elasticities of supply and demand for funds (both deposits and bank loans) will determine how much will be shifted to each part.

stochastic steady-state. As it will become clear later, banks can overcome the tax disadvantage of regulatory capital without charging a spread only if they shift the full burden of the corporate tax to its stockholders. That is, they can reduce dividend payments[19] in the amount of the tax as long as dividends do not reach the zero floor.

2.3.2 Households

The representative household in the economy maximizes its lifetime utility by choosing the optimal lifetime profile of consumption (c_t), labor (l_t), bank deposits (D_{t+1}) and bank stock shares (s_{t+1}). Households also have access to a storage technology that pays no return (i.e. cash holdings: Z_{t+1}). This asset does not provide any service to households other than being an alternative way to smooth consumption.[20]

The flow budget constraint below indicates that the household income is made of interest payments from deposits, wages, bank dividends (Δ_t) net of personal income tax ($\Delta_t \phi(\Delta_t)$) and a lump-sum government transfer financed with this tax plus a corporate income tax paid by banks (TR_t). The tax function $\phi(.)$ is assumed to be increasing in dividend level reflecting the progressivity built in the tax code.[21] Households also receive whatever resources they stored last period (Z_t). Therefore, the representative household

[19]The fact that the bank supply of shares is inelastic allows the bank to translate the full amount of the tax to stockholders.

[20]By no-arbitrage condition in the assets portfolio of households, cash holdings are zero if the return on the other assets is positive.

[21]Without loss of generality I assume that only bank dividends are subject to income tax. I could assume that all sources of income pay tax without affecting the main mechanism at work in the model

optimization problem is given by:

$$\max_{\{c_t, l_t, D_{t+1}, s_{t+1}, Z_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t, l_t)\right]$$

$$\begin{aligned} & \text{s.t.} \\ (1+r_t)D_t + Z_t + w_t l_t + \Big[\delta_t\Big(1-\phi(\Delta_t)\Big) + p_t\Big]s_t + TR_t \;\; & \geq \\ c_t + D_{t+1} + Z_{t+1} \;\; & + \;\; p_t s_{t+1} \qquad (2.12) \\ Z_t \geq 0 & \end{aligned}$$

And solving the dynamic programming problem:

$$-\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = w_t \qquad (2.13)$$

$$u_c(c_t, l_t) = \beta(1+r_{t+1})E_t\Big[u_c(c_{t+1}, l_{t+1})\Big] \qquad (2.14)$$

$$u_c(c_t, l_t) = \beta E_t\left[u_c(c_{t+1}, l_{t+1})\left(\frac{p_{t+1} + \delta_{t+1}(1-\phi(\Delta_{t+1}))}{p_t}\right)\right] \qquad (2.15)$$

$$u_c(c_t, l_t) \geq \beta E_t\Big[u_c(c_{t+1}, l_{t+1})\Big], \quad Z_t \geq 0 \qquad (2.16)$$

where δ_t is simply the dividend rate, i.e. $\delta_t \equiv \frac{\Delta_t}{s_t}$.

Equation (13) equates the marginal rate of substitution between consumption and leisure to the wage rate. Equations (14) and (15) are the Euler conditions describing the optimal inter-temporal choice between current and future consumption by allocating savings to bank deposits and bank equity respectively. Equation (16) governs the decision about cash holdings. Only if this equation holds with equality will the household store a positive amount.

2.3.3 Firms

The representative firm is competitive and maximizes the present value of current plus expected future cash flows. For that purpose it chooses the optimal profile of investment (I_t), labor demand and bank borrowing. The discount rate used here is related to the opportunity cost of funds for the firms' owners (the banks), which is given by the rate on deposits (r_t).

Therefore the firm's problem is represented by:

$$\max_{\{I_t, l_t, L_{t+1}\}} \quad E_0 \sum_{t=0}^{\infty} \left[\prod_{j=0}^{t} \frac{1}{1+r_j} \right] \pi_t^{firm} \qquad r_0 = 0$$

s.t.

$$\pi_t^{firm} = A_t F(K_t, l_t) - w_t l_t - I_t + L_{t+1} - (1+i_t) L_t \tag{2.17}$$

$$K_{t+1} = I_t + (1-\delta) K_t \tag{2.18}$$

$$L_{t+1} \geq K_{t+1} \tag{2.19}$$

$$\log A_{t+1} = \rho \log A_t + \epsilon_{t+1}, \qquad \epsilon_{t+1} \sim N(0, \sigma^2) \tag{2.20}$$

Equation (18) gives the law of motion for the economy's capital stock (K_t) and (20) is the exogenous process followed by the total factor productivity (TFP represented by the index A_t). The inequality constraint on loans in (19) imposes the need for bank financing in the model. Since the interest rate on loans is greater than or equal to the discount rate, firms prefer to use internal sources (i.e. cash flows) rather than external financing. Thus, the constraint will hold with equality.[22] That is, firms' assets (i.e. capital stock) is equal to

[22] For this equality to hold in every period, capital depreciation must be paid out of firm's cash flow while net investment must be entirely financed with new debt (i.e. $L_{t+1} - L_t$).

their liabilities (i.e. outstanding bank loans) which means that the banks own the firms. The implication of this assumption is that one state variable can be eliminated from the problem (we choose to eliminate K). Solving the dynamic programming problem we get,

$$A_t F_l(L_t, l_t) = w_t \tag{2.21}$$

$$\frac{1}{(1+r_{t+1})} \quad E_t \left[A_{t+1} F_K(L_{t+1}, l_{t+1}) + (1-\delta) - (1+i_{t+1}) \right] = 0 \tag{2.22}$$

where after deriving we have substituted K_t with L_t.

Equation (21) is the static condition for optimal labor input and equation (22) is the Euler equation indicating the optimal intertemporal decision of the firm as regards capital accumulation.

2.3.4 The Recursive Competitive Equilibrium

The decentralized stationary recursive competitive equilibrium implies that each decision-making unit solves an independent dynamic programming problem. We distinguish between aggregate state variables (Υ) and the individual agents state variables over which they have control. In equilibrium it will be true that aggregate state variables will coincide with their individual counterparts (Cooley and Prescott, 1995).

The state variables for households are $\upsilon_t^h = [D_t, Z_t, s_t, r_t, \Upsilon_t]$ where Υ_t stands for the economy wide counterparts of all state variables in the model $A_t, K_t, L_t, D_t, e_t, Z_t, s_t, r_t$ and i_t. For banks and firms the states are given by $\upsilon_t^b = [D_t, L_t, e_t, r_t, i_t, \Upsilon_t]$ and $\upsilon_t^f = [A_t, K_t, L_t, i_t, r_t, \Upsilon_t]$ respectively.

The recursive competitive equilibrium in this economy consists of:

- Decision-making units value functions: $V^h(\upsilon_t^h)$; $V^b(\upsilon_t^b)$ and $V^f(\upsilon_t^f)$.

- A set of optimal decision rules: $c(\upsilon_t^h), l(\upsilon_t^h), D(\upsilon_t^h), Z(\upsilon_t^h), s(\upsilon_t^h)$ for households; $D(\upsilon_t^b), L(\upsilon_t^b), RE(\upsilon_t^b), \Delta(\upsilon_t^b)$ for banks; and $l(\upsilon_t^f), I(\upsilon_t^f), L(\upsilon_t^f)$ for firms.

- The corresponding set of aggregate decision rules.

- Price functions: $i(\Upsilon_t), r(\Upsilon_t), p(\Upsilon_t)$ for financial assets, $w(\Upsilon_t)$ and shadow prices $\eta(\Upsilon_t), \mu(\Upsilon_t)$.

such that these functions satisfy:

- Households, banks and firms intertemporal optimization conditions (equations 8-11, 13-16, 20, 21 and 22).

- Market clearing conditions (i.e. labor, bank deposits, loans and bank shares markets).

- The consistency of individual and the corresponding aggregate decisions.

- Household's budget constraint (12), bank's budget constraint (7), capital regulation constraint (6), non-negativity of dividends (3), non-negativity of Z_{t+1}, $s_{t+1} = 1$ and $L_{t+1} = K_{t+1}$.

2.4 Numerical Solution and Results

In this section we seek to derive the optimal response functions mapping the state space Υ_t into the agents' decisions. After imposing $K_{t+1} = L_{t+1}$, $TR_t = T_t + \Delta_t\phi(\Delta_t)$, $s_{t+1} = 1$ and using the bank's budget constraint (12) to eliminate Δ_t, these functions are the solution to the functional equation problem given by (8)-(11), (12)-(16) and (20)-(22).

These optimal response functions cannot be obtained analytically, they can only be approximated numerically. For this purpose we use a finite-element method (see McGrattan, 1999 and Fackler, 2005). This method belongs to the more general class of weighted residual methods (Judd, 1991), where the approximation to the policy functions is done through a linear combination of known basis functions such as polynomials. The coefficients on the linear combination are the objects to be computed to obtain the approximate solution. These coefficients can be found by Collocation Method (among other possibilities), that is solving the non-linear system of equations that arises from setting an appropriately defined residual function to zero (for example, equations (8)-(11), (12)-(16) and (20)-(22) evaluated at the approximate solution). The non-linear system can be solved through generic root-finding algorithms such as Newton's method or Quasi-Newton methods. Alternatively, the structure of the problem suggests to solve for the coefficients through a fixed-point iteration scheme that demands far less computer effort and memory requirements than the previous ones (Fackler, 2005).

A complete discussion on the practical issues involved in the implementation of the method can be found in Fackler (2005).[23] The appendix to this paper includes an explanation of some numerical issues specific to this model as well as a short discussion comparing the solution method used here with alternative algorithms commonly used to obtain numerical solutions in DSGE models.

[23] A Matlab implementation was programmed by Fackler (2005). Many other utilities included in the CompEcon toolbox (Fackler and Miranda, 2002) are also used here.

The approximate solutions and the numerical simulations of the model are used here to examine the qualitative dynamics of the system in response to the exogenous TFP process. Although it is not the purpose of this study to do a calibration exercise, in order to approximate the solutions numerically, values must be assigned to the parameters as well as functional forms to the production and utility functions.

Households are assumed to behave according to the preferences specified by Greenwood, Hercowitz and Huffman (GHH) which implies a constant relative risk-aversion (CRRA) specification over an aggregate of consumption and leisure, $u(c_t, l_t) = \frac{\left(c_t - \frac{l_t^\omega}{\omega}\right)^{1-\theta}}{1-\theta}$. A Cobb-Douglas specification is assumed for the production technology $A_t F(k_t, l_t) = A_t k_t^\alpha l_t^{1-\alpha}$.

The personal income tax function is parameterized as follows: $\phi(\Delta_t) = a\Delta_t^b$. This reflects the progressivity of the income tax system. The parameters a and b are calibrated to match the average and marginal tax rates in the US.

The model's period is specified to be one year. The parameters values for α, β, δ, ω and θ[24] are standard in the RBC literature for the US post-war annual data (Prescott, 1986). The autocorrelation coefficient ρ and the standard deviation of the shocks σ are in the range of estimations from TFP process arising from the US business cycle measured at annual frequency.[25]

[24] It is common to find in the literature values of the coefficient of relative risk aversion θ ranging from 1 (i.e. log utility) to 2. Without loss of generality I use a value of 1.1 in the benchmark calibration, but the results do not change significantly with a coefficient of 2.

[25] As it is made clear in Prescott (1986), the HP filtered log of the TFP for the US economy in the period III-1955 to I-1984 "displays considerably serial correlation, with their first differences nearly serially uncorrelated" (i.e. random walk). Kydland and Prescott find that a highly persistent AR(1) (for example, with $\rho = 0.9$) results in essentially the same fluctuations as a random walk process.

The required CA ratio γ is set to 8% as specified in the Basel Accord of 1988 and the corporate income tax rate τ is set to 25%.

2.4.1 Results

2.4.1.1 An Increase in Capital Requirements and the Credit Crunch

In order to evaluate the effect of changes in capital requirements on bank lending, it is necessary first to understand why banks hold capital above the minimum required. There is little hope in understanding the effect of regulatory changes in banks' optimal behavior if this "excess capital" held by banks cannot be accounted for.

This model explains why the representative bank finds it optimal to hold "excess capital". Figure 2 shows the stationary distribution of several variables belonging to the bank's problem.[26] In particular, the mean of the optimal CA ratio is well above the minimum required of 8%. Comparing the expected values of these variables (vertical solid lines) with the deterministic steady-state counterparts (vertical dashed lines) it can be seen that, when faced with uncertainty, banks decide to hold more equity and less deposits.

From Euler equation (11), banks balance the benefit of using tax-exempt debt financing with the fact that the resulting decrease in bank capital financing implies a higher probability of hitting the legal minimum and thus a higher probability of the non-negativity constraint on dividends binding next period (i.e. an expected increase in the shadow price of the non-negativity constraint on dividends $E[\eta_{t+1}] > 0$). The regulatory constraint on bank capital is closely linked to the non-negativity constraint of dividends because if the

[26] The distributions were computed from 500 simulations each 1000 periods long.

former is binding then, in order to rebuild equity, banks will retain earnings as long as the latter does not bind. Thus, whenever CA ratio is too low banks face a high probability of the regulation binding next period and a high probability of retaining earnings. Additionally, risk-averse bank managers[27] have incentives to smooth dividend payments Δ_t over time. That is, as the likelihood of reducing dividend payments next period increases, bank managers expected "marginal utility" (i.e. $w(\Delta_{t+1})$) goes up. This in turn increases the cost of using debt financing.

The reason why bank behavior ends up in overaccumulation of capital above the regulation limit is that the bank must acquire self-insurance. Self-insurance arises when there is a nonnegativity restriction on asset holdings.[28] Aiyagari and McGrattan (1998) and Ljungqvist and Sargent (2000) have analyzed the issue of self-insurance for households (when they are subject to borrowing constraints) in the context of idiosyncratic uncertainty and incomplete markets. The key result they obtain is that in their models the stationary equilibrium interest rate falls short of the rate of time preference β^{-1}. The lower interest is consistent with a finite overaccumulation of assets above the credit limit. If the interest rate were equal to β^{-1} agents would accumulate an infinite amount of assets. The constraint on the net worth of the bank operates in the same manner here. With aggregate uncertainty the bank desires a buffer of equity. The bank, however, does not accumulate an infinite amount of equity (i.e. all-equity financing) because in equilibrium the return on equity obtained by the bank falls short of the cost of funds (which

[27]In effect, they behave like risk-averse agents due to the curvature of the bank's objective introduced through the progressive income tax.

[28]For the case of the banks in this model, the capital regulation operates as a restriction on net asset holdings (i.e. $(1-\gamma)L_t - D_t \geq 0$).

is approximately equal to $(1+r)$). This is shown in Figure 2 (middle right panel) by the gap between the solid and dashed lines.[29] Note that a return on equity lower than $(1+r)$ is consistent with a risk-premium on bank shares. Risk-averse households will hold bank shares only if they are compensated for risk. With an inelastic supply of bank shares, the demand s_{t+1}^{d} and the price of shares p_t both adjust so that the expected gross return on bank shares is higher than the interest rate on risk-free deposits.

Note that the excess capital is so large in the simulations that the probability of hitting the regulation constraint is virtually zero. The explanation for this is that for a lower level of excess capital (i.e. one in which the probability of hitting the constraint is positive) it is not guaranteed the bank will be able to meet the inequality constraint in any state of nature. The reason is that from (19), net investment is financed with new lending $(L_{t+1} - L_t)$ which implies that the largest reduction in bank lending is limited to $-\delta K_t$ (i.e. zero gross investment). Thus, when after a negative shock equity falls, the bank first attempts to recapitalize via retention of earnings. If equity falls enough then dividends eventually fall to zero and after that the bank must cut back on lending in order to meet the minimum requirement. However, from (19) the bank is also limited in the amount by which it can reduce lending. Therefore, in some states of nature the constraint would not be met. In light of this scenario, the banks build up enough excess capital for this to happen with probability zero.

A second issue that is necessary to understand for the evaluation of the credit crunch hypothesis is how banks respond to an increase in capital

[29] The true return on equity obtained by the bank is $\frac{\Delta_t + RE_t}{e_t}$. However, on average $RE_t = 0$.

requirements. Do they increase equity or do they cut-back on lending? Figure 3 shows the expected path followed by bank equity and lending as banks adjust to an unexpected and permanent change in capital adequacy ratios, from 6% to 8%.[30] The simulations were performed by setting starting values of the variables at the mean of the stochastic steady-state corresponding to $\gamma = 0.06$. Thus the figure shows the transitional dynamics of the model from a low-γ to a high-γ steady-state. The policy change is introduced in period 10 of the simulation.

Banks respond to an increase in capital requirements mainly by increasing equity holdings (around 97% of the percentage increase in the optimal CA ratio is explained by recapitalization). They retain earnings until the higher level of equity is reached. That is, both equity and dividends increase over the long run (see top right and bottom left panels), but dividends fall on impact as retained earnings increase enough. The bottom right panel shows the ratio of bank dividends to equity. As usual the bank finances the excess equity holding by paying a lower return on it. Bank lending does not change significantly and, therefore, the optimal CA ratio increases from around 8.7% to 10.1%.

Banks' behavior follows from equation (11) which describes the financing decisions of the bank. The change in the required ratio essentially squeezes the excess capital on impact. Since the probability of the constraints binding increases, the bank will retain earnings and move to a higher CA ratio. The bank balances the tax exemption on deposits with the expected cost of a bind-

[30]These figures roughly resemble the change in the capital regulation occurred in the US between 1990 and 1992. The US had implemented solvency regulations since 1981, setting the legal minimum to 6%. After the adoption of the Basel Committee standards, the ratio was increased to 8%.

ing constraint. Thus, after the change in the regulation the bank adjusts the debt/equity financing mix so that the expected marginal cost equalizes the marginal benefit.

However, the regulatory shock does not end in the change of the financing mix. Looking at the time path followed by bank loans it is evident that they are also affected by the increase in the capital requirements. In this general equilibrium analysis it is clear that when the bank retains earnings and thus reduces dividend payments, by arbitrage, the interest rate on deposits must also fall on impact.[31] As the deposits interest rate falls, households savings in demand deposits go down (while consumption increases). Demand deposits fall by more than the increase in equity and bank lending falls (see middle-left panel). This means that banks also cut-back on lending as a way to restore the capital-to-asset ratio to its optimal level. This result has not been obtained before. That is, the standard view both in previous theoretical work as well as in informal analysis is that banks cut-back on lending only if the capital regulation becomes binding (Blum and Hellwig,1995; Van den Heuvel,2003; Aiyagari and Gertler, 1998). However, according to my results 3% of the percentage increase in the optimal CA ratio is due to a reduction of lending even when that ratio is not even close to the minimum required.

These results have direct implications for the credit crunch hypothesis after the increase in bank capital requirements. The findings in the literature are mixed and in general provide weak support to this hypothesis. The simulations in Figure 3 seems to confirm those findings. It shows that the banks do cut-back on lending after the change in capital requirements, although this

[31] There is no reason for the bank to use deposits if the interest rate to be paid is higher than the dividend rate paid for equity financing.

change is rather small compared to the amount of credit given out by banks. The expected value of loans in the simulations falls just 0.5% while interest rate increases in no more than 1 basis point in the long-run.

Of course, this does not mean that the capital adequacy regulation does not play any role during a downturn of the economy. The stringency of bank capital requirements may well influence the dynamics of macroeconomic variables as the economy heads towards a recession. This link is investigated in the next section.

2.4.1.2 A Financial Accelerator of Aggregate Fluctuations

In this section the model is used to explore the extent to which bank capital requirement can work as an automatic amplifier of aggregate fluctuations. To my knowledge, this hypothesis has not been studied before in a structural general equilibrium model.

As a first step, we analyze the economy's response to a TFP shock under a no-regulation scenario (i.e. $\gamma = 0$). That is, the idea is to capture how the economy behaves in a no-regulation scenario in response to a TFP shock and later compare it to the regulated economy. Due to the tax exemption on deposits banks will choose to hold no equity when there are no capital requirements. With no equity and thus no dividend payments, inequality constraints (3) and (6) become irrelevant for the problem. Therefore, the model collapses to a standard closed-economy RBC model with firms making investment and production decisions and households making consumption-saving decisions. Banks are completely redundant in this setting.

As usual in standard RBC models, the interest rate is positively related to TFP shocks, as firms demand for credit changes.[32] Since banks are perfectly competitive, the bank interest rate spread is zero. The responses of output, consumption, labor and investment are all the expected ones. All them are positively linked to the TFP process, the only source of fluctuations in the model.[33]

It is worth noting that the fluctuations in investment, capital and production all arise from the effect of TFP shocks on the demand for credit (i.e. the marginal product of capital). This implies that for the bank capital regulation to work as an amplification mechanism of these fluctuations there must be an additional fall in credit coming from the supply side of the market. That is, an extra indirect effect of the TFP shock over the supply of credit (operating trough the capital requirement) is needed in addition to the direct effect of the TFP shock on the demand for credit.

