Essays on Banking

by

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ABSTRACT

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Does monetary policy act as a constraint on the quantity of bank credit? Does it affect banks' risk-taking? Do markets monitor banks' risk-taking behavior? These questions have important implications on our understanding of the consequences of monetary policy and—in light of recent financial crises—on the design of macro-prudential regulation.

I address these question in the context of thrifts—U.S. banks that specialize in mortgage lending—in the years preceding the Sub-prime Crisis. Exploiting loan-level data on banks' lending, I find that the effects of monetary policy do not conform to traditional theories of the *bank lending channel*: the quantity of small banks' lending is not especially sensitive to monetary policy—it is larger banks that are considerably more responsive. I also examine the cross-sectional effects of monetary policy on banks' risk-taking. Using a novel contemporaneous measure of banks' risk-taking that I construct from loan approval data, I find that less-capitalized banks' increase risk-taking more in response to loose policy. This finding suggests that loose policy leads to excessive risk-taking in the presence of agency problems between bank owners and bank liability holders. Finally, I find mixed evidence on the role of market monitoring. Following the economic turmoil of 2001, the market for bank deposits appeared to take note of the differences in the riskiness of banks' assets; however, the effect declined gradually over the next few years—by the eve of the Sub-prime crisis, it was not measurable.

CHAPTER I

Introduction

1.1 Motivation

The 2008 Sub-prime Crisis in the U.S. and the subsequent debt crises in Europe have focused attention on financial intermediaries—banks broadly defined—and their impact on the real economy. The run-up to the crises (2001–2007) was a period characterized by relatively loose monetary policy, financial deregulation and innovation, as well as declining underwriting standards in the housing sector. At the onset of the crisis, weakness in the housing market caused sub-prime borrowers to default at high rates, leading to a spate of failures in the financial sector. The resulting widespread uncertainty about financial intermediaries' solvency created considerable problems in the money markets.

The post-crisis period was characterized by sustained efforts by the Federal Reserve to keep money markets functioning, with Fed policy driving interest rates down to historic lows. Despite the Fed's aggressive actions, the economy entered a prolonged and severe recession; after six years of unambiguously expansive policy, the U.S. unemployment rate still stands at nearly 8%.

In retrospect, the declines in underwriting standards in the pre-crisis period appear excessive. The oft-cited anecdotes of mortgages being issued to borrowers with no income, no assets, and no down payment may border on caricature, but one that has the ring of truth. But to accept that risk-taking during this period was ex-ante inefficient raises questions as to the origins of the inefficiency. Was it a matter of monetary policy being too loose? Was deregulation and financial innovation in the financial sector pervert the incentives of bank owners or managers? If so, did loose monetary policy contribute to this perversion? And why did markets fail to restrain the excesses?

In the post-crisis period, the slow rate of recovery raises questions about the efficacy of monetary policy. Certainly, things could have been much worse: at the height of the Great Depression, the unemployment rate topped 35% and only returned to pre-crash levels after the U.S. entry into World War II[1]. If—as is frequently argued—the experience of the 1930s is a case study in the consequences of an inadequate monetary policy response to a crisis, the recent post-crisis experience may offer a case study in the limits to the effectiveness of monetary policy. The response to the Sub-prime Crisis and the broader U.S. financial crisis has not been timid: consistently expansionary policy has led to negative real interest rates and a three-fold expansion of the monetary base. The low rates and the glut of new bank reserves has not led to a robust recovery; this raises long-standing questions about how monetary policy works. In particular, what is the role of banks in monetary policy transmission?

While formal macro-economic models tend to ignore banks, it has long been recognized that negative developments in the banking sector can lead to significant disruption to the real economy. The danger of such disruptions has led governments to adopt policies designed to mitigate them. Examples include lender of last resort facilities, depositor insurance schemes, capital and reserve requirements, restrictions on banks' activities, and various forms of bank supervision. As a consequence, the functioning of the banking sector is as much driven by the design of banking regulation as by market forces. Due to banks' important role in the allocation of capital,

1. Historical Statistics of the United States: Colonial Times to 1970 Part I (1975). Series D-I-10 "Labor Force and its Components 1900–1947"

the payment system, and their potential role in the transmission of monetary policy, the success of policy-maker's design efforts is an important question.

1.2 Overview

In the following chapters, I examine several issues relating to the design of the banking system with implications to the recent crisis. First, I examine the issue of how monetary policy affects the supply of bank credit. The recent post-crisis experience suggests that a banking system awash with reserves does not necessarily lead to major increases in bank lending. This observation runs counter to predictions of the *bank lending channel* developed in Bernanke and Blinder (1988) and Stein (1998) in which regulatory reserve requirements endow banks with a special role in the transmission of monetary policy: bank reserves serve as the key constraint on the quantity of bank lending. Thus, monetary policy's effects on the quantity of bank reserves should affect the quantity of credit available to bank-dependent borrowers. Earlier studies of the bank lending channel have produced mixed results (Altunbaş, Fazylov, and Molyneux (2002)), with the U.S. evidence tending to be support this view (canonically, Anil K Kashyap and Stein (2000)). I revisit this issue in a cleaner empirical setting using data covering a period during which banks operated under a "modern" regulatory environment and consistent monetary arrangements.

The bank lending channel is just one part of broader set of proposed *credit channels* of monetary policy transmission (see for example, Bernanke and Gertler (1995)) which are characterized by monetary policy affecting the *supply* of bank credit. Interest in the credit channels arose due to perceived shortcomings in the standard neoclassical channel of monetary policy transmission in which monetary policy operates exclusively through the cost of capital. My analysis of the supply of bank credit finds that a credit channel is operational; however, my results are inconsistent with the traditional conception of the bank lending channel and suggest that a different supply mechanism is at work.

Second, I consider monetary policy's effects on bank's risk-taking. It is frequently noted by economic historians that financial crises tend to follow periods of loose monetary policy, with the suggestion that "easy money" plays a role in *excessive* risk-taking.[2] However, economic theory provides little in the way of a formal justification for this view. Standard portfolio theory predicts that—under fairly general conditions—reductions in the risk-free rate induce agents to shift their portfolios towards riskier assets. Such shifts cannot be described as "excessive": reductions in the discount rate increase the value of assets and hence agents' wealth, which—under declining relative risk aversion—leads agents to tilt their portolio allocations toward riskier assets. Similarly, lower discount rates may render more projects viable, and to the extent that these marginally viable projects are riskier, this can lead to increased risk-taking in the economy. Again, this mechanism cannot be said to represent an excessive response. My focus here will be on a less benign factor in banks' risk-taking—agency problems resulting from leverage (i.e. low bank capital) and its interaction with monetary policy. I exploit loan-level data to construct a novel measure of risk-taking that is contemporanous, and hence well-suited to an analysis of banks' risk-taking response to monetary policy. I find evidence broadly consistent with loose policy *exacerbating* agency problems at under-capitalized banks, suggesting an inefficient response due to shortcomings in the regulatory design.

Finally, I examine the role of depositors in monitoring banks' risk-taking. The extent to which depositors are capable of monitoring banks actions is an important issue in the design of the banking system. If, as is commonly maintained, depositors offer little in the way of monitoring and are prone to panics resulting from "sun-spot" equilibria,[3] then a system in which banks exposed to significant agency problems compete

2. See for example, Allen and Gale (2007); however Galbraith (1955) takes issue with this preposition.

3. See Diamond and Dybvig (1983) for the canonical exposition of this view.

for deposits is bound to produce inefficient outcomes. Alternatively, depositors may perform valuable monitoring functions that cannot easily be duplicated by regulators such as acting quickly on information that is difficult to quantify. [4] Hence, an understanding depositors' capabilities is critical to the design of the regulatory system. If depositors' capabilities are very limited, bank monitoring may be best left to the regulators, with limits on competition for deposits and enhanced deposit guarantees. If on the other hand, depositors capabilities are significantly complimentary to those of the regulators, then depositors' incentives to exercise these capabilities may need to be enhanced through increased competition and reduced deposit guarantees.

1.3 Approach

My approach is to examine these issues in the context of thrifts—banks that specialize in mortgage lending—in the years preceding the recent sub-prime crisis. The motivation for studying thrifts is four-fold. First, thrifts' activities in the pre-crisis period were (and continue to be) heavily concentrated in real-estate lending (specifically consumer mortgage lending); the present crisis—as well as many other banking crises—has its origins this sector.[5] Second, due to a statutorily-imposed lack of diversification, thrifts provide an unobstructed view of the interactions between bank policies, macro-economic developments, demand for credit, and the supply of funding; thrifts are simple and relatively homogeneous with respect to their business model: unlike commercial banks, thrifts do not engage in significant investment banking,

4. Calomiris and Kahn (1991) offer a stylized characterization of this view to explain the fragility of the banking system.

5. Recently, the Irish, U.K, and Spanish banking crises were all related to asset price bubbles in the property markets. The collapse of the Thai real estate market in 1997 has been cited as precipitating the subsequent East Asian currency and banking crises (see Renaud, Zhang, and Koeberle (2001)). Similarly, the Scandinavian banking crises of the late 1980s and early 1990s feature asset price bubbles in real estate as proximate causes (see Englund (1999) for a discussion of the Swedish experience). Suggestively, the U.S. Savings and Loan Crisis of the late 1980s was preceded by a boom in home prices. On a related note, Bernanke (1983) argues that the rapid increase in mortgage indebtedness during the 1920s contributed to the severity of the Great Depression.

proprietary trading, or commercial lending—nor do they have much of an international presence.[6] By and large, thrifts focus on two activities: mortgage banking, viz. originating loans for sale in the secondary market (the originated-to-distribute (OTD) model), and traditional bank lending, viz. collecting deposits to fund holdings of loans and securities. Thrifts' lack of complexity, the homogeneity in their business model, and the regulatory-imposed lack of alternative investment opportunitites greatly simplifies their analysis. Moreover, the thrift—in many important respects—bears a closer resemblance to the banks of financial theory, then does the commercial bank. Third, because U.S. regulations require the disclosure of loan-level data of banks' mortgage applications, thrifts' credit demand is largely observable. Finally, because thrifts are subset of the bank population that is rarely used in studies of bank lending, they represent a unique opportunity to perform "out of sample" tests.

1.4 Context

Broadly, the following chapters are related to several strands of the finance and macroeconomic literature. Common to each is the idea that financial intermediaries (i.e. banks) matter—that we do not live in a Miller-Modigliani world where banking is nothing but a veil. The credit models of Bernanke and Gertler (1987) and Holmstrom and Tirole (1997) are common theoretical starting points. In these models, shocks to the banks affects their ability to supply credit in the economy. These credit supply shocks generate real economic effects through bank-dependent borrowers. Recent studies documenting such effects include Chava and Purnanandam (2011) who show the 1998 Russian debt crisis decreased credit to firms dependent on banks with a Russian exposure, and Puri, Rocholl, and Steffen (2011) who find that German banks

6. There are of course exceptions; the failed (international) insurance giant AIG operated as a thrift holding company. However, this was atypical even for the largest thrifts: very large thrifts such as Washington Mutual Bank and Country-wide Financial followed a relatively simple—albeit risky—strategy of lending on houses.

exposed to the U.S. subprime crisis reduced local retail lending post-crisis. These studies offer fairly direct refutations of the Miller-Modigliani world.

Here, my goal is somewhat different: I do not set out to provide evidence for (or measure) banks' relevance—rather, I take this for granted and aim instead to examine some of the mechanisms that affect banks' credit supply.

Much of the post-crisis literature has focused on the role of large, complex financial institutions (LCFIs), the growth of the subprime market, the development of "shadow banks", financial innovations such as the originate-to-distribute (OTD) business model, and the moral hazard stemming from "too big too fail" (TBTF) type guarantees.[7] Many of these changes have in turn been linked to extensive financial innovation and liberalization (or rather, deregulation). In the aftermath of the crisis, many of the reforms that have been advocated, recommended, and enacted aim to reduce the systemic risk created by the LCFIs, curtail the ills of OTD, and limit TBTF guarantees that undermine market monitoring, foster moral hazard, and generate popular discontent by returning—in various degrees—to the *status quo ante*. Such proposals often prominently feature separating (or "ring-fencing") traditional banking activities from other, riskier activities such as market making, proprietary trading, and investment banking.[8] However, as has been noted by various commentators (see for example Goodhart (2012), or Reinhart and Rogoff (2009)), the boom and bust cycles at the heart of the recent crisis, as well as the crisis itself, are anything but new: the extent to which a return to the *status quo ante* could prevent these problems in the future is an important open question on which my research will shed

7. The significance of subprime lending is documented in Mian and Sufi (2009). The shadow banking system is discussed in Gorton (2010) and Gorton and Metrick (2010)). Agency issues in the originated-to-distribute (OTD) model are documented by Keys et al. (2010). A discussion of agency issues at modern financial intermediaries in general can be found in Rajan (2006). Richardson et al. (2010) provides a discussion of LCFIs and the TBTF problem.

8. Arguments to this effect can be found in Richardson et al. (2010). U.K.'s Independent Commission on Banking (Vickers et al. (2011)), the proposals of the E.U. Expert Group (Liikanen (2012)), and the Volcker Rule of the 2010 Dodd-Frank legislation, feature ring-fencing, legal separation, or prohibitions on various non-traditional activities as central tenets.

light.

In the subsequent chapters, I first describe thrifts—the banks that serve as the subject of my analysis. In Chapter III I analyze monetary policy and the supply of bank credit. In Chapter IV, I turn my attention to its effect on banks' risk-taking. In Chapter V, I examine the question of depositor monitoring.

CHAPTER II

Thrifts

2.1 History

Thrifts' front-row seats to the Sub-prime Crisis makes them interesting in its own right.[1] However, their role in the U.S. economy has been declining for some time, and the future viability of the thrift charter is in doubt.[2] Thus, thrifts' experience is most valuable if it sheds light on mechanisms operating in a broader banking context. I shall argue that in the "inter-crisis" period marked by the Savings and Loan Crisis in the early 1990s and the recent Sub-prime Crisis, thrifts' experience did have relevance on the broader bank population.

Over the inter-crisis period—and unlike over any other prior period in their long history—thrifts functioned very much like their non-thrift banking contemporaries: they could issue the same types of liabilities, their deposits were insured by the same agency, they were subject to the same reserve and capital regulations, and they had equal access to the same lender of last resort facilities. The major difference was that thrifts were subject to the Qualified Thrift Lender test, which required 65% of assets to be invested in residential mortgage loans and other qualified consumer loans (and

1. Among depository institutions, thrifts are at the top of the leaderboard of the largest bank failures. Notable thrift failures include Washington Mutual Bank, IndyMac, and AIG.

2. With the passage of Dodd-Frank in 2010, the (few) remaining advantages of the thrift charter were largely eliminated.

prohibited thrifts from holding more than 10% of assets in commercial loans).[3]

In earlier periods, thrifts' large holdings of residential mortgage assets would have been enough to render them quite distinct from the rest of the bank population. Residential, fixed-rate, amortizing mortgage loans are not a traditional bank asset: they have long durations, limited liquidity, and entail significant interest rate risk.[4] Historically, commercial banks avoided them and preferred instead to invest in liquid, short-term commercial paper. With the growth of government-sponsored enterprises (GSEs), mortgage securitization, and legal changes permitting the issuance of adjustable rate mortgages, mortgage assets lost much of this distinctness: loans conforming to GSE specifications became some of the most liquid of bank assets, while the less liquid, non-conforming loans were increasingly structured as adjustable-rate products with short durations. This, coupled with post-war growth in commercial banks' residential mortgage lending made thrifts' activities significantly less distinct. This had not always been the case: thrifts—whose origins go back to British building societies of the eighteenth century—were once quite different from their commercial bank contemporaries. The evolution of the thrift from its decidedly non-bank origins to its present—bank-like—form can be attributed to two major events: the Great Depression and the Savings and Loan (S&L) Crisis.

Great Depression

In the late nineteenth and early twentieth century, thrifts—then building societies and mutual savings banks—bore little resemblance to commercial banks of the

3. Much of the appeal of the the Federal thrift charter was due to thrifts' ability to branch across state lines; however, with the passage of the Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) in 1994, much of this relative advantage was lost. It should also be noted that thrift regulation was largely consolidated in the Office of Thrift Supervision (at least for thrifts with Federal charters) whereas commercial banks were subject to various overlapping regulation by states, the Office of the Comptroller of the Currency (OCC), the Federal Deposit Insurance Corporation (FDIC), and/or the Federal Reserve Board.

4. Legal restrictions prevented banks from issuing adjustable-rate mortgages for much of the post-war period. See Peek (1990) for a discussion.

time.[5] Thrifts were dominant players in intermediated mortgage lending with a near monopoly in the issuance of the now-standard amortizing mortgages; thrifts' assets consisted of mortgages and very little else.[6] Conversely, commercial banks played a very small role in mortgage lending; their assets primarily consisted of short-term corporate paper.[7] The liabilities of commercial banks and thrifts were also quite different. Commercial banks issued (interest-free) demand deposits which facilitated the payment system. Thrifts on the other hand were funded with less liquid liabilities: building societies issued shares or participations while mutual savings banks issued savings accounts. Both forms of liability could only be redeemed with notice and in the case of building societies' shares offered no guarantee as to the eventual redemption value.

The relative illiquidity of thrifts' liabilities did not spare them in the Great Depression. Thrifts' lending was severely disrupted by foreclosures, deteriorating economic conditions, and problems of confidence leading to redemption requests and deposit outflows.[8] The Federal Home Loan Bank Act of 1932 was aimed at mitigating problems in the mortgage sector. It established the Federal Home Loan Bank (FHLB)

5. Thrifts have largely been neglected not only by students of finance, but also by students of history; of the few historical treatments, Mason (2004) provides an excellent account, on which much of the following is based.

6. For mutual savings banks of the time, it is more accurate to say that their loan portfolio consisted of mortgages and very little else. Mutual savings banks did hold buffer stocks of liquid securities primarily consisting of government and railway bonds. These holdings represented approximately one third of total assets (see Hart (1938), Tables 14,15)

7. The role of various intermediaries in mortgage lending is documented by Snowden (1995), who reports that toward the end of the nineteenth century, thrifts (i.e. mutual savings banks and building societies) held 72% of all mortgage assets held by financial intermediaries. At this time, commercial banks held only 3% of these assets. The rest were held by insurance companies and finance companies. Outside the thrift sector, lending for residential real estate financing was provided at generally unfavorable terms: loan-to-value ratios were often in the 50% range and such loans were typically "bullet" loans with short maturities (1–5 years). Snowden attributes this to agency problems in long-distance lending, illiquidity of mortgage paper, and commercial banks' reluctance to undertake the maturity-transformation role now generally cited (canonically in Bryant (1980) or Diamond and Dybvig (1983)) as banks' *raison d'être*.

8. The problems were most pronounced in the building societies. Hart (1938) reports (Table 11) that between 1931 and 1936, building societies' assets dropped from $8.4 billion (with $6.0 billion in mortgages) to $5.6 billion (with $3.3 billion in mortgages) while membership fell from approximately 11 million to 6 million.

system and the Federal Savings and Loan Association charter, under which thrifts could access a lender of last resort facility similar to that provided to commercial banks by the Federal Reserve through its discount window.[9]

Shortly thereafter, the National Housing Act of 1934 established Federal Savings and Loan Insurance Corporation (FSLIC)—a deposit insurance scheme similar to the newly created Federal Deposit Insurance Corporation (FDIC), but aimed at the thrift lenders. Prior to this, the business models in the thrift sector were an adaptation to the problems of agency and illiquidity central to mortgage lending. Thrifts overcame these problems through a combination of small scale, directors' "good name" in the local community, mutual-ownership, or reliance on less liquid liabilities.

With the FHLB and FSLIC, the rules of the game changed considerably. By 1937, approximately thirteen hundred institutions obtained the new Federal Savings and Loan Charter, and the 3,886 thrifts belonging to the FHLB system came to be responsible for 41% of new (intermediated) mortgage originations, while FHLB-eligible institutions held 86% of intermediated mortgage assets (Fahey (1937), Tables B and C). In the post-war housing housing boom, thrifts were able to maintain their dominance in home lending and significantly expanded their economic importance. By 1980, thrifts (savings and loans and mutual savings banks) held 19% of the total financial assets held by all financial services firms; this was a little more than half of commercial banks holdings (37%). By comparison, in 1945 thrifts played a much smaller role in the banking sector: they held only 10% of total financial assets while commercial banks held 65% (see Barth (1991), Table 2-1). This growth in the role of thrifts reflected fundamental changes in the business of banking. No longer were commercial banks focused on discounting commercial bills and providing working capital finance by interest-free demand deposits; increasingly, they were a source of

9. The FHLB was open to "savings and loan associations, cooperative banks, homestead associations, life-insurance companies, and mutual savings banks, either State, or federally chartered" (Fahey (1937)).

funds for long-term investment projects funded through interest-bearing liabilities like savings accounts and certificates of deposit. In this sense, commercial banks were starting to resemble thrifts.

Savings and Loan Crisis

The second historical episode critical to shaping the modern thrift was the Savings and Loan Crisis of the 1980s—it is here that the modern thrift truly came into being. Thrifts' focus on mortgage lending became a serious problem during Federal Reserve Chairman Paul Volcker's battle with inflation in the early 1980s. At the time, thrifts were subject to significant restrictions on their permitted activities including prohibitions on the issuance of variable rate mortgages and limitations on commercial lending. These restrictions left thrifts holding an undiversified portfolio with a large asset-liability mismatch. This led to a growing gap between thrifts' income and expense: their portfolio of long-term fixed-rate mortgage assets (originated years earlier) was not covering the increasing cost of short-term funding—a cost that was only increasing under the Fed's anti-inflation policies.

Early legislative responses did little to solve thrifts' problems but left a lasting legacy. The Monetary Control Act of 1980 eliminated Regulation Q limits on deposit interest rates, regularized reserve requirements, gave thrifts access to the Fed discount window, and permitted thrifts to offer transaction accounts; but, it did nothing to address the restrictions on thrifts' lending activities. Although transaction accounts provided a new, low-cost source of funds and access to the discount window mitigated thrifts' liquidity problems, the elimination of interest rate ceilings only made thrifts' negative interest margin problem more acute. It was only with the Garn-St. Germain Act of 1982 that restrictions on thrifts' permitted activities were finally relaxed: thrifts were permitted to diversify into commercial lending, limits on loan-to-value ratios were removed, and restrictions on adjustable-rate mortgages were scaled back (although not eliminated). This also marked the beginning of a period characterized by increasingly lax regulatory oversight: additional legislation and a series of regulatory rulings further expanded thrifts' permitted activities, relaxed accounting rules, and encouraged the use of regulatory forbearance. By this time, thrifts' financial circumstances were so dire that the lax regulatory climate only exacerbated moral hazard problems which were manifested through "gambling for resurrection" strategies (Brewer and Mondschean (1994)) and outright theft (Akerlof et al. (1993)). The resulting binge of risk-taking and thievery culminated in the Savings and Loan Crisis, which was characterized by widespread thrift failures, insolvencies in state insurance funds, and the eventual failure of the FSLIC.

To resolve the crisis, Congress passed the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA). With this legislation, restrictions on thrifts' permitted activities were reinstated and strengthened. Under the Qualified Thrift Lender (QTL) test (a measure of "thriftiness"), 70% of a thrift's asset were to be related to residential lending. Failure to pass the test would prevent access to FHLB advances, restrict branching powers, and place limits on the payment of dividends. Thrifts' commercial lending activities were limited to 20% of assets, with lending to large firms (i.e. firms not qualifying as "small businesses") further limited to a maximum 10% of assets.[10] In addition, the Federal Home Loan Bank Board (the much maligned regulator of the Savings and Loans) was eliminated and replaced with the newly formed Office of Thrift Supervision (OTS).

One thing FIRREA did not do was turn back the clock. Aside from the QTL restrictions, few distinctions between thrifts and commercial banks would remain post-FIRREA: both could issue the same types of deposits (now insured by the FDIC), they would both be subject to the same reserve and capital requirements, and they would both operate under similar tax regimes. In addition, thrifts and commercial

10. This does not appear to have been a binding constraint for most thrifts. For example, in 1992:IV, real estate loans made up 93% of thrifts' loan holdings. In 2007:II, they made up 86%.

banks would enjoy access to the same liquidity facilities: FIRREA extended access to FHLB advances to commercial banks, and thrifts' access to the Fed's discount window (granted by the MCA of 1980) continued intact. One remaining point of difference was that Federally-chartered thrifts continued to enjoy greater branching powers post-FIRREA than commercial banks—they could engage in *de novo* branching in any state (only subject to approval from the OTS). But even this distinction would not last long: in 1994, the Riegle–Neal Interstate Banking and Branching Efficiency Act (IBBEA) greatly expanded commercial banks' ability to branch across state lines. Thus, toward the start of the inter-crisis period, thrifts did not retain significant distinctive features besides the restrictions on the composition of their assets: put simply, they were banks specializing in mortgage lending.

The relative lack of variation in the asset-side activities of the thrifts in the years following FIRREA makes them an attractive empirical setting. At the time, the commercial bank population was large and diverse, ranging from the simple—local banks focusing on small business and mortgage loans—to the complex—international money-center banks engaging in all types of financial activities. In contrast, the thrift population was relatively homogeneous; thrifts all did essentially the same thing: they borrowed funds (primarily through deposits) and used these funds to issue loans (primarily mortgage loans).[11] Because of this homogeneity in the business model, studies of lending at a modern thrift are less susceptible to omitted variables likely to bias studies of commercial banks' lending activity.[12] However, there was one feature of this period that makes for some complications: the growth of mortgage securitization.

11. Increasingly, thrifts also engaged in the related business of mortgage banking, which I discuss below.

12. For example, a commercial bank with significant exposure to C&I and residential mortgage loans can change the composition of its balance sheet (altering the mix of new residential and commercial loans). This ability makes it difficult to interpret changes in lending activity. Similarly, differences in the use of loan commitments (to customers or off-balance-sheet entities) cause similar issues.

The Modern Thrift and Securitization

The role of securitization in mortgage lending is significant and has received considerable attention (see Gorton (2010) for details). Market-based holdings of mortgage assets first exceeded bank's on-balance-sheet holdings around 1990 (Adrian and Shin (2008)). Such holdings have only increased, and by now account for approximately two thirds of all mortgage assets.

With continued growth in securitization in the 1990s, the typical thrift engaged in two related lines of business: mortgage banking and bank lending. In the former, the thrift would originate loans for sale in the market (i.e. the OTD model), while in the latter it would issue loans funded through deposits (i.e. the traditional banking model). Both businesses required essentially identical skills—screening and servicing—but the types of loans that were originated in each reflected institutional features of the market for mortgage-backed securities as well as thrifts' portfolio considerations.

In the market for mortgage-backed securities, guarantees provided by the government-sponsored enterprises (GSEs) ensured a virtually inexhaustible source of funding for loans "conforming" to GSE standards. By and large, these conforming loans were conventional, fixed-rate loans. A liquid forward market in GSE pools made up of such loans (described in some detail in Vickery and Wright (2010)) kept a tight lid on the yield spreads of conforming loans. While fixed-rate conforming loans became a staple of mortgage securitizations, their attractiveness as a thrift asset was limited: low yield spreads generated low returns, and their fixed-rate terms created significant exposure to interest rate risk. Given their unpleasant experiences in the 1980s, thrifts were eager to avoid this exposure. With the elimination of restrictions on the issuance of adjustable-rate mortgages (with FIRREA in 1989) thrifts were finally able to do so.

Funding adjustable-rate loans through the balance sheet while selling (eligible) fixed-rate loans into the market became an attractive strategy for thrifts in the 1990s. Although data on the terms of banks' mortgage loans is rather limited, by the end of 1997 thrifts reported that 75% of their on-balance-sheet mortgage loans were scheduled to re-price or mature within 15 years or less; this suggests that the traditional thirty-year fixed-rate mortgage was playing an decreasing role on thrifts' balance sheets.[13]

Securitizing fixed-rate loans while funding adjustable-rate loans through the balance sheet can have significant—and somewhat counter-intuitive—implications for the dynamics of a bank's loan growth and its interaction with monetary policy. For mortgage borrowers, interest rates affect not only the overall demand for credit, but also the relative attractiveness of fixed-rate and adjustable-rate products. Informally, when long-term rates are high, borrowers prefer adjustable-rate loans. This idea is developed formally in Koijen, Hemert, and Nieuwerburgh (2009), who attribute the time-series variation in borrowers' preferences to time-series variation in the bond premium. They propose that borrowers employ a simple "rule of thumb" to estimate the bond premium using the difference between the long rate and the average of recent short rates. If monetary policy affects long-term rates (through standard expectations-based mechanisms), this can lead to situations where monetary tightenings *increase* the demand for bank credit (at the expense of market-funded credit). Under the rule of thumb, higher long-term rates lead to higher estimates of the bond premium, resulting in borrowers' substitution away from fixed-rate loans (funded by the market) into adjustable-rate loans (funded through bank balance sheets).[14] This highlights the importance of a bank's product mix in its lending activity.

13. Based on aggregate figures from the FDIC Statistics on Depository Institutions; 1997 is the first year for which re-pricing data is available. Because few conventional thirty year loans "survive" for fifteen years (the average duration of such loans is approximately seven years), the 75% figure consists largely of fixed-rate loans originated with shorter terms (e.g. construction loans, balloon loans, fifteen and twenty year fixed-rate loans) and adjustable-rate loans.

14. There is some debate on the extent of monetary policy's effects on long-term interest rates; see Berument and Froyen (2009) for a survey and some evidence.

An Anecdote: Washington Mutual Bank

For some additional insight on thrifts' portfolio decisions, I turn to some anecdotal evidence from the annual reports of Washington Mutual Bank (WAMU), which—on account of its failure in 2008—is perhaps one of the most infamous thrifts, and—due to its SEC filings—one of the more transparent. WAMU is interesting because at its peak it was the largest thrift. Due to its large scale, WAMU was relatively unconstrained in implementing its portfolio strategy: it had access to the most sophisticated personnel and technologies, and would have been least affected by transaction costs (say in hedging). Despite this, WAMU's strategy was very much in line with the simple description provided earlier in this section: it originated fixed-rate loans for sale and used its balance sheet for adjustable-rate loans.

Washington Mutual Inc., was a savings and loan holding company formed in a 1994 reorganization of Washington Mutual Saving Bank. The bank's history dates back to 1889, but it was in the late 1980s that it began its spectacular rise. Between 1988 and 1996, it completed no fewer than twenty acquisitions which turned Washington Mutual into a major lender in the North-West. With the reorganization and the subsequent acquisitions of American Savings Bank (ASB) and Great Western Bank (GWB)—two of California's largest mortgage lenders—WAMU would become the nation's largest thrift (and eighth largest banking company), with over $160 billion in assets.

At the end of 1996—toward the beginning of the inter-crisis period—WAMU had $45 billion in assets and operated approximately 500 branches.[15] The company's activities included mortgage lending, commercial banking, insurance, as well as a full-service securities brokerage and investment advisory service. As a thrift, WAMU was subject to the QTL and the majority of its assets were restricted to residential loans and other qualified consumer and small business loan products. Of its $45 billion

15. This is the earliest date for which SEC 10-K filings are available.

in assets, $30 billion consisted of direct lending, with approximately $26 billion in residential and consumer loans (and less than $400 million in commercial loans).

According to WAMU's 1996 10-K filing, one of the its major goals was to "limit the sensitivity of interest rate movements". This was to be achieved through "the retention of internally originated adjustable-rate mortgages". It is also noted that the company has "decreased the percentage of fixed-rate assets and increased the percentage of adjustable-rate assets in its loan and investment portfolios", and that "the Company securitized and then sold a substantial portion of the fixed-rate loans it originated, while retaining nearly all of its adjustable-rate loan production". The report projects "that a portion of the remaining fixed-rate securities may be replaced with adjustable-rate GSE MBS, adjustable-rate private-issue MBS, collateralized mortgage obligations, and purchased loan pools as well as new originations of ARMs, as the fixed-rate securities pay down or are sold as market conditions permit". In short, the company's lending operations consisted of a mortgage banking business originating fixed-rate products for sale in the market and a tradition bank lending business originating adjustable rate mortgage products, construction loans, and other short-term loans for retention on the balance sheet.

The pursuit of this two-pronged strategy was evident in WAMU's financial statements. During 1996, its real estate loan originations totaled $12 billion, of which $3.7 billion was in fixed-rate single-family residential (SFR) loans. Of the $12 billion in originated loans, approximately $2 billion were sold and the vast majority of these were fixed-rate SFR loans. Thus, most of the bank's origination activity was destined for the balance sheet and attributable to the traditional bank lending. Of the $10 billion funded through the balance sheet, the bulk ($6.2 billion) consisted of adjustable-rate SFR loans, with the remainder a mixture of construction loans ($1.3 billion), consumer loans ($1.3 billion), and commercial loans ($350 million).

The annual report also makes clear the previously discussed effect of interest rates on the composition and disposition of originated loans. It is noted that the "ability to originate ARMs in lieu of fixed-rate loans [had] varied in response to changes in market interest rates." These swings could be very large: during 1992–1993 (when interest rates were low), adjustable-rate originations constituted 25% of of residential originations, and "when interest rates rose in 1994", adjustable-rate originations shot up to 62%.

2.2 Data Sources

The samples used in subsequent analyses cover thrifts' lending activity in the inter-crisis years; starting in 1992 and ending in 2006. The year 1992 is a natural place to start in that it marks the approximate start of the inter-crisis period. Practically, it is the first year for which much of the data is available. In most of my analyses, I end in 2006 in order to ensure that the sample covers relatively normal times. The data on thrifts' lending comes from two two sources: thrifts' quarterly regulatory filings, and their annual loan-level disclosures mandated by the Home Mortgage Disclosure Act (HMDA).

Thrift Financial Reports

The main bank-level data sources used in the analysis are Thrift Financial Reports (TFRs) filed by each thrift with the Office of Thrift Supervision (OTS). [16] TRFs are analogous to the Consolidated Reports of Condition (Call Reports) filed by commercial banks and include similar information from the bank balance sheet and income statement. The TFR data were obtained from the Federal Deposit Insurance Corporation (FDIC).[17] Although the TFRs are available at the quarterly frequency—due

16. After the passage of FIRREA in 1989, thrifts became subject to regulation by the OTS. The Dodd-Frank Act of 2010 eliminated this agency and placed thrift supervision under the Office of the Comptroller of the Currency (OCC).

17. The FDIC normalizes Call Reports and TFRs for use in their Statistics on Depository Institutions (SDI) system. This system provides a uniform schema that—for the most part—eliminates

to limitations of the HMDA data described later in this section—most of the analysis is at the bank-year level.

Over the inter-crisis period, important changes were afoot in the regulatory domain. In 1994, the Riegle–Neal Interstate Banking and Branching Efficiency Act (IBBEA) repealed provisions in the Bank Holding Company Act (BHCA) of 1956 that prevented bank mergers across state lines while in 1999, the Gramm–Leach–Bliley Act (GLBA) repealed provisions of the Glass-Steagall Act preventing business combinations between banks, insurance companies, and securities firms. As significant as these changes were, they had limited direct effects on thrifts. Federally-chartered thrifts had long enjoyed broad branching powers including the ability to open *de novo* branches in any state. Thus, the effect of IBBEA was primarily to alter thrifts' competitive environment. Commercial banks taking advantage of the new provisions could now more easily merge to compete with thrifts at the national level. The major effect of GLBA on thrifts was to close the "unitary thrift loophole" that had allowed non-banking firms to purchase unitary thrift holding companies.[18] This had the effect of reducing the value of the thrift charter as it no longer provided a means to circumvent a key provision of the BHCA.

The lifting of branching restrictions led to a wave of consolidation throughout the banking industry. Coming out of the S&L crisis, thrift numbers were at historic lows, with only 1,953 thrifts operating (compared to 3,993 in 1980). These numbers would soon seem large: by 2006:IV, only 817 thrifts remained. Over the same period assets in the thrift sector grew from $850 billion to $1.5 trillion. Figure 2.1 plots these trends.

Despite these changes, thrifts by and large continued to focus on mortgage lending. By the end of the sample period, thrifts' holdings of C&I loans did see a large (three-

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differences resulting from heterogeneity in reporting requirements. Throughout, I use the normalized SDI data for the analysis to avoid inconsistencies in the field definitions. This data is available from the FDIC website at `http://www2.fdic.gov/sdi`

18. The BHCA prevented most business combinations between banks and commercial firms.

fold) increase and came to make up some 4% of assets. However, this was still considerably below QTL limits. Use of uninsured deposits also experienced significant growth: they came to represent between 11%–13% of thrift assets. The pattern is consistent with information frictions inhibiting small banks' access to uninsured funding.

Home Mortgage Disclosure Act Reports

A key feature of my analysis is the use of loan-level data. I use this data to control for the effects of credit demand and to measure banks' risk-taking. The source of this data is the Home Mortgage Disclosure Act (HMDA). Originally enacted in 1975, HMDA directed bank regulators to collect data on banks' mortgage lending activities to provide a picture of geographic and demographic trends in mortgage lending.[19] With the passage of FIRREA (in 1989) and the Federal Deposit Insurance Corporation Improvement Act (FDICIA in 1991), the scope of HMDA was expanded and a data collection standard was introduced that continues largely unchanged to the present day.

Starting in 1991, HMDA required nearly all depository institutions and subsidiaries as well as non-depository mortgage lenders to report loan-level data on all home mortgage loan applications received along with details on their disposition.[20] These loan-level reports are know as Loan Application Registers (LARs).[21] Each originator's LAR contains one record for each residential mortgage loan issued, purchased, or applied for in a given year. Each record contains information on the loan amount, the borrower's race and income, the location of the property (state,

19. Motivations include monitoring compliance with laws designed to prevent racial and gender discrimination and measuring the efficacy of laws aimed at encouraging investment in disadvantaged communities.

20. Depository institutions are required to file HMDA reports if they have more than approximately $30 million in assets (in year 2000 dollars) and have a branch office located in a metropolitan statistical area (MSA): very small banks operating exclusively in rural areas are exempt.

21. HMDA data are available for from the FFIEC web site, `http://www.ffiec.gov/hmda/`.

county, census tract, Metropolitan Statistical Area (MSA)), the property type (single or multi-family), loan purpose (purchase, improvement, or refinance), the owner occupancy status, the loan type (conventional, FHA, or VA), the loan purchaser (bank, affiliate, GSE, or other party), whether the loan was approved—alternatively the reason for denial, and—if approved—whether the loan was accepted by the borrower.

As far as publicly accessible U.S. regulatory bank filings go, the data provided in the LARs are unusually detailed; however, there are several limitations. Particularly unfortunate omissions include important information on the loan terms (fixed vs. adjustable, maturity, and pricing) as well as information about the borrowers' credit history (i.e. credit scores).[22] In addition, the data released to the public does not contain specific information about timing—the data is at an annual granularity.[23] That said, the data does provide an unusually comprehensive picture of credit conditions for an important sector covering an extended period of time.

The HMDA LARs from 1991–2006 contain nearly 400 million loan-level observations. Preliminary processing of the HMDA data involves fix-ups in the reporting entity identifiers,[24] normalization of MSA identifiers, elimination of entries containing reporting errors.[25] and the elimination of entries pertaining to loans that were purchased (rather than applied for). This eliminates approximately one quarter of the observations.

In my analysis, I use the HMDA data in three ways. First, I use data on loan applications to construct measures of the demand for *bank credit*—credit provided

22. Starting with 2002, pricing for certain high-priced loans is reported.

23. Avery, Brevoort, and Canner (2007) provide a thorough discussion of the limitations.

24. These can be the result of a changes in the reporting entity's charter (e.g. a thrift that becomes a bank), or continued (individual) reporting by entities that have been acquired. These discrepancies are resolved so as to maintain consistency with bank regulatory filings (i.e. the TFRs and Call Reports).

25. Many of these appear to be the result of what amounts to an incorrect placement of the decimal point, others are likely the result of data-entry errors. To deal with these, I eliminate all observations flagged (by the collecting agency) as having "edit errors" and those where the borrower's income or loan amount are in the top 1% of the respective distribution (in a given MSA-year). I also eliminate records where the geographic information is missing.

through the banks' own balance sheets for each bank-year. Second, I use the disposition of loan applications to estimate banks' underwriting standards. Third, I use the geographical information about a bank's approved loans to construct a measure of its exposure to local economic risks. In each case, I am interested in loans destined for the originating bank's balance sheet, and consequently I eliminate OTD loans (all loans originated by non-banks as well as bank-originated OTD loans). Eliminating these loans leaves approximately fifty million direct applications for bank credit at from over ten thousand distinct banks. These origination volumes are summarized in Figure 2.2, which shows that thrifts were the primary source of bank credit at the start of my sample. However, since the mid 1990s commercial banks' participation has significantly increased, accounting for approximately 67% of the application volume at the end of the sample period.