Figure 4 displays banks' optimal responses in the regulated environment. The capital requirement graph in the bottom right panel shows that for a big enough negative shock the regulation starts to have an effect. The middle left panel shows that the banks will cut dividend payments and retain earnings as a way to recapitalize. But, eventually, dividends hit the non-negativity constraint (middle right) and the only possibility is to cut-back on lending. When all banks in the sector reduce lending, the interest rate spread $(i_{t+1} - r_{t+1})$ increases at the same time the interest rate on deposits falls by an extra amount (see top panels). The countercyclical interest rate spread for

[32]The demand for credit arises from the relationship between the expected marginal productivity of capital and the expected interest rate (see equation 22).

[33]Impulse-response functions were computed for non-regulation variables, but the graphs are not included here.

competitive banks shows up as a consequence of the regulation.

Figure 5 shows the impulse-response functions for the bank's variables. They were derived by perturbing the system with a TFP shock big enough to make the capital requirement bind (see bottom left panel). In the current calibration such a shock is around -18% of the deterministic steady-state value of TFP.

Banks respond as expected during the recession. They first retain earnings in an attempt to avoid cutting-back on loans (see middle left panel), but eventually either the non-negativity constraint on dividends is hit or the marginal utility on dividends goes up so much that banks prefer to reduce credit. In any case, comparing equations (15) and (16) it becomes clear that with the regulation binding ($\mu_t > 0$) the interest rate spread increases (see top right panel), making the interest rate on deposits decrease by more than in the no regulation case. With a countercyclical interest spread and an extra fall in deposits interest rate, households reduce consumption by less and savings by more than in the economy with no capital requirement. Due to the reduced demand deposits and to the fall in equity, bank loans decrease more than in the economy with no regulation. As the capital stock decreases one to one with bank loans, output, consumption and investment all will display more persistence than in the economy with no capital requirement.

The fact that such a big shock (-18%) is needed for the constraints to kick-in is consistent with the stationary distributions shown in Figure 2. In those simulations, the probability of such big realization of the shocks is almost zero and thus the probability of the constraint binding is also zero. One could conclude from this that the financial accelerator is a mere theoretical possibility that would never arise in practice. However, as it was made clear in the simulation corresponding to Figure 3, the constraints reshape banks' optimal behavior even when they do not actually bind. As a result, it will be shown next that the financial accelerator is at work even for shocks of moderate size.

For a medium size negative shock (say 2%) banks start cutting-back on loans right away, at the same time they retain earnings. A negative TFP shock (of any size) reduces bank profitability and thus the CA ratio falls. The buffer of excess capital falls below the desired level and banks retain earnings and reduce dividend payments. Thus, the return on bank shares falls and, by arbitrage, the interest rate on deposits also declines. As a result, demand deposits fall by more (and consumption falls by less) than in the non-regulation case and bank loans supply decreases (in addition to the fall in demand for credit).

This is shown in Figure 6, which displays the responses of output, capital, consumption and investment to a negative shock (thicker lines correspond to the regulated economy). On impact consumption decreases by less and investment by more than in the non-regulation scenario. After that, all macroeconomic variables remain below their no regulation counterparts as the economy returns to its steady-state. It is worth noting that output is the only variable that on impact does not behave differently than in the unregulated model. However, as the differential effect on investment builds up over time and capital stock recovers at a slower pace, output starts to lag behind.

As can be seen in the dynamic response of the system, the size of the financial accelerator effect is small compared to the size of the TFP shock. This remains true for several parameterizations of the model.[34] As it was described before, along the stochastic steady-state banks keep a buffer of excess capital to cushion the effect of negative aggregate shocks. An unexpectedly large shock may make equity fall enough to make the constraint bind on impact. However, immediately after the shock banks try to restore the buffer of capital to its normal level. Thus, the financial accelerator is very short-lived; it just operates on impact. The TFP process governing the dynamics of the demand for credit, on the other hand, is highly persistent. The reduction in the demand for credit of course relaxes the regulation constraint. And due to the persistence of the TFP process, this effect not only operates on impact but also builds up over time.

2.5 Conclusions

The Basel Accords set a benchmark for solvency standards by stating that banks capital should not fall below 8% of their risk-weighted portfolio of assets. However, several basic questions as regards how exactly this capital regulation affect banks' behavior and what are its macroeconomic implications are left unanswered by the existing banking and macroeconomics literatures.

A DSGE model is used here to suggest possible answers to some of these questions. The main findings from a qualitative analysis of the model dynamics follow. First, uncertainty combined with rational forward-looking behavior make banks hold capital in excess of the minimum required by the

[34]The model was solved for different values of ω, governing the labor supply elasticity, α for demand elasticity of capital and γ the level of the minimum CA ratio. The comparison of the two models, with and without regulation, seems to be robust to all these changes.

regulation. This is true even when equity is a more expensive financing method than bank deposits.

Second, an increase in the capital requirements like the one implemented in the US in the early 1990s make optimal CA ratios increase. Banks change the equity/debt financing mix mainly by accumulating more equity but also, to a lesser extent, by cutting-back on loans. This result is noteworthy as it was previously believed that the reduction in bank credit as a way to meet capital requirements would be the last resort used by banks, only if banks were still undercapitalized and if capitalization via retention of earnings was no longer available.

Third, this paper does not give much support to the hypothesis that the adoption of Basel Accords resulted in a credit crunch for the US economy, at least from a theoretical point of view. The model predicts a slow reaction of bank loans to a change in the regulation. This seems to be confirmed by the weak evidence on a credit crunch found in the empirical literature.

Finally, no formal thought has been given in the previous literature to the idea of fixed bank capital requirements operating as a financial accelerator of business cycles. The results in this study do not support the belief (from informal analysis) that the financial accelerator works only when the capital regulation binds and dividends fall to zero after a negative shock, leaving banks no other choice than cutting-back on lending. The simulations in this paper show that the presence of the capital regulation and the non-negativity constraint on dividends in the problem reshapes banks' lending behavior, even if they do not actually bind in any state of nature.

There are extensions to this research that would give interesting insights about the importance of this financial accelerator. Considering an oligopolistic market structure would make banks profit rate depend on the demand for bank credit. This could render in a more persistent financial accelerator, as the dynamics of bank profits and thus bank equity would be now determined by the TFP process. Modelling economies of scale in the intermediation services of banks would alternatively enhance the financial accelerator in the same way. Also, introducing bank assets of maturity longer than one period would increase the persistence of the financial accelerator (this point was suggested by Blum and Hellwig, 1995).

On the contrary, there are other relevant extensions to the model that would likely decrease the importance of the financial accelerator effects. Introducing bank heterogeneity by considering that the degree of capitalization is different across banks would break the rigid link between bank capital and aggregate lending.[35] Another extension to consider is the fact that banks have developed different strategies to overcome the restriction implied by the capital requirements.[36]

Finally, it would be interesting to explore the same questions addressed in this paper but under the light of the new guidelines set in the so-called Basel II. The capital requirements in Basel II are derived from banks' own credit-risk models (internal-rating-based approach). Kashyap and Stein (2004) argue that this will result in countercyclical required CA ratios as the probability

[35]As firms switch from poorly capitalized banks to healthier banks during the economic recession, bank lending and investment would fall by less than in the representative bank model.

[36]The practice of securitization of banks' risky assets and other forms of artificially increasing the CA ratio are regulated in subsequent amendments to Basel I guidelines. By making use of these instruments banks could avoid decreasing loans as the stringency of the regulation increases during the downturn of the cycle.

of default attached to the borrowers increases during recessions which in turn increases the capital charges associated to them. Therefore, the mild financial accelerator effects obtained under Basel I framework may become very significant under Basel II.