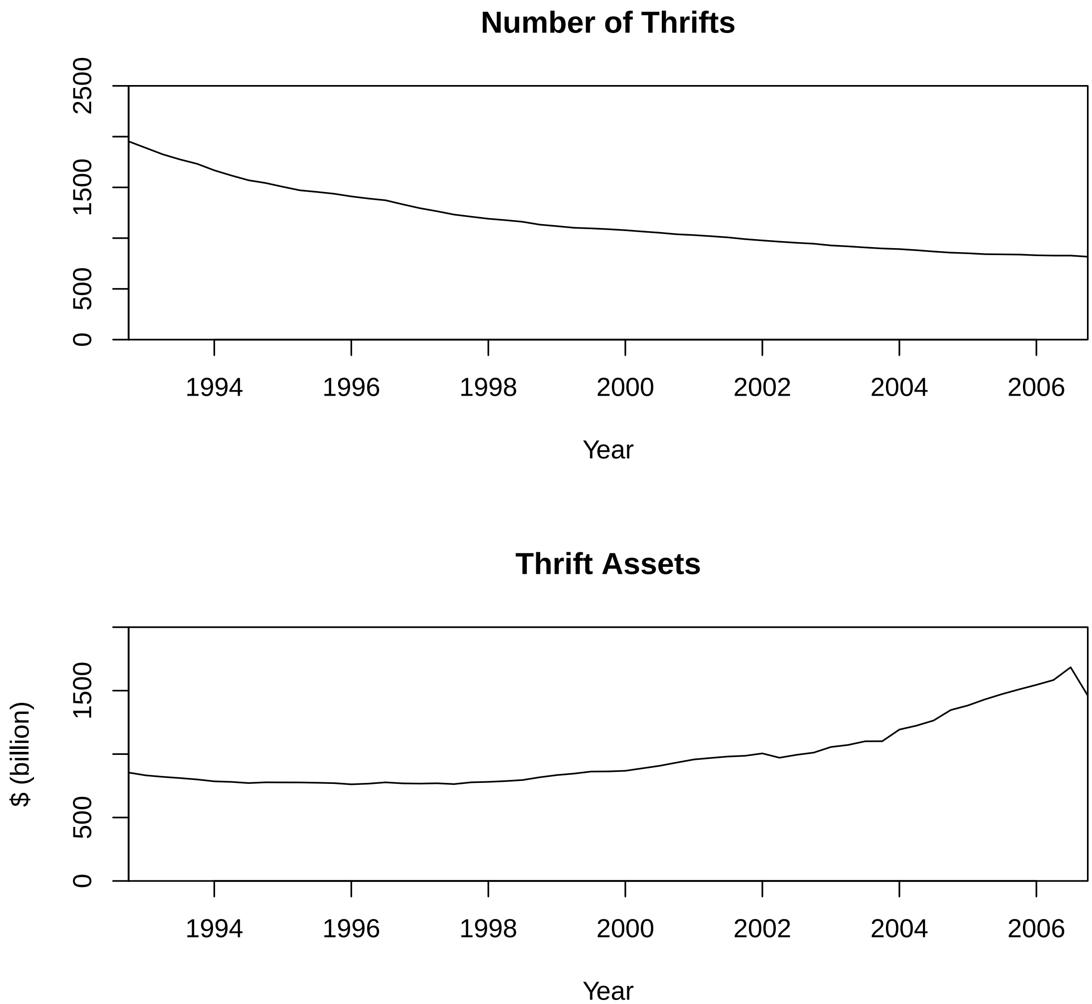

Figure 2.1: Thrifts: numbers and total assets

Figure 2.1 plots the number and total assets of thrifts making up the sample.

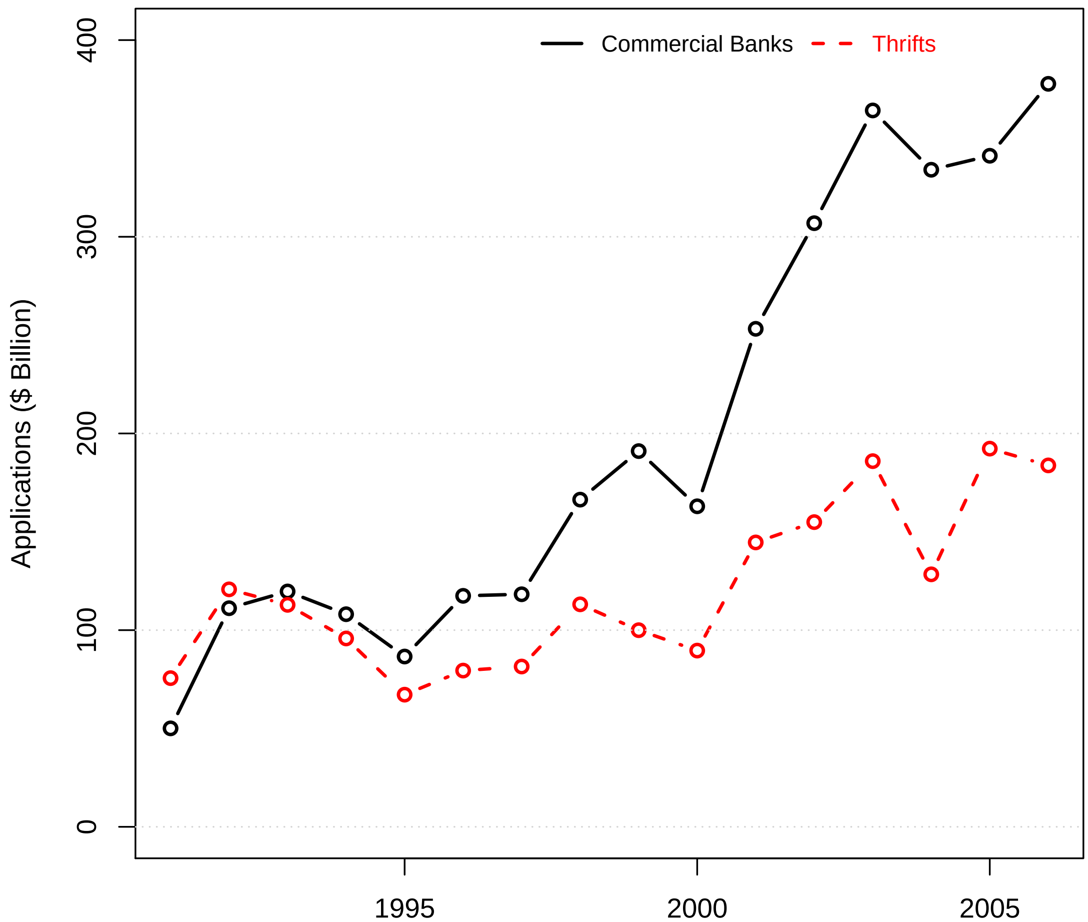

Figure 2.2: Applications for bank credit at thrifts and commercial banks

Figure 2.2 plots the dollar amount of applications for residential mortgage loans at thrifts and commercial banks. The totals are computed from loan-level HMDA data. Loans sold to third parties, purchased loans, and loans originated through brokers are excluded from the totals.

CHAPTER III

Monetary Policy and the Supply of Bank Credit

3.1 Introduction

In this chapter, I study how monetary policy and financial frictions in the banking sector interact to affect the supply of bank credit and to create a monetary policy transmission channel operating through the banking system. Interest in the role of banks in the transmission of monetary policy stems from shortcomings in the standard, neoclassical interest rate channel (also known as the "money channel"). Banks play no special role in the interest rate channel: monetary policy affects the return on risk-free assets, altering the discount rate used in the calculation of the cost of capital. Changes to the cost of capital in turn affect the level of investment.

The interest rate channel is found lacking due to the low observed elasticities of investment (Chirinko (1993)). This has led some (notably, Bernanke and Gertler (1995)) to emphasize the importance of *credit channels* of monetary policy transmission. In these channels, financial frictions take center stage. In particular, financial frictions limiting banks' ability to obtain deposit funding gives rise to a *bank lending channel* of monetary policy transmission. It is this mechanism that is the focus of this chapter.

The original conception of the bank lending channel is due to Bernanke and Blinder (1988). There, it is the interaction of monetary policy and banks' reserve requirements that causes shifts in banks' loan supply. The monetary authorities affect the quantity of reserves in the banking system through open market operations; because banks are required to hold reserves against deposits, this affects the quantity of deposits in the banking system. Changes in the quantity of deposits are accompanied by a corresponding changes in bank lending as loans are financed through deposits.

Early evidence for the bank lending channel was provided by Bernanke and Blinder (1992), who used aggregate VAR evidence to make the case that shocks to the Federal Funds rate produced responses in bank deposits, loans, and security holdings consistent with the bank lending channel. That is, positive innovations in the Fed Funds rate (a tightening) are followed by permanent reductions to bank deposits with bank loans declining some six months after the shock.

This aggregate pattern is suggestive, but admits alternative explanations and the proposed bank lending channel mechanism has been the subject of criticism. Romer and Romer (1990) point out that in the modern banking system, reserves are not the constraint they may have once been: it is only transaction deposits that are subject to significant reserve requirements, and banks can easily overcome any shortage of reserves by issuing liabilities not subject to reserve requirements (e.g. certificates of deposit). If a large segment of bank liabilities are not subject to reserve requirements, then the quantity of reserves is irrelevant to the supply of bank credit.

In response to this critique, the bank lending channel was reframed in a cross-sectional context. Stein (1998) argues that banks do not have equal access to all forms of liabilities: banks with high information frictions have a harder time raising uninsured funding. Because liabilities not subject to reserve requirements are more likely to be uninsured, banks with low information frictions may be relatively unaffected by the bank lending channel, however, those with high information frictions (i.e. banks dependent on insured deposits) would continue to be affected. This formulation has the additional benefit of providing a more plausible identification strategy based on micro-level bank panel data. Specifically, if one assumes that banks with low information frictions face borrowers similar to those of banks with high information frictions, then supply effects can be identified through cross-sectional variation in banks' lending growth following monetary policy shocks.

This cross-sectional identification strategy was the basis for subsequent empirical work on the bank lending channel, starting with Anil K. Kashyap and Stein (1995) and Anil K Kashyap and Stein (2000). Using data on commercial bank lending covering a period beginning in the 1970s and ending in the early 1990s, Kashyap and Stein find that loan growth at small banks is more sensitive to monetary policy shocks than lending at large banks, and attribute the difference to bank lending channel effects. Furthermore, they find that balance sheet strength (i.e. large holdings of marketable securities) insulates smaller banks from the effects of the policy shocks; they argue that this is consistent with security holdings being used as “buffer-stocks” that absorb deposit outflows.

Using a similar approach and data, Ashcraft (2006) find that banks affiliated with a multi-bank holding companies are less responsive to monetary policy shocks. This is broadly consistent with the bank lending channel mechanism: banks that are not part of banking group are likely to have limited access to uninsured funding and hence more dependent on reservable insured deposits.

Kishan and Opiela (2006) extend the bank lending channel analysis to incorporate bank capital effects and find evidence of lending response that is consistent with a bank lending channel mechanism, albeit one that interacts with a banks' capital position. Specifically, they find that small banks with low capital reduce loan supply more than large banks in contractions (per the bank lending channel), but do not increase loan supply more than large banks in expansions. This asymmetry is attributed to bank capital acting as the binding constraint for banks with low capital .

While studies using U.S. commercial bank data from the 1970s through early 1990s have tended to support the bank lending view, the evidence is not conclusive. One problem is the identification strategy. A key assumption in these analyses is that the sensitivity of loan demand to monetary policy is constant across various bank categories (i.e. size, capitalization, or affiliation). This allows inter-group differences in banks' lending response to be attributed to changes in banks loan supply rather than to changes in borrowers' demand for loans. However, it is not clear that this assumption is warranted. Different types of banks have different types of borrowers: smaller banks and banks that are not part of larger bank groups cater to smaller borrowers Keeton (1995). Consequently, differences in the semi-elasticities of loan growth across bank categories may simply reflect differences in borrowers' semi-elasticities of loan demand. This problem is especially acute in the context of commercial and industrial loans which are the main focus of the earlier studies.[1]

A second issue with the bank lending channel evidence is the data on which it is based. U.S. studies of the bank lending channel rely heavily on data from the 1970s and 1980s. This period is problematic in that it includes several years of unconventional monetary policy (the Volcker explicit quantity-targeting regime between 1979–1982), as well as a decade during which reserve quantities potentially played some role in Fed policy (1982–1992). Moreover, the regulatory regime during much of this period was either dysfunction or undergoing major change. The dysfunction took the form of recurring periods of disintermediation resulting from Regulation Q price controls on interest rates interacting with the high inflation of the 1970s. The regulatory changes—the Monetary Control Act of 1980 (MCA), and the associated interest ceiling phase-outs—were a response to this dysfunction. Implementation of the MCA involved numerous changes to the monetary mechanism over an extended period: in the 1973–1992 period, there were forty-five changes to banks' reserve requirements,

1. While J.P. Morgan Chase and Bank of Ann Arbor may face similar borrowers (and demand) for home and consumer loans, they are likely to have very dissimilar commercial customers.

while in the 1993–2006 period, there was only one.[2]

Empirical tests of credit channels are complicated by changes to monetary arrangements, the complexity of the banking sector, as well as difficulties in observing the demand for credit. Consequently, the existence and nature of the underlying mechanism remain open questions.

To shed light on these questions, I investigate the bank lending channel mechanism in the context of U.S. thrifts in the years preceding the Sub-prime Crisis. My empirical strategy follows the approach of previous micro-data studies in which cross-section differences in banks' monetary policy response are used to identify credit supply shifts. However, I augment this approach with potentially critical—but generally unobserved—controls for credit demand. I construct these bank-level controls from loan-level data on banks' loan application activity as reported in Home Mortgage Disclosure Act (HMDA) filings.

Moreover, by focusing on thrifts, I get a cleaner picture of banks' response. Because thrifts have limited opportunity to diversify into non-housing related assets and have limited off-balance sheet exposures, there is far less scope for unobserved variable bias in my analysis. Changes in thrifts' residential mortgage loan lending are unlikely to be confounded by changes to portfolio preferences.

Finally, by considering the pre-crisis period, I avoid the regulatory instability that was common to the earlier studies. And—perhaps more importantly—by focusing on a period with "modern" regulatory arrangements, my analysis has more relevance to the future conduct of policy.

The results from my analysis of thrifts' mortgage lending over the pre-crisis period is inconsistent with traditional formulations of the bank lending channel. Following

2. The history of changes to reserve requirements is summarized in Federal Reserve Statistical Release H.3. In tallying the changes for the two periods, I ignore annual changes resulting from indexing used in the calculation of the upper bound of the MCA's "low-reserve tranche"—the transaction deposits subject to reduced reserve requirements. The one change to reserve requirements in the later period was the 1998 change from contemporaneous to lagged reserve accounting.

earlier studies, I use bank size as a proxy for information frictions, with small banks are assumed to be afflicted with more severe information frictions. However, I find that it is big banks' credit supply that is more affected by monetary policy. This finding suggests that—as originally argued in Romer and Romer (1990) (and more recently in Bernanke (2007))—the emphasis on reserves-based mechanisms in the bank lending channel is misplaced. My findings suggest that another—quite different—supply mechanism is at work.

The rest of this chapter is organized as follows. In Section 3.2, I describe the empirical strategy and data. In Section 3.3, I present my results. The final section concludes.

3.2 Empirical Strategy

Key to understanding the mechanisms underlying the bank lending channel is the questions of how a bank's information frictions and regulatory constraints interact with monetary policy. The common premise of bank lending channel theories is that these interactions affect banks' ability to *supply* credit, and that these changes in supply have important macro-economic consequences. Distinguishing shifts in banks' credit supply from traditional interest rate channel effects is problematic in aggregate data, as both effects lead to similar consequences. Consequently, to identify the specific transmission mechanism, one must turn to micro-data.

The standard micro-data identification strategy used in the bank lending channel literature amounts to generalized difference-in-difference: cross-sectional differences in banks' loan growth following a monetary policy shock are attributed to shifts in banks' loan supply. This strategy rests on a critical identifying assumption: the semi-elasticity of bank customers' loan demand is homogeneous across banks. Failing this assumption, cross-sectional differences in banks' loan growth may be due to different types of banks having different types of customers who respond differently to changes in interest rates. In my analysis, I follow the standard micro-data identification strategy; however, I augment it with explicit controls for banks' loan demand. I construct these controls from loan-level data on banks' loan applications, thus better isolating supply shifts.

Following earlier studies, the baseline regression specification in my analysis is a reduced-form dynamic panel model in growth rates of the following form:

$$\begin{aligned}\Delta log(L_{it}) = \alpha + \sum_{\tau=0} \varphi_\tau \Delta log(L_{it-\tau}) + \sum_{\tau=0} \beta_\tau \Delta FF_{t-\tau} + \delta D_{it} + \sum_{\tau=0} \gamma_\tau \Delta FF_{t-\tau} * D_{it} \\ + \sum_j \gamma_j X_{jt} + \varepsilon_{it},\end{aligned} \tag{3.1}$$

where i and t index over banks and time respectively, D_{it} is an indicator variable indicating the bank's membership in some category based on a cross-sectional bank characteristic (e.g. "big bank"). The change in the policy rate (here, the Fed Funds rate), ΔFF_t, serves as the (generalized) indicator for the policy shock.[3] The vector of controls, X_{jt}, includes macroeconomic and financial variables that may be confound the monetary policy shock; these may include: GDP growth, inflation, long-term rates, or yield spreads. Other variables such as bank balance sheet characteristics, time trends, year fixed effect, and explicit demand controls may also be included. These controls are interacted with the category dummies to allow for arbitrary category-level differences in the coefficients. The auto-regressive lag structure allows for one year (or four quarters) of lags, and is intended to represent limitations in banks' ability to quickly adjust the growth in lending (e.g. it takes time to build branches, hire loan officers, etc.) which leads to auto-regressive dynamics.

In the baseline specification, I maintain the assumption of no bank fixed effects. Doing so avoids the inconsistency of OLS in dynamic fixed effect models (see Nickell

3. It is "generalized" in the sense of being a continuous variable. In a conventional difference-in-difference, this would be the binary "pre/post" indicator variable.

(1981)). In robustness checks, I consider specifications with fixed effects but without dynamics as well ones with both dynamics and fixed effects. I estimate the dynamic fixed effect models using OLS.

In all specifications, the coefficients of interest are on the category–dummy interactions, i.e. the γ_τs. This is interpreted as the incremental loan growth response to a 100bp shock in the Fed Funds rate attributable to the banks' membership in some cross-sectional category (e.g. "big bank").

The empirical strategy is best illustrated with tests of the traditional bank lending channel hypothesis: that banks with high information frictions—such as small banks—should be relatively more responsive to monetary policy. Formally,

$$\left.\frac{\partial L_{it}}{\partial FF_t}\right|_{i\in Small, L^D} < \left.\frac{\partial L_{it}}{\partial FF_t}\right|_{i\in Big, L^D} < 0. \tag{3.2}$$

In terms of the standard regression specification, if D_{it} is defined such that it indicates membership in the "big bank" category, then the hypothesis is $\sum \gamma_\tau > 0$. That is, big banks' loan growth response to a positive monetary policy shock is higher, i.e. it is *less negative* than the response of small banks.

Critical to the above is the previously alluded to identification assumption that the estimated differences are not a result of cross-sectional differences in the monetary policy sensitivity of bank borrowers' credit demand. Loose monetary policy makes more projects viable (the traditional interest rate channel of monetary policy) and strengthens borrower's balance sheets (the balance-sheet channel of Bernanke and Gertler (1995)); both of these factors can increase the effective demand for credit. If demand sensitivities of borrowers differ across banks in the different categories, then the strategy's ability to identify supply effects is undermined. The typical approach is to assume that demand sensitivities are orthogonal to bank characteristics (or argue that the bias is an unfavorable direction). Thus, if small banks reduce lending more in response to monetary tightening, this is attributed to small banks' inability to supply credit, rather than to small banks' borrowers reducing their demand for credit.

The validity of this assumption in the context of commercial banks' commercial and industrial (C & I) lending is questionable. Big banks' commercial borrowers are likely to be quite different from commercial borrowers at small banks. In particular, since small banks tend to cater to small firms, there are significant differences between small and large bank borrowers' ability to access alternative funding sources, their collateral, and their potential investment projects. As C & I lending at commercial banks is the most frequent focus of bank lending channel studies, this raises some questions as to the interpretation of the prior findings.[4]

As my analysis focuses on thrifts' mortgage lending, it much less susceptible to this critique. Thrifts' borrowers are relatively homogeneous—the majority are individuals financing their home. However, even in simple and undiversified thrifts, the homogeneous demand sensitivity cannot be taken for granted. A thrift's product offerings (e.g. a specialization in ARM products) can have important implications on its credit demand. For mortgage borrowers, interest rates affect not only the overall demand for credit, but also the relative attractiveness of fixed-rate and adjustable-rate products. When long-term rates are high, borrowers prefer adjustable-rate loans.[5] This can lead to situations where monetary tightenings increase demand for bank credit (i.e. loans funded through bank balance sheets) due to borrowers' substituting away from fixed-rate products (which are more likely to be funded through market sources) into adjustable-rate products (which are more likely to be funded through

4. Another issue with commercial lending is cross-sectional variability in the use of loan commitments (see for example, Duca and Vanhoose (1990)).

5. This idea is developed formally in Koijen, Hemert, and Nieuwerburgh (2009), who attribute the time-series variation in borrowers' preferences to time-series variation in the bond premium. They propose that borrowers employ a simple "rule of thumb" to estimate the bond premium using the difference between the long rate and the average of recent short rates. Under the rule of thumb, higher long-term rates lead to higher estimates of the bond premium, resulting in borrowers' substitution away from fixed-rate loans into adjustable-rate loans.

banks' balance sheets).[6] This highlights the importance of a bank's product mix in its lending response and can undermines homogeneous demand assumptions even in the most simple settings.

To address problems, I construct bank-level demand controls using loan-level HMDA data. For each bank-year, I sum the dollar amount of all applications not resulting in a securitized origination, to obtain measure of demand for bank-supplied credit, $Apps_{it}$. To measure credit demand growth, I use the difference in logs: $\Delta log(Apps_{it})$.

This measure is not without problems. A bank's applications may be endogenous to its ability to supply credit: banks that are financially constrained may be less inclined to solicit business (e.g. through advertising expenditures) and in this way, supply constraints can cause a reduction in applications. To deal with this potential endogeneity, I instrument each bank's loan demand using the local demand in the areas where each bank lends. For each bank-year, I tally the dollar amount of the bank's loan applications by Metropolitan Statistical Area (MSA). From these bank-year-MSA totals, I calculate a MSA-weight vector for each bank-year (i.e. the fraction of each bank's loan applications originating in each MSA). Next, for each MSA-year, I calculate the growth in total application activity. I then weight these MSA-year growth rates by each bank's MSA-weight vector from the previous year, to obtain an instrument for banks' demand growth, $LocalAppGrowth_{it}$.

I estimate the regression using several estimation methods, including pooled OLS, fixed effects, and IV. Most of the analysis uses a bank-year panel. In addition to data limitations (the HMDA data is annual) there are two reasons for performing the analysis at the annual frequency. First, mortgage lending is seasonal and the degree of this seasonality varies from bank to bank and from region to region. This heterogeneity in seasonality implies that a simple dynamic panel model estimated at

6. This presumes that monetary policy affects long-term rates. There is some debate on the extent of this effect; see Berument and Froyen (2009) for a survey and some evidence.

higher frequencies is likely to be mis-specified. Second, monetary policy follows a low-frequency process (see Figure 3.2): not much is lost by performing the analysis at an annual frequency. Moreover, higher-frequency estimates would be subject to collinearity problems.

Data

The primary data source for this analysis is the FDIC SDI database containing a panel of thrift balance sheets and income statements obtained from thrifts' regulatory filings and covering the inter-crisis period (i.e. 1992–2006). A general description of this data set can is found in Section 2.2. I augment this panel with my derived measures of loan demand ($Apps_{it}$, and $LocalAppGrowth_{it}$) constructed from the HMDA data. Over the sample period, U.S. banking industry underwent considerable consolidation. One issue with consolidation is that observed growth in a bank's lending—the dependent variable—may reflect acquisitions rather than growth. To avoid this, I eliminate bank-years where the bank was involved in merger activity (as either an acquirer or a target).[7]

In addition to this bank-quarter panel, my analysis makes use of macro-level data on monetary policy stance. I measure monetary policy stance with the change in the average annual effective Fed Funds rate, ΔFF_t (so that $\Delta FF_t > 0$ corresponds to a monetary contraction). Figure 3.2 plots the average annual Fed Funds rate together with the corresponding monthly series for my sample period. In terms of measuring monetary policy stance, the sample period has two attractive features: it was characterized by stable monetary arrangements and—as is clear from Figure 3.2—monetary policy evolved slowly and hence little is lost from conducting the analysis at the annual frequency.

Ambiguity about the implementation of monetary policy had made the measure-

7. Data on merger activity is obtained from the Federal Financial Institutions Examination Council's (FFIEC's) National Information Center web site, `http://www.ffiec.gov/nicpubweb/`

ment of monetary policy stance a non-trivial problem in earlier periods. In addition to changes in the Fed Funds rate, various—more elaborate—measures were proposed that attempted to overcome this ambiguity. Examples include: a subjective index constructed from readings of Federal Open Market Committee (FOMC) documents (Boschen and Mills (1995)), the quantity of non-borrowed reserves (Christiano and Eichenbaum (1992)), and a measure based on a structural model of the market for bank reserves (Bernanke and Mihov (1998)). In the 1992–2006 period, there was little ambiguity about how monetary policy was conducted: it was affected through changes to the Fed Funds rate. Therefore, I do not consider these alternative measures.[8]

As the analysis focuses on cross-sectional differences in banks' response to monetary policy shocks across bank size categories, it is necessary to define the categories. I define three: $Small_t$, $Medium_t$, and Big_t. These are based on size cut-offs taken to be at the 75$^{\text{th}}$ and 95$^{\text{th}}$ percentile of each year's thrift size distribution. The cut-offs are somewhat arbitrary; they were chosen to ensure that each category contains a non-trivial number of banks. At the start of the period, this implies 1464 small banks, 391 medium banks, and 98 big banks, representing 15%, 26%, and 59% of the in-sample banks' total assets. The balance sheet composition of banks in each of these categories at the start and end of the sample period are shown in Tables 3.1 and 3.2, respectively.

At the start of my sample (1992:IV), 1,953 thrifts were operating. Their size distribution was similar to that of contemporary commercial banks. Thrifts tended to

8. The use of measures based on monetary aggregates (such as M2, deposits, etc) waned in the 1990s due to problems reconciling such measures with certain stylized facts: the absence of Granger-causality from monetary aggregates to output in the presence of interest rates (described in Litterman and Weiss (1985) and a similar absence of Granger-causality from monetary aggregates to short term interest rates (described in Leeper and Gordon (1992)). This led Bernanke and Blinder (1992) to argue that measurements of monetary policy should be based on innovations in the interest rate. Monetary policy—so measured—had the expected effects on output. A more compelling rationale was provided in Bernanke and Mihov (1998) who found that in the latter half of the 20$^{\text{th}}$century, the Federal Reserve had targeted interest rates and largely accommodated fluctuations in the demand for reserves (as argued earlier in Tobin (1970)). The major exception to this appears to be the 1979–1982 period of explicit reserve-quantity-targeting.

be bigger than commercial banks, but the very biggest commercial banks (i.e. those the top 2%) were bigger than the biggest thrifts. Commercial and industrial (C&I) lending at thrifts was very limited: C&I loans represented only 1% of total assets—considerably below the regulatory limits. One might imagine that thrifts did not generally possess the "technology" for making C&I loans, or that the C&I lending technology was not efficient at the smaller scale implied by QTL restrictions. The pattern in thrifts' cash holdings—smaller thrifts held more cash—is consistent with intuition: smaller thrifts should have more limited access to external funding and should therefore hold more cash as a liquidity buffer. One might also expect this pattern to hold in the holdings of securities, but it does not. Here the relationship is non-monotonic, with the the smallest (below 75^{th} percentile) and biggest thrifts' (above 95^{th} percentile) holdings of securities making up 21% and 25% of assets respectively, while for medium-sized thrifts, security holdings made up 28% of assets.

In terms of liabilities, small thrifts were much more dependent on insured deposits than the larger thrifts. In 1992:IV, 85% of small thrifts' assets were funded through insured deposits. For medium and big thrifts, insured deposits made up 80% and 71% of assets respectively. This difference was not due to uninsured deposits: in all size categories thrifts made hardly any use of uninsured deposits (they accounted for only 2.6% to 3.8% of thrifts' assets). Most of the difference in funding was due to larger thrifts' extensive use of FHLB advances and interbank borrowings (Fed Funds).

3.3 Results

I first analyze the role information frictions play in the impact of monetary policy shocks on loan growth (Table 3.3). Then, I extend this analysis to include the effects of bank capital (Table 3.4).

Information Frictions

Table 3.3 reports the results from the analysis of the impact of monetary policy on loan growth across bank-size categories. Each column corresponds to a different set of controls or an alternate estimation method. In each case, the dependent variable is the change in the log of the book value of residential mortgage loans, $\Delta log(L_{it})$. The regression specification is described in the previous section (Equation 3.1). Following Anil K Kashyap and Stein (2000), I include GDP growth, a linear time trend, and Federal Reserve Board district dummies, as well as balance sheet liquidity (i.e. the ratio of cash and securities to assets), B_{it-1}, and its interactions with the the monetary policy indicator, GDP growth, and the linear time trend. Balance sheet liquidity is included because buffer stocks of cash and securities can insulate banks from the impact of contractionary shocks (securities can be sold to finance loan growth). In addition to these standard covariates, I also include changes in bank-level loan demand, $\Delta Apps_{it}$, (potentially instrument with $LocalAppGrowth_{it}$ as well as changes to the prevailing thirty year conventional mortgage rate, ΔMTG_t. The former is intended to control for cross-sectional heterogeneity in banks' demand sensitivities. The latter is an important factor in the aggregate level of demand for bank credit.[9] I report the estimates from regressions with only contemporaneous effects—inclusion of lags does not materially alter the results. All reported standard errors are heteroskedasticity consistent and clustered by bank and all tests are two-sided.[10]

According to the traditional bank lending channel hypothesis, small banks—which are said to suffer from high information frictions—should be more responsive to monetary policy shocks. Under all specifications, I find no evidence for increased mone-

9. Note that increases in mortgage rates can *increase* demand for bank-supplied mortgage credit. See footnote 5.

10. For robustness, I compute standard errors clustered at the category-year level allowing for arbitrary cross-sectional covariance structure within each category-year (but not for within-bank correlation). Standard error estimates obtained under this alternative clustering scheme do not have a qualitative effect on the interpretation of my results; for brevity, I do not separately report them.

tary policy sensitivity at smaller banks. Tightenings ($\Delta FF_t > 0$) do not reduce small banks' credit supply (the coefficient estimates on ΔFF are not negative). Conversely, the hypothesis that large banks are less responsive (vis-á-vis small banks) is rejected: big banks are considerably more responsive (the coefficients on $\Delta FF \times Big$ are negative). Following a 100bp contractionary shock to the Fed Funds rate, big banks' lending is estimated to fall by 3.1%–5.7%, with the inclusion of bank-level demand controls leading to larger estimates.

Two additional predictions of the traditional bank lending channel relate to balance sheet liquidity, B_{it}. First, for small banks, balance sheet liquidity should mitigate the effects of a policy shock:

$$\left.\frac{\partial^2 L_{it}}{\partial FF_t \partial B_{it}}\right|_{i \in Small} > 0, \tag{3.3}$$

where $\partial L_{it}/\partial FF_t|_{i \in Small} < 0$. Liquid assets can act as a "buffer stock" which can be drawn down when policy is tight. Second, for big banks, low information frictions and the resulting easy access to wholesale funding makes liquidity less of an issue:

$$\left.\frac{\partial^2 L_{it}}{\partial FF_t \partial B_{it}}\right|_{i \in Small} > \left.\frac{\partial^2 L_{it}}{\partial FF_t \partial B_{it}}\right|_{i \in Big}. \tag{3.4}$$

The first prediction (i.e. that the estimates of the coefficients on $\Delta FF_t \times B_{it-1}$ are positive) finds no support (the estimates are either negative or statistically insignificant). The second prediction (i.e. that the estimates of the coefficients on $\Delta FF_t \times B_{it-1} \times Big_{it}$ are positive) is rejected: it is at big banks that balance sheet liquidity appears to mitigate the effects of policy. For a big bank with 10% in liquid assets, a 100bp increase to the policy rate is associated with a 4.0% reduction in loan growth; for a big bank with 20% in liquid assets, the same 100bp shock is associated with a 2.3% reduction (based on estimates from specification (6)). Thus, for a typical big bank in my sample, a doubling of liquid asset holdings corresponds roughly to halving the monetary policy sensitivity. These large differences (the average annual loan growth over my sample period is approximately 5%) are statistically significant in all the specifications, and are larger in the specifications that include bank-level demand controls.

These results do run counter to some earlier studies of the bank lending channel in the U.S. commercial lending context (Anil K. Kashyap and Stein (1995) and (2000)). In addition to differences in the type of lending, sample period, and the availability of demand controls, there is the potential that methodological differences (such as the annual frequency) play a role. As a robustness check, I reproduce the methodology of Anil K Kashyap and Stein (2000) and apply their "one-step" estimation to data on quarterly mortgage lending for banks in my sample. They focus on the effects of liquidity (i.e. its mitigating effect), and in Table 3.5 I report the estimates of these effects. They paint a similar picture: small banks' balance sheet liquidity does not mitigate the impact of monetary policy (line 1); the mitigating effect increases with size category (lines 2 and 3): balance sheet liquidity mitigates the impact of monetary policy at the medium and large banks (statistical significance obtains only for the medium-sized banks).

Capital Constraints

One issue that I have ignored so far is bank capital. Capital constraints may play an important role in banks' response to monetary policy shocks, leading to a potential bank capital channel of monetary policy transmission (Peek and Rosengren (1995)): following an expansionary shock, banks subject to binding capital constraints may not be able to expand lending because regulatory capital constraints prevent the usual bank lending channel from operating. Thus, in the short-term, banks with low capital will be less affected by monetary policy shocks (at least by expansionary shocks). However, over time, loose policy improves bank balance sheets and net interest margins, thereby relaxing the capital constraint (Van den Heuvel (2002)). This second effect can lead to the opposite effect in the medium-term.

Table 3.4 shows the effect of capital and banks' monetary policy sensitivity. I sort banks on leverage ratio to form two sub-samples. The first includes the less-capitalized banks (those below the 50^{th}percentile), and the second the rest. I fit the main loan growth regression (specification (6) in Table 3.3) on each of the two sub-samples. The heightened sensitivity of the larger banks to monetary policy shocks is present (and slightly stronger) in the less-capitalized sub-sample: among better-capitalized banks, cross-sectional differences in the monetary policy response are absent. This casts doubt on the notion that capital constraints suppress the traditional bank lending channel in the short-term. However, it may be that relatively under-capitalized banks are more exposed to the bank lending channel due to greater difficulties finding funding in the wholesale markets.

3.4 Discussion

Nothing in my results suggests that the traditional bank lending channel mechanism is at work. Monetary policy does not appear to constrain small banks through its effects on reserves: it is big banks that appear more responsive to policy. Moreover, this differential in the response appears to originate at the less-capitalized banks. This is perhaps not too surprising to critics of the bank lending channel (e.g. Romer and Romer (1990)) who have long maintained that in the modern financial system the reserve constraints at the heart of the bank lending channel are not likely to bind due to the wide variety of funding sources not subject to reserve requirements.

More recently, a similar point was made by Bernanke (2007), who suggested that the reserve-driven quantity effects of monetary policy might be "quantitatively unimportant", and that the bank lending channel should be reinterpreted in other terms. However, without the rigid structure of the conventional (reserve-based) interpretation, alternative cross-sectional predictions become possible: a reinterpreted bank lending channel can imply that small banks should in fact be *less* sensitive to monetary policy then big banks; my findings could then be construed as providing support for such reformulations.

One example of such a reformulation is found in the model of Disyatat (2011). In his model, monetary policy affects banks' lending supply through its effect on banks' health: increases to the policy rate reduce the value of bank assets, bank health suffers, which leads to higher equilibrium borrowing costs (i.e. an increase to the external finance premium), which reduces the supply of bank lending. Although not explicitly modeled, banks reliant on insured deposits—i.e. small, under-capitalized banks—would be insensitive to monetary policy: changes in these banks' condition is not reflected in their cost of (insured) funding. Similarly, such effects should be less of a factor at banks that are well-capitalized; this is broadly consistent with my findings.[11]

Recently, Carpenter and Demiralp (2012) obtained similar results in an aggregate VAR study of commercial banks' lending from roughly the same period (1990–2007). They found that bank loans at small banks *increase* following a contractionary shock—lending at big and medium banks declines following the shock. They interpret this as evidence against the traditional formulations of the bank lending channel.

An alternative possibility is that the big banks' more pronounced quantity response is due to credit rationing. Stiglitz and Greenwald (2003) develop a "generalized loanable funds" theory where banks' credit supply is the solution to an optimization problem in which the additional returns from credit expansion are counter-balanced by an increasing likelihood of (inefficient) liquidation. In their model, there are no finance premia or borrowing constraints—banks may borrow as much as they wish at a rate dictated by policy. However, banks face adverse selection problems on the

11. A similar mechanism is proposed in Black, Hancock, and Passmore (2007); there, stable core deposits mitigate the effects of monetary policy at traditional banks.

asset side (i.e. from their borrowers). If the adverse selection problem is not too severe then changes to the policy rate affect the optimum level of lending—generally, higher rates lead to less lending. However, if the adverse selection problem is severe, small changes to the policy rate will not effect the quantity of credit supplied. Intuitively, for a bank with severe adverse selection problems, the equilibrium lending *rate* is constrained by adverse selection concerns: small changes to the bank's borrowing costs do not affect the lending rate and credit supply is unchanged (i.e. the bank is at a "kink"). Conversely, if the adverse selection problem is not too severe, the bank's borrowing costs can be passed on through the lending rate to the bank's borrowers, reducing the equilibrium quantity of credit in the process. Small banks—due to their limited geographical diversification—may face more severe adverse selection problems and operate at the kink. If this is the case, changes to monetary policy would have less of an impact on the quantity of credit supplied by small banks. However, it is not clear why such cross-sectional differences would arise only at the less-capitalized banks; this feature of the data tends to favor a bank health interpretation of my findings.

Limitations

With much of my analysis being done at the annual frequency, reverse causality is a potential problem: the results I have reported may be due not to monetary policy's effects on banks' lending, but due to the effects of banks' lending on monetary policy. Lacking truly exogenous monetary policy shocks requires resorting to arguments against such interpretation; here there are at least two.

First, there is considerable reason to doubt that lending activity in the mortgage sector should have had a significant *direct* causal effect on monetary policy during the period in question: sector-specific financial market conditions are not—or at least were not—a major factor in the central bank's policy rule: this has been affirmed in statements of the Federal Open Market Committee over this period.[12] In terms of *indirect* effects, the growth in mortgage lending certainly had an effect on residential investment growth, which contributes to GDP growth, which affects the policy rate; however, the inclusion of GDP growth in my regressions is sufficient to control for indirect effects operating through the GDP channel.[13]

The second problem with the reverse causality interpretation is that it is not does not offer a natural (or at least obvious) explanation for the observed cross-sectional differences. For the reverse causality story to hold, cross-sectional differences in mortgage loan growth must affect monetary policy through a distinct causal path.[14] It is not clear why the central bank should lower the policy rate when large banks expand mortgage lending more than small banks. Absent a plausible motivation for such actions—or some unobserved third cause—the interpretation in which monetary policy causes the cross-section differences in lending growth is the most compelling.

I find that—in thrifts—traditional bank lending channel mechanisms do not appear to be at work. An important question is whether these findings have more general applicability. Traditional reserve-based explanations for the bank lending channel rely on stylized models of banking that have more in common with thrifts than with complex commercial banks—thus, if they are not applicable here, it is unlikely that they should be applicable anywhere else.

Another potential problem relates to Federal Home Loan Bank (FHLB) advances.

12. For example, in the June 29–30, 2005 minutes, with regard to monetary policy's role in addressing "possible imbalances" in the housing market, the meeting participants stressed "the importance of the pursuit of their core objectives of price stability and maximum sustainable economic growth. To the extent that an asset price movement threatened the achievement of those objectives, it would of course be taken into consideration in setting policy. However, given the unavoidable uncertainties associated with judgments regarding the appropriate level of and likely future movements in asset prices, a strategy of responding more directly to possible mis-pricing was seen as very unlikely to contribute, on balance, to the achievement of the Committee's objectives over time."

13. I assume that there are no causal paths from mortgage loan growth to monetary policy that do not operate via GDP growth or via changes in mortgage rates. Also, it is assumed that monetary policy has no contemporaneous effect on GDP growth.

14. Distinct in the sense that the cross-sectional differences in loan growth affect policy directly, or via some indirect causal path that does not include GDP growth or changes in mortgage rates, which are included in my regressions.