Table 2.1: Parameter Values

α	β	γ	δ	ω	τ	θ	ρ	σ	a	b
0.36	0.96	0.08	0.1	2	0.25	1.1-2	0.9	0.01	4	1

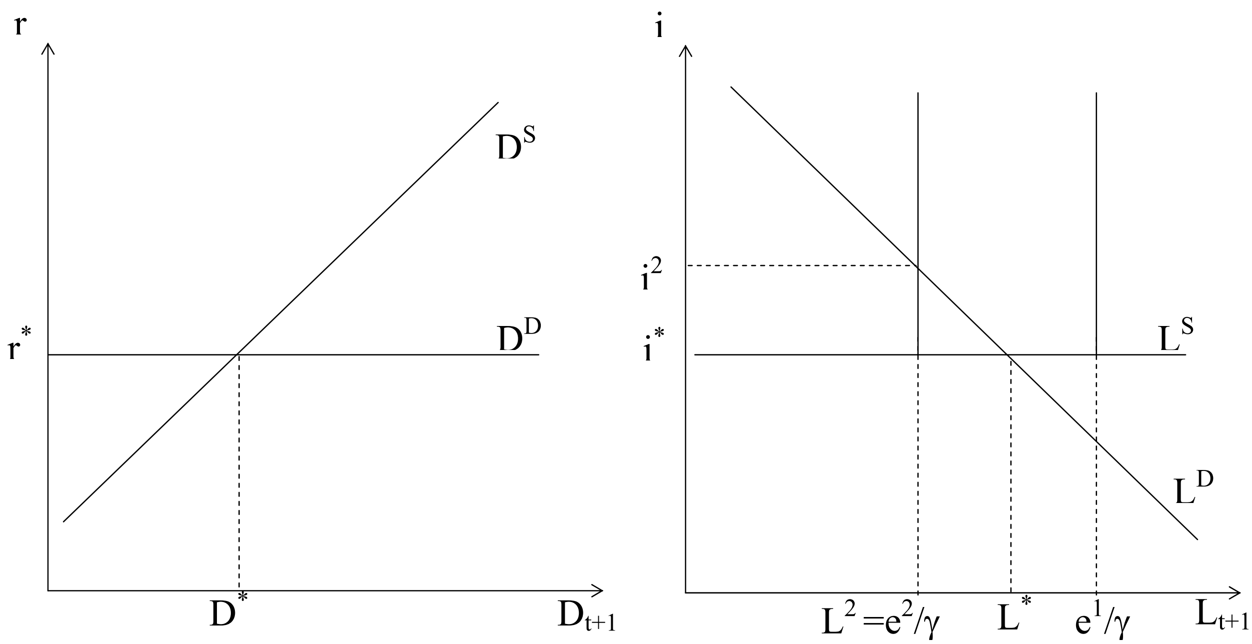

Figure 2.1: Deposits and Bank Loans Markets

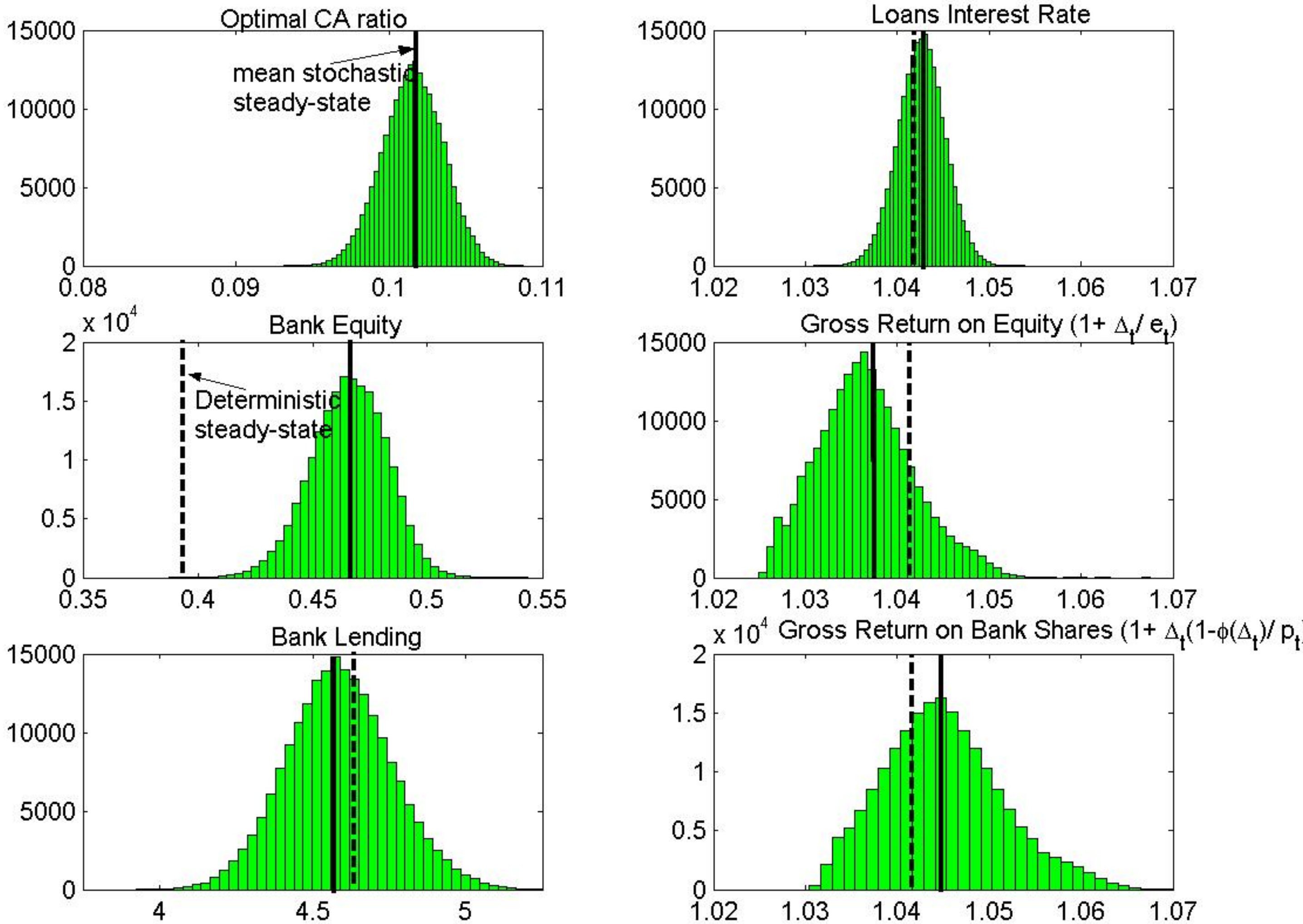

Figure 2.2: Stationary Distribution of Bank Variables

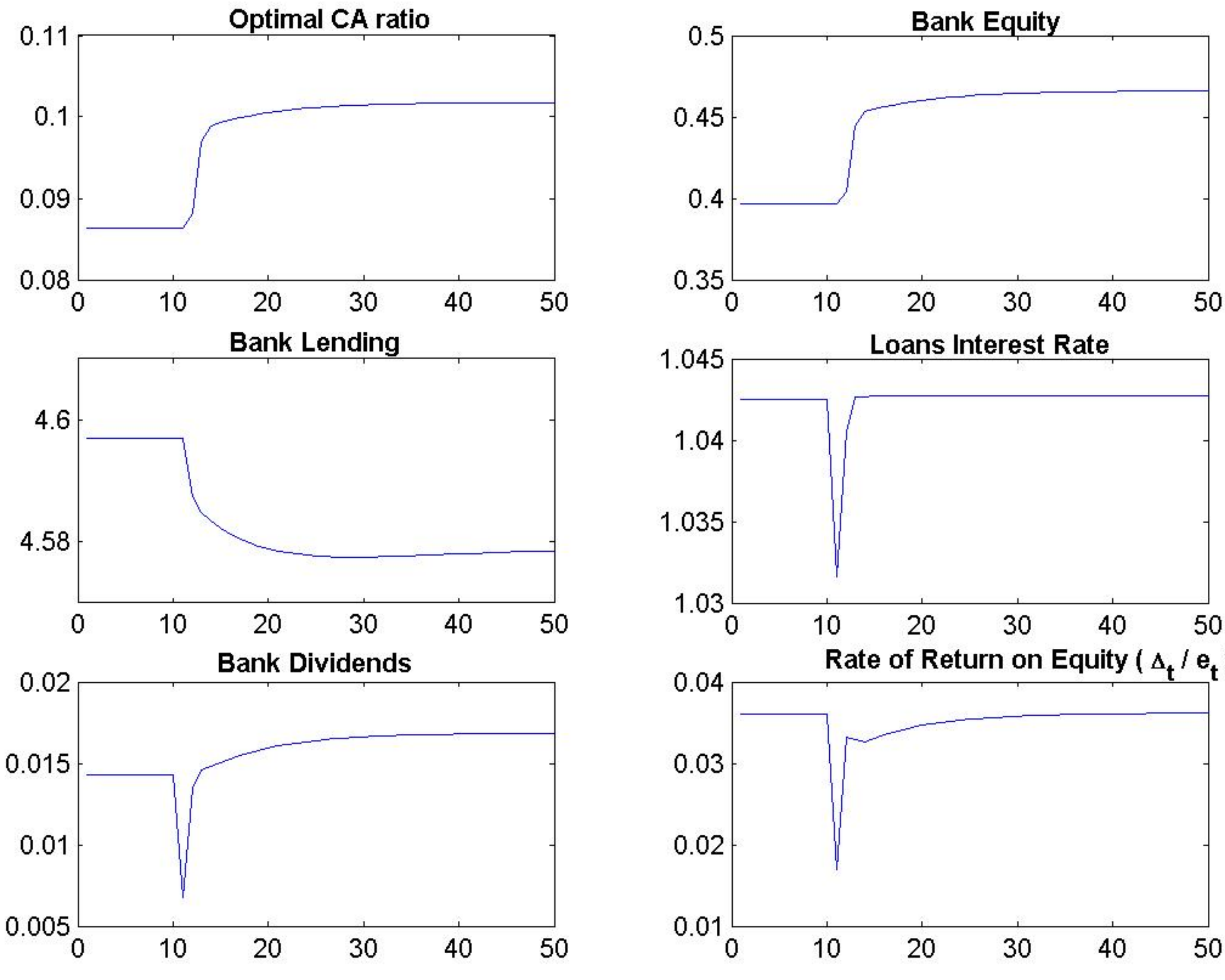

Figure 2.3: Transitional Dynamics for a Permanent Change in γ

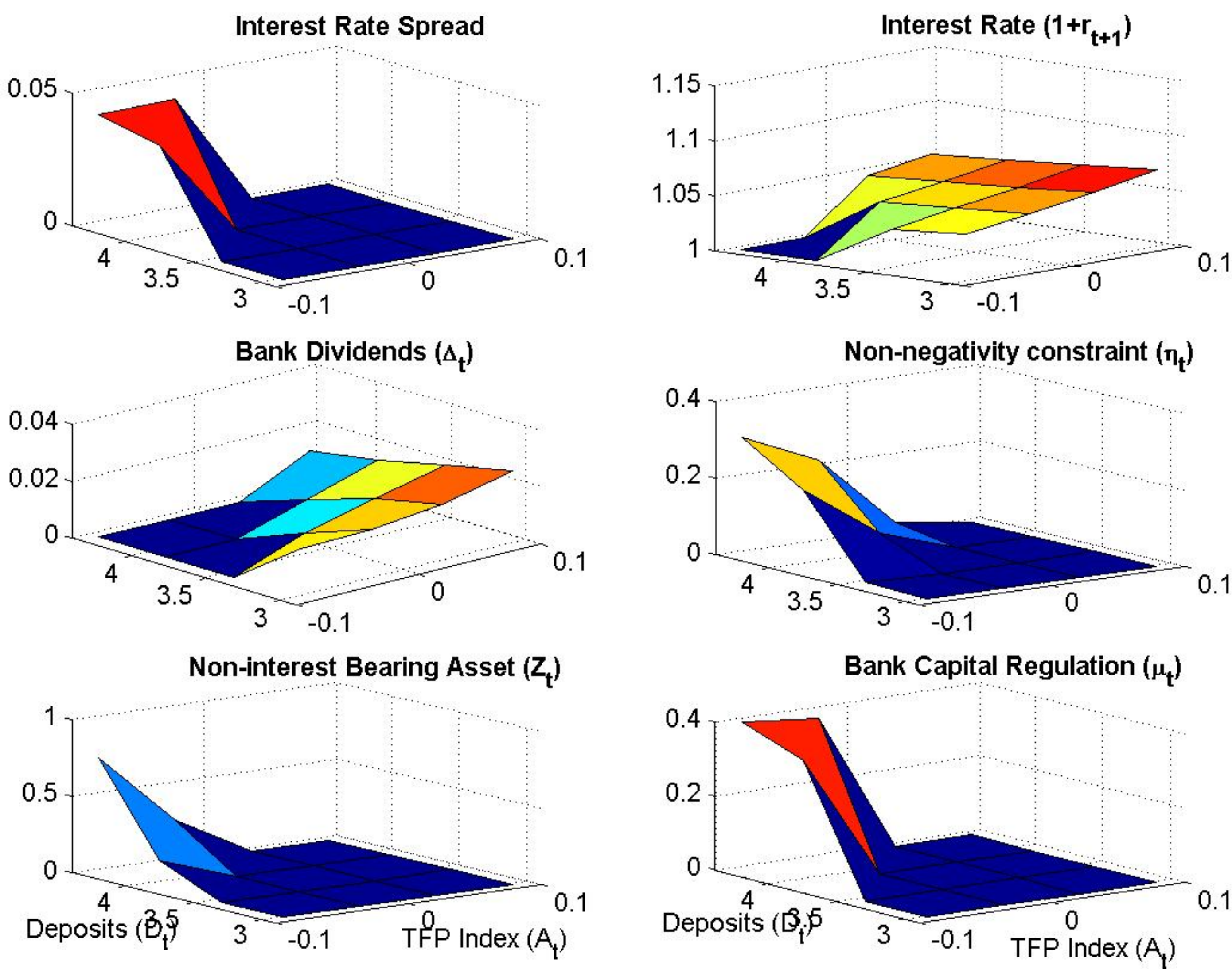

Figure 2.4: Bank Optimal Response Functions

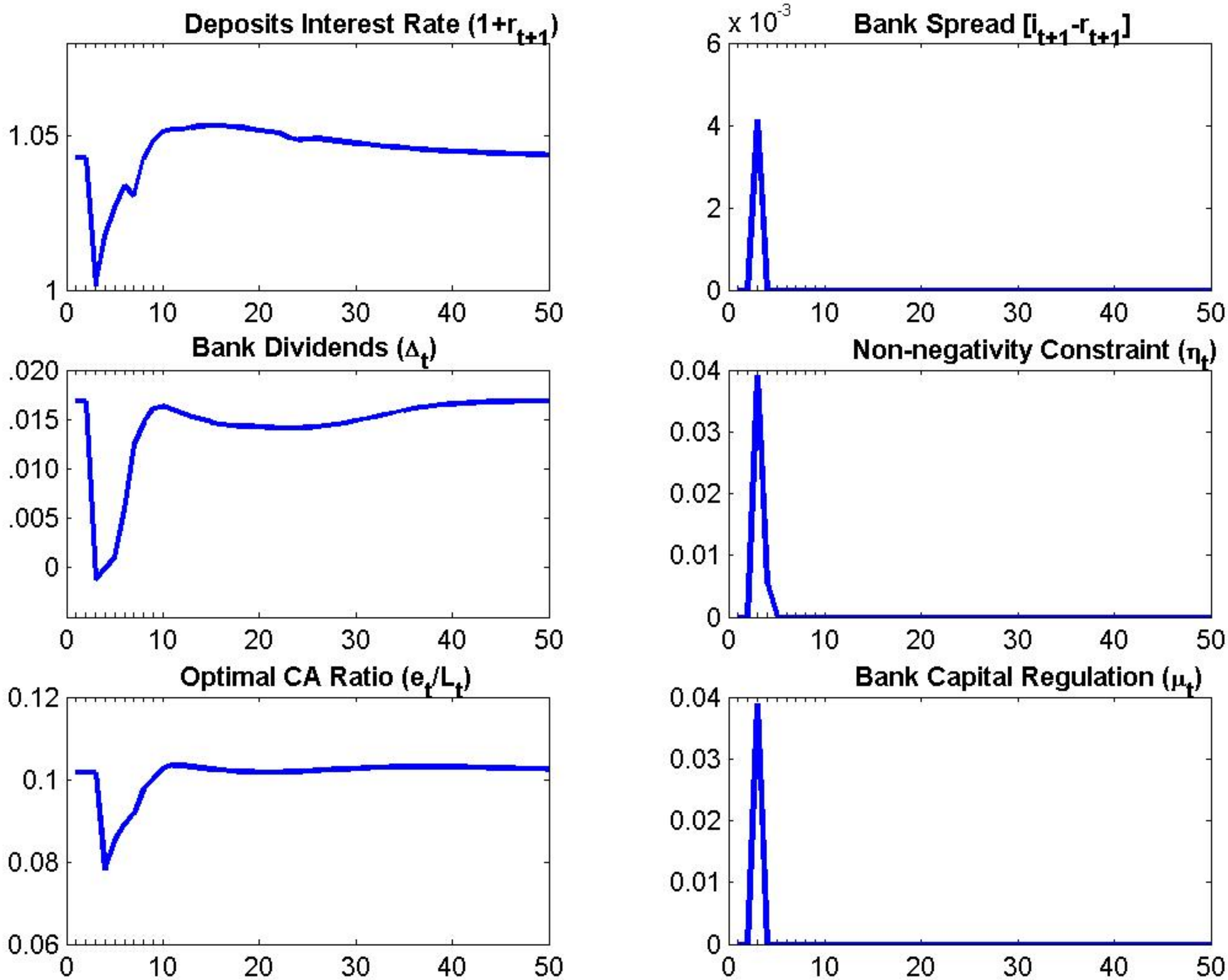

Figure 2.5: Impulse-Response Functions for Bank Variables

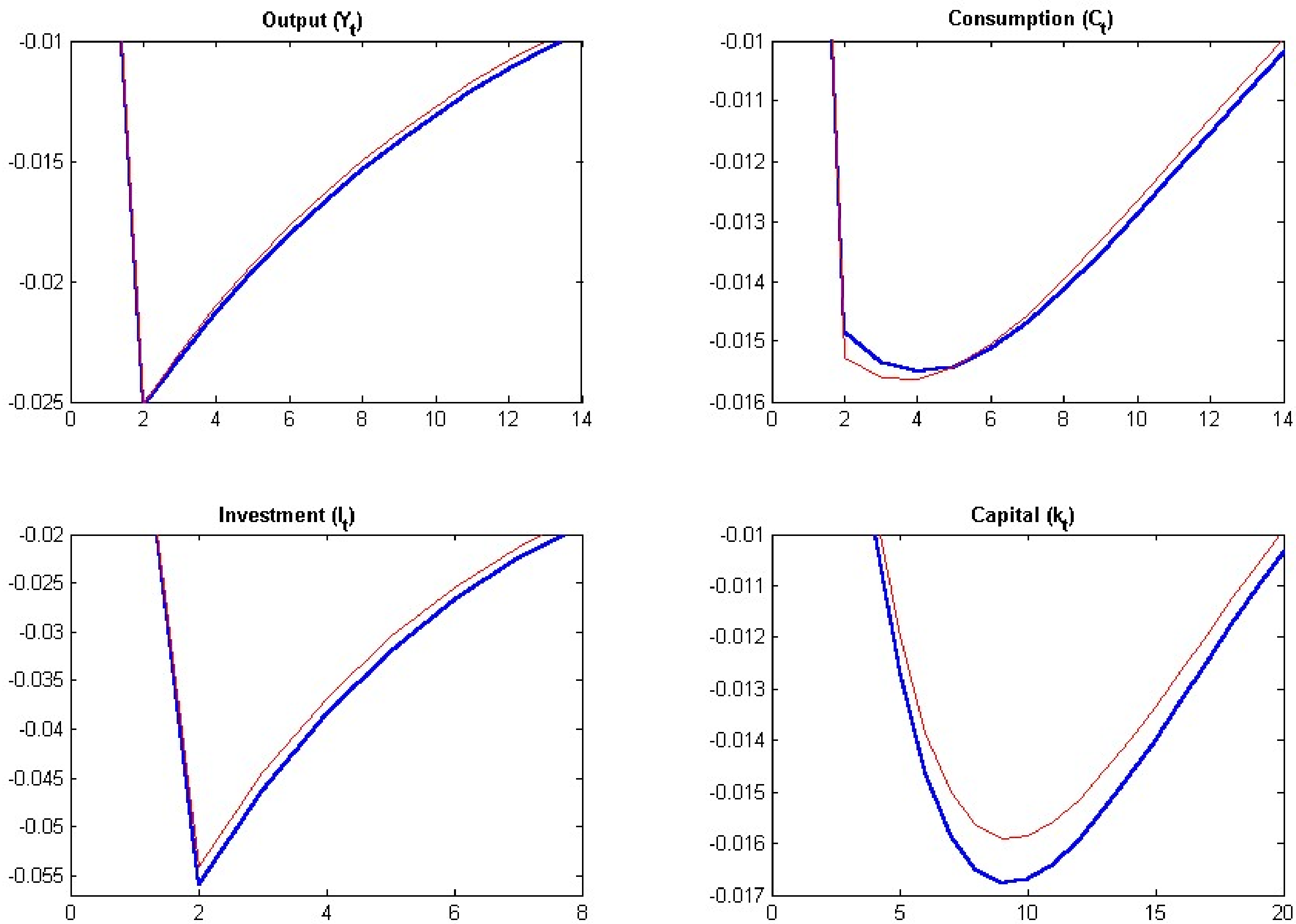

Figure 2.6: Impulse-Response Functions for Regulated Economy

Chapter 3

The Cyclical Behavior of Banks Price-Cost Margins (joint with María Olivero)

3.1 Introduction

After the seminal contributions by Rotemberg and Saloner (1986) and Rotemberg and Woodford (1991 and 1992) an extensive body of theoretical and empirical literature studies the endogenous variation of price-cost margins in response to aggregate shocks. This literature focuses on goods markets and looks at how endogenous price-cost margins can become an additional channel through which such shocks affect the economy[1]. For financial markets,

[1]Rotemberg and Saloner (1986) was the first contribution to the theoretical macroeconomic studies that model oligopolistic markets and the cyclical pattern for markups. In this literature the reasons for markups being countercyclical are, among others, implicitly colluding oligopolies that find collusion more difficult when their demand is relatively high (Rotemberg and Saloner (1986)), demand composition effects such that some types of increases in aggregate demand imply a procyclical elasticity faced by oligopolistic firms (Gali (1994)), and "deep habit" formation that allows the demand faced by each individual producer to depend on past consumption levels, and the price elasticity of demand to be procyclical (Ravn, Schmitt-Grohé and Uribe (2005)). Also in the context of dynamic general equilibrium models, Olivero (2004) and Aliaga-Díaz (2005) model countercyclical markups, but specifically for loans markets. In Olivero (2004) countercyclical price-cost margins in an oligopolistic market for bank credit arise from a procyclical interest rate elasticity of the demand for loans. In Aliaga-Díaz (2005) an occasionally binding capital adequacy requirement

Bernanke and Gertler (1989) and Bernanke, Gertler and Gilchrist (1996 and 1998) study the role of an endogenous external finance premium (the difference between the cost of funds raised externally and the opportunity cost of funds internal to the firm) as amplifier of business fluctuations. In their "principal-agent" model, the borrowers' net worth acts as a source of output dynamics as it is inversely related to the agency cost and external finance premium of financing real capital investment. Aggregate shocks are exacerbated in this framework as a result.

Therefore, to the extent that borrowers' net worth is procyclical, this theory predicts countercyclical external finance premia. The interest rate on deposits can be considered a good proxy for firms' opportunity cost of internal funds (in Bernanke, Gertler and Gilchrist (1998) this opportunity cost is the risk-free interest rate obtained by households on their savings). Thus, evidence on the countercyclicality of bank margins (calculated basically as the difference between the interest rate on loans and deposits) is partial evidence in favor of the "financial accelerator" in Bernanke, Gertler and Gilchrist (1996 and 1998). We say partial because the reason for the countercyclicality observed in the data might be different from that advocated in their theoretical model (Bernanke et al themselves argue that they use the "principal-agent" view of credit markets as *one* of the various ways of theoretically rationalizing a financial accelerator). So far, the literature on the empirical relevance of the

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determines whether or not competitive banks charge a margin. The regulation binds during recessions when higher default rates lower banks equity, and the margin is countercyclical as a result. This paper is closely related to the vast empirical literature that measures the cyclicality of markups in goods markets. This includes Domowitz et al. (1986), Lebow (1992), Chevalier and Scharfstein (1995 and 1996), Galeotti and Schiantarelli (1998) and Bloch and Olive (2001), among others.

financial accelerator focuses on firms and looks at two of its implications: first, the "flight to quality" in credit extension and second, the differences in real activity between firms more or less subject to agency costs[2].

Despite this influential literature, the cyclical behavior of margins in credit markets has not been explored before. The literature still lacks empirical evidence on this cyclicality as an indicator of the existence and importance of the "financial accelerator". This paper attempts to start filling this gap. It focuses on the banking sector in the United States and studies the cyclical behavior of their price-cost margins.

Several facts are indicative of the importance of studying the market for bank credit in the American economy and in particular, banks' optimal choice of loans prices and its macroeconomic impacts. First, total loans and leases granted by commercial banks in the United States averaged almost 45% of gross domestic product in 2004 and the first quarters of 2005. Second, the ratio of loans to total bank assets has fluctuated around 60% since 1973. Therefore, financial sector deepening does not seem to have lowered the share of loans in banks' portfolios. Last and most importantly, according to the credit channel of monetary policy, bank loans are a key transmission mechanism for monetary policy to exert real effects on the economy (Kashyap and Stein (2000), Kashyap, Stein and Wilcox (1993)). Although whether there is in fact a bank lending channel for monetary policy is still an unsettled issue, there is consensus on the fact that the supply of bank loans affects investment

[2]Several empirical studies support the hypothesis that in recessions credit flows away from borrowers more subject to agency costs. Previous work also finds important cross-sectional differences between borrowers more and less subject to agency costs in how real economic activity responds to adverse shocks.

and production decisions of credit-dependent firms. Actually, around 75% of the debt issued by US firms corresponds to bank loans.

This paper focuses on banks' pricing of loans and studies the cyclical behavior of banks' margins, using time series quarterly data for the period 1979-2005. Our results document the countercyclicality of margins, a key fact about US business fluctuations that has received little attention before.

It is worth noting here that this paper uses both net interest margins (NIMs, calculated as the ratio of the difference between interest revenues and interest expenses to assets) and spreads (obtained as the difference between loan and deposit rates) as measures of banks' price-cost margins.

We believe the countercyclicality of margins in the market for credit has important implications for both macroeconomic theory and stabilization policy, in particular as a mechanism for the propagation of macroeconomic shocks. With price-cost margins in the market for credit being countercyclical according to our results, a financial accelerator seems to be operating in the American economy. In bad times, countercyclical margins make credit become more expensive relative to economies where margins behave differently. Firms may as a result delay investment and production decisions and recessions may be made even worse. Further research should assess whether this fact provides additional grounds for stabilization policy in economies where these margins are more countercyclical.

Monetary policy and credit risk are sometimes suggested as the main, and maybe the only, determinants of the cyclical behavior of margins. On the one hand, according to the bank lending channel of monetary transmission, there is a direct relationship between Federal funds rate and margins, so that if policy rates exhibit a particular cyclical behavior, not controlling for monetary policy could bias the coefficient on the cycle indicator. On the other hand, credit risk is expected to be countercyclical and to be directly related to margins, so that default should help explain the countercyclicality of margins.

Based on these two observations, our empirical methodology consists of two steps. In a first step, the paper tests whether the negative and significant contemporaneous sample raw correlation between margins and a business cycle indicator is robust to the inclusion of controls related to monetary policy, default risk and banking regulation. Results show it is, so that there seems to be other channels through which fluctuations in the economy give rise to the observed countercyclicality of margins. In a second step, this study looks for these channels and offers alternative explanations for the observed behavior. In a regression where margins are the dependent variable, no explanatory power should be left to the business cycle measure after an expanded set of controls is introduced. Interest rate risk, the economy's financial depth, banks liquidity, capital holdings and the share of total assets held by big banks all exert a significant impact on margins. These conclusions are consistent across several alternative definitions for the margins and the cycle measure.

Previous studies address the determinants of margins in the banking sector both theoretically and empirically. Theoretical work looking at the optimal choice of margins by banks includes Ho and Saunders (1981), Allen (1988), Wong (1997) and Saunders and Schumacher (2000). Among others, Angbazo (1997), Demirgüç-Kunt and Huizinga (2000), Angelini and Cetorelli (2003) and Demirgüç-Kunt, Laeven and Levine (2004) study the empirical relationship between margins and risk, financial development, bank performance, banking regulations and market structure.

However, to our knowledge, the cyclical behavior of margins has been previously analyzed only by Dueker and Thornton (1997). They focus on the markup of the bank prime lending rate over the marginal cost of funds for banks and they find evidence that in cyclical downturns banks opt for a relatively high price-cost margin, which leads to countercyclical markups in the pricing of bank loans. As indicators of the phase of the business cycle, they do not use production or loans, but arguably less accurate measures of economic activity, namely, the lagged spread between the commercial paper rate and the Treasury bill rate and the slope of the yield curve. They do not control for other factors that might affect the cyclical behavior of margins and they do not offer explanations for the observed countercyclical behavior. Chen, Higgins and Mason (2005) find evidence for a substantial element of procyclicality in banks' efficiency in the US economy. Their work provides support to our results[3].

The paper proceeds as follows. Section 2 presents the data and some preliminary evidence on the cyclicality of margins. Section 3 describes the econometric methodology used in this paper. Section 4 presents the estimation results for a reduced form model of margins and tests for asymmetries in the cyclicality across phases of the business cycle. Section 5 provides some potential explanations for the cyclical behavior documented in Section 4. The last section concludes and outlines some directions for further research. The appendices contain a detailed description of the data and extended results.

[3] Angelini and Cetorelli (2003) include the growth rate of GDP among their regressors and find a negative impact on both price-cost margins and Lerner indexes in Italy. In their cross-country study of the impact of bank regulations, market structure and institutions, Demirgüç-Kunt, Laeven and Levine (2004) find that economic growth is negatively (although only weakly) associated with margins.

3.2 The Data and Preliminary Evidence on the Cyclicality of Margins

This study uses time series quarterly data for the period 1979-2005. Balance sheet and income data for banks is taken from the Call Reports on Condition and Income data, available for all banks regulated by the Federal Reserve System, Federal Deposit Insurance Corporation, and the Comptroller of the Currency[4]. This is bank-level data and it is averaged for each period for this paper.

Eight alternative definitions are used here for margins. Margins 1, 2 and 3 are all calculated as the difference between the ratio of interest income on loans to the volume of loans and the ratio of interest expense on deposits and the volume of deposits. The main difference among these three is given by the way in which the loans volume is adjusted for delinquent loans. Margin 4 is calculated as the ratio of the difference between interest income and expenses to banks assets. Margin 5 is calculated as the ratio of the difference between interest income and expenses to loans. The spread between bank prime and Treasury bill rates is the only case for which cited interest rate series are used[5]. Margins C&I 1 and 2 are obtained as the difference between the ratio of interest income on commercial and industrial (C&I) loans to the volume of those loans and the ratio of interest expense on deposits and the volume of

[4]These data are available from the Federal Reserve Bank of Chicago. There is an important change in the Call Reports between 1987 and 1988. However, consistent time series have been built for this study. See Appendix A for details.

[5]The Treasury bill rate is taken as a proxy for the interest rate on deposits paid by commercial banks. Dueker and Thornton (1997) also use the bank prime as the lending rate in their study of markups in the banking sector. They argue that a change in the prime rate is indicative of a general shift in lending rates.

deposits. Margin C&I 1 adjusts the volume of C&I loans for delinquent loans. The reader is referred to Appendix A for details on variable definitions and sources. Figure 1 plots all the price-cost margin measures.

It is important to state here the distinction between spreads and net interest margins. The pure spread is the rate spread between loan and deposit rates. NIMs are calculated as the ratio of the difference between interest revenues and interest expenses to assets, whereas spreads are obtained as the difference between interest returns (i.e., interest revenues/earning assets) and interest costs (i.e., interest expenses minus provisions for loans losses, divided by interest bearing liabilities) (Angbazo, 1997). In this sense, margins 1,2 and 3 as well as C&I 1 and 2 more closely measure spreads, while margin 4 and 5 are strictly "NIMs"[6].

Three alternative business cycle measures are used in this study: GDP per capita and both total and C&I loans. The sample correlation of these two loan definitions with GDP is 0.57 and 0.78, respectively. Adding loans as an alternative measure is useful because they may be even more sensitive to the cycle than GDP. It is also conjectured here that loans may reflect more closely than GDP the behavior of aggregates that are key to study the cyclicality of banks' price-cost margins. This is because these aggregates, such as investment and production, depend critically on bank financing. Figure 2 plots the three

[6]Refer to Table A.1 for margin definitions. Demirgüç-Kunt, Laeven and Levine (2004) calculate NIMs as interest income minus interest expense divided by interest-bearing assets. Angbazo (1997) calculates NIMs as the difference between interest revenues and interest expenses (before loan loss provisions) divided by average earning assets. Demirgüç-Kunt and Huizinga (2000) define margins as banks' net interest income / total assets, where net interest income is banks profits plus operating costs and loan loss provisions - non-interest income.

business cycle indicators together.

Table 1 shows the sample raw correlations between alternative measures of the detrended margin and detrended business cycle indicators to provide a first insight on the cyclicality of margins. The contemporaneous correlation with GDP per capita is always negative for all margin measures. Correlations are very low and become insignificant in the few cases in which they are positive. It is relevant to highlight that the non-significance of the correlations for the last three margins is not evidence against the countercyclicality of margins. Several forces like changes in banking regulation and seasonality of the data not accounted for in these raw correlations may be distorting the picture. The paper shows later that when controlling for the effects of banking regulation and seasonality as well as monetary policy and default risk, the coefficient on the business cycle indicator becomes negative and significant in all cases.