Historically, thrifts have belonged to the FHLB system which provides facilities similar to the Fed discount window. Member banks are able to obtain advances against suitable collateral (whole loans, mortgage-backed and other government securities) not only to meet unforeseen liquidity needs, but also as a means of financing day-to-day lending activity.[15] An important feature of this facility is that it is not discriminatory: the smallest community thrifts enjoy access similar to that of the largest national lenders.[16] This is in contrast to sources of wholesale funding such as the Fed Funds market or large denomination (uninsured) CDs—the usage of which is heavily skewed toward large institutions. Many thrifts make regular use of FHLB advances as a source of wholesale funding, and this usage is not inconsequential: at the end of my sample period FHLB advances totaled approximately $650 billion.[17] The onset of the crisis demonstrated the significance of the FHLB facility: advances approached the $1 trillion mark in 2007. Thus, it may be that the mechanisms affecting thrifts' supply of credit are heavily influenced by the existence of this facility.

I do not have an empirical refutation of this FHLB-based explanation. However, since the Financial Institutions Reform Recovery and Enforcement Act (FIRREA) of 1989, FHLB membership has been open to commercial banks with at least 10% of assets in mortgage products—a relatively low bar.[18] In the ensuing years, membership (and advances) to commercial banks have grown rapidly. Overwhelmingly, system members have large amounts of uncommitted collateral and make use of FHLB ad-

15. FHLB advances do not have the "frown costs" of the discount window, they enjoy a "super-lien" on bank assets (no default has never occurred), and are subsidized due to implicit government guarantees on the FHLB system's liabilities. Thrifts' increasing use of these advances (see Tables 3.1 and 3.2), suggests that they represent an attractive funding source, although direct comparison of FHLB borrowing costs to other sources of wholesale funding (or to the discount window) is somewhat complicated as advances require a simultaneous purchase of FHLB equity shares (Ashcraft, Bech, and Frame (2010) provide a discussion).

16. Subject to each Federal Home Loan Bank's specific credit standards. Due to the collateralized nature of the advances and FHLB's "super-lien" alluded to in the previous footnote, there is little incentive for extensive monitoring.

17. Data on aggregate FHLB usage is available through the FHLB's Office of Finance. Each thrift's usage of FHLB facility is reported on the TFR.

18. At the start of my sample period, commercial banks' real estate lending represented approximately 30% of commercial bank assets.

vances to fund commercial loans.[19] Thus, it is unlikely that FHLB advances set thrifts apart.

Conclusion

Does monetary policy affect banks' credit supply? Does tight money constrain certain banks more than others? These questions are key to understanding the credit channels of monetary policy transmission. Using bank-level and loan-level data on U.S. mortgage lending, I am able to examine these questions in a setting where bank-specific credit demand can be controlled. I find that policy has more pronounced effects at large banks rather than at small banks, contrary to the predictions of traditional bank lending channel theory. My findings suggest that conceptions of the bank lending channel of monetary policy transmission should not be taken for granted—I find no evidence to suggest that conventional—reserve-based—mechanisms play a significant role in banks' supply of credit. However, my findings are consistent with bank health playing a role in monetary transmission and suggests that monetary policy's effects on the markets for bank liabilities has potentially important consequences for policy.

19. Legally, usage of FHLB advances is restricted to residential lending; the frangibility of money makes this impossible to enforce (or even define). The empirical evidence suggests that banks use this facility as if it were a general wholesale lending facility, see Frame, Hancock, and Passmore (2007) for details.

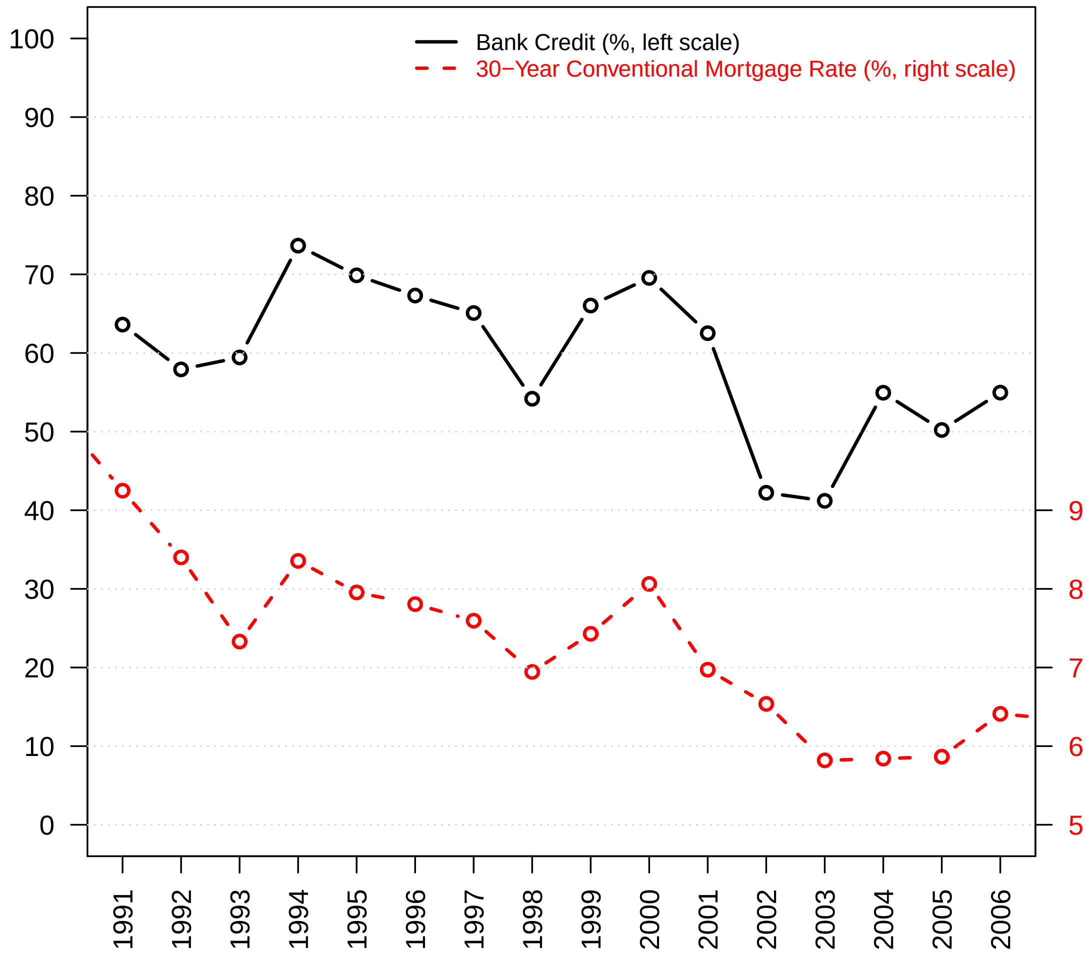

Figure 3.1: Mortgage rates and on-balance-sheet lending

Figure 3.1 plots the percentage of bank-originated mortgage loans funded through bank balance sheets along with the average thirty-year conventional mortgage rate. The former is calculated from banks' loan-level HMDA filings which contain information on whether an originated loan was sold. The mortgage rate is from the Freddie Mac Primary Mortgage Market Survey.

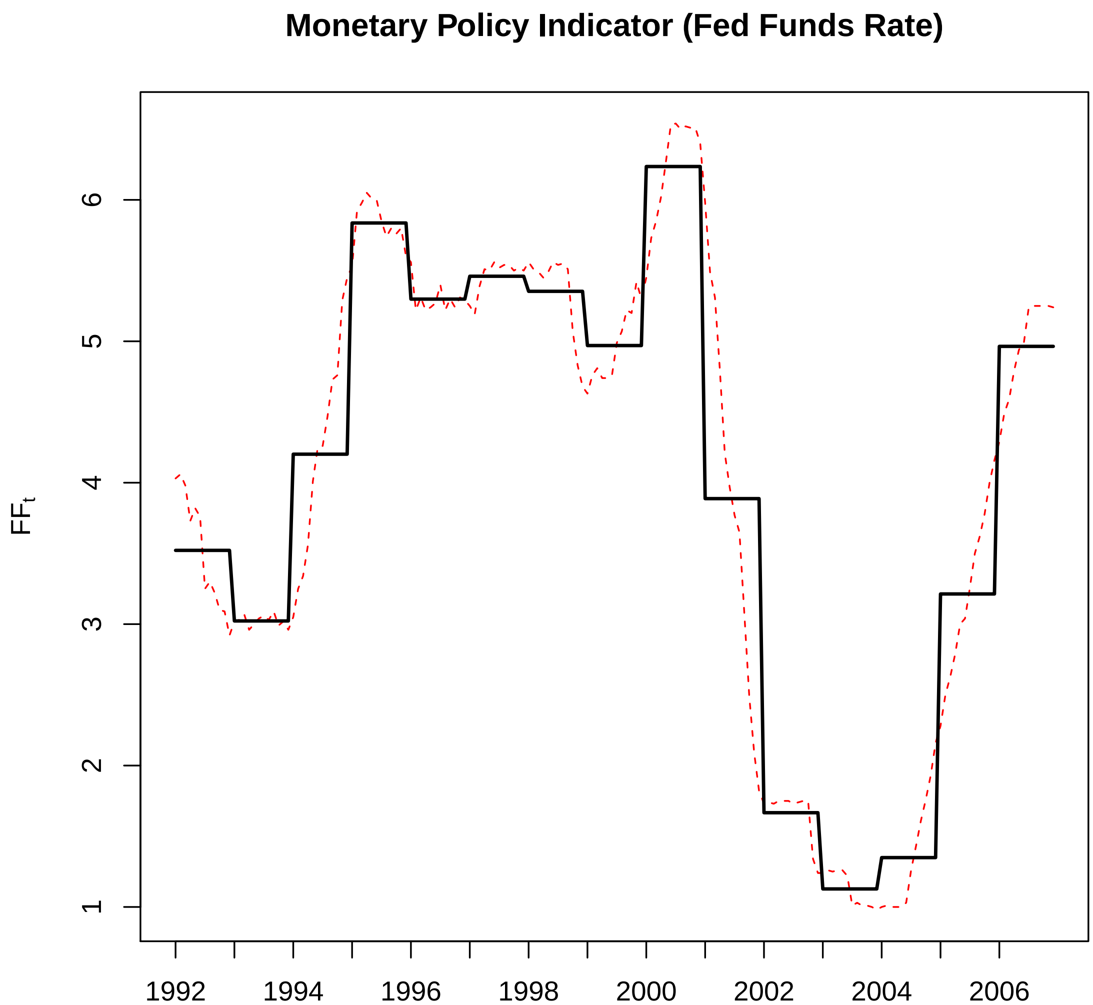

Figure 3.2: The Fed Funds rate

Figure 3.2 plots the monthly Fed Funds rate, together with its annual average. The change in annual average Fed Funds rate, ΔFF_t, is the monetary policy indicator used throughout the analysis.

Table 3.1: Aggregate balance sheets of banks in each size category (1992:IV)

	Below 75th percentile	Between 75th–95th percentile	Above 95th percentile
Mid_i	0	1	0
$Large_i$	0	0	1
Number of thrifts	1464	391	98
Mean assets ($ million)	85	563	5196
Median assets ($ million)	69	456	2906
Percent of total thrift assets	15	26	60
Assets	100	100	100
Cash	8	5	2
Interest bearing	7	3	1
Securities	21	28	25
FedFunds lent	1	1	1
Loans	64	59	63
Real estate loans	49	42	45
Consumer loans	4	3	4
C&I loans	1	1	1
Other assets	5	7	9
Liabilities and equity	100	100	100
Deposits	88	84	75
Insured deposits	85	80	71
Core deposits	81	77	66
Brokered deposits	0	1	2
FedFunds borrowed	0	1	4
Subordinated debt	0	0	1
Other liabilities	4	8	15
FHLB advances	3	6	10
Equity	7	7	6

Table 3.1 shows the aggregate balance sheet composition of banks in each size category as of 1992:IV. All balance sheet items are reported as a fraction of total assets. The size categories $Small_t$, Med_t, and Big_t are formed based on cutoffs at the 75^{th} and 95^{th} percentile of the bank size distribution at time t.

Table 3.2: Aggregate balance sheets of banks in each size category (2006:IV)

	Below 75th percentile	Between 75th–95th percentile	Above 95th percentile
Mid_i	0	1	0
$Large_i$	0	0	1
Number of thrifts	612	164	41
Mean assets ($ million)	144	1167	28815
Median assets ($ million)	118	878	14292
Percent of total thrift assets	6	13	81
Assets	100	100	100
Cash	5	4	2
Interest bearing	4	2	0
Securities	17	17	16
FedFunds lent	1	1	2
Loans	71	72	72
Real estate loans	45	35	53
Consumer loans	3	5	6
C&I loans	3	4	4
Other assets	5	6	9
Liabilities and equity	100	100	100
Deposits	76	71	57
Insured deposits	65	57	44
Core deposits	54	46	35
Brokered deposits	2	5	8
FedFunds borrowed	1	2	5
Subordinated debt	0	0	1
Other liabilities	11	16	24
FHLB advances	10	14	17
Equity	12	11	13

Table 3.2 shows the aggregate balance sheet composition of banks in each size category as of 2006:IV. All balance sheet items are reported as a fraction of total assets. The size categories $Small_t$, Med_t, and Big_t are formed based on cutoffs at the 75th and 95th percentile of the bank size distribution at time t.

Table 3.3: Regressions of mortgage loan growth on monetary policy shocks

	Specification					
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV	(6) IV/FE
ΔFF_t	0.008	0.002	0.023	0.014	0.014	
	(0.003)***	(0.003)	(0.003)***	(0.003)***	(0.003)***	
$\Delta FF_t \times Med_{it}$	-0.002	0.003	-0.011	-0.005	-0.005	-0.004
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta FF_t \times Big_{it}$	-0.046	-0.049	-0.054	-0.060	-0.060	-0.057
	(0.017)***	(0.019)**	(0.021)**	(0.021)***	(0.021)***	(0.021)***
$\Delta FF_t \times B_{it-1}$	-0.002	-0.002	-0.015	-0.013	-0.013	-0.013
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$\Delta FF_t \times B_{it-1} \times Med_{it}$	0.024	0.024	0.046	0.046	0.044	0.045
	(0.027)	(0.027)	(0.023)**	(0.023)**	(0.023)*	(0.023)*
$\Delta FF_t \times B_{it-1} \times Big_{it}$	0.139	0.138	0.181	0.184	0.183	0.185
	(0.056)**	(0.056)**	(0.072)**	(0.071)**	(0.071)**	(0.071)***
B_{it-1}	0.175	0.175	0.052	0.049	0.056	0.063
	(0.066)***	(0.065)***	(0.065)	(0.065)	(0.069)	(0.068)
$B_{it-1} \times Med_{it}$	-0.315	-0.315	-0.157	-0.152	-0.153	-0.160
	(0.166)*	(0.166)*	(0.150)	(0.149)	(0.154)	(0.154)
$B_{it-1} \times Big_{it}$	-0.678	-0.640	-0.445	-0.340	-0.354	-0.379
	(0.271)**	(0.285)**	(0.400)	(0.424)	(0.425)	(0.411)
$\Delta log(GDP_t)$	0.936	0.904	0.249	0.151	0.083	
	(0.357)***	(0.356)**	(0.407)	(0.404)	(0.419)	
$\Delta log(GDP_t) \times Med_{it}$	-0.172	-0.134	0.413	0.502	0.437	0.257
	(0.916)	(0.914)	(0.873)	(0.871)	(0.895)	(0.893)
$\Delta log(GDP_t) \times Big_{it}$	0.257	0.486	1.503	2.041	2.083	1.607
	(1.955)	(1.968)	(2.167)	(2.196)	(2.202)	(2.105)
ΔMTG_t		0.022		0.037	0.037	
		(0.003)***		(0.004)***	(0.004)***	
$\Delta MTG_t \times Med_{it}$		-0.018		-0.023	-0.022	-0.022
		(0.010)*		(0.010)**	(0.010)**	(0.010)**
$\Delta MTG_t \times Big_{it}$		0.009		0.013	0.013	0.011
		(0.026)		(0.025)	(0.025)	(0.025)
$\Delta log(L_{it-1})$	0.234	0.237	0.216	0.222	0.223	0.224
	(0.026)***	(0.027)***	(0.031)***	(0.031)***	(0.032)***	(0.032)***
$\Delta log(Apps_{it})$			0.071	0.074	0.074	0.080
			(0.005)***	(0.005)***	(0.005)***	(0.006)***
N	12711	12711	8431	8431	8268	8268
R^2	0.097	0.100	0.148	0.156	0.157	0.145

Table 3.3 shows the results of bank-year dynamic panel regressions where the dependent variable is on-balance-sheet residential mortgage loan growth, $\Delta log(L_{it})$. Covariates include the change in the average annual Fed Funds rate, ΔFF_t, the change in the thirty-year conventional mortgage rate, ΔMTG_t, GDP growth, $\Delta log(GDP_t)$, bank-level application growth, $\Delta log(Apps_{it})$, bank's balance sheet liquidity, B_{it}, size category dummies, Big_{it} and Med_{it}, Federal Reserve District dummies (not reported), linear time trends (not reported), as well as various interactions. In the specifications reported in columns (5) and (6), bank-level application growth, $\Delta log(Apps_{it})$ is instrumented by local application growth in the MSAs where the bank lends ($IVApps_{it}$, described in Section 3.2). The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

Table 3.4: Regressions of mortgage loan growth on monetary policy shocks fit separately for bank capitalization sub-samples

	Low Capital ($< 50^{\text{th}}$ percentile)	High Capital ($> 50^{\text{th}}$ percentile)
$\Delta FF_t \times Med_{it}$	-0.009	-0.001
	(0.010)	(0.012)
$\Delta FF_t \times Big_{it}$	-0.069	0.028
	(0.022)***	(0.046)
$\Delta FF_t \times B_{it-1}$	-0.029	0.001
	(0.022)	(0.009)
$\Delta FF_t \times B_{it-1} \times Med_{it}$	0.054	0.040
	(0.038)	(0.032)
$\Delta FF_t \times B_{it-1} \times Big_{it}$	0.209	0.017
	(0.078)***	(0.143)
B_{it-1}	-0.005	0.085
	(0.118)	(0.081)
$B_{it-1} \times Med_{it}$	0.145	-0.396
	(0.247)	(0.195)**
$B_{it-1} \times Big_{it}$	-0.404	1.268
	(0.466)	(1.335)
$\Delta log(GDP_t) \times Med_{it}$	1.358	-0.592
	(1.229)	(1.256)
$\Delta log(GDP_t) \times Big_{it}$	1.605	9.632
	(2.283)	(12.096)
$\Delta MTG_t \times Med_{it}$	-0.021	-0.023
	(0.015)	(0.013)*
$\Delta MTG_t \times Big_{it}$	0.016	0.024
	(0.027)	(0.049)
$\Delta log(L_{it-1})$	0.185	0.292
	(0.043)***	(0.041)***
$\Delta log(Apps_{it})$	0.074	0.084
	(0.008)***	(0.007)***
N	4382	3881
R^2	0.128	0.182

Table 3.4 shows the results of bank-year dynamic panel regressions where the dependent variable is on-balance-sheet residential mortgage loan growth, $\Delta log(L_{it})$. The two columns correspond to estimates obtained from (approximately) equal-sized disjoint sub-samples constructed by sorting banks on leverage ratio (Tier 1 capital to total assets). In the left column, the estimates from the sub-sample consisting of banks below the 50^{th} percentile are reported. In the right column, estimates from the sub-sample consisting of banks above the 50^{th} percentile are reported. The regression specification is the same as that of column (6) in Table 3.3. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

Table 3.5: Quarterly regressions of loan growth on monetary policy shocks

	Specification (1)	(2)	(3)	(4)
Small Banks	0.000	-0.000	-0.007	-0.008
	(0.009)	(0.009)	(0.010)	(0.010)
Medium Banks	0.046	0.044	0.030	0.029
	(0.020)**	(0.019)**	(0.017)*	(0.017)*
Big Banks	0.076	0.075	0.039	0.036
	(0.050)	(0.050)	(0.043)	(0.042)
Medium - Small	0.046	0.045	0.036	0.036
	(0.022)**	(0.022)**	(0.020)*	(0.020)*
Big - Small	0.076	0.076	0.046	0.043
	(0.051)	(0.051)	(0.044)	(0.043)
$\Delta MTG_{it-\tau}$		Yes		Yes
$\Delta log(Apps_{it-4})$			Yes	Yes
N	55543	55543	35192	35192
R^2	0.084	0.085	0.078	0.079

Table 3.5 shows the results of bank-quarter dynamic panel regressions where the dependent variable is on-balance-sheet residential loan growth. The regression specification corresponds to the the "one-step" estimate in Anil K Kashyap and Stein (2000):

$$\Delta log(L_{it}) = \sum_{j=1}^{4} \alpha_j log(L_{it-j}) + \sum_{j=0}^{4} \mu_j \Delta FF_{t-j} + \sum_{j=0}^{4} \pi_j \Delta GDP_{t-j} + \Theta TIME_t + \sum_{k=1}^{3} \rho_k QUARTER_{kt}$$
$$+ B_{it-1}\left(\eta + \delta TIME_t + \sum_{j=0}^{4} \phi_j \Delta FF_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta GDP_{t-j}\right) + \varepsilon_{it}.$$

The regression is fit separately for banks in each size category. Reported are estimates of $\sum_{j=0}^{4} \phi_j$ and the differences in these estimates across the bank size categories. These coefficients represent the degree to which balance sheet liquidity mitigates the effects of policy. Column (1) shows the estimates from the standard specification; columns (2), (3), and (4), include additional (non-standard) controls. In all cases, balance sheet liquidity plays a larger role in mitigating the effects of policy shocks at larger banks. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

CHAPTER IV

Monetary Policy and Banks' Risk-Taking

4.1 Introduction

Does loose monetary policy contribute to *excessive* risk-taking by financial intermediaries? The recent financial crises in the U.S. and Europe have reignited interest in this question—one which has important implications for the future conduct of monetary policy and the design of macro-prudential regulation. In this chapter, I use loan-level data on banks' lending in the run-up to the 2008 financial crisis to examine how banks' risk-taking responds to monetary policy. I find that the traditional proxy for a bank's exposure to agency problems—capitalization—is a key determinant in a bank's response: banks with low capital levels increase risk-taking following a monetary expansion by much more than their better-capitalized peers, suggesting that bank owners' incentives to *risk shift*—to take more risk than they would in the absence of bank debt—are exacerbated by loose policy. My approach is the first to use U.S. loan-level data to measure banks' risk-taking from *contemporaneous* underwriting standards, allowing me to exploit within-bank variation in risk-taking. As in the previous chapter, I analyze data on thrifts—banks that specialize in mortgage lending. By focusing on thrifts, I avoid undesirable heterogeneity in banks' business models, lending opportunities, and portfolios that complicate analyses of the broader bank population. My study makes contributions to the understanding of monetary policy transmission, the causes of financial crises, and the efficient design macro-prudential regulation.

It is widely recognized that credit expansions are associated with financial crises.[1] Monetary policy that is "too loose" is frequently implicated in contributing to excessive credit growth. Most recently, in the European debt crisis, many commentators have blamed the one size fits all monetary policy of the Euro area for fueling excessive credit growth in the periphery (where economic conditions warranted higher rates) while too loose monetary policy in the U.S. has been blamed for fueling the housing boom that led to the sub-prime crisis. Empirical evidence for such claims have been provided by Taylor (2008) (in the U.S. context), and Maddaloni and Peydró (2011) (for U.S. and Europe). In these studies, the notion that policy is too loose is fundamentally macro-economic: it is based on the idea that the level of the policy rate is inappropriate for the given macro-economic conditions.[2] However, although it is not difficult to see how policy that is too low can lead to inefficient allocations, losses in social welfare, and inflation, it is far from obvious how it can explain the types of spectacular excesses that have characterized the recent crises.[3] A natural place to look for such explanations are distorted incentives stemming from agency problems in the financial sector.

1. Schularick and Taylor (2009) demonstrate that credit growth is a powerful predictor of crises using a historical data set covering fourteen countries over the 1870–2008 period. A more narrative argument is provided in Kindleberger (1978), who devotes a chapter to the role of credit expansion in the development of financial crisis, echoing the arguments of Minsky (1986). Earlier commentators including Smith (1776) and Schumpeter (1934) also stress the role of credit expansion, or "overtrading".

2. Both focus on Taylor rule residuals, which—presumably—represent deviations from the appropriate (or "natural") level for the policy rate.

3. Asset price bubbles and "speculative frenzies" have been noted as the hallmarks of financial crises by economic historians (see previous footnote). The recent housing crises in U.S. and Europe have generated countless anecdotes in the financial press about lending behavior that (in hindsight) appear to have defied business sense. These include "LIAR" loans, loans without (or with negative) equity, loans with payments that exceed borrowers' income, etc. Such excesses receive only limited treatment in the macro-economic literature, and when they are considered, they are often treated as the results of an exogenous process that (for unspecified reasons) generates deviations in asset prices away from "fundamentals" (see for example, Bernanke and Gertler (1989) and Bernanke and Gertler (2001)).

Agency problems are one of the central concerns of the corporate finance literature. A bank, being a highly levered firm with a investments that are difficult to monitor, is particularly exposed to agency conflict between its equity-holders (the bank's owners) and its debt-holders (mainly, the depositors). Leverage, coupled and limited liability means that bank owners hold option-like claims on the banks' cash flows (Merton (1977)). As a result, increasing the volatility of a bank's assets increases the value of the owners' claims. Thus, substituting risky assets for safe assets may benefit a bank's owners, even if such substitutions lead to reductions in the value of total bank assets; owners may even benefit from funding negative-NPV projects (Jensen and Meckling (1976)).

Financial theory would suggest that bank owners' incentives to risk-shift—-to invest in inferior assets at the expense of debt-holders—would be recognized by rational debt-holders (i.e. depositors) who would then demand additional returns, require monitoring or audits, or simply withdraw funding. In any case, a bank's owners would bear the costs of agency ex-ante, and ex-post occurrences of risk-shifting would not—in themselves—be a matter of great concern: they would simply be a manifestation of the second best.

However, there are reasons to suspect that banks' financing arrangements do not represent optimal contracting in any conventional sense. Banks are unique: their liabilities serve as money and consequently banks play a critical role in the payments system. Because the payments system is indispensable to the functioning of the economy, banks have historically received considerable attention from government regulators: very little in banking has been uninfluenced by regulation. Banks are—or have at one point—been subject to restrictions on the types of liabilities they may issue, the pricing of their liabilities, and the composition of their assets. They have also enjoyed unique benefits such as access to the lender of last resort, mis–priced deposit insurance, and various implicit government guarantees. Given that the banks' regulatory environment is shaped by political—rather than economic—forces and considering the important role that banks play in the allocation of capital, deficiencies in the "design" of this regulatory system has potentially large welfare implications.[4]

In particular, government's provision of guarantees for bank deposits and for the banking system as a whole has important implications on the significance of risk-shifting problems in banking. Depositors who bear little risk have minimal incentive to monitor; if the government fails to provide the requisite level of monitoring, bank owners' risk-shifting incentives can lead to excessive risk-taking. The Savings and Loan Crisis of the late 1980s and early 1990s provided a dramatic demonstration of how such agency problems can lead to inefficient allocations and significant financial disruptions (Keeley (1990), Barth (1991)). The subsequent adoption of Basel capital requirements was aimed in part at alleviating the agency problems resulting from high leverage.

While risk-shifting and bank capital have received considerable attention in the literature, their interaction with monetary policy has not.[5] Although loose monetary policy is frequently associated with banking crises, its effects on the agency problems between bank owners and debt-holders are theoretically ambiguous. By increasing liquidity in the banking system, loose policy can abet risk-shifting by propping up the value of risky assets (as in Allen and Gale (2000)) or by decreasing agents' risk perceptions (as in Farhi and Tirole (2012)). Loose policy may also increase opportunities for risk-shifting as investors' "search for yield" (Minsky (1986), Rajan (2006)) reduces their monitoring incentives. On the other hand, by increasing the value of risky assets and by widening bank intermediation spreads, loose policy can raise banks' net-worth and thereby reduce the motive to risk-shift (Dell'Ariccia, Laeven, and Marquez (2011), De Nicolò et al. (2010)). Thus, the effect of monetary policy on

4. More complete arguments to this effect can be found in Kane (1986).

5. For an analysis of the risk-taking–bank capital relationship, see Calem and Rob (1999).

banks owners' risk-shifting incentives is ultimately an empirical question. The goal of this analysis is to distinguish between some of these competing hypotheses.

This study contributes to the emerging literature on the *risk-taking channel* of monetary policy transmission. Coined by Borio and Zhu (2012), the risk-taking channel covers a range of mechanisms through which monetary policy may affect the risk perceptions or risk-tolerance of economic agents, leading to real effects on the economy. The potential mechanisms are diverse and have distinct implications for policy—thus, differentiating between them is important. For example, the simplest way in which a risk-taking channel can operate is via banks' portfolio optimization problem. Under fairly general conditions, and in the absence of additional financial frictions, reductions in the return on the risk-free asset leads economic agents to tilt their portfolios toward riskier assets.[6] In this setting, observed changes in risk-taking following a monetary loosening would be entirely appropriate (i.e. efficient) and would not warrant concern or regulatory action. Similarly, if agency problems are absent, but liquidation is costly, risk-neutral, value-maximizing banks would act in a risk-averse manner. The degree of a bank's effective risk-aversion would be determined by its proximity to the default boundary: if a bank had low net worth, its effective risk aversion would be high. Thus, under-capitalized banks would avoid risky projects and their portfolios would be relatively insensitive to changes in policy.[7] Finding such a pattern in the data would suggest that too little risk (relative to the fist-best without liquidation costs) was undertaken by the banks, and that loose monetary policy does not contribute to excessive risk-taking. Alternatively, if banks are subject

6. The general conditions being decreasing relative risk aversion which ensures that increases to wealth leads to higher risk tolerance. The absence of frictions is not complete as some frictions—sticky prices or wages—are assumed for the sake of non-neutrality of money (as in Ball, Mankiw, and Romer (1988). The absence of *additional* frictions refers to frictions—such as agency problems—in the financial sector.

7. Stiglitz and Greenwald (2003) develop one such model. Well-capitalized banks (efficiently) hold more risk and (efficiently) respond to loose policy by increasing risk-taking based on the portfolio considerations. Under-capitalized banks' effective risk aversion is too high (relative to first best with no liquidation costs). There is an implicit assumption that the net-worth effects of monetary policy are not large enough to materially change an under-capitalized bank's level of effective risk-aversion.

to agency problems of the risk-shifting type, these problems may be exacerbated by loose policy. For example, bank debt-holders may have nominal yield targets which facilitates financing for banks pursuing high risk strategies when nominal yields are low. In this case, one would expect to observe risk-taking that is higher and more responsive to policy at under-capitalized banks. Finding this pattern would suggest that regulatory arrangements are inadequate, and that loose policy contributes to excessive risk-taking. The focus here shall be on this last—less benign—mechanism; key to its identification are interactions between monetary policy, bank capital, and risk-taking.[8]

My approach is to examine this mechanism by exploiting loan-level data on U.S. thrifts' mortgage lending. Thrifts are relatively undiversified banks, with a heavy concentration in residential mortgage loans.[9] Because provisions of the Home Mortgage Disclosure Act require mortgage lenders to disclose loan-level detail on mortgage applications and their disposition, thrifts provide a unique opportunity to examine the evolution of risk-taking at the bank level. Using these disclosures, I measure each bank's risk-taking using underwriting standards revealed through each bank's propensity to approve a constant quality loan and banks' exposures to their borrowers local economic risks. I find that banks' risk-taking response to monetary policy is mediated by bank capitalization: banks with low capital have a more pronounced response to policy: their risk-taking increases considerably following a loosening while at their better-capitalized peers, risk-taking is largely unchanged. My findings are broadly consistent with the key premise of the risk-taking channel of monetary policy

8. Throughout, I focus on the agency problem between bank owners and debt-holders. Alternatively, agency issues between bank owners and managers can produce excessive risk-taking. Acharya and Naqvi (2012) develop a model where the agency problem originates in bank owners' reluctance to audit bank managers' effort; consequently, audits only occur when there is a liquidity shortage. In their model, the managers' equilibrium compensation contract is based on loan volume, so managers take excessive risk if audits are unlikely to occur. Savers' preference for bank deposits over direct investment (say in turbulent economic conditions) and abundant central bank liquidity decrease the risk of such an audit.

9. Thrifts are described in Chapter II.

transmission: loose policy increases risk-taking. More importantly, this increase is most pronounced where agency problems are most severe, suggesting that loose policy aggravates certain agency problems.

The interactions between bank capital and monetary policy have previously been explored in the literature on the credit channels of monetary policy transmission (Bernanke and Gertler (1995)). There, the focus has been on banks' capital constraint limiting the effectiveness of the bank lending channel (Kishan and Opiela (2000), Kishan and Opiela (2006)) and on monetary policy's impact on banks' capital constraints (Van den Heuvel (2002)).[10]. These effects have been referred to as the *bank capital channel*, and the associated literature has—as with the bank lending channel—explored how monetary policy affects the *quantity* of loans that banks can supply, but has largely ignored implications on the *quality* of banks' lending.

Studies of the quality of banks' lending in response to monetary policy are limited. Maddaloni and Peydró (2011) use loan officer surveys in the U.S. and Euro-area to examine aggregate measures of lending standards. They find that low short-term rates soften lending standards while low long-term rates do not, suggesting that monetary policy plays a special role in banks' risk-taking.[11] The approach here is more like that of Jiménez et al. (2010), who use extensive loan-level data on Spanish banks' lending to examine the effects of monetary policy on the cross-section of banks' risk-taking. They too find that low capital banks increase risk-taking more in response to loose policy.

The rest of this chapter is organized as follows. In the next section, I describe the empirical strategy and data. In Section 4.3, I discuss my results. In the final section I conclude with a discussion of the findings.

10. In the former, a bank subject to a binding capital constraint cannot increase the supply of loans in response to an increased availability of reserves. In the latter, monetary policy alters banks' capital constraints through its effects on asset prices and net interest margins.

11. Although Lown and Morgan (2006) failed to find such effects using similar data.

4.2 Empirical Strategy

The goal of this analysis is to identify cross-sectional differences in the risk-taking response to monetary policy of banks subject to varying degrees of agency problems. Of particular interest is the response of banks with a relatively large exposure to agency problems.

Bank's exposure to agency problems is not directly observable, and as is common in the literature, I proxy agency problems by a measure of the banks' capitalization, specifically the leverage ratio. I divide banks into three capitalization categories based on their leverage, with cutoffs at the 5% and 10% level.

My analysis of changes in the banks' risk-taking employs a similar identification strategy to the one used in my study of banks' quantity response (see Section 3.2). Here, the focus is on changes to banks' risk-taking, Γ_{it}, in response to changes in monetary policy, ΔFF_t. I mainly rely on dynamic panel regressions of the following form:

$$\Gamma_{it} = \alpha + \sum_{\tau=0} \varphi_\tau \Gamma_{it-\tau} + \sum_{\tau=0} \beta_\tau \Delta FF_{t-\tau} + \delta D_{it} + \sum_{\tau=0} \gamma_\tau \Delta FF_{t-\tau} * D_{it} + \sum_{j} \gamma_j X_{jt} + \varepsilon_{it}. \tag{4.1}$$

The dynamic panel structure is used to take account of partial adjustment to bank's risk-taking policy arising from adjustment costs: changing lending practices may requires costly action (e.g. retraining loan officers) whereas continuing with the *status quo* involves no upfront costs. The change in the policy rate (here, the Fed Funds rate), ΔFF_t, is the monetary policy indicator. X_{jt} are other macroeconomic and bank-level variables intended to control for demand effects: GDP growth, long-term mortgage rates, and bank-level growth in loan demand.

To measure growth in a bank's loan demand, I start by using HMDA data to total the dollar amount of a banks' loan applications in a given year. This yields a measure of the demand for bank credit faced by each bank, $Apps_{it}$. To measure credit demand growth, I take the difference in logs of this measure. As a bank's applications may be endogenous to its ability to supply credit, I instrument each bank's loan demand using the local demand in the areas where each bank lends.[12]

The controls are interacted with the category dummies to allow for arbitrary category-level differences in the coefficients. The lag structure is assumed to be AR(1). For the most part, I maintain the assumption of no bank fixed effects, implying within-category homogeneity in unconditional expected loan growth rates. Doing so assumes away the problems of fixed effects in dynamic panel models described in Nickell (1981). The coefficients of most interest are on the category dummy interactions, i.e. the γ_τs.

The main problem here is one of measurement: how can risk-taking be observed? In most studies of banking, risk-taking is unobservable; here however, the HMDA loan-level data provides a unique opportunity to do so. Because this data includes information on applicant characteristics as well as the banks' loan approval decisions, it can be used to construct proxies for bank's underwriting standards. To do so, I first estimate a loan approval model, $\mathcal{M}$, using application data from all banks (including out-of-sample banks) over the entire sample period (I exclude non-bank originations and OTD loans). I then use this model to score each (in-sample) bank's loan applications; the extent to which a bank approves more loans that the model predicts represents the (relative) laxness of its underwriting standards.

To estimate the loan approval model, $\mathcal{M}$, I fit a logistic regression:

$$\mathbb{E}[approved_j|\mathbf{W}_j] = logit^{-1}(\beta \cdot \mathbf{W}_j + \epsilon_j), \tag{4.2}$$

where j indexes over the loan applications, $approved_j$ is an indicator variable indicating whether the loan was approved, and $\mathbf{W}_j$ is a vector of application characteristics. This model gives the estimated probability of a loan with a certain set of character-

12. Additional details on the construction of these measures can be found in Chapter III.

istics, $\mathbf{W}_j$, being approved:

$$\hat{\mathbb{E}}_{\mathcal{M}}[approved_j|\mathbf{W}_j] = logit^{-1}(\beta_s \cdot \mathbf{W}_j).$$

With the loan approval model, $\mathcal{M}$, I estimate a bank's risk-taking Γ_{it}, as the ratio of the bank's realized approval rate on its applications from that year to the expected approval rate predicted by the model on the same applications:

$$\Gamma_{it} = \frac{\left(\sum_{j \in A_{it}} approved_j\right)}{\left(\sum_{j \in A_{it}} \hat{\mathbb{E}}_{\mathcal{M}}[approved_j|\mathbf{W}_j]\right)}.$$

My measure of risk-taking can be interpreted as a bank's propensity to "over-approve" loan applications. An over-approval ratio of $\Gamma_{it} = 1.05$ indicates that the bank approved 5% more of its loan applications than the model predicted.

The application characteristics that I include in the loan approval model attempt to capture factors relevant to underwriting subject to the limitations of the HMDA data. Along with these, I include dummies for the applicant's MSA (interacted with all subsequent variables) to allow for arbitrary geographic differences in the underwriting model. I include dummies indicating whether the loan had a high (above 28%) or medium (above 20%) payment-to-income (PTI) ratio (as calculated from the loan amount and the prevailing 30-year conventional mortgage rate), and the ratio of borrower's income to his MSA's median to proxy for the borrower's relative financial strength. I also include dummies indicating whether the loan is for an owner-occupied residence or a refinancing. Finally, I include a dummy indicating whether the borrower is black or Hispanic: this serves as a proxy for the borrower's credit history (interacted with all other variables).[13]

13. Borrowers' actual credit scores are a prominent omission from the HMDA reports; this has led to considerable debate about the degree to which racial and ethnic disparities in lenders' denial rates can be attributed to discrimination. Munnell et al. (1996) analyzed a subset of the HMDA data that was augmented with credit scores and other borrower characteristics. They conclude that "minority

Figure 4.1 plots the time series of median changes in banks' over-approval rates for my sample. The pattern does not reveal any obvious secular trends. In Figure 4.2, I plot the median change in over-approval rates against changes in the Fed Funds rate; this reveals a positive association between increases in over-approval rates and monetary loosening.

In addition to the risk measure based on banks' over-approval rates, I also consider the risk originating in banks' exposure to the local economic conditions faced by their borrowers. The risks from the geographic composition of banks' lending has recently received considerable attention: Mian and Sufi (2009) has argued that the Sub-prime crisis can be traced back to growth of mortgage credit in neighborhoods with stagnant (or declining) income growth. Similarly, Anderson, Capozza, and Van Order (2011) attribute much of the mortgage melt-down to the extension of credit in areas with poor economic fundamentals, potentially resulting from banks' mis-estimation of default risks.[14]

To get at this geographic aspect of banks' risk exposures, I begin with the *Life Of Loan Default* metric from University Financial Associates LLC (UFA). Estimated from loan-level foreclosure experience of securitized loans, this metric assess the *relative* default risk of a loan originated in a given ZIP-code in a given year.[15] [16]

I convert these ZIP-code-level metrics to census-tract-level using "crosswalk" map-

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applicants, on average, do have less wealth, weaker credit histories, and higher loan-to-value ratios than white applicants, and that these disadvantages do account for a large portion of the difference in denial rates." These findings suggest that in my analysis—to the extent that lenders' propensity to discriminate is not a function of monetary policy—race and ethnicity are reasonable proxies for applicants' credit histories.

14. See also Murfin (2012), who provide evidence that banks adjusted underwriting standards to recent loan loss experience.