3.3 Empirical Methodology

The empirical methodology consists of two steps. In a first step, the paper tests whether the negative and significant contemporaneous sample raw correlation between margins and a business cycle indicator is robust to the inclusion of controls related to monetary policy, default risk and banking regulation. Results show it is, so that there seems to be other channels through which fluctuations in the economy give rise to the observed countercyclicality of margins. In a second step, this study looks for these channels and offers alternative explanations for the observed behavior. In a regression where margins are the dependent variable, no explanatory power should be left to the business cycle measure after an expanded set of controls is introduced.

Augmented Dickey-Fuller (ADF) tests were run for all the variables in our sample to test for the presence of unit roots. Except in a few obvious cases, we did not have a priori on the process followed by each variable under the null of a unit root. Thus, this paper follows the methodology put forth by Dolado, Jenkinson and Sosvilla-Rivero (1990). In short, this methodology starts from the most unrestricted model that includes a constant and a time trend like in equation (1)[7].

$$y_t - y_{t-1} = \alpha + \beta t + \gamma y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} \tag{3.1}$$

Then it tests for the joint significance of α, β and γ using the critical values tabulated by Dickey and Fuller. If this model cannot be rejected, then the hypothesis of a unit root (i.e. $\gamma = 0$) is tested using critical values from the Student's t distribution. The advantage of this method is that once the "true" model is known under the null, the power of the unit root test can be increased by using the usual critical values from the t distribution instead of the critical values tabulated by Dickey and Fuller (this result is due to Sims, Stock and Watson, 1990). If the model in equation (1) is rejected, then the methodology continues in the same fashion with the more restricted model of difference stationary (DS) with drift. Again, if this more restricted model cannot be rejected, then ordinary critical values from the t distribution are used to test the null of $\gamma = 0$. Finally, if this second model is rejected, then the methodology ends by testing the null of a DS process using Dickey and Fuller critical values.

The optimal lag length p for the ADF regressions was based on the Akaike Information Criterion and the Schwartz Bayesian criterion as well as

[7] A difference stationary (DS) process with drift plus trend under the null of unit root

on the Box-Pierce Q test for white noise of the errors of the regression. Table A.5 in Appendix A shows the results of the stationarity checks performed.

When detected, non-stationarity was dealt with by transforming the original series into stationary processes. Trend stationary (TS) variables were detrended by regressing them on a constant and a polynomial of time. The order of the polynomial was chosen based on fit. Difference stationary (DS) variables were "detrended" using the Hodrick-Prescott filter with a smoothing parameter of 1600. All detrended variables were proven to be stationary using ADF tests. The original model was redefined in terms of these stationary variables.

This study tests for autocorrelation in the disturbances using two alternative tests: A Durbin-Watson (DW) test for first-order autocorrelation and a Breusch-Godfrey (BG) test for possible autocorrelation of up to order 4. It has been suggested that an AR(4) model is appropriate for quarterly data because of seasonal autocorrelation. Indeed, in several cases the null of no autocorrelation cannot be rejected with the DW statistic, but it is rejected when using the BG test (see Table 5 and tables B.1-B.6 in Appendix B). In all cases in which some form of autocorrelation was found, standard errors were obtained by using the Newey-West robust, consistent estimator for autocorrelated disturbances of unspecified structure.

Our specification also presents potential endogeneity problems. A system of equations bias can be affecting our results if, as expected, some of the explanatory variables are simultaneously determined with the dependent variable. Specially prone to this bias are the business cycle indicator and the share of total assets held by big banks as, when thought of as a measure of concentration, this share might itself be a function of margins, the dependent variable.

To account for endogeneity, the model was also estimated by two-stage least squares (2SLS). The instrumented variables are the cycle indicator and "Share big" (if included in the specification). The instruments used were the rest of the explanatory variables plus two lags of the instrumented variable. Since instrumental variables methods are relatively inefficient compared to OLS, a Hausman specification test was run in order to evaluate the compromise between efficiency and consistency of our estimations. Three-stage least squares (3SLS) would have allowed for correlation among the error terms of the three equations: the margin, the cycle indicator and the share of big banks in total assets. 3SLS gives more efficient estimates, but 2SLS ones are still consistent. Moreover, 3SLS would pose the risk that wrongly specified equations for the instrumented variables bias the estimators of interest in the margin equation.

Last, variance inflation factor tests detected no multicollinearity in our regressions.

3.4 Step 1: A Reduced Form Model for Price-Cost Margins

The regression specification for margins is shown in equation (2).

$$y_t = \alpha + \beta log(X_t) + \sum_{i=1}^{K1} \gamma_i Z_{i,t} + \sum_{i=1}^{K2} \delta_i R_{i,t} + \sum_{i=1}^{3} \theta_i Q_{i,t} + \epsilon_t \qquad (3.2)$$

where y is the margin measure and X is the business cycle indicator. Eight measures of margins are used here and presented in detail in Appendix A. GDP per capita and both total and C&I loans are used as alternative indicators of the business cycle phase. The countercyclicality of margins should be documented by a negative and significant β coefficient.

The R matrix includes dummy variables to control for three important regulatory changes that took place in the United States banking sector during the period covered by this study. First, in 1980 the Depository Institutions Deregulation and Monetary Control Act of 1980 eliminated the deposit interest rate ceilings imposed by Regulation Q and increased the limit of deposit insurance by the FDIC from $40,000 to $100,000 per account. Second, in 1994 the Riegle-Neal Interstate Banking and Branching Efficiency Act repealed the Douglas Amendment. It allowed national banks to operate branches across state lines after June 1, 1997. Third, the Gramm-Leach-Bliley Act (GLBA) enacted in November of 1999 increased the activities allowed for banks and their holding companies. Before 1999 commercial banks were prevented from expanding into a wide range of financial services such as investment banking.

The Q matrix includes dummy variables to control for seasonality in the quarterly data.

Monetary policy and default risk are generally suggested as the two main (and maybe the only) determinants of the cyclical behavior of margins. Thus, this paper includes both determinants as controls in the Z matrix in regression equation (2). The goal is to assess whether there is any explanatory power left to the cycle indicator after controlling for the effects of monetary policy and credit risk. Subsections 4.1 and 4.2 discuss the bases for the inclusion of these controls.

3.4.1 Monetary Policy

Monetary policy is an obviously relevant determinant of the behavior of both interest rates and margins. This paper uses the federal funds rate as a measure of the stance of monetary policy[8].

There are several reasons to expect a positive effect of the federal funds rate on margins. Angelini and Cetorelli (2003) suggest that interest rates on deposits are characterized by more inertia than those on loans, so that monetary policy shocks should imply a positive relationship between interest rates and margins. Hannan and Berger (1991) and Neumark and Sharpe (1992) also find evidence for the rigidity of deposit rates.

Another rationale for a positive coefficient on the federal funds rate in regression equation (2) is given by the bank lending channel of monetary policy. As a result of a contractionary monetary policy, banks can react to the fall in reserves by relying more on non-reservable liabilities, such as certificates of deposits (CD), to finance loans. However, these alternative funds are not covered by deposit insurance and this leaves investors exposed to credit risk. Thus, if there are adverse selection problems in the CD market, banks may choose to not fully offset the effects of the policy, and they may let lending fall as a result. With lending falling, the cost of borrowing increases and this effect is added to any increase in interest rates on open market securities. If interest rates on deposits reflect the behavior of these rates, interest rate margins can be expected to increase as a result.

The federal funds rate is procyclical in the period covered by this study[9]. Then, if indeed this policy rate and margins are directly related, not including a control for monetary policy might bias the estimation of the β coefficient upwards.

[8]Kashyap, Stein and Wilcox (1993) and Bernanke and Blinder (1992) discuss some advantages of using the federal funds rate over the Romer-dates type of measures.

[9]See Table A.4.

Given that the level of economic activity can respond with lags to monetary changes, both the current and the lagged values of the federal funds rate are used as controls to thoroughly account for the effects of monetary policy[10].

3.4.2 Credit Risk

This paper uses the net charge-off rate as a measure of the degree of default or credit risk in the economy[11]. This rate is defined as loan charge-offs[12] net of loan recoveries as a percentage of total loans.

Optimally chosen margins should be enough to cover the cost of increasing banks' capital as risk exposure increases. Thus, an increase in the economy's default rate on loans should imply an increase in the margin charged by commercial banks. If, as expected, a higher credit risk is associated with periods of declining economic activity, risk is a very important candidate to explain the countercyclical behavior of margins[13]. Thus, failing to control for the effect of risk might bias the coefficient β downwards. Moreover, it could happen that just credit risk fully explains the cyclicality of margins and that not explanatory power is left to business cycles per se.

[10]As a robustness check, up to four lags of the federal funds rate were included in the regression. This implied no important qualitative changes. Results are available from the authors upon request.

[11]We use a 1 period lagged value of the charge-off rate arguing that when observing changes to the credit risk banks face,they should adjust their pricing of loans with a lag.

[12]Charge-offs are the value of loans removed from banks' books and charged against loss reserves.

[13]The contemporaneous correlation of GDP per capita (GDPpc), total loans and commercial and industrial (C&I) loans with the default measure are -0.22, -0.13 and -0.01, respectively. See Table A.4 in Appendix A.

However, we do not expect credit risk measures to fully explain the countercyclicality of margins. All our price-cost margins use ex-post interest rates on loans, calculated using the actual income obtained by banks after accounting for bad loans. Actually, for these margin measures, a negative sign can be expected for the coefficient on the risk variable as an increase in the share of bad loans can imply a fall in the income measure used to compute ex-post margins. The spread between the bank prime and the Treasury bill rates, also used as one of our margin measures, is an ex-ante variable[14]. However, credit risk should not play an important role even in this case as both rates used to calculate this spread include only a small risk premium, if any.

3.4.3 Results

Results for this specification are summarized in Table 2[15]. The countercyclicality of price-cost margins is documented with a negative and significant coefficient β for all the specifications of the business cycle indicator and for all definitions of price-cost margins. Margins are countercyclical even after controlling for the effects of monetary policy and default risk. The result is robust to the inclusion of controls for banking regulation and seasonality in the data. Importantly, the coefficients on the margins on C&I loans and the bank prime-Treasury bill spread become significantly different from zero, even when the sample raw correlations presented in Table 1 are not.

[14]It is calculated using cited interest rates series as opposed to banks actual interest income.

[15]To save space, only the coefficients on the business cycle indicator are shown in this table. The full regression output, including the coefficients on the policy and risk variables, are available from the authors upon request.

A positive effect of the federal funds rate is obtained for almost all specifications for margins and business cycle indicators[16]. Monetary policy affects interest rates and margins in the same direction. We interpret the positive and significant coefficient found as evidence of the bank lending channel of monetary policy being at work in the US economy for the period of this study. This result is robust to the inclusion of up to four lags of the federal funds rate[17].

According to our results the credit risk measure has no significant impact on margins. This is also true when using the delinquency rate[18], the loss rate[19] and the Baa-Treasury bond spread[20] as measures of credit risk. Price-cost margins keep being countercyclical in all these cases.

As a robustness check, the cyclical behavior of margins was also studied when not controlling for monetary policy and default risk. All the margin measures were regressed against each of the three alternative business cycle indicators and just the dummies controlling for regulations and seasonality in

[16]The coefficients on the current and lagged values of the federal funds rate are added for this assessment.

[17]The cross-correlations of the rate with GDP are all negative up to four lags. We believe this should account for the major part of the effect of monetary policy. The results for this specification are available upon request. The coefficient on the cycle indicator is still negative and significant in all cases. Lags 3 and 4 of the federal funds rate do not exert a significant effect on margins. However, by adding up the coefficients that are significant, there is still evidence of monetary policy affecting interest rates and margins in the same direction.

[18]According to the Federal Reserve's definition, delinquent loans and leases are those past due thirty days or more and still accruing interest as well as those in non-accrual status.

[19]Defined here as the ratio of loans loss allowances to total loans.

[20]This spread has been suggested as a useful indicator of the default risk prospects on private debt.

the data. The countercyclicality of price-cost margins is robust to this change in the econometric specification.

3.4.3.1 Economic Significance of the Results

The goal of this subsection is to assess the quantitative importance of our results and also to facilitate the comparison across margins of the sensitivity to the cycle indicator.

The importance of the coefficients shown in Table 2 can be better understood by comparing the standard deviation of the margins with the implied change after a one standard deviation change of the cycle indicator[21]. For example, the coefficient of -0.011 of Margin 1 on the logarithm of GDP per capita shows that a one standard deviation increase of output from its trend (roughly a 2% increase) is associated to a fall of approximately 1/3 of a standard deviation of the margin relative to its own trend (around 0.02 percentage points fall in the margin). The coefficients shown in Table 2 can be misleading if one omits the standard deviations from the analysis. For example, the coefficient of -0.0072 on the logarithm of total loans, although lower than that on GDP per capita, actually shows that a one standard deviation increase of loans from their trend implies a fall of 1/2 of standard deviation of Margin 1 relative to its own trend. With this interpretation in mind, Table 3 shows the number of standard deviations by which margins change after a one standard deviation increase in the cycle measure. Alternatively, coefficients in Table 3 can be interpreted as the share of the typical deviation of each price-cost margin that

[21] See Table A.3 in the appendix for standard deviations of detrended business cycle measures and margins.

can be explained by the typical deviation in each business cycle indicator.

3.4.4 Asymmetric Behavior of Price-Cost Margins

In the framework in Bernanke and Gertler (1989) where accelerator effects on investment emerge due to costly state verification in financial contracts, they argue that agency problems may bind only on the downturn of the business cycle. Thus, they suggest that the the external finance premium may behave asymmetrically across stages of the business cycle.

This section tests for the presence of these asymmetries in the cyclical behavior of margins. With this goal, this section estimates equation (3)

$$y_t = \alpha + \beta_1 log(X_t) + \beta_2 log(X_t)D_t + \sum_{i=1}^{K1} \gamma_i Z_{i,t} + \sum_{i=1}^{K2} \delta_i R_{i,t} + \sum_{i=1}^{3} \theta_i Q_{i,t} + \epsilon_t \quad (3.3)$$

where the regressors are the same as before except for an interaction term of the business cycle indicator with a dummy variable (D). The dummy variable indicates the phase of the business cycle and it classifies the direction of economic activity (i.e. recession or expansion) rather than the level (i.e. below or above trend). $D_t = 1$ if the economy is in the downward phase of the cycle and zero otherwise.

Two alternative definitions are used to construct the dummy. In the first case the paper uses the turning points published by the Business Cycle Dating Committee of the National Bureau of Economic Research. In the second, the series for GDP per capita and loans are visually inspected to construct a dummy with more variability than the NBER-based counterpart[22]. The main

[22] The period 1979-2005 covered by this study contains only four recessions according to

difference between the two definitions is given by the periods 1991-1993 and 2001-2003 which, based on the behavior of total loans, are still classified as recessions in the second definition. Figure 3 plots the business cycle indicators and the two dummy variables together.

Thus, the coefficient β_2 captures the difference across phases of the business cycle in the response of margins to the fluctuations in economic activity.

Table 4 presents the results of this exercise. In the case of the interaction with the NBER dummy the results show lack of evidence of asymmetric behavior. Most of the estimations for β_2 are insignificant, and they do not alter the sign for the coefficient on the main effect. In the few cases in which the estimations are significant, the coefficient jumps from positive to negative across different definitions for margins and cycle indicators. The instability of these estimations is expected due to the fact that the NBER dummy used for the interaction effect is non-zero in just a few periods in each recession.

We confirm this expectation when we use our phase indicator to construct the interaction effect. The regression results in the bottom portion of the table show more stable coefficients across definitions of margins and cycle indicators. Still, only in half of the cases the estimated value of β_2 is significantly different from zero, providing only partial support to the hypothesis of an asymmetric pattern of margins over the cycle[23]. For all these cases, the coefficients are always negative with the main effects becoming insignificant.

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the NBER statistics. Two of them are very close to each other, so that the series exhibits very small variability.

[23]Twelve out of twenty-four estimations are significant: Margins 4 and 5 and the spread BP-TB for the three cycle indicators plus Margins 1, 2 and 3 for the case of C&I loans

The type of asymmetry implied by these results is one in which banks price-cost margins increase during recessions while they exhibit no cyclical behavior during expansions. This is in line with the type of asymmetry suggested by Bernanke and Gertler (1989) referred to above.

3.5 Step 2: Explaining the Cyclical Behavior of Price-Cost Margins

An additional set of both macroeconomic and bank-related regressors are added to equation (2) in this section. The goal is to explain the counter-cyclical behavior of margins documented before, that is to determine what are the actual channels through which the phase of the business cycle affects the choice of margins by banks. Thus, no explanatory power should be left to the cycle measure after introducing this expanded set of controls. Subsections 5.1 and 5.2 below discuss the bases for the inclusion of each of these additional regressors. This is in line with the type of asymmetry described by Bernanke and Gertler (1989) referred to above.

3.5.1 Macroeconomic Determinants

Monetary policy, default risk (already discussed and included as a regressor in Section 4), interest rate risk, the economy's financial depth, the availability of funds for banks and inflation are conjectured as potential macroeconomic determinants of the cyclicality of margins.

Monetary Policy: Together with the Federal funds rate already included in the basic specification in Section 4, two different interaction variables are included here to appropriately measure the full impact of monetary policy on bank margins.

The first is built as the interaction between a measure of the liquidity of banks balance sheets[24] and the federal funds rate. Gibson (1996) finds that the macroeconomic effects of monetary policy are weaker when banks in the aggregate hold more liquid portfolios. In their cross-sectional study, Kashyap and Stein (2000) find that the impact of monetary policy on lending is weaker for banks with more liquid balance sheets, as they can react to a fall in reserves due to a contractionary monetary policy and protect their loan portfolios by drawing from the buffer of cash and securities. They find this to happen mainly for small banks that do not have access to alternative uninsured external financing. For them, the liquidity of the balance sheet is key to determine their response to the policy shock. Conversely, for larger banks, they obtain a positive effect of liquidity on the strength of monetary policy. This study uses aggregate data for the entire size distribution of banks and bigger banks with close to perfect access to uninsured sources of finance are more heavily weighted[25]. Therefore, our results can be expected to reproduce theirs for the case of big banks.

The second variable is the interaction between a concentration measure given by the Herfindahl-Hirschman index in the market for loans and the federal funds rate. Cottarelli and Kourelis (1994) find that entry barriers in banking slow policy transmission, although they do not find significant effects from differences in market concentration. More recently, Adams and Amel (2005) study the relationship between banking competition and the transmis-

[24]The liquidity measure used is the same that is included later as a determinant of the cyclicality of margins.

[25]Average margins are weighted averages across banks, with loans used as weights.

sion of monetary policy, and find that the impact of monetary policy is weaker in more concentrated markets. Therefore, we expect a negative sign for the coefficient on this regressor[26].

Interest Rate Risk: Previous theoretical and empirical studies have shown the importance of accounting for interest rate risk given that banks are expected to charge a premium to compensate for this type of risk (Ho and Saunders (1981), Saunders and Schumacher (2000) and Demirgüç-Kunt, Laeven, and Levine (2004)).

Both the contemporaneous and the lagged values of the volatility of short-term interest rates are included among the regressors in equation (2) as a proxy for the interest rate risk faced by banks. Following Saunders and Schumacher (2000), the measure used is the standard deviation over each quarter of the weekly series for the 3-month Treasury bill rate. If this risk measure and margins are positively correlated, countercyclical risk can help to explain the countercyclicality of margins.

Because high volatility increases the probability of a future recession[27], the lagged value of interest rates volatility is a countercyclical risk measure and therefore, likely to explain the cyclical behavior of margins.

The Economy's Financial Depth: A negative sign is expected for the coefficient on the degree of financial deepening in the economy. A deeper financial sector should imply a bigger availability of substitutes to bank credit

[26]Peltzman (1969) develops a theoretical model that relates market structure in banking to the transmission of monetary policy.

[27]Volatility hampers investment and lowers consumer confidence, exerting a negative effect on future GDP levels.

and banks should therefore need to charge lower margins[28].

Following Kashyap, Stein and Wilcox (1993), financial depth is measured as the ratio of commercial paper issued by the nonfarm nonfinancial corporate business sector to the sum of commercial paper and bank loans for the nonfarm nonfinancial corporate business and nonfarm noncorporate business sectors. This measure is procyclical. One explanation for the procyclicality can be found in Kashyap, Stein and Wilcox (1993). They show that in expansions, countercyclical monetary policy (i.e. monetary contractions and high federal funds rates) makes bank lending decrease by more than commercial paper. Our financial deepening indicator increases as a result.

With this procyclicality and with an expected negative coefficient, the inclusion of financial depth as a control should help to explain the countercyclicality of margins[29].