15. The UFA life-of-loan default multipliers, capture the *relative* default experience of a constant-quality loan originated at different times and in different places. That is, if $LOL_{60606,2005:9} = 1.5$ and $LOL_{48105,2009:12} = 1.0$, then a loan originated in September 2005 for a property in ZIP-code 60606 would be expected to default at a rate approximately 1.5 times greater than a similar loan originated in December of 2009 in ZIP-code 48105.

16. The UFA metrics are provided at a monthly frequency. I annualize them by weighing the monthly data by the U.S. Census *New One Family Houses Sold* series. The metrics are multipliers, with 1 corresponding to the average default rate in the 1990s. Additional details can be found in the appendix of Anderson, Capozza, and Van Order (2011).

pings provided by the U.S. Department of Housing and Urban Development.[17] This yields a series of life of loan default multiplier vectors, $\mathbf{d}_t$ (i.e. each *element* of $\mathbf{d}_t$ corresponds to a census tract).

Next, I use each banks annual loan application registers (LARs) to construct portfolio weight-vectors, $\mathbf{w}_{it}$, where each element of $\mathbf{w}_{it}$ contains the fraction of bank-year i, t's loan originations (and purchases) that occurred in a particular census tract.[18] I use the dollar value of loan originations and purchases to compute the weights.

With the preceding definitions,

$$\mathbf{w}_{it} \cdot \mathbf{d}_t,$$

can be said to measure bank i's exposure to *local risks* from its loan originations (and acquisitions) in period t. For the purposes of measuring a bank's *response* to macro-economic conditions, this measure has a problem: it captures *passive* changes to a bank's risk exposure. That is, banks with constant loan origination policies will experience changes to their local risk exposure due to changes in local economic conditions, (i.e. due to changes in the $\mathbf{d}_t$ vector). To capture only the *active* aspect of a bank's risk exposure—the exposure arising from a bank's actions (i.e. changes in loan origination policies)—I define a slightly different measure, the *active local risk exposure*:

$$\Lambda_{it} \equiv (\Delta \mathbf{w}_{it}) \cdot \mathbf{d}_t.$$

Whereas the over-approval rate, Γ_{it}, is intended to capture risks arising from a bank's decision as to *whom* to lend to, the active local risk, Λ_{it}, is intended to capture changes to the risk arising from banks' decisions as to *where* to lend.

The identification strategy here amounts to a generalized difference-in-difference

17. These files may be found at `http://www.huduser.org/portal/datasets/usps_crosswalk.html`.

18. The LARs are from the Home Mortgage Disclosure Act filings are described in Section 2.2.

approach. That is, I examine cross-category differences in banks' risk-taking, pre- and post- monetary policy shock. Of interest here are differences in response attributable to agency problems, so I divide banks into three categories ($LowCap_t$, $MedCap_t$, and $HiCap_t$) based on their leverage ratio—a traditional proxy of bank's exposure to agency problems. To define the categories, I set leverage ratio cutoffs at 5% and 10%.[19]

Table 4.1 summarizes aggregate balance sheets of banks in each capitalization category at the start of the sample period. Tables 4.3 and 4.4 summarize the variables used in the analysis.

4.3 Results

Over-approval Rates

Results from tests of factors affecting banks' risk-taking (Equation 4.1) are presented in Table 4.5. Each column corresponds to a variant of the specification described in Section 4.2, and in each case the dependent variable is the over-approval measure of risk-taking, Γ_{it}. Column (1) corresponds to a pooled specification, column (2) includes time fixed effects, while column (3) dispenses with the dynamics and includes a bank fixed effect. All reported standard errors are heteroskedasticity consistent and clustered by bank and all tests are two-sided. The coefficients of primary interest are the interactions between monetary policy, ΔFF_t, and the capitalization category dummies ($\Delta FF_t \times LowCap_{it-1}$ and $\Delta FF_t \times HiCap_{it-1}$) which correspond to cross-category differences in the response.

In the specifications without time fixed-effects (column (1) and (3)), the total

19. That is, banks in the $LowCap_t$ category cannot be "well-capitalized" according to the standard regulatory definition (i.e. leverage ratio of more than 5%, risk-weighted Tier 1 capital ratio of more than 6%, and total risk-weighted capital of more than 10%). For the purposes of proxying agency issues, the leverage ratio is the most relevant quantity as it excludes "capital" items such as subordinated debt, which—in terms of the equity–debt conflict—do not represent the owners' "skin in the game".

"effect" of monetary policy can be estimated. There, for reasonably well-capitalized banks (i.e. those in the baseline, $MedCap_t$, category), monetary policy is not associated with changes in risk-taking (i.e. the estimates of the ΔFF_t coefficient are statistically indistinguishable from zero).

However, for banks with low capitalization (and presumably significant agency problems) there is an effect: risk-taking at banks belonging to the $LowCap_t$ category is more sensitive to monetary policy. In the pooled specification of column (1), the same 100bp shock is associated with a 6.2% increase in the over-approval ratio (sum of the ΔFF_t and $\Delta FF_t \times LowCap_{it-1}$ coefficient estimates). In the specification with time fixed effects of column (2), total effects cannot be estimated but the differential effect paints a similar picture. For low capital banks, a 100bp decrease in the Fed Funds rate is associated with a 7% increase in the over-approval rate relative to banks in the baseline, $MedCap_t$, category.

Based on the dynamic panel specifications, risk-taking at banks with low capital appears to be significantly more sensitive to short-term policy rates than risk-taking at better-capitalized banks. The low capital banks also exhibit lower persistence in the their-risk taking, with an AR(1) parameter estimate of approximately 0.5–0.6, as compared to 0.7 for banks in the $MedCap_t$ categories, respectively. Low capital banks also appear to have higher over-approval ratios overall. For low capital banks, the unconditional expected over-approval ratio is approximately 1.3; for banks in the medium and high capitalization categories it is 1.0.

Estimated differences between banks in the medium and high capitalization categories are generally small and statistically insignificant. The main exception is that banks in the high capitalization categories exhibit somewhat higher persistence in their over-approval rates (i.e. their AR(1) parameter is larger).

In column (3), I report the estimates from a specification without dynamics; this corresponds to the case of costless adjustment in banks' underwriting standards. The estimates are similar, with low capital banks exhibiting the same differential response to monetary policy shocks.

It also appears that low capital banks may increase risk-taking in response to *increases* in mortgage rates: the coefficient estimates for $\Delta MTG_{it} \times LowCap_{it-1}$ are positive and statistically significant in two of the specifications. This is probably due to mortgage rates entering into the underwriting model through the payment-to-income (PTI) ratio: other things being equal, a higher mortgage rate increases the PTI ratio which reduces the underwriting model's prediction of a loan being approved. Thus, riskier banks (those not concerned about underwriting ratios) will appear to increase risk-taking when mortgage rates are high.

Active Local Risk

Table 4.6 reports estimates from the regressions of active local risk exposure. Again, estimates from four alternative specifications are reported.

Unlike the over-approval ratio, the active local risk exposure does not increase more at under-capitalized banks following a monetary policy shock. In all specifications, the coefficient estimates on the interactions between monetary policy, ΔFF_t, and the capitalization categories are very small and statistically indistinguishable from zero. Thus, there is no evidence to suggest that loose policy causes low capital banks to shift lending toward riskier areas.

However, changes in mortgage rates do seem to have differential effects. Low capital banks take active local risk exposures—they shift lending toward riskier areas—following declines in mortgage rates. A 100bp decrease in mortgage rates is associated with a differential increase of 0.014–0.018 in the average life of loan default multiplier for loans originated at low capital banks relative to the baseline ($MedCap_t$) banks. This increase is not attributable to changes in the local economic conditions in the bank's area of operations; rather it is due to changes in where the banks chooses to lend. Somewhat unexpectedly, this is also the case for the high capital banks ($HiCap_t$), although the estimated magnitude of the effect is smaller by a factor of three.

4.4 Discussion

At least as far as underwriting (i.e. the over-approval rate) is concerned, it appears that agency problems are a factor in banks' risk-taking decisions as well as in their risk-taking sensitivity to monetary policy. The former finding is not at all surprising given standard theories of banks' risk-shifting incentives. It does however represent a fairly direct measure of the problem. The latter finding—that risk-taking is more sensitive to monetary policy at low capital banks—is not entirely obvious. First, as argued earlier, one potential effect of policy is to increase bank profitability and net worth and in so doing reduce the incentives for bank owner/managers to behave badly when capital is low. This does not appear to be the case; my analysis provides evidence for the alternate story in which "easy money" encourage banks to take excessive risks.

These findings are consistent with several recent empirical studies. Jiménez et al. (2010) report similar results in their analysis of lending at Spanish banks. Using an exhaustive loan register covering all of Spanish banks' commercial loans going back to 1984, they find that bank risk-taking (measured as loans to firms with a history of doubtful loans) increases following expansionary policy shocks; this increase is most pronounced at under-capitalized banks. Ioannidou, Ongena, and Peydro (2009) rely on the Bolivian loan register, and they too find that low capital banks risk-taking most in response to expansionary policy shocks.

One objection to this interpretation of the results is that risk-taking may be confounded with the effects of capital constraints. That is, a bank with very low capital may be prevented from lending due to a regulatory capital requirement. Loose policy relaxes this constraint (through its effect on asset values) and allows previously-constrained banks to lend. If the bank's marginal borrower is of a lower quality than its average borrower—a reasonable supposition—then this could account for the observed pattern in the data even in the absence of any agency problems. If this is indeed the case, then under-capitalized banks should also exhibit a larger quantity response (i.e. increase lending more in response to loose policy). Table 4.7 presents the estimates from a regression of residential mortgage loan growth, $\Delta log(L_{it})$, on the usual covariates. There is no evidence for differentials in the quantity response across bank capital categories, casting doubt on the binding capital constraint interpretation.

The lack of a direct relationship between policy rates and risk-taking as measured by active local risk exposure raises additional doubts. However, it may be that banks cannot easily adjust the geographic composition of their lending. This might explain the differential response to changes in long-term (mortgage) rates: banks may delay "geographical" risk-taking until there's an expectation of low policy rates to persist into the future.

In addition, one might doubt the external validity of the results: thrifts may not have been exposed to the same levels of market discipline as commercial banks, or they may have enjoyed an especially lax regulatory regime. The latter is often taken as conventional wisdom and this perception played a major role in the elimination of the OTS.[20] On the other hand, the thrifts' simple business model should have made regulatory oversight and market discipline easier to implement, which would point toward agency problems playing an even larger role in risk-taking in the broader (more complex) population. Similarly, this simplicity almost certainly contributed to

20. Congressman Barney Frank has famously referred to the regulation provided by the OTS as worse than the "policing provided by meter maids" (Dennis (2009)). Meanwhile, then-acting OTS chief, John Bowman, asserted in a speech in Tokyo that the Dodd-Frank Act made the OTS a "scape-goat" (Hopkins (2010)). His claims are perhaps buttressed by the fact that the OTS's predecessor—the Federal Home Loan Bank Board—witnessed a similar fate thirty years earlier largely due to circumstances beyond its control. There are few extant studies of regulators' performance in this period, but Donelson and Zaring (2010) find some limited support for the idea that OTS did no worse than the other regulators.

thrifts' lower share of subsequent government bailouts, and *ex ante* expectations of such an outcome should have increased monitoring incentives.

Conclusion

Using bank-level and loan-level data on U.S. mortgage lending, I examine how monetary policy affects banks' lending standards. I find that a bank's leverage ratio is an important determinant to its response to policy—monetary loosening leads banks with high leverage to increase risk-taking more than their better-capitalized peers. A natural interpretation of these results is that agency issues lead to an "excessive" risk-taking response to monetary loosening. This raises questions about the efficacy of current macro-prudential regulation in constraining the behavior of even the most conventional of financial intermediaries and creates doubt about the ability of ring-fences and similar measures to provide adequate restraints on excessive risk-taking.

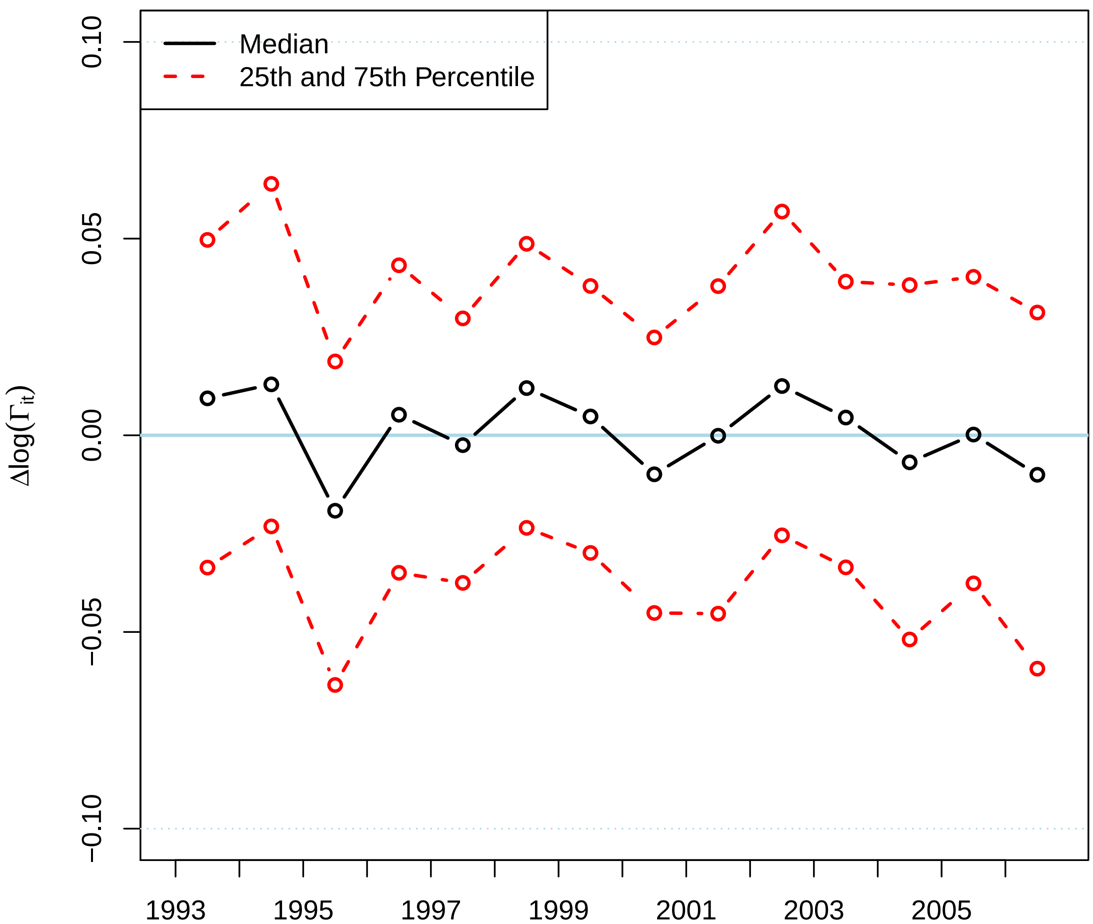

Figure 4.1: Growth in risk-taking

Figure 4.1 summarizes growth in banks' (on-balance-sheet) risk-taking. Each year, median risk-taking growth is plotted. Growth in risk-taking is $\Delta log(\Gamma_{it})$, where

$$\Gamma_{it} = \frac{\left(\sum_{j \in A_{it}} approved_j\right)}{\left(\sum_{j \in A_{it}} \hat{\mathbb{E}}_{\mathcal{M}}[approved_j | \mathbf{W}_j]\right)},$$

is a bank's "over-approval" ratio: the extent to which a bank approves more loans than would be expected given the observable characteristics of the applications it received. This measure of risk-taking is computed using loan-level HMDA data on the banks' mortgage loan applications. The methodology is described in Section 4.2.

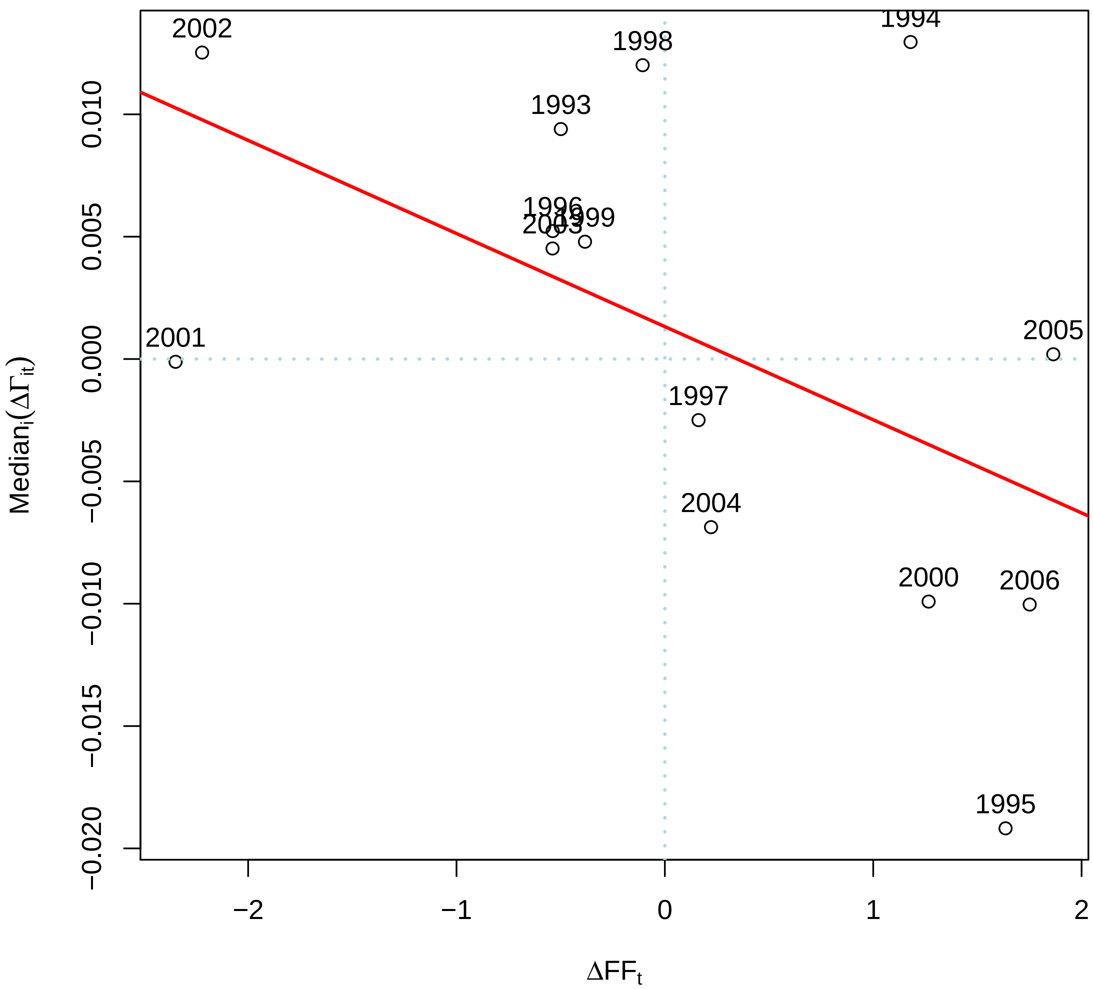

Figure 4.2: Monetary policy and risk-taking

Figure 4.2 plots the median growth in banks' risk-taking (see Figure 4.1) against contemporaneous monetary policy shocks (the change to the Fed Funds rate). Also plotted is the univariate regression fit.

Table 4.1: Aggregate balance sheets of banks in each capitalization category (1992:IV)

	Below 5%	Between 5%–10%	Above 10%
$LowCap_i$	1	0	0
$HiCap_i$	0	0	1
Number of thrifts	262	1233	383
Mean assets ($ million)	772	437	200
Median assets ($ million)	123	114	66
Percent of total thrift assets	24	63	9
Assets	100	100	100
Cash	3	4	5
Interest bearing	1	2	4
Securities	30	24	23
FedFunds lent	1	1	2
Loans	57	65	65
Real estate loans	38	49	50
Consumer loans	3	3	7
C&I loans	1	1	1
Other assets	9	7	5
Liabilities and equity	100	100	100
Deposits	76	80	80
Insured deposits	73	76	77
Core deposits	69	71	72
Brokered deposits	3	1	0
FedFunds borrowed	4	3	0
Subordinated debt	0	0	0
Other liabilities	16	10	7
FHLB advances	11	8	2
Equity	4	7	13

Table 4.1 shows the aggregate balance sheet composition of banks in each capitalization category as of 1992:IV. All balance sheet items are reported as a fraction of total assets. The capitalization categories $LowCap_t$, $MedCap_t$, and $HiCap_t$ are formed based on cutoffs at the 5% and 10% leverage ratio (the ratio of Tier 1 capital to total assets).