Supply of Funds: The supply of deposits available to banks is used as a proxy for their marginal cost of funds[30]. It is argued here that the cost is an important determinant of margins. Therefore, if the supply of funds is inversely related to margins (through banks costs being directly related to

[28]Demirgüç-Kunt and Huizinga (2000) show evidence that countries with underdeveloped financial systems that move towards more development see bank profitability and margins fall. However, once they control for bank and market development, they cannot find independent effects on margins of financial structure per se.

[29]The lagged value of the variable is used based on this measure being more procyclical than the contemporaneous counterpart.

[30]It would be interesting to extend the paper by including alternative measures of the operative costs of banks. Data on non-interest expenses, banks' spending on furniture and equipment and salaries and benefits are available from the Call Reports on Condition and Income data.

them), a procyclical behavior for this regressor should help to explain the countercyclicality of margins.

Inflation: The detrended value of the consumer price index (CPI) is included as a measure of inflation. Banks might require higher risk premia when inflation or nominal interest rates are high[31]. Given the negative correlation between economic activity and inflation at business cycle frequencies, a positive effect of inflation on margins might provide another explanation for the countercyclical behavior of the latter.

3.5.2 Banking Industry Determinants

This subsection discusses the role of several banking sector variables as potentially good explanations of the cyclicality of margins. They are banks liquidity and capital holdings and the market share held by big banks.

Liquidity: The ratio of cash plus investment securities to assets is introduced among our regressors as a measure of aggregate liquidity for banks[32].

[31]Huybens and Smith (1999) argue that inflation may make informational asymmetries stronger and lead to higher margins. Demirgüç-Kunt and Huizinga (2000) provide support to the fact that banks profits increase in inflationary environments. Saunders and Schumacher (2000) present evidence for margins increasing with higher interest rate volatility, which has been associated with high and variable inflation. Boyd, Levine and Smith (2001) find a significant, economically important and negative relationship between inflation and banking sector development. In turn, lower development can be conjectured to derive in increased net interest margins. Demirgüç-Kunt, Laeven and Levine (2004) show that inflation has a robust, positive impact on bank margins and overhead costs. Angelini and Cetorelli (2003) document a negative effect of inflation on price-cost margins in Italy, though.

[32]See data appendix for definition. Kashyap and Stein (1997) define liquidity for each bank as the ratio of cash plus securities plus federal funds sold to total assets. Due to the lack of data on federal funds for several periods, we depart slightly from them and define it

Previous studies find evidence that banks with more liquid assets have lower net interest margins[33]. However, it could also be argued that when banks choose to hold more liquid portfolios, they pay for the cost of that liquidity by raising their margins[34].

Economic activity and liquidity are inversely related. In recessions credit risk increases more for risky and illiquid assets, such as loans, than for more liquid assets such as government securities. This results in banks shifting their asset portfolios toward more liquid assets during bad times. Also, banks opportunity cost of holding more liquid and less profitable assets falls in recessions when there are fewer investment opportunities. If there is in fact

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as cash plus securities over total assets. The aggregate measure is calculated as the weighted average across banks, with the weights given by each bank's share in total assets for each period.

[33]Demirgüç-Kunt, Laeven and Levine (2004) argue that banks with high levels of liquid assets in cash and government securities may receive lower interest income than banks with less liquid assets. If the market for deposits is reasonably competitive, then greater liquidity will tend to be negatively associated with interest margins. Angbazo (1997) finds that as the proportion of funds invested in cash or cash equivalents increases, banks liquidity risk declines and leads to a lower liquidity premium in net interest margins.

[34]Ho and Saunders (1981) and Saunders and Schumacher (2000) develop a model where banks charge margins that are mainly fees for the provision of "immediacy services" (the immediate provision of deposits and loans). Banks have to temporarily invest funds in the money market whenever a deposit arrives at a time different from a new loan demand, and they face a *reinvestment risk* if the short term rate falls. If banks face a demand for a new loan without a contemporaneous supply of new deposits, they need to borrow temporarily in the money market, facing a *refinancing risk* should the short term interest rate go up. The margin compensates banks for bearing this risk. Holding more liquid assets can be viewed as an alternative to having to resort to the money market to provide these services. Therefore, their model provides a rationale for a positive relationship between margins and banks liquidity.

a positive effect of liquidity on margins, the countercyclicality of liquidity can provide another explanation for that of margins.

Banks Capital Holdings: The ratio of equity capital to loans is used as another regressor to control for the effect of capital requirements for banks. After the Basle Accords of 1988 banks are required to hold a minimum of capital as a percentage of risk weighted assets[35]. Moreover, there is empirical evidence that banks hold capital against credit risk in excess of the minimum 8% of total risk weighted assets required by the Accords[36].

There are several reasons to expect capital holdings to exert a positive impact on margins. Given that holding equity is costly relative to debt[37], banks may need to charge higher margins to finance this extra cost. Hellman, Murdock and Stiglitz (2000) present a context that provides an alternative story for capital requirements to increase margins. They show that when capital requirements increase banks cost of funding, they lower the franchise value of banks and this increases the incentives to risk-taking and increases margins as a result. Last, Demirgüç-Kunt, Laeven and Levine (2004) argue that highly capitalized banks have lower bankruptcy risks and lower funding costs, and that they therefore charge higher price-cost margins when interest rates on loans are insensitive to equity.

[35]Data on risk capital and risk-adjusted assets are available from the Report of Condition and Income data only after 1991. Therefore, total loans are used instead bearing in mind that loans are one of the riskiest assets in banks' portfolios.

[36]In our sample equity represents 14% of loans. According to the Bank of International Settlements, the average ratio of capital to risk-weighted assets of major banks in G-10 countries rose from 10% in 1988 to 11% in 1996.

[37]This is due mainly to taxation issues.

As a result of loans being more procyclical than equity[38], the capital to assets ratio is countercyclical in our sample period. Thus, if the ratio is directly related to margins, the inclusion of this regressor in the expanded set of controls can explain the countercyclicality of margins.

The Market Share of Big Banks: The share of total bank assets held by big banks is included among the controls as a measure of both market concentration and of the relative importance of bigger banks in the economy. It can therefore capture differences, if any, in the behavior of these banks relative to the rest. The Herfindahl-Hirschman index (HHI) for the market for loans is an alternative measure of concentration, but both measures comove in our dataset[39]. Worthy of note is an important increase in both concentration measures over the last years.

If higher market concentration is a good proxy for less competition, there should be a positive relationship between market concentration and price-cost margins. Also, for a given interest rate on loans, concentration

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[38]Equity is directly related to the level of economic activity because default, which lowers equity, is countercyclical.

[39]We looked at two different measures for the Herfindahl index: an aggregate measure and a weighted average of states indexes. This distinction becomes specially relevant for the pre-1997 period when interstate branching was not allowed in the US. To understand the need for this adjustment, consider an economy where banks are restricted to operate in only one state and where there is only one bank in each state. The aggregate HHI in that economy would be $\sum(1/N^2) = 1/N$ with N being the number of states. With the transformed measure, the weighted HHI would equal $\sum(1 * 1/N) = 1$. Therefore, the aggregate measure would be underestimating the concentration measure in an economy where banks are perfect monopolies in each of their areas of operation. The variability over time of these two measures can be expected to be different if the shares of each state in total assets change significantly at business cycle frequencies. However, we do not expect these changes to be very important.

will increase margins if it allows banks to offer lower deposit rates[40]. However, Jackson (1992 and 1997), Rhoades (1995) and Hannan (1997) present models of oligopolistic competition alternative to Cournot, according to which there might be an inverse relationship between price-cost margins and concentration indexes[41]. Last, Smirlock (1985) argues that market concentration is not random, but the result of more efficient banks "endogenously" gaining larger market shares. He finds support to the hypothesis that there is no causal relationship between concentration and profitability in banking. Therefore, the relationship between concentration and margins is not that obvious.

Regarding the interpretation of this variable as a measure of the importance of bigger banks, there is evidence that they charge lower margins than smaller banks[42]. This should imply a negative sign for the coefficient on the share of total assets held by big banks.

[40]Berger and Hannan (1989) provide strong evidence of a negative relationship between market concentration and deposit rates. Hannan and Berger (1991) find that banks in more concentrated markets have more rigid deposit rates, and that deposit rates are stickier upwards than downwards. Neumark and Sharpe (1992) find that in more concentrated markets deposit rates rise more slowly and fall faster after a change in input costs. They also find that banks in concentrated markets offer lower rates on deposits than more competitive banks.

[41]The basic idea in these models is that banks operate in a perfectly competitive market for loans, but have market power when getting deposits from savers in the economy. Thus, more concentrated markets pay lower rates on deposits and should have higher margins. Jackson (1997) provides evidence of a non-monotonic relationship between market concentration and price rigidity.

[42]Flannery (1981) shows that large banks effectively hedge themselves against market rate risk by holding assets and liabilities of similar average maturities, and therefore can charge smaller margins. Ho and Sunders (1981) also show that smaller banks have a one third of a percent larger margin than bigger banks.

The share is highly procyclical in our sample. Two explanations for the procyclicality are based on the non-competitive behavior of large banks over the cycle. First, in a setting of imperfect competition originated in product differentiation, we can think of big banks being more aggressive than smaller banks in capturing most of the increased demand for credit in booms. A second explanation can be found in a setting of strategic behavior of big banks as in a colluding oligopoly along the lines of Rotemberg and Saloner (1986). During booms players revert to the non-collusion equilibrium with lower prices and higher quantities. If the larger banks in the industry are the ones that implicitly collude while smaller banks do not have such a strategic behavior, then big banks will expand their share of the market during booms when the collusion is more difficult to sustain.

Based on the previous discussion, it is not clear what sign to expect for the coefficient on the share of big banks, but if the negative effect is stronger, the procyclicality of the share provides an alternative explanation for the countercyclical behavior of margins.

3.5.3 Explaining the Countercyclicality: Results

For almost all regressions, the cycle measure completely loses its explanatory power[43] after the expanded set of regressors is used. This evidence suggests that at least a subset of the included controls are important channels through which fluctuations in the economy translate into cyclical movements of the margins (i.e. at least a subset of them can explain the countercycli-

[43]The only exception corresponds to the particular case of Margins C&I 1 and C&I 2 with C&I loans, for which the quantity indicator keeps its significance and negative sign.

cality of margins documented before). With the purpose of saving space and given the similarity in the qualitative results across the different margins and business cycle measures, Table 5 includes the regression outputs of just four selected margins and only for GDP and total loans. Results for the rest of margins and for C&I loans as well as a number of regression diagnostic tests are all included in Tables B.1 to B.3 of Appendix B.

Overall, the federal funds rate retains its positive and significant impact on margins even after introducing the additional controls. Moreover, in the case in which the coefficient on the contemporaneous rate is negative, the total effect of monetary policy on margins is still positive when considering the effect of the rate's lagged value[44].

Our results cannot provide full support to the effect studied in Kashyap and Stein (2000) related to the interaction between monetary policy and banks liquidity. This hypothesis would imply a negative sign for the interaction between liquidity and the federal funds rate. Conversely, the coefficients obtained here are insignificant in all possible combinations of margins and cycle indicators. Moreover, consistently across business cycle measures, they are positive for all margins except for the ones on C&I loans. However, our findings can be easily reconciled with theirs recalling that their hypothesis is specially relevant for small banks that typically have less than perfect access to uninsured sources of finance. For larger banks they also find a positive and even significant effect of this interaction variable on banks loan supply. In our aggregate data, large banks[45] weight more heavily than the rest, so that the positive although in-

[44]The only exception is given by the case of Margin 5 with GDP and with C&I loans. Monetary policy exerts a negative effect on margins in these two cases.

[45]Bank size was determined as in Kashyap and Stein (2000). Large banks are those in the

significant coefficient on this interaction that we obtain is not evidence against Kashyap and Stein (2000) findings.

The results in this paper provide some support to the hypothesis that monetary policy is weaker with higher concentration in the banking industry. The coefficient obtained for the interaction between the measure of monetary policy and concentration is negative, although insignificant in some cases. One reason for this lack of significance might be that the structure of the banking industry does not change dramatically at business cycle frequencies.

Regarding credit risk, the coefficients on the lagged value of the charge-off rate are positive although insignificant. However, as discussed before, we are not particularly concerned about risk with any of our NIM or spread measures.

Interest rate risk has a positive and in most cases significant impact on margins.

As expected, the financial depth measure exerts a negative although in some cases insignificant effect.

The supply of deposits faced by banks and used as a proxy for their marginal cost of funds does not have a consistently significant impact on margins. Future research could try to incorporate alternative measures of operation costs for banks.

Inflation rates do not seem to affect banks price-cost margins. However, consistently across cycle indicators, inflation has a positive and significant impact on the spread between the bank prime and the treasury bill rates.

99-100th percentile of total asset distribution, medium size banks are those in the 95-99th percentiles and the rest are small banks.

The liquidity of banks portfolios increases margins for the case of Margins 1-3. In this sense, our results are consistent with those in Angbazo (1997) and Demirgüç-Kunt, Laeven and Levine (2004). However, no conclusive evidence can be found as the coefficient is insignificant for other margins and it is even negative and significant for margins on C&I loans.

The coefficient on the capital to assets ratio is positive and significant across the different alternative specifications, except again for the case of the NIM on C&I loans. In general, banks seem to charge higher margins to cover the costs of capital holdings.

One explanation we can exercise for the fact that both banks liquidity and capital holdings have a different impact on C&I margins is related to the possibility available to banks of cross-subsidizing some product mixes. Demirgüç-Kunt, Laeven and Levine (2004) suggest that this may affect the pricing of loans. If banks are subject to more competition in the market for C&I loans than in others (such as credit card loans or mortgages), these loans may be good candidates for subsidies when banks try to cover the costs of liquidity and capital adequacy provisions.

The share of total assets held by big banks negatively influences the dependent variable. This is consistent with previous evidence that larger banks charge lower markups over their marginal cost of funds.

Summarizing, at the macroeconomic level, the best candidates to explain the countercyclicality of margins are monetary policy, interest rate risk and the economy's financial depth. Among the variables describing the banking sector, banks liquidity, capital holdings and the share of total assets held by big banks seem to exert a significant impact on margins. These conclusions are consistent across several alternative definitions used for price-cost margins and three different business cycle indicators.

It is clear from our results that margins for C&I loans are more sensitive to the cycle than the other margin measures. In a couple of cases the cycle indicator retains its explanatory power even after introducing the larger set of controls. A first potential explanation for the larger sensitivity of margins for C&I loans relative to other margin measures is that C&I loans are generally of shorter maturity than other major lending categories, such as long-term mortgages. Thus, banks can adjust their volume and price faster[46]. A second explanation is related to the different cyclicality of various types of loans. While C&I loans are highly procyclical (see Figure 2), other lending categories such as mortgages and credit card loans can be expected to be less dependent on the cycle.

3.6 Concluding Remarks

After the seminal contributions by Rotemberg and Saloner (1986) and Rotemberg and Woodford (1991 and 1992) an extensive theoretical and empirical literature studies the endogenous variation of price-cost margins in response to aggregate shocks. This literature focuses on goods markets and looks at how endogenous margins can become an additional channel through which shocks affect the economy. For financial markets, the role of endogenous price-cost margins in the amplification of economic shocks was recognized by Bernanke and Gertler (1989) and Bernanke, Gertler and Gilchrist (1996 and 1998). However, the cyclical behavior of margins in credit markets has not

[46]Kashyap and Stein (1997) offer this explanation in a related although different context.

been empirically explored before. Thus, the literature lacks empirical evidence on the cyclicality of banks margins as an indicator of the existence and importance of this “financial accelerator”.

This study attempts to start filling this gap. It documents the countercyclicality of banks’ price-cost margins for the United States banking sector, a key fact about US business fluctuations that has received little attention before. The results are robust to several definitions for the margins and to three different cycle indicators.

Our results have interesting policy implications due to their macroeconomic impacts. With price-cost margins in the market for credit being countercyclical, a financial accelerator seems to be operating in the American economy. This may provide additional grounds for stabilization policy in economies where these margins are more countercyclical.

The tests for the presence of asymmetries in the cyclical behavior of margins find no evidence of differences across phases of the business cycle.

Some potential explanations for this cyclical behavior are offered in this study. According to our results, monetary policy, the economy’s degree of financial deepening, interest rate risk, banks liquidity and capital holdings and the share of total assets held by big banks exert a significant impact on margins over the cycle. All of them provide channels through which fluctuations in the economy give rise to the observed countercyclicality.

Further research could try to incorporate alternative explanations for the countercyclical behavior of margins alternative to those offered in this paper. The first relates to the banks owners’ preference structure. When adjusting interest rates downwards during recessions, banks face a trade-off between profits and market share. As in Dueker and Thornton (1997), if firms with market power have preferences for smoother profit streams, in recessions they may smooth profits by charging relatively high prices. The second explanation involves issues of asymmetric information in the lender-borrower relationship. Banks face adverse selection when they increase their market share during downturns: they are faced to borrowers with bigger default probabilities. Therefore, they may need to increase markups over their marginal costs. Third, the degree of market power may be countercyclical in itself. Forbes and Mayne (1989) present evidence on the procyclicality of the elasticity of the demand for credit faced by banks. Last, as in Rotemberg and Saloner (1986), costs of collusion may increase during economic expansions.

Building a general equilibrium model that can account for this cyclical behavior of margins and using it to assess how countercyclical margins can provide a channel through which aggregate productivity shocks can affect economic activity is left for future work.

Table 3.1: Correlation of Margins with Business Cycle Measures

	Marg 1	**Marg 2**	**Marg 3**	**Marg 4**	**Marg 5**	**BP/TB**	**C&I 1**	**C&I 2**
GDPpc	-0.20	-0.23	-0.21	-0.26	-0.34	-0.24	-0.07	-0.07
	(0.040)	(0.016)	(0.029)	(0.016)	(0.001)	(0.012)	(0.549)	(0.503)
Total loans	-0.35	-0.42	-0.40	-0.31	-0.52	-0.11	0.14	0.13
	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.283)	(0.202)	(0.222)
C&I loans	-0.34	-0.40	-0.39	-0.35	-0.53	0.01	0.03	0.02
	(0.002)	(0.000)	(0.000)	(0.001)	(0.000)	(0.938)	(0.810)	(0.851)

See Table A.1 for margin definitions. GDPpc: GDP per capita. Significance levels shown in parentheses.

Table 3.2: The Cyclical Behavior of Banks Price-Cost Margins

	Margin 1			Margin 2			Margin 3			Margin 4		
GDPpc	-0.0111*	–	–	-0.0122*	–	–	-0.0113*	–	–	-0.0052*	–	–
	(0.011)	–	–	(0.006)	–	–	(0.009)	–	–	(0.099)	–	–
Total loans	–	-0.0072	–	–	-0.0078	–	–	-0.0074	–	–	-0.0019	–
	–	(0.000)	–	–	(0.000)	–	–	(0.000)	–	–	(0.084)	–
C&I loans	–	–	-0.0063	–	–	-0.0071	–	–	-0.0064	–	–	-0.0023
	–	–	(0.002)	–	–	(0.000)	–	–	(0.001)	–	–	(0.131)
Adjusted R^2	0.201	0.363	0.309	0.191	0.388	0.342	0.19	0.377	0.339	0.242	0.258	0.255
Observations	104	104	84	104	104	84	104	104	84	85	85	84

Table 2 (ctd.)

	Margin 5			BP/TB			C&I 1			C&I 2		
GDPpc	-0.0074*	–	–	-0.0653*	–	–	-0.0408*	–	–	-0.0408*	–	–
	(0.077)	–	–	(0.066)	–	–	(0.001)	–	–	(0.001)	–	–
Total loans	–	-0.0037*	–	–	-0.0406*	–	–	-0.0104	–	–	-0.0102	–
	–	(0.029)	–	–	(0.046)	–	–	(0.07)	–	–	(0.067)	–
C&I loans	–	–	-0.0041	–	–	-0.0275	–	–	-0.0222	–	–	-0.0216
	–	–	(0.031)	–	–	(0.006)	–	–	(0.000)	–	–	(0.000)
Adjusted R^2	0.451	0.508	0.485	0.418	0.412	0.219	0.586	0.555	0.639	0.586	0.552	0.632
Observations	85	85	84	104	104	84	85	85	84	85	85	84

* From 2SLS regression, Hausman test rejected at 10% level.

P-value of t-test in parentheses. Newey-West robust standard errors. Corrected by heteroscedasticity and possible autocorrelation up to AR(4).

The full regression output, including the coefficients on the monetary policy and default risk variables, along with important regression diagnostic statistics are available from the authors upon request.

Table 3.3: Economic Significance of the Coefficients

	Marg 1	Marg 2	Marg 3	Marg 4	Marg 5	BP/TB	C&I 1	C&I 2
GDPpc	-0.36	-0.41	-0.38	-0.30	-0.29	-0.23	-0.46	-0.47
Total loans	-0.48	-0.54	-0.52	-0.23	-0.30	-0.30	-0.24	-0.24
C&I loans	-0.35	-0.41	-0.37	-0.23	-0.27	-0.17	-0.43	-0.43

Cells show the number of standard deviations by which margins change after a one standard deviation increase in the cycle measure. Alternatively, coefficients can be interpreted as the share of the typical deviation of each margin that can be explained by the typical change in each business cycle indicator.

Table 3.4: Asymmetries in the Cyclical Behavior of Margins*

NBER dummy	Marg 1	Marg 2	Marg 3	Marg 4	Marg 5	BP/TB	C&I 1	C&I 2
GDPpc	-0.016	-0.017	-0.016	-0.003	-0.005	-0.066	-0.032	-0.033
	(0.000)	(0.000)	(0.000)	(0.25)	(0.171)	(0.121)	(0.006)	(0.005)
GDPpc*NBER	0.026	0.029	0.027	-0.019	-0.014	-0.056	-0.013	-0.015
	(0.000)	(0.000)	(0.000)	(0.034)	(0.294)	(0.461)	(0.617)	(0.54)
Total loans	-0.008	-0.009	-0.008	-0.002	-0.004	-0.035	-0.010	-0.010
	(0.000)	(0.000)	(0.000)	(0.096)	(0.010)	(0.071)	(0.071)	(0.069)
Total loans*NBER	0.014	0.015	0.013	-0.005	-0.011	-0.017	0.009	0.008
	(0.139)	(0.130)	(0.172)	(0.046)	(0.000)	(0.842)	(0.404)	(0.475)
C&I loans	-0.006	-0.007	-0.006	-0.002	-0.004	-0.030	-0.027	-0.023
	(0.003)	(0.001)	(0.002)	(0.119)	(0.038)	(0.005)	(0.000)	(0.000)
C&I loans*NBER	-0.002	-0.003	-0.004	0.002	-0.001	0.054	0.026	0.026
	(0.659)	(0.581)	(0.518)	(0.645)	(0.790)	(0.111)	(0.003)	(0.005)

Table 4 (ctd.)

Phase dummy	Marg 1	Marg 2	Marg 3	Marg 4	Marg 5	BP/TB	C&I 1	C&I 2
GDPpc	-0.012	-0.015	-0.012	0.002	0.002	0.022	-0.030	-0.030
	(0.003)	(0.000)	(0.001)	(0.473)	(0.716)	(0.495)	(0.055)	(0.052)
GDPpc*Ind	0.005	0.009	0.006	-0.013	-0.016	-0.176	-0.005	-0.006
	(0.478)	(0.257)	(0.443)	(0.000)	(0.002)	(0.000)	(0.768)	(0.714)
Total loans	-0.005	-0.007	-0.005	0.000	-0.001	0.010	-0.011	-0.010
	(0.009)	(0.000)	(0.001)	(0.962)	(0.483)	(0.590)	(0.099)	(0.102)
Total loans*Ind	-0.004	-0.003	-0.004	-0.005	-0.008	-0.095	0.001	0.000
	(0.204)	(0.414)	(0.187)	(0.004)	(0.000)	(0.000)	(0.885)	(0.977)
C&I loans	-0.003	-0.004	-0.003	0.000	-0.001	-0.007	-0.023	-0.022
	(0.197)	(0.119)	(0.177)	(0.864)	(0.737)	(0.592)	(0.001)	(0.001)
C&I loans*Ind	-0.008	-0.009	-0.009	-0.006	-0.010	-0.059	0.002	0.001
	(0.018)	(0.011)	(0.012)	(0.003)	(0.000)	(0.003)	(0.844)	(0.903)

* Table shows results for 48 different regressions, 24 for each dummy definition. In each case, regressions are run for 8 alternative definitions for margins and 3 business cycle indicators: GDPpc, total loans and C&I loans.

P-value of t-test in parentheses. Newey-West robust standard errors (four lags included)

The full regression output, including the coefficients on the monetary policy and default risk variables, along with important regression diagnostic statistics are available from the authors upon request.

Table 3.5: Some Explanations for the Cyclical Behavior of Margins

	Margin 1		**Margin 4**		**BP/TB***		**Margin C&I 1**	
GDPpc	0.0019		0.0000		0.0128		-0.0097	
	(0.634)		(1.000)		(0.767)		(0.557)	
Total loans		-0.0029		-0.0025		0.0260		-0.0079
		(0.467)		(0.434)		(0.281)		(0.406)
Macroeconomic Determinants								
FF rate	0.0253	0.0276	0.0109	0.0107	-0.1152	-0.0817	0.0784	0.0736
	(0.000)	(0.000)	(0.180)	(0.193)	(0.049)	(0.144)	(0.003)	(0.001)
FF rate$_{t-1}$	0.0096	0.0100	-0.0096	-0.0088	0.2436	0.2639	0.0235	0.0287
	(0.244)	(0.221)	(0.155)	(0.229)	(0.001)	(0.000)	(0.368)	(0.259)
Liquidity*FF rate	0.2909	0.2640	0.4507	0.4173	1.3655	0.8292	-1.0823	-1.2946
	(0.290)	(0.308)	(0.324)	(0.382)	(0.605)	(0.719)	(0.480)	(0.400)
HHI*FF rate	-0.7694	-0.7883	-0.0586	-0.5287	-31.53	-17.76	-24.38	-28.44
	(0.879)	(0.865)	(0.990)	(0.891)	(0.474)	(0.653)	(0.025)	(0.008)
Charge-off rate	0.1307	0.1279	0.0656	0.0723	0.1095	0.2574	0.0949	0.1838
	(0.424)	(0.402)	(0.502)	(0.526)	(0.946)	(0.859)	(0.798)	(0.641)
Volatility TB	0.0201	0.0235	0.0572	0.0517	0.8422	0.8427	0.2029	0.1859
	(0.252)	(0.192)	(0.037)	(0.057)	(0.001)	(0.001)	(0.097)	(0.111)
Volatility TB$_{t-1}$	0.0232	0.0245	0.0726	0.0698	0.1598	0.2097	0.0924	0.0990
	(0.135)	(0.108)	(0.007)	(0.010)	(0.517)	(0.414)	(0.215)	(0.204)
Financial depth	-0.0087	-0.0080	-0.0070	-0.0063	-0.0519	-0.0600	-0.0348	-0.0346
	(0.098)	(0.118)	(0.036)	(0.069)	(0.258)	(0.197)	(0.015)	(0.020)
Deposits	0.0026	0.0020	-0.0022	-0.0024	0.0182	0.0214	-0.0020	-0.0019
	(0.207)	(0.370)	(0.072)	(0.038)	(0.316)	(0.180)	(0.739)	(0.753)
CPI	0.0000	-0.0001	-0.0001	-0.0001	0.0016	0.0013	-0.0002	-0.0002
	(0.860)	(0.336)	(0.418)	(0.251)	(0.009)	(0.002)	(0.360)	(0.278)
Banking Industry Determinants								
Liquidity	0.0208	0.0195	0.0015	-0.0003	0.0603	0.0719	-0.0639	-0.0734
	(0.001)	(0.001)	(0.841)	(0.975)	(0.284)	(0.152)	(0.030)	(0.010)
K-A ratio	0.0354	0.0301	0.0337	0.0290	0.0272	0.0606	-0.1002	-0.1131
	(0.075)	(0.122)	(0.003)	(0.023)	(0.777)	(0.605)	(0.113)	(0.093)
Share big	-0.0427	-0.0347	-0.0256	-0.0162	0.2873	-0.0166	-0.1573	-0.1394
	(0.005)	(0.118)	(0.023)	(0.261)	(0.147)	(0.900)	(0.001)	(0.011)
Observations	104	104	85	85	104	104	85	85
B-G p-value	0.0020	0.0020	0.0960	0.0990	0.0000	0.0000	0.0060	0.0050
DW statistic	1.3300	1.3440	1.5320	1.5070	2.0880	2.0210	1.2660	1.2930
Adjusted R^2	0.5860	0.5890	0.4020	0.4100	0.6060	0.6270	0.7380	0.7380

* From 2SLS regression; Hausman test rejected at 10% level.

P-value of t-test in parentheses. Newey-West robust standard errors. Corrected by heteroscedasticity and possible autocorrelation up to AR(4). FF rate: Federal funds rate. HHI: Herfindahl index for total loans. Share big: Share of total assets held by big banks.

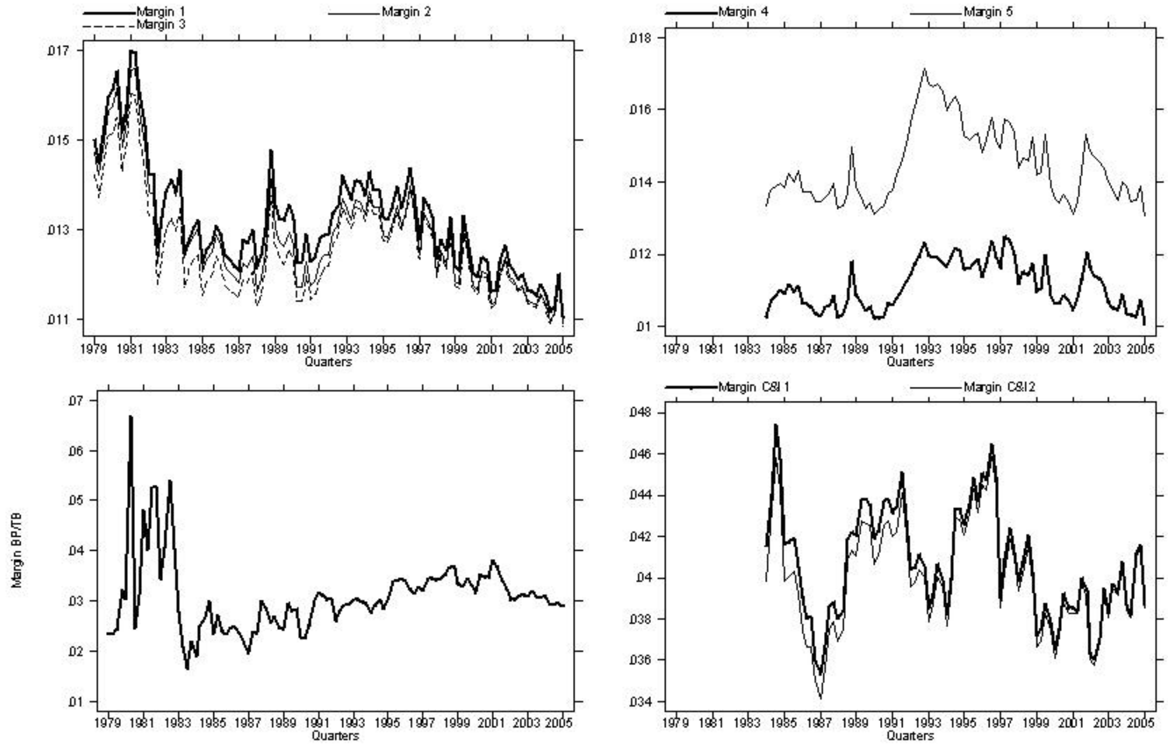

Figure 3.1: Banks Price-Cost Margins

Source: RCI data and Board of Governors.

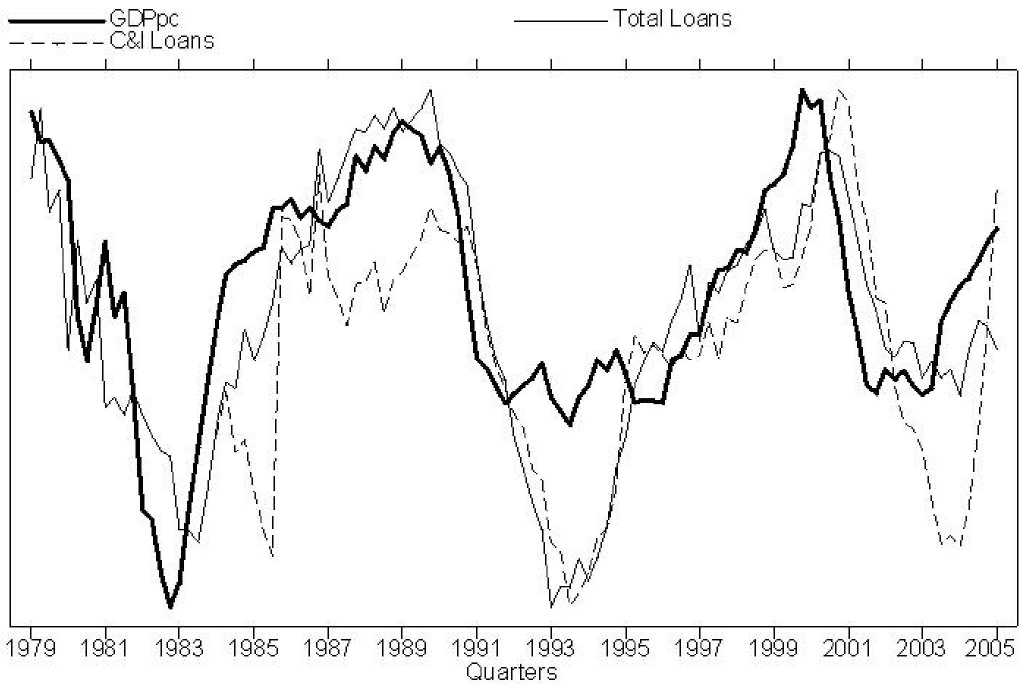

Figure 3.2: Detrended Business Cycle Indicators

Source: RCI data and NIPA-BEA.

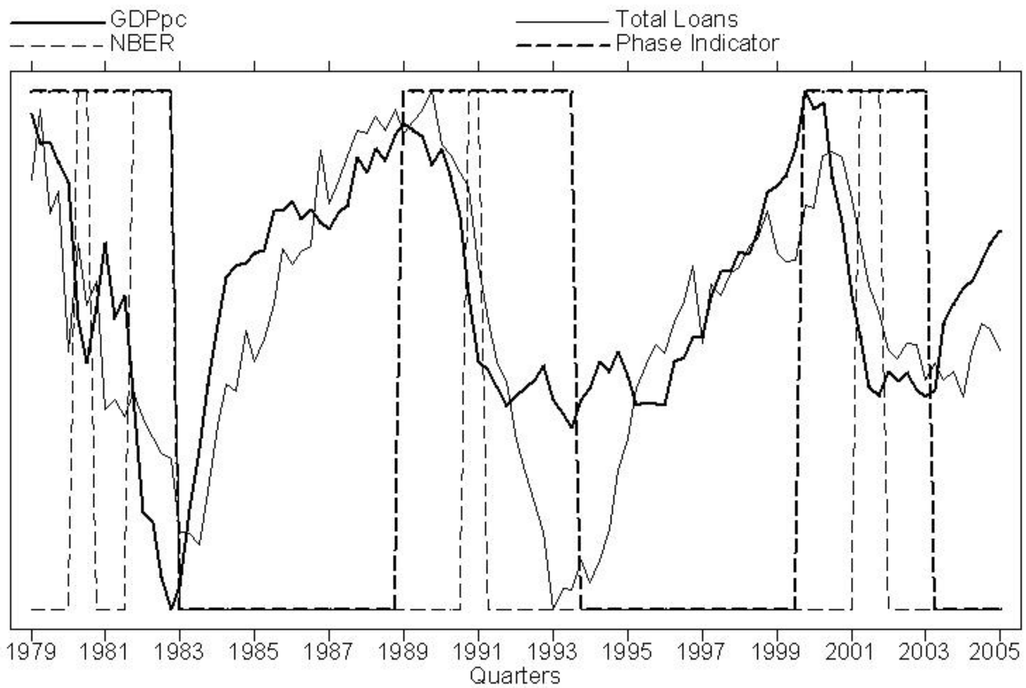

Figure 3.3: Phases of the Business Cycle

"NBER" shows the dummy variable built using the NBER reference dates, and "phase indicator" shows the dummy built by visual inspection of the GDPpc and loans series. The dummy equals 1 for the downward phase of the cycle.

Source: RCI data, NIPA-BEA and NBER.

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Appendices

Appendix A

Appendix to Chapter 1

The optimization problem of the firms is very similar to the one described in equations (1.25)-(1.28) in the main text, except for the fact that $c^L = 0$ and $\vartheta(p, \frac{iv}{k}) = 0$. Under these circumstances equation (1.26) now is

$$H_{iv} = q = 0 \tag{A.1}$$

and from FOC $H_k = -\dot{\mu}$

$$AF_k = (r + p + \delta) \tag{A.2}$$

Using households FOC (1.4) to eliminate r we get

$$AF_k\lambda = (\rho + p + \delta)\lambda - \dot{\lambda} \tag{A.3}$$

Using equation (1.2) to eliminate λ, and taking into account that now goods resource constraint is simply $C + \sum_{i=1}^{N} iv(p_i) = \sum_{i=1}^{N} AF[k(p_i)]$ we get

$$\begin{aligned} \frac{\partial U'(C)}{\partial t} &= U''(C)[AF_k - x]\dot{k} - U''(C)k\dot{x} && \text{(A.4)} \\ AF_k U'(C) &= (\rho + p + \delta)U'(C) - U''(C)[AF_k - x]\dot{k} + U''(C)k\dot{x} && \text{(A.5)} \end{aligned}$$

And rearranging we get

$$\underbrace{-\frac{U''(C)}{U'(C)}k}_{\bar{A}_1}\,\dot{x} = \underbrace{[(\rho + p + \delta) - AF_k]}_{\bar{A}_2}\underbrace{-\frac{U''(C)}{U'(C)}[AF_k - x]}_{\bar{A}_3}\,\dot{k} \tag{A.6}$$

Appendix B

Appendix to Chapter 2

B.1 Numerical Method

Due to the occasionally binding nature of the regulation constraint and the non-negativity constraint on dividends, perturbation methods are not appropriate to approximate numerically the model's solution.

In principle, the non-convexities in the optimal response functions could be handled well by value function iteration (VFI) or policy function iteration (PFI) methods. However, this model cannot be reformulated in terms of a Central Planner's problem. Using either of these methods in the context of a decentralized competitive environment is not practical because solving for market-clearing prices adds an extra loop to the algorithm.[1]

The method of parameterized expectations approach (PEA) is another alternative. PEA produces a numerical approximation to the policies by solving simultaneously from the set of first-order conditions arising from agents optimization, market clearing conditions and inequality constraints (see Marcet and Lorenzoni, 1999). However, there are a number of disadvantages of this method as compared to the more general class of minimum weighted residual

[1]Roughly speaking, it would be necessary to iterate over the Bellman equation for each agent in the economy taking prices as given and then check if markets clear at those prices. If they do not, the algorithm should update prices and then solve all over again. For example, see Mendoza and K. Smith (2002) for an application of VFI with occasionally binding constraints in a decentralized economy setting.

methods (see Judd, 1991). First of all, in order to evaluate the fit of a candidate approximation the PEA relies on running Monte Carlo simulations of the dynamic path and then computing the Euler equation errors along the simulated path. In order to make up for the errors introduced by the Monte Carlo approach, long simulations must be run, substantially reducing the efficiency of the algorithm.[2] Second, the method for moving from one set of parameters to another after starting with an initial guess has unknown convergence properties. Although the learning ideas behind this iterative scheme have an intuitive appeal, according to Judd (1991), there is no reason to prefer this over available algorithms for solving nonlinear equations which are quadratic in convergence. Moreover, Judd (1991) explains that PEA often have explosive oscillations, particularly as one attempts to use more flexible approximations. Finally, the inequality constraints introduce kinks into the functions being approximated that are difficult to replicate with the approximate solution. This is true for all Spectral methods as their bases are non-zero almost everywhere in the domain, but specially for PEA that uses exponentials of low-order polynomials as the basis for the approximation to the unknown expectation.

Depending on the nature of the bases functions selected, Weighted Residual methods can be classified into Finite-Elements method and Spectral method. The method used in this paper is a Finite-Element. The general idea in Weighted Residual methods (see Judd, 1991 and McGrattan, 1999) is to represent the approximate solution to the functional equation problem with a linear combination of known basis functions such as polynomials. The

[2]On a more practical note, long simulations of the dynamic path can be problematic when the dynamic system is not highly stationary. In that case the estimation of parameters by nonlinear least squares from the simulated series (as suggested in Marcet and Lorenzoni, 1999) could result inconsistent.

method consists of finding the coefficients of the combination that minimize an appropriately defined residual function evaluated at the approximate solution. The Finite-Element method can be understood as a piecewise application of the Weighted Residual method. That is, the domain of the state space is divided into no-overlapping sub-domains and low-order polynomials are fitted to each one of them. The local approximations are then pieced together to give the global approximation.

Following Fackler (2003) there are several choices to make related to the implementation of this method: first, how the expectation operators in the model are approximated; second, what family of basis functions are used to represent the solution; third, what method is used to find the coefficients of the linear combination and finally, what algorithm is used to solve for these parameters.

First, it has been shown that expectation operators can be approximated well by a discrete distribution (see Miranda and Fackler, 2002 and Burnside, 1999).

$$E[f(e)] \approx \sum_j w_j f(e_j)$$

Where e is the random variable and w_j are the weight or probabilities associated to each realization of e. The idea is to approximate numerically the integral involved in the expectation. In this paper we use a five-point Gaussian quadrature approach.

Second, the optimal response functions are of unknown form so they must be approximated numerically. The optimal policy is a function of the state variables both directly and also indirectly through the conditional expectation function (which is also of unknown form). Thus, there are two possibilities: one can directly approximate the policy functions or one can first approximate numerically the expectations as a function of the states and then solve for the optimal policy from the equilibrium conditions. This second alternative is close to the Parameterized Expectations Approach (see Marcet and Lorenzoni, 1999).

As regards the approximant functions used in either method, it is convenient to work with families of functions that are linear in a set of coefficients (Fackler, 2003). For example, functions of the form $\phi(\Upsilon)\theta$, where Υ represents the state space, $\phi(\Upsilon)$ is a vector of basis functions and θ is a matrix of coefficients. Specifically, polynomials and polynomial splines (including piecewise linear functions) fall into this category. In this paper I use piecewise linear functions. This basis tends to give a better approximation when there are kinks in the approximate solutions such as those corresponding to inequality constraints. Also, the limited support of the basis function makes it possible to use sparse matrix methods which are extremely useful in dealing with high-dimensional problems like the one at hand.

Once the approximant function has been selected one needs to select a criterion to determine the weights of the basis functions given by the matrix of coefficients θ. One possibility among others is the Collocation Method (Miranda and Fackler ,2002 explain it in detail). The idea is to partition the state space at n points, called the collocation nodes. The coefficients can be found by requiring the approximant to make an appropriately defined residual function (such as the functional equation itself) equal to zero at those nodes. Since the approximant consists of n basis functions and n coefficients, the collocation method amounts to replace the infinite-dimensional functional equation problem with a system of n nonlinear equations.[3] In order to solve for the coefficient values, standard algorithms can be used such as Newton's method and a more efficient Quasi-Newton Method called Broyden's Method.

Fackler (2003) also suggests an alternative to these memory-consuming root-finding methods that consists on a fixed-point iteration scheme. The iteration starts with some guess on the parameter values and then it computes optimal policies for next period $t + 1$ for each and every state of nature by using the transition rule for the states. With these next period policies and the shocks one can approximate numerically the integral corresponding to the expectation function. Once the values of the expectation functions are known, one can re-compute the optimal policy and update the initial guess. The iterations continues until the change in the policies or in the parameters is sufficiently small. The choice of initial guess turns out to be critical in this fixed-point iteration, and even with good initial values convergence is not guaranteed. Due to the curse of dimensionality, I have to use the fixed-point iteration in this paper.

The Matlab implementation for all these steps including different choices of family of basis functions, the Collocation Method and the fixed-point iteration scheme to solve for the coefficients was programmed by Fackler (2003) and is called `resolve`. The command allows for great flexibility in specifying all the options discussed above. Many other utilities included in the `CompEcon` toolbox (Fackler and Miranda, 2002) are also used here.

[3]The system would be n^m equations in n^m unknowns for a state-space of dimension m, and it would increase to $p \times n^m$ if there are p response functions being approximated. However, with linear splines and making the breakpoints of the spline to coincide with the collocation nodes the actual number of coefficients to compute falls to $p \times n \times m$.

B.2 Discretization of the State Space

For the implementation of the numerical solution, the representative bank's balance sheet was used to express the model in terms of e_t and D_t only (i.e. eliminating L_t). Since both loans and deposits are risk-free, deposit interest rate $(1 + r_t)$ and the interest rate spread $spread_t \equiv (1 + i_t) - (1 + r_t)$ are state variables. The dimension of the state-space is then $m = 6$:

$$\Upsilon = [e_t, D_t, (1 + r_t), spread_t, Z_t, A_t]$$

Due to the high dimensionality of the state-space, and because of memory limitations, there are severe restrictions in the number of grid points that can be introduced in each dimension. This in turns reduces the quality of the approximation. In this sense, a lot can be gained if the policy functions exhibit a moderate degree of curvature (other than the kink corresponding to the regulation constraint) and we use linear spline basis. Stacking two breakpoints of the spline at the kink and spreading the others over the rest of the domain can significantly improve the quality of the approximation even with a low number of breakpoints. This strategy, however is difficult to apply when the "kink" is a non-constant unknown function, for example $f : R^m \to R^{m-1}$. In such a case, a second-best is to spread the breakpoints unevenly over the domain, concentrating them more in the region where the kink is most likely to lie. The points were more heavily concentrated at low values of e_t and A_t and at high values of D_t as both the regulation constraint and the non-negativity constraint on dividends are more likely to bind during recessions and when bank equity is relatively low or, what it is the same, when bank deposits are relatively high. The vector of grid points along each dimension is given by:

$$
\begin{aligned}
\mathbf{e} &= e_{min} + \left[0, \frac{1}{6}, \frac{1}{3}, \frac{1}{2}, \frac{3}{4}, 1\right](e_{max} - e_{min}) \\
\mathbf{D} &= D_{min} + \left[0, \frac{1}{4}, \frac{1}{2}, \frac{2}{3}, \frac{5}{6}, 1\right](D_{max} - D_{min}) \\
\mathbf{A} &= A_{min} + \left[0, \frac{1}{6}, \frac{1}{3}, \frac{1}{2}, \frac{3}{4}, 1\right](A_{max} - A_{min}) \\
\mathbf{x} = \{(\mathbf{1{+}r}), \mathbf{spread}, \mathbf{Z}\} &\rightarrow \textit{4 evenly spaced points in} \quad [x_{min}; \quad x_{max}]
\end{aligned}
$$

B.3 Starting Values

Normally, the initialization of the coefficients of the approximation θ is done by fitting the basis functions to the solution from a log-linear approximation around the deterministic steady-state. When there are occasionally binding constraints, as in the present case, a good initialization can be obtained simply by ignoring those constraints in the linearization. This strategy, however, is not helpful in the present model because the deterministic steady-state implies a corner solution for the optimal capital-to-asset ratio of the bank, with the regulation constraint always binding. With no interior solution for the expansion point we cannot simply ignore the constraints. An alternative would be to assume they are always binding (i.e. in the stochastic steady-state, the bank is always at a corner as regards CA ratio). However, using the policy functions resulting from this later assumption as starting values would be very misleading as we expect a radically different behavior of the bank over the true stochastic steady-state where an interior optimal capital-to-asset ratio is the most likely state of nature.

One possibility is to substitute the regulatory constraint and the non-negativity restriction on dividends by smooth penalty functions. If the penalty functions have a high enough degree of curvature, the resulting decision rules would mimic fairly well the optimal behavior of agents with occasionally binding constraints.[4] This, probably, provides a very good informed guess of the true decision rules.

Good starting values are critical at increasing the probability of convergence of the method to the true solution. However, they are neither a necessary nor a sufficient condition for convergence. For example, one can achieve convergence even if constant decision rules are used as a starting guess. That is, if we assume that an equilibrium exists (we have not proved that) and if the method achieves convergence every time then the issue of choosing the "best" starting values becomes less important. In one version of the programs, for example, we assumed an arbitrary breaking between equity and deposits[5] and we even allowed one Euler equation not to hold with equality in order to obtain an interior solution for an artificial steady-state. It turns out that the decision rules obtained by applying log-linearization provided good initialization values for the coefficients of the approximation.

[4]Due to the high non-linearities in the model with penalty functions, second or higher-order approximation methods may provide even more accurate solutions than the regular log-linearization approach.

[5]The assumption was based on a guess about the average CA ratio over the stochastic steady-state.

Appendix C

Appendix to Chapter 3

C.1 Data Appendix

Time series were constructed taking into account the "Notes on forming consistent time series". These are provided with the Call Reports on Condition and Income data in the Federal Reserve Bank of Chicago web site and based on Kashyap and Stein (1997).

In addition, the data was cleaned to avoid the results to be affected by outliers and other obvious data problems. First, observations for which total assets or total loans are zero or missing were deleted. Second, banks in US territories were dropped from the database. Since there are very few banks in each territory, concentration measures are significantly higher there than in the continental US. Third, banks interest income, expenses and charge-off and recoveries are all measured as cumulative year to date totals. Therefore, the appropriate adjustment was made to get the corresponding values for each quarter. Thus, banks for which there is no data in at least one of the four quarters in a given year were not included in the computation of the margin and of the net charge-off rate in that year.

Finally, net interest margins are based on individual bank-level data as described in Table A.1. The margin measure was obtained by computing the weighted average over the banks, with the weights given by each bank's share in total loans. The weights used were the share in total loans for Margins

1-5, and the share in C&I loans for Margins C&I. Since a few very significant outliers were detected for the margin measures, only margins falling into the interval defined by the [2nd-99th] percentiles were used to compute the average. Table A.2 describes the construction of other bank variables using the Call Reports. Net charge-off rates and delinquency rates were also computed as loan-weighted averages. Liquidity and Capital-to-Assets ratio were obtained by using total assets as weights.

Table C.1: Margins Definitions

Variable	Description
Margin 1	Int. income on loans/loans net of allowances and provision – int. expense on deposits/total deposits (riad4010/rcfd2125-riad4170/rcfd2200))
Margin 2	Int. income on loans/loans net of loans past 90 days due – int. expense on deposits/total deposits (riad4010/(rcfd2122-rcfd1407)-riad4170/rcfd2200)
Margin 3	Int. and fee income from loans / total loans – int. on deposits / total deposits (riad4010/rcfd1400 - riad4170/rcfd2200).
Margin 4	(Total int. income – total int. expense)/ (gross loans + securities)((riad4107-riad4073)/(rcfd1400 + rcfd0390))
Margin 5	(Total int. income – int. expenses) / Total loans (riad4107-riad4073)/rcfd1400
spread BP-TB	Bank prime loan rate – Treasury Bill rate (3 month secondary market)
Margin C&I 1	Int. income on C&I loans /C&I loans net of loans past 90 days due – int. expense on deposits/total deposits((riad4249/(rcfd1766-rcon1223))-(riad4170/rcfd2200))
Margin C&I 2	Int. income on C&I loans/C&I loans – int. on deposits/total deposits (riad4249/rcfd1766-riad4170/rcfd2200)

All margin measures are from the Report of Condition and Income data. The spread BP-TB is from the Board of Governors of the Federal Reserve System, historical data on selected interest rates.

Table C.2: Variables Definitions and Sources: Business Cycle Indicators

Variable	Description	Source
GDPpc (in chained 2000 $)	Real gross domestic product per capita in chained 2000 dollars. Annual population data.	Bureau of Economic Analysis (BEA), National Income and Product Accounts and Population Division, US Bureau of the Census.
Total loans (in thousands)	Total loans and leases (variable rcfd1400). The aggregate gross book value of total loans (before deduction of valuation reserves).	Report of Condition and Income data from Call Reports of the Federal Reserve Bank of Chicago.
C&I loans (in thousands)	C&I loans (variable rcfd1766+rcfd1755).	Report of Condition and Income data.

Table C.2(ctd.)

Variable	Description	Source
Controls		
Federal funds (FF) rate	Real rate of interest in money and capital markets, short-term or money market, NSA.	Board of Governors of the Federal Reserve, historical data on selected interest rates.
Charge-off rate	(Total loan charge-offs - total loan recoveries)/total loans ((riad4635-riad4605)/rcfd1400)	Report of Condition and Income data.
Loss rate	(Total loans (gross) - total loans net of loan loss allowances)/total loans ((rcfd1400-rcfd2125)/rcfd1400)	Report of Condition and Income data.
Volatility TB	Volatility in the 3-month Treasury Bill rate, std. dev. of weekly series over each quarter.	Board of Governors, historical data on selected interest rates.
Financial depth	Ratio of commercial paper issued by the nonfarm nonfinancial corporate business sector to commercial paper plus bank loans for the nonfarm nonfinancial corporate business and nonfarm noncorporate business sectors (following Kashyap, Stein and Wilcox (1993)).	Board of Governors of the Federal Reserve, Flows of Funds Accounts.
Deposits	Demand and other checkable deposits, NSA, in billions of dollars. Log of the real value obtained using the GNP deflator.	Board of Governors of the Federal Reserve.
CPI	All items, US city average, NSA, base period 1982-84.	Bureau of Labor Statistics.
Liquidity	(Cash + total investment securities)/Total assets ((rcfd0010+rcfd0390)/rcfd2170)	Report of Condition and Income data.
K-A ratio	Total equity capital / total loans ((rcfd3210/rcfd1400))	Report of Condition and Income data.
Share big	Sum of shares in total assets for banks in the 95th percentile and up of the total asset distribution.	Report of Condition and Income data.
HHI	Herfindahl Index for total loans (rcfd1400).	Report of Condition and Income data.

GNP deflator used to get real values for both total and C&I loans.

Table C.3: Summary Statistics: Detrended Variables

Variable	Obs	Std. Dev.	Min	Max	Mean (of Vbles. in Levels)
Business Cycle Indicators					
GDPpc (in logs)	105	0.0229	-0.0630	0.0410	4.4645
Total loans (in logs)	105	0.0474	-0.1057	0.0822	3.5038
C&I loans (in logs)	85	0.0395	-0.0831	0.0832	2.9877
Margins (rates)					
Margin 1	105	0.0007	-0.0020	0.0023	0.0132
Margin 2	105	0.0007	-0.0019	0.0022	0.0129
Margin 3	105	0.0007	-0.0019	0.0022	0.0126
Margin 4	85	0.0004	-0.0007	0.0011	0.0111
Margin 5	85	0.0006	-0.0011	0.0016	0.0145
Spread BP-TB	105	0.0064	-0.0142	0.0318	0.0308
Margin C&I 1	85	0.0020	-0.0047	0.0052	0.0407
Margin C&I 2	85	0.0020	-0.0046	0.0052	0.0400
Basic Controls					
FF rate	105	0.0161	-0.0304	0.0495	0.0575
Charge-off rate	105	0.0006	-0.0012	0.0020	0.0020
Loss rate	100	0.0046	-0.0076	0.0106	0.1072
Additional Controls					
Volatility TB	105	0.0032	-0.0089	0.0197	0.0030
Financial depth	105	0.0128	-0.0234	0.0420	0.1332
Deposits (in logs)	105	0.0450	-0.1041	0.0987	2.8158
CPI	105	1.9095	-4.4118	3.8266	135.93
Liquidity	105	0.0106	-0.0208	0.0340	0.2851
K-A ratio	105	0.0047	-0.0112	0.0120	0.1390
Share big	105	0.0060	-0.0112	0.0122	0.7814
HHI	105	0.0009	-0.0015	0.0031	0.0100

Sample period for all variables is 1979:I-2005:I, except for C&I loans, Margin 4, Margin 5 and Margin C&I loans (1984:I-2005:I) and loss rate (1980:II-2005:I).

Table C.4: Cyclicality of Variables

	GDPpc	Total Loans	C&I Loans
Macroeconomic Determinants			
FF rate	0.2176	0.2588	0.5317
	(0.026)	(0.008)	(0.000)
FF rate$_{t-1}$	0.0965	0.2367	0.5868
	(0.330)	(0.016)	(0.000)
Liquidity*Fed funds rate	0.2212	0.2566	0.1924
	(0.023)	(0.008)	(0.078)
HHI*Fed funds rate	0.2554	0.2904	0.3601
	(0.009)	(0.003)	(0.001)
Charge-off rate	-0.2177	-0.1284	-0.0145
	(0.026)	(0.194)	(0.896)
Volatility TB	-0.0745	0.0218	0.0915
	(0.450)	(0.825)	(0.405)
Volatility TB$_{t-1}$	-0.1395	-0.0314	0.0816
	(0.158)	(0.752)	(0.458)
Financial depth	-0.0019	0.1709	0.439
	(0.985)	(0.083)	(0.000)
Deposits	0.1134	-0.1152	-0.3084
	(0.249)	(0.242)	(0.004)
CPI	-0.7221	-0.6831	-0.3992
	(0.000)	(0.000)	(0.000)
Banking Industry Determinants			
Liquidity	-0.228	-0.489	-0.4609
	(0.019)	(0.000)	(0.000)
K-A ratio	-0.2365	-0.4764	-0.3917
	(0.015)	(0.000)	(0.000)
Share big	0.6675	0.8034	0.6978
	(0.000)	(0.000)	(0.000)

Values shown are correlation coefficients of each variable with each cycle indicator. Significance levels in parentheses.

Table C.5: Stationarity Tests

Variable	Lags	Model Ho	Test	Statistic	Process	Detrention Method
Business Cycle Indicators						
GDPpc	2	DS drift +trend	t	3.45	TS	t^3 polynomial
Total loans	8	DS	ADF	1.97	TS	t^4 pol.
C&I loans	4	DS	ADF	0.45	DS	HP filter
Margins (in rates)						
Margin 1	9	DS drift +trend	t	3.51	TS	t^4 pol.
Margin 2	9	DS drift +trend	t	3.56	TS	t^4 pol.
Margin 3	9	DS drift +trend	t	3.61	TS	t^4 pol.
Margin 4	1	DS	ADF	0.27	DS	HP filter
Margin 5	1	DS	ADF	0.27	DS	HP filter
Spread BP-TB	2	DS drift	t	2.98	TS	t^4 pol.
Margin C&I 1	4	DS	ADF	0.32	DS	HP filter
Margin C&I 2	4	DS	ADF	0.18	DS	HP filter
Basic Controls						
FF rate	7	DS	ADF	2.33	TS	t^4 pol.
Charge-off rate	4	DS	ADF	0.75	DS	HP filter
Loss rate	4	DS	ADF	0.55	DS	HP filter
Additional Controls						
Volatility TB	4	DS	ADF	2.46	TS	t^4 pol.
Financial depth	3	DS	ADF	1.63	DS	HP filter
Deposits	3	DS	ADF	0.15	DS	HP filter
CPI	3	DS drift+trend	ADF	3.85	TS	t^4 pol.
Liquidity	4	DS	ADF	1.56	DS	HP filter
K-A ratio	5	DS	ADF	1.71	DS	HP filter
Share big	2	DS	ADF	2.67	TS	t^4 pol.
HHI	5	DS	ADF	1.76	TS	t^4 pol.

The same tests were run on all detrended variables and they were proven to be stationary. DS (TS) stands for difference (trend) stationary processes. HP stands for Hodrick-Prescott.

C.2 Regression Results Tables

Table C.6: Explaining the Countercyclicality - GDP per capita

	Margin 1		**Margin 2**		**Margin 3**		**Margin 4**	
GDPpc	0.0019	-0.0038	0.0023	-0.0040	0.0027	-0.0031	0.0000	-0.0043
	(0.634)	(0.443)	(0.588)	(0.457)	(0.454)	(0.504)	(1.000)	(0.538)
FF rate	0.0253	0.0290	0.0244	0.0292	0.0239	0.0286	0.0109	0.0127
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.180)	(0.121)
FF rate$_{t-1}$	0.0096	0.0099	0.0075	0.0083	0.0079	0.0089	-0.0096	-0.0091
	(0.244)	(0.274)	(0.357)	(0.352)	(0.303)	(0.286)	(0.155)	(0.184)
Liquidity*FF rate	0.2909	0.2939	0.3132	0.3012	0.3888	0.3688	0.4507	0.4394
	(0.290)	(0.351)	(0.268)	(0.347)	(0.134)	(0.218)	(0.324)	(0.407)
HHI*FF rate	-0.7694	0.8767	0.5668	2.4953	-0.3470	1.4671	-0.0586	1.3563
	(0.879)	(0.860)	(0.907)	(0.599)	(0.940)	(0.747)	(0.990)	(0.775)
Charge-off rate	0.1307	0.0991	0.1303	0.1008	0.1225	0.0989	0.0656	0.0354
	(0.424)	(0.546)	(0.413)	(0.522)	(0.409)	(0.501)	(0.502)	(0.709)
Volatility TB	0.0201	0.0209	0.0126	0.0140	0.0161	0.0178	0.0572	0.0533
	(0.252)	(0.325)	(0.514)	(0.553)	(0.311)	(0.376)	(0.037)	(0.043)
Volatility TB$_{t-1}$	0.0232	0.0217	0.0182	0.0179	0.0200	0.0205	0.0726	0.0747
	(0.135)	(0.207)	(0.276)	(0.319)	(0.186)	(0.216)	(0.007)	(0.018)
Financial depth	-0.0087	-0.0085	-0.0081	-0.0079	-0.0070	-0.0068	-0.0070	-0.0067
	(0.098)	(0.106)	(0.107)	(0.116)	(0.139)	(0.150)	(0.036)	(0.057)
Deposits	0.0026	0.0021	0.0027	0.0022	0.0032	0.0027	-0.0022	-0.0026
	(0.207)	(0.291)	(0.173)	(0.262)	(0.087)	(0.134)	(0.072)	(0.065)
CPI	0.0000	-0.0001	0.0000	-0.0001	0.0000	-0.0001	-0.0001	-0.0001
	(0.860)	(0.392)	(0.961)	(0.296)	(0.902)	(0.263)	(0.418)	(0.203)
Liquidity	0.0208	0.0222	0.0181	0.0194	0.0176	0.0188	0.0015	0.0025
	(0.001)	(0.000)	(0.007)	(0.001)	(0.003)	(0.000)	(0.841)	(0.766)
K-A ratio	0.0354	0.0345	0.0390	0.0377	0.0402	0.0390	0.0337	0.0320
	(0.075)	(0.105)	(0.038)	(0.062)	(0.030)	(0.050)	(0.003)	(0.006)
Share big	-0.0427	-0.0456	-0.0499	-0.0575	-0.0487	-0.0580	-0.0256	-0.0280
	(0.005)	(0.075)	(0.001)	(0.017)	(0.000)	(0.012)	(0.023)	(0.135)
Observations	104	104	104	104	104	104	85	85
B-G p-value	0.0020		0.0010		0.0040		0.0960	
DW statistic	1.3300		1.3170		1.3670		1.5320	
Adjusted R^2	0.5860	0.5820	0.5820	0.5760	0.6110	0.6060	0.4020	0.3990
Hausman p-value		0.2160		0.1490		0.1900		0.4090

Table C.6 (ctd.):

	Margin 5		Spr. BP/TB		Margin C&I 1		Margin C&I 2	
Macroeconomic Determinants								
GDPpc	0.0032	-0.0019	-0.0249	0.0128	-0.0097	-0.0227	-0.0112	-0.0232
	(0.550)	(0.820)	(0.503)	(0.767)	(0.557)	(0.232)	(0.492)	(0.223)
FF rate	0.0086	0.0105	-0.0580	-0.1152	0.0784	0.0829	0.0780	0.0825
	(0.379)	(0.259)	(0.335)	(0.049)	(0.003)	(0.003)	(0.003)	(0.004)
FF rate$_{t-1}$	-0.0140	-0.0129	0.2677	0.2436	0.0235	0.0310	0.0218	0.0290
	(0.094)	(0.129)	(0.001)	(0.001)	(0.368)	(0.252)	(0.416)	(0.299)
Liquidity*FF rate	0.4338	0.4449	0.6200	1.3655	-1.0823	-1.2651	-1.0622	-1.2647
	(0.423)	(0.483)	(0.804)	(0.605)	(0.480)	(0.439)	(0.502)	(0.447)
HHI*FF rate	-0.5297	1.2341	-15.81	-31.53	-24.38	-19.07	-25.74	-20.76
	(0.924)	(0.829)	(0.693)	(0.474)	(0.025)	(0.067)	(0.016)	(0.044)
Charge-off rate	0.0757	0.0441	0.1795	0.1095	0.0949	0.0043	0.0390	-0.0439
	(0.556)	(0.708)	(0.903)	(0.946)	(0.798)	(0.989)	(0.915)	(0.887)
Volatility TB	0.0731	0.0680	0.8737	0.8422	0.2029	0.1761	0.2120	0.1874
	(0.024)	(0.025)	(0.001)	(0.001)	(0.097)	(0.127)	(0.089)	(0.116)
Volatility TB$_{t-1}$	0.0707	0.0734	0.2174	0.1598	0.0924	0.1271	0.0854	0.1209
	(0.033)	(0.050)	(0.369)	(0.517)	(0.215)	(0.138)	(0.256)	(0.144)
Financial depth	-0.0077	-0.0074	-0.0532	-0.0519	-0.0348	-0.0358	-0.0357	-0.0368
	(0.065)	(0.101)	(0.244)	(0.258)	(0.015)	(0.045)	(0.010)	(0.032)
Deposits	-0.0027	-0.0031	0.0155	0.0182	-0.0020	-0.0030	-0.0014	-0.0023
	(0.077)	(0.078)	(0.372)	(0.316)	(0.739)	(0.621)	(0.819)	(0.700)
CPI	0.0000	-0.0001	0.0007	0.0016	-0.0002	-0.0004	-0.0002	-0.0003
	(0.638)	(0.325)	(0.089)	(0.009)	(0.360)	(0.113)	(0.370)	(0.126)
Banking Industry Determinants								
Liquidity	0.0141	0.0152	0.0625	0.0603	-0.0639	-0.0636	-0.0612	-0.0612
	(0.121)	(0.130)	(0.248)	(0.284)	(0.030)	(0.035)	(0.044)	(0.048)
K-A ratio	0.0525	0.0502	0.0118	0.0272	-0.1002	-0.1088	-0.1007	-0.1089
	(0.000)	(0.000)	(0.908)	(0.777)	(0.113)	(0.097)	(0.110)	(0.095)
Share big	-0.0377	-0.0418	0.0567	0.2873	-0.1573	-0.1895	-0.1480	-0.1808
	(0.013)	(0.068)	(0.518)	(0.147)	(0.001)	(0.036)	(0.005)	(0.053)
Observations	85	85	104	104	85	85	85	85
B-G p-value	0.0620		0.0000		0.0060		0.0030	
DW statistic	1.5740		2.0880		1.2660		1.2490	
Adjusted R^2	0.6100	0.6080	0.6260	0.6060	0.7380	0.7350	0.7310	0.7280
Hausman p-value		0.4410		0.0300		0.6050		0.5910

For all regression output tables: P-values for t-tests in parentheses. The Newey-West consistent estimator for robust standard errors was used when either the Durbin Watson (DW) statistic is less than 1.6 or the p-value for the Breusch-Godfrey (B-G) autocorrelation test is less than 15%. For each measure of the margin, the first column corresponds to an OLS regression and the second one to a 2SLS regression. The last row shows the p-value of the corresponding Hausman Specification test. Instrumented variables are the cycle indicator (GDPpc, total loans or C&I loans respectively) and "Share big" (if included in the specification). Instruments used were the rest of the explanatory variables plus two lags of the instrumented variable.

Table C.7: Explaining the Countercyclicality - Total Loans

	Margin 1		Margin 2		Margin 3		Margin 4	
Macroeconomic Determinants								
Total loans	-0.0029	-0.0037	-0.0033	-0.0052	-0.0028	-0.0041	-0.0025	-0.0021
	(0.467)	(0.364)	(0.404)	(0.188)	(0.457)	(0.266)	(0.434)	(0.563)
FF rate	0.0276	0.0284	0.0270	0.0290	0.0265	0.0285	0.0107	0.0110
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.193)	(0.171)
FF rate$_{t-1}$	0.0100	0.0105	0.0080	0.0091	0.0083	0.0095	-0.0088	-0.0071
	(0.221)	(0.204)	(0.325)	(0.255)	(0.287)	(0.211)	(0.229)	(0.303)
Liquidity*FF rate	0.2640	0.2436	0.2841	0.2357	0.3670	0.3172	0.4173	0.3773
	(0.308)	(0.404)	(0.284)	(0.424)	(0.140)	(0.256)	(0.382)	(0.467)
HHI*FF rate	-0.7883	-0.8618	0.6032	0.4277	-0.1117	-0.1373	-0.5287	0.0330
	(0.865)	(0.852)	(0.887)	(0.918)	(0.979)	(0.974)	(0.891)	(0.994)
Charge-off rate	0.1279	0.1346	0.1258	0.1418	0.1136	0.1305	0.0723	0.0755
	(0.402)	(0.416)	(0.380)	(0.355)	(0.407)	(0.375)	(0.526)	(0.524)
Volatility TB	0.0235	0.0248	0.0164	0.0195	0.0194	0.0221	0.0517	0.0558
	(0.192)	(0.222)	(0.395)	(0.377)	(0.227)	(0.240)	(0.057)	(0.034)
Volatility TB$_{t-1}$	0.0245	0.0262	0.0196	0.0235	0.0208	0.0249	0.0698	0.0808
	(0.108)	(0.135)	(0.215)	(0.190)	(0.168)	(0.141)	(0.010)	(0.015)
Financial depth	-0.0080	-0.0079	-0.0073	-0.0071	-0.0063	-0.0061	-0.0063	-0.0070
	(0.118)	(0.112)	(0.141)	(0.136)	(0.180)	(0.173)	(0.069)	(0.046)
Deposits	0.0020	0.0019	0.0020	0.0018	0.0026	0.0024	-0.0024	-0.0024
	(0.370)	(0.418)	(0.338)	(0.421)	(0.203)	(0.248)	(0.038)	(0.048)
CPI	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.336)	(0.261)	(0.303)	(0.119)	(0.292)	(0.123)	(0.251)	(0.245)
Banking Industry Determinants								
Liquidity	0.0195	0.0190	0.0167	0.0153	0.0167	0.0155	-0.0003	-0.0007
	(0.001)	(0.002)	(0.005)	(0.010)	(0.002)	(0.005)	(0.975)	(0.940)
K-A ratio	0.0301	0.0285	0.0330	0.0293	0.0350	0.0323	0.0290	0.0290
	(0.122)	(0.130)	(0.069)	(0.098)	(0.051)	(0.067)	(0.023)	(0.023)
Share big	-0.0347	-0.0358	-0.0410	-0.0436	-0.0408	-0.0469	-0.0162	-0.0269
	(0.118)	(0.307)	(0.059)	(0.193)	(0.043)	(0.131)	(0.261)	(0.207)
Observations	104	104	104	104	104	104	85	85
B-G p-value	0.0020		0.0020		0.0050		0.0990	
DW statistic	1.3440		1.3300		1.3820		1.5070	
Adjusted R^2	0.5890	0.5870	0.5850	0.5830	0.6130	0.6070	0.4100	0.4070
Hausman p-value		0.9130		0.9000		0.8100		0.8540

Table C.7 (ctd.):

	Margin 5		**Spr. BP/TB**		**Margin C&I 1**		**Margin C&I 2**	
Macroeconomic Determinants								
Total loans	-0.0050	-0.0048	0.0260	-0.0176	-0.0079	-0.0108	-0.0076	-0.0107
	(0.194)	(0.250)	(0.281)	(0.679)	(0.406)	(0.450)	(0.431)	(0.450)
FF rate	0.0095	0.0096	-0.0817	-0.1020	0.0736	0.0742	0.0726	0.0736
	(0.335)	(0.294)	(0.144)	(0.086)	(0.001)	(0.005)	(0.002)	(0.007)
FF rate$_{t-1}$	-0.0132	-0.0111	0.2639	0.2458	0.0287	0.0418	0.0273	0.0400
	(0.139)	(0.188)	(0.000)	(0.001)	(0.259)	(0.104)	(0.298)	(0.132)
Liquidity*FF rate	0.4038	0.3427	0.8292	1.2274	-1.2946	-1.5872	-1.2881	-1.5877
	(0.500)	(0.594)	(0.719)	(0.637)	(0.400)	(0.345)	(0.415)	(0.351)
HHI*FF rate	-0.6023	0.1608	-17.76	-31.42	-28.44	-26.07	-30.17	-27.89
	(0.897)	(0.974)	(0.653)	(0.431)	(0.008)	(0.014)	(0.005)	(0.010)
Charge-off rate	0.0666	0.0655	0.2574	0.0773	0.1838	0.2178	0.1380	0.1747
	(0.632)	(0.645)	(0.859)	(0.956)	(0.641)	(0.523)	(0.720)	(0.598)
Volatility TB	0.0621	0.0710	0.8427	0.8623	0.1859	0.1893	0.1957	0.2007
	(0.062)	(0.021)	(0.001)	(0.002)	(0.111)	(0.068)	(0.097)	(0.060)
Volatility TB$_{t-1}$	0.0602	0.0744	0.2097	0.1656	0.0990	0.1598	0.0949	0.1546
	(0.066)	(0.054)	(0.414)	(0.485)	(0.204)	(0.076)	(0.241)	(0.084)
Financial depth	-0.0058	-0.0067	-0.0600	-0.0475	-0.0346	-0.0375	-0.0359	-0.0387
	(0.193)	(0.136)	(0.197)	(0.274)	(0.020)	(0.045)	(0.013)	(0.032)
Deposits	-0.0036	-0.0036	0.0214	0.0146	-0.0019	-0.0018	-0.0011	-0.0010
	(0.021)	(0.020)	(0.180)	(0.436)	(0.753)	(0.755)	(0.858)	(0.859)
CPI	-0.0001	-0.0001	0.0013	0.0012	-0.0002	-0.0004	-0.0002	-0.0004
	(0.160)	(0.162)	(0.002)	(0.093)	(0.278)	(0.117)	(0.332)	(0.138)
Banking Industry Determinants								
Liquidity	0.0119	0.0113	0.0719	0.0530	-0.0734	-0.0802	-0.0712	-0.0779
	(0.244)	(0.311)	(0.152)	(0.352)	(0.010)	(0.007)	(0.015)	(0.011)
K-A ratio	0.0425	0.0422	0.0606	-0.0050	-0.1131	-0.1237	-0.1127	-0.1235
	(0.006)	(0.006)	(0.605)	(0.968)	(0.093)	(0.120)	(0.094)	(0.117)
Share big	-0.0154	-0.0261	-0.0166	0.3405	-0.1394	-0.1855	-0.1331	-0.1782
	(0.398)	(0.267)	(0.900)	(0.191)	(0.011)	(0.095)	(0.016)	(0.110)
Observations	85	85	104	104	85	85	85	85
B-G p-value	0.0740		0.0000		0.0050		0.0030	
DW statistic	1.5140		2.0210		1.2930		1.2790	
Adjusted R^2	0.6190	0.6180	0.6270	0.5730	0.7380	0.7360	0.7310	0.7280
Hausman p-value		0.9150		0.1420		0.7180		0.6950

Table C.8: Explaining the Countercyclicality - C&I Loans

	Margin 1		Margin 2		Margin 3		Margin 4	
Macroeconomic Determinants								
C&I loans	-0.0030	-0.0025	-0.0032	-0.0030	-0.0028	-0.0026	0.0001	-0.0002
	(0.153)	(0.322)	(0.094)	(0.197)	(0.137)	(0.257)	(0.949)	(0.909)
FF rate	0.0282	0.0299	0.0283	0.0310	0.0276	0.0300	0.0107	0.0108
	(0.018)	(0.014)	(0.011)	(0.007)	(0.012)	(0.008)	(0.189)	(0.178)
FF rate$_{t-1}$	0.0020	0.0038	0.0028	0.0055	0.0012	0.0039	-0.0097	-0.0076
	(0.864)	(0.738)	(0.796)	(0.599)	(0.910)	(0.708)	(0.154)	(0.220)
Liquidity*FF rate	0.6255	0.5444	0.8258	0.7100	0.7992	0.6910	0.5008	0.4683
	(0.343)	(0.465)	(0.182)	(0.305)	(0.201)	(0.323)	(0.287)	(0.368)
HHI*FF rate	-3.92	-3.45	-3.04	-2.41	-2.93	-2.33	-0.0044	0.3067
	(0.461)	(0.530)	(0.552)	(0.648)	(0.566)	(0.659)	(0.999)	(0.943)
Charge-off rate	0.1126	0.1266	0.1144	0.1430	0.0938	0.1203	0.0555	0.0671
	(0.483)	(0.479)	(0.438)	(0.379)	(0.521)	(0.457)	(0.641)	(0.589)
Volatility TB	0.0308	0.0354	0.0198	0.0259	0.0201	0.0254	0.0534	0.0506
	(0.414)	(0.369)	(0.575)	(0.476)	(0.563)	(0.479)	(0.048)	(0.059)
Volatility TB$_{t-1}$	0.0001	0.0156	-0.0104	0.0103	-0.0118	0.0079	0.0652	0.0738
	(0.998)	(0.762)	(0.791)	(0.826)	(0.760)	(0.867)	(0.036)	(0.056)
Financial depth	-0.0015	-0.0028	0.0000	-0.0011	-0.0001	-0.0012	-0.0073	-0.0075
	(0.724)	(0.592)	(0.995)	(0.832)	(0.974)	(0.812)	(0.023)	(0.077)
Deposits	0.0027	0.0029	0.0029	0.0031	0.0031	0.0033	-0.0022	-0.0021
	(0.204)	(0.199)	(0.138)	(0.125)	(0.113)	(0.103)	(0.074)	(0.107)
CPI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
	(0.900)	(0.762)	(0.815)	(0.613)	(0.928)	(0.562)	(0.406)	(0.266)
Banking Industry Determinants								
Liquidity	0.0186	0.0176	0.0183	0.0168	0.0173	0.0159	0.0020	0.0011
	(0.119)	(0.176)	(0.094)	(0.160)	(0.112)	(0.182)	(0.793)	(0.892)
K-A ratio	0.0220	0.0206	0.0294	0.0276	0.0294	0.0276	0.0333	0.0324
	(0.263)	(0.328)	(0.126)	(0.174)	(0.126)	(0.173)	(0.002)	(0.004)
Share big	-0.0202	-0.0371	-0.0271	-0.0498	-0.0272	-0.0488	-0.0250	-0.0334
	(0.228)	(0.293)	(0.076)	(0.106)	(0.070)	(0.112)	(0.046)	(0.083)
Observations	84	84	84	84	84	84	84	84
B-G p-value	0.0070		0.0140		0.0170		0.0980	
DW statistic	1.2610		1.3050		1.3120		1.5220	
Adjusted R^2	0.3840	0.3830	0.4480	0.4440	0.4450	0.4410	0.3920	0.3890
Hausman p-value		0.8940		0.6540		0.6720		0.7540

Table C.8 (ctd.):

	Margin 5		Spr. BP/TB		Margin C&I 1		Margin C&I 2	
Macroeconomic Determinants								
C&I loans	-0.0006	-0.0014	0.0086	0.0049	-0.0180	-0.0171	-0.0164	-0.0158
	(0.708)	(0.468)	(0.472)	(0.761)	(0.001)	(0.030)	(0.003)	(0.050)
FF rate	0.0098	0.0100	0.0224	0.0056	0.0764	0.0793	0.0750	0.0783
	(0.318)	(0.278)	(0.667)	(0.920)	(0.000)	(0.002)	(0.000)	(0.003)
FF rate_{t-1}	-0.0145	-0.0116	0.0817	0.0802	0.0377	0.0478	0.0353	0.0453
	(0.092)	(0.133)	(0.114)	(0.123)	(0.090)	(0.056)	(0.131)	(0.079)
Liquidity*FF rate	0.5169	0.4811	-3.5101	-2.9754	-0.9632	-1.2067	-0.9629	-1.2076
	(0.380)	(0.447)	(0.101)	(0.166)	(0.513)	(0.426)	(0.524)	(0.433)
HHI*FF rate	0.3285	0.6665	-26.57	-28.44	-27.95	-25.99	-29.62	-27.72
	(0.946)	(0.898)	(0.153)	(0.160)	(0.003)	(0.009)	(0.004)	(0.010)
Charge-off rate	0.0535	0.0752	-0.6833	-0.7775	0.4013	0.4490	0.3315	0.3843
	(0.723)	(0.626)	(0.518)	(0.492)	(0.306)	(0.239)	(0.398)	(0.306)
Volatility TB	0.0681	0.0631	0.6459	0.5810	0.1475	0.1454	0.1603	0.1587
	(0.042)	(0.040)	(0.002)	(0.005)	(0.130)	(0.089)	(0.107)	(0.074)
Volatility TB_{t-1}	0.0577	0.0669	0.2975	0.2229	0.0469	0.1043	0.0452	0.1015
	(0.148)	(0.149)	(0.283)	(0.426)	(0.681)	(0.337)	(0.702)	(0.362)
Financial depth	-0.0066	-0.0060	-0.0630	-0.0558	-0.0132	-0.0171	-0.0166	-0.0200
	(0.108)	(0.256)	(0.049)	(0.121)	(0.391)	(0.418)	(0.274)	(0.337)
Deposits	-0.0031	-0.0030	0.0021	0.0017	-0.0016	-0.0009	-0.0007	0.0000
	(0.063)	(0.082)	(0.815)	(0.844)	(0.781)	(0.888)	(0.896)	(0.994)
CPI	-0.0001	-0.0001	0.0007	0.0009	-0.0002	-0.0004	-0.0002	-0.0003
	(0.425)	(0.245)	(0.017)	(0.022)	(0.108)	(0.059)	(0.161)	(0.080)
Banking Industry Determinants								
Liquidity	0.0157	0.0145	0.0490	0.0521	-0.0708	-0.0754	-0.0684	-0.0730
	(0.095)	(0.152)	(0.248)	(0.204)	(0.002)	(0.004)	(0.005)	(0.007)
K-A ratio	0.0517	0.0508	-0.0602	-0.0548	-0.0944	-0.1003	-0.0950	-0.1007
	(0.000)	(0.000)	(0.400)	(0.437)	(0.132)	(0.128)	(0.129)	(0.125)
Share big	-0.0319	-0.0405	-0.0114	0.0795	-0.1234	-0.1827	-0.1197	-0.1781
	(0.050)	(0.064)	(0.880)	(0.431)	(0.003)	(0.015)	(0.006)	(0.023)
Observations	84	84	84	84	84	84	84	84
B-G p-value	0.0550		0.0000		0.0010		0.0000	
DW statistic	1.5310		1.1610		1.3970		1.3610	
Adjusted R^2	0.6050	0.6010	0.4650	0.4590	0.7760	0.7750	0.7620	0.7610
Hausman p-value		0.6090		0.6110		0.8250		0.7950