Table 4.2: Aggregate balance sheets of banks in each capitalization category (2006:IV)

	Below 5%	Between 5%–10%	Above 10%
$LowCap_i$	1	0	0
$HiCap_i$	0	0	1
Number of thrifts	3	391	423
Mean assets ($ million)	1256	3080	598
Median assets ($ million)	79	237	121
Percent of total thrift assets	0	82	17
Assets	100	100	100
Cash	16	2	3
Interest bearing	0	1	2
Securities	8	14	25
FedFunds lent	0	2	1
Loans	69	73	66
Real estate loans	39	54	32
Consumer loans	12	4	14
C&I loans	7	3	11
Other assets	7	9	5
Liabilities and equity	100	100	100
Deposits	72	62	52
Insured deposits	68	48	43
Core deposits	61	38	36
Brokered deposits	28	7	6
FedFunds borrowed	2	4	5
Subordinated debt	0	1	0
Other liabilities	20	23	17
FHLB advances	16	17	10
Equity	6	10	25

Table 4.2 shows the aggregate balance sheet composition of banks in each capitalization category as of 2006:IV. All balance sheet items are reported as a fraction of total assets. The capitalization categories $LowCap_t$, $MedCap_t$, and $HiCap_t$ are formed based on cutoffs at the 5% and 10% leverage ratio (the ratio of Tier 1 capital to total assets).

Table 4.3: Summary of variables (averages).

Variable	Average 1993Q4	Average 2006Q4	Description
N_t	1732	817	Number of banks.
ΔFF_t	-0.50	1.75	Change in the annual average of the Fed Funds rate.
ΔMTG_t	-1.07	0.55	Change in the annual average home mortgage rate (from Freddie Mac).
$\Delta log(GDP_{it})$	0.06	0.04	GDP growth.
$\Delta log(Apps_{it})$	0.15	-0.02	Growth in the bank's mortgage applications.
$LocalAppGrowth_{it}$	0.08	-0.01	Growth in mortgage applications in the bank's lending area.
$HiCap_{it}$	0.26	0.52	High capitalization (Tier 1 Capital > 10%) category.
$MedCap_{it}$	0.66	0.48	Medium capitalization (Tier 1 Capital between 5% and 10%) category.
$LowCap_{it}$	0.09	0.00	Low capitalization (Tier 1 Capital < 5%) category.
Λ_{it}	0.00	0.00	The bank's active local risk exposure.
Γ_{it}	1.06	1.07	The bank's over-approval rate.

Table 4.3 summarizes the variables in the panel. Averages are reported for the first and last quarter in the panel.

Table 4.4: Summary of variables (standard deviations).

Variable	Std. Dev. 1993Q4	Std. Dev. 2006Q4	Description
$\Delta log(Apps_{it})$	0.62	0.50	Growth in the bank's mortgage applications.
$LocalAppGrowth_{it}$	0.16	0.11	Growth in mortgage applications in the bank's lending area.
Λ_{it}	0.05	0.07	The bank's active local risk exposure.
Γ_{it}	0.22	0.23	The bank's over-approval rate.

Table 4.4 summarizes the standard deviations of the variables in the panel. Standard deviations are reported for the first and last quarter in the panel.

Table 4.5: Regressions of over-approval rates on monetary policy shocks

	Specification		
Γ_{it}	(1)	(2)	(3)
$\Delta FF_t \times LowCap_{it-1}$	-0.059	-0.070	-0.067
	(0.023)**	(0.023)***	(0.024)***
$\Delta FF_t \times HiCap_{it-1}$	-0.002	-0.000	-0.001
	(0.003)	(0.003)	(0.003)
$\Delta MTG_t \times LowCap_{it-1}$	0.038	0.039	0.057
	(0.025)	(0.022)*	(0.022)***
$\Delta MTG_t \times HiCap_{it-1}$	0.002	-0.001	-0.006
	(0.006)	(0.005)	(0.004)
$\Delta log(GDP_t) \times LowCap_{it-1}$	-4.769	-3.273	-6.539
	(2.827)*	(2.658)	(2.734)**
$\Delta log(GDP_t) \times HiCap_{it-1}$	0.183	0.047	0.223
	(0.319)	(0.278)	(0.275)
$\Delta log(Apps_{it})$	0.026	0.021	0.020
	(0.004)***	(0.004)***	(0.004)***
$\Delta log(Apps_{it}) \times LowCap_{it-1}$	0.044	0.018	0.014
	(0.033)	(0.030)	(0.024)
$\Delta log(Apps_{it}) \times HiCap_{it-1}$	0.002	0.002	-0.004
	(0.008)	(0.007)	(0.006)
$\Gamma_{it-1} \times LowCap_{it-1}$	-0.076	-0.181	
	(0.082)	(0.080)**	
$\Gamma_{it-1} \times HiCap_{it-1}$	0.060	0.066	
	(0.040)	(0.034)**	
Γ_{it-1}	0.660	0.687	
	(0.021)***	(0.019)***	
ΔFF_t	-0.003		-0.002
	(0.002)		(0.002)
ΔMTG_t	0.018		0.018
	(0.004)***		(0.003)***
$\Delta log(GDP_t)$	0.185		0.149
	(0.228)		(0.208)
$LowCap_{it-1}$	0.347	0.378	0.401
	(0.186)*	(0.185)**	(0.153)***
$HiCap_{it-1}$	-0.057	-0.058	-0.000
	(0.051)	(0.041)	(0.016)
Time Fixed Effects		Yes	
Bank Fixed Effects			Yes
N	9080	9003	9003
R^2	0.454	0.496	0.018

Table 4.5 shows the results of bank-year dynamic panel regressions where the dependent variable is bank's risk-taking, as measured by the loan "over-approval" rate, Γ_{it}. In all specifications bank-level application growth, $\Delta log(Apps_{it})$ is instrumented by local application growth in the MSAs where the bank lends. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

Table 4.6: Regressions of active local risk exposure on monetary policy shocks

	Specification		
Λ_{it}	(1)	(2)	(3)
$\Delta FF_t \times LowCap_{it-1}$	0.009	0.009	0.006
	(0.008)	(0.008)	(0.010)
$\Delta FF_t \times HiCap_{it-1}$	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
$\Delta MTG_t \times LowCap_{it-1}$	-0.014	-0.015	-0.018
	(0.008)*	(0.008)*	(0.009)**
$\Delta MTG_t \times HiCap_{it-1}$	-0.004	-0.004	-0.004
	(0.002)*	(0.002)*	(0.002)
$\Delta log(GDP_t) \times LowCap_{it-1}$	-0.267	-0.155	-0.140
	(0.756)	(0.755)	(0.984)
$\Delta log(GDP_t) \times HiCap_{it-1}$	0.011	0.012	0.007
	(0.118)	(0.118)	(0.130)
$\Delta log(Apps_{it}) \times LowCap_{it-1}$	0.010	0.010	0.007
	(0.009)	(0.009)	(0.014)
$\Delta log(Apps_{it}) \times HiCap_{it-1}$	-0.001	-0.000	-0.004
	(0.002)	(0.002)	(0.003)
$\Lambda_{it-1} \times LowCap_{it-1}$	-0.110	-0.101	
	(0.078)	(0.078)	
$\Lambda_{it-1} \times HiCap_{it-1}$	-0.127	-0.126	
	(0.028)***	(0.028)***	
Λ_{it-1}	-0.201	-0.204	
	(0.019)***	(0.019)***	
$LowCap_{it-1}$	0.006	0.001	-0.002
	(0.042)	(0.042)	(0.054)
$HiCap_{it-1}$	-0.002	-0.002	-0.000
	(0.006)	(0.006)	(0.007)
$\Delta log(Apps_{it})$	-0.008	-0.007	-0.008
	(0.001)***	(0.002)***	(0.002)***
ΔFF_t	0.001		0.001
	(0.001)		(0.001)
ΔMTG_t	0.002		0.001
	(0.001)		(0.001)
$\Delta log(GDP_t)$	-0.027		0.071
	(0.078)		(0.084)
Time Fixed Effects		Yes	
Bank Fixed Effects			Yes
N	8774	8774	9292
R^2	0.079	0.077	0.013

Table 4.6 shows the results of bank-year panel regressions where the dependent variable is a bank's *active* local risk exposure, Λ_{it}. In all specifications bank-level application growth, $\Delta log(Apps_{it})$ is instrumented by local application growth in the MSAs where the bank lends. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

Table 4.7: Regressions of residential loan growth on monetary policy shocks

	Specification		
$\Delta log(L_{it})$	(1)	(2)	(3)
$\Delta FF_t \times LowCap_{it-1}$	0.001	-0.008	-0.001
	(0.026)	(0.026)	(0.023)
$\Delta FF_t \times HiCap_{it-1}$	-0.001	0.002	0.001
	(0.003)	(0.003)	(0.004)
$\Delta MTG_t \times LowCap_{it-1}$	-0.005	0.034	0.010
	(0.033)	(0.034)	(0.028)
$\Delta MTG_t \times HiCap_{it-1}$	0.000	-0.007	-0.001
	(0.008)	(0.008)	(0.007)
$\Delta log(GDP_t) \times LowCap_{it-1}$	1.619	1.413	0.968
	(2.916)	(2.939)	(2.886)
$\Delta log(GDP_t) \times HiCap_{it-1}$	-0.696	-0.697	-0.945
	(0.366)*	(0.370)*	(0.376)**
$\Delta log(Apps_{it}) \times LowCap_{it-1}$	-0.039	-0.070	0.008
	(0.038)	(0.042)*	(0.039)
$\Delta log(Apps_{it}) \times HiCap_{it-1}$	-0.000	-0.007	0.005
	(0.009)	(0.009)	(0.009)
$\Delta log(L_{it-1}) \times LowCap_{it-1}$	-0.072	-0.123	
	(0.095)	(0.090)	
$\Delta log(L_{it-1}) \times HiCap_{it-1}$	0.005	-0.018	
	(0.046)	(0.047)	
$\Delta log(L_{it-1})$	0.247	0.240	
	(0.029)***	(0.029)***	
$LowCap_{it-1}$	-0.107	-0.100	-0.037
	(0.165)	(0.165)	(0.160)
$HiCap_{it-1}$	0.019	0.019	0.035
	(0.019)	(0.020)	(0.021)*
$\Delta log(Apps_{it})$	0.078	0.089	0.066
	(0.006)***	(0.008)***	(0.006)***
ΔFF_t	0.012		0.011
	(0.003)***		(0.003)***
ΔMTG_t	0.033		0.032
	(0.006)***		(0.004)***
$\Delta log(GDP_t)$	0.905		0.676
	(0.284)***		(0.295)**
Time Fixed Effects		Yes	
Bank Fixed Effects			Yes
N	8331	7720	8985
R^2	0.143	0.134	0.075

Table 4.7 shows the results of bank-year dynamic panel regressions where the dependent variable is residential loan growth, $\Delta log(L_{it})$. In all specifications bank-level application growth, $\Delta log(Apps_{it})$ is instrumented by local application growth in the MSAs where the bank lends. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

CHAPTER V

Market Monitoring of Banks' Risk-Taking

5.1 Introduction

A consequence of the recent series of financial crises is a an erosion of incentives for market participants to monitor financial intermediaries. In the the aftermath of the U.S. Sub-prime Crisis, the retail deposit insurance guarantee scheme has been expanded significantly and the rescue of financial firms such as Bear Sterns, AIG, and Citigroup further solidified the notion that firms "too big to fail" are in fact too big to fail. In Europe, various implicit government guarantees on the liabilities of national banking systems (notably, in Ireland and Spain) have become explicit. These types of policy responses have a long tradition. In the U.S., the Federal deposit insurance schemes (the FDIC, and the FSLIC) were spawned by the Great Crash of 1929. Similarly, the failure of Continental Illinois in 1984 validated the notion of implicit guarantees and "too big to fail", while the Savings and Loan Crisis of the 1980s and early 1990s led to further strengthening of the explicit insurance schemes. With each expansion of the government safety net provided to the banking system come warnings of the moral hazard that it creates and its potential to fuel an even bigger crisis in the future. Thus, a key question in the design of policy is the value of market discipline: is anything lost when monitoring incentives are reduced? In this chapter, I examine this issue in the context of the market for bank liabilities during the run-up to the U.S. Sub-prime Crisis.

Prior literature on bank monitoring by liability-holders has focused on their ability to assess bank default risk using measures analogous to those used by bank regulators. The approach is to determine whether the market for a bank's liabilities responds to the bank's condition. Bank condition is typically summarized by balance sheet ratios that proxy for different aspects of bank risk. There is a close correspondence between the risk proxies and the inputs to bank regulators' supervisory ratings (i.e. *CAMELS* in the U.S.).[1] Thus, the question being answered is whether investors use the same information in their decision to supply funds as regulators use in their supervisory assessments. Early empirical studies have focused on the price response, and generally support the hypothesis that depositors exact a price for bank risk. For example, Baer and Brewer (1986) and Hannan and Hanweck (1988) find that bank risk factors influence the cross-section of CD yields. Brewer and Mondschean (1994) examine the S&L Crisis period and find a positive relationship between a S&L's CD yield and its junk bond holdings. Ellis and Flannery (1992) employ a time series methodology and find similar results at six large money center banks. Flannery (1998) provides a comprehensive survey of this earlier literature. If banks face a upward-sloping deposit supply schedule, then the presence of market discipline should also be manifested through a quantity response; this has been examined in studies such as Calomiris and Wilson (2004), Park and Peristiani (1998) and Peria and Schmukler (2001) where bank risk is found to have a negative effect on deposit quantities.

While prior studies find evidence of bank monitoring by liability-holders based on information used by regulators in their risk assessments, it is not clear that the existence of such monitoring has major implications on the moral hazard debate. If market discipline does not *complement* regulatory discipline and if the market's as-

1. CAMELS is an acronym for Capital Adequacy, Asset Quality, Management, Earnings, Liquidity, and Sensitivity to Market Risk.

sessments are not more accurate (or timely) than those of regulators, then there is not much of a case for preserving market discipline. Evidence on this complimentary value of depositor monitoring is lacking, and it is not unreasonable to suppose that it is absent. Bank regulators have natural advantages when it comes to obtaining information about a bank's condition: they employ trained, specialized examiners, fund research departments devoted to banking issues, and have the power to compel disclosure. They also have access to information that is not released to the public. Studies by Berger and Davies (1998) and Cole and Gunther (1998) present evidence that bank examiners are able to detect new "bad" information not available in regulatory filings. Similarly, DeYoung et al. (1998) argue that bank regulators collect information that is priced by market participants only after a considerable delay.[2] Moreover, the information used by regulators is—somewhat tautologically—the type of information that is most amenable to regulatory action. Thus, if liability-holders' monitoring *adds* value, it is unlikely to arise from their ability to duplicate regulatory assessments.

In order to get at the question of whether market discipline provides any additional value, augmenting the traditional approach is required: one must consider information not summarized by the usual proxies of bank risk. As a practical matter, this information needs to be both quantifiable yet difficult for regulators to use. A failure of the former condition would preclude an econometric analysis while a failure of the latter would make any market discipline so identified equally subject to the preceding criticism.

In this analysis, I augment the traditional analysis with three additional measures of a bank's *asset quality*. The first, is the geographical make-up of a bank's lending. The second, is its underwriting standards. The third is the post-crisis performance of its loans. I test whether a bank's cost of funds responds to these measures of

2. More recently, Iyer, Puri, and Ryan (2013) find that depositor monitoring is largely a response to prior regulatory action, and contains little "independent discipline".

asset quality. While prior studies have included banks' asset quality as a default risk factor, the proxies employed have largely been limited to lagged balance sheet ratios such as non-performing assets or the historical volatility of the market value of equity. However, in the case of mortgage lending, rising home prices make delinquency and default easy to avoid, reducing the information content in such measures. It is only when prices fall that the measures reveal the full extent of asset quality. Moreover, because it is relatively simple to promulgate regulatory policies based on such measures, any information contained in them may be better-used by regulators.[3]

As in the previous chapters, I focus on lending at U.S. thrifts—banks that specialize in mortgage lending—in the run-up to the Sub-prime Crisis. Several factors contribute to making this is a unique venue for evaluating the potential value of market monitoring. First, thrifts—being undiversified—provide a clean empirical setting: lending standards in a thrift's mortgage portfolio should be reflected rather directly in its cost of funds as thrifts have little opportunity to offset increased risk in one line of business (i.e. mortgage lending) with decreased risk in another (e.g. business loans).[4] Second, U.S. mortgage loans are a uniform, commoditized product subject to detailed regulatory reporting requirements; consequently, mortgage lending standards are more readily quantified than lending standards for other types of loans.[5] Third, circumstances around the crisis and its run-up are favorable to the analysis. The sudden decline in home prices and its heterogeneous effect on banks' post-crisis loan performance reveals information about cross-sectional differences in banks' pre-crisis lending standards. In addition, this period was characterized by a large fraction

3. Various other measures of asset quality previously employed suffer similar problems. For example, Brewer and Mondschean (1994) and Ellis and Flannery (1992) use a bank's portfolio weight on different asset *classes* (e.g. junk bonds vs. houses) to measure asset quality. Again, such measures are problematic. On the one hand, they hide non-obvious risks (i.e. some types of home loans are riskier than some types of junk bonds), and on the other hand they are easy for regulators to act on (i.e. it is simple for regulators to assign risk-weights based on asset class).

4. Thrifts' business model, and regulatory history is described in more detail in Chapter II.

5. A unique feature of mortgage lending is the Home Mortgage Disclosure Act, which mandates the disclosure of details about *individual* loan applications.

of thrifts' deposit balances being uninsured, creating an incentive for monitoring by large depositors. A final benefit of focusing on thrifts' lending standards is that regulators—who do not enjoy wide discretion in their action—may not be able to respond to subtle (but consequential) changes in bank underwriting policies as easily as market participants.

The last point—regulators' limited ability to respond to banks' lending standards—will have important implications for the interpretation of my results. It is regulators limited ability to monitor some aspect of bank behavior that gives market monitoring a distinct advantage. But are regulators really limited in their ability to monitor banks' lending standards? The revelations about poor underwriting in the pre-crisis period offers some *prima facie* evidence for the this proposition.[6] More fundamentally, a premise of democratic society is "rule of law" which places bounds on the discretion afforded to government agents; it is therefore plausible to believe that regulators face considerable difficulties in adapting to new circumstances. It is difficult to imagine a regulatory framework that would have allowed bank regulators to chastise banks lending in Arizona or Florida in 2005 based on regulatory assessments of those markets having poor future prospects. In addition to such calls requiring considerable discretion, it would almost certainly expose the regulator to political pressure from lawmakers in those states. Similarly, regulators may be subject to conflicting policy objectives. Expansion of mortgage lending to low-income borrowers and neighborhoods provides a case in point: this while often implicated as contributing to the crisis, it also satisfied long-standing public policy objective of encouraging home ownership.[7]

The null hypothesis that serves as the focus of my analysis is that market participants fail to incorporate information about bank risk-taking (as proxied by my

6. It also provides evidence for the limitations of market monitoring. However, such a claim is more tenuous, as incentives for market monitoring are relatively suppressed.

7. Specifically, provisions of the Community Reinvestment Act encouraged banks to extend loans in low-income areas and to disadvantaged borrowers.

measures) in their decision to supply funds. Rejection of this null suggests that market monitoring provides additional value beyond regulatory monitoring under the assumption that regulators are less able to use this type of information. To test the hypothesis, I augment the traditional approach of the depositor monitoring literature in which a bank's cost of funds and deposit growth is regressed against balance-sheet risk-factors with my measures of loan quality. I find that a bank's cost of funds is generally responsive to the geographical composition of its lending, while lending standards appear to have little effect on the cost of funds. I find that the sensitivity of the cost of funds to geographical risks peaked in 2001 and then experienced a prolonged decline over the 2002–2005 period; the pricing of geographical risks in banks' costs of funds reemerged in 2006. Similarly, I find that a bank's cost of funds did not begin to reflect the post-crisis performance of its portfolio until around 2005. These findings suggest that risks not captured by balance-sheet ratios can be priced by the market for banks' liabilities; however, they also highlight the willingness of this market to ignore such risks for prolonged periods.

The rest of this chapter is organized as follows. In Section 5.2 I describe the data and empirical strategy. In Section 5.4 I present the results. The final section concludes with a discussion of the findings.

5.2 Empirical Strategy

A typical approach to measuring market discipline on banks involves pooled cross-sectional regressions of bank liability yields on various bank characteristics thought to play a role in the default probability. This approach can be summarized by the following reduced-form regression specification:

$$y_{it} = \alpha_t + \gamma' x_{it-1} + \lambda' f_{it-1} + \epsilon_{it}$$

where i, t indexes over banks and time periods, y_{it} is the yield on some bank liability, x_{it} is a vector of controls, and f_{it} is a vector of risk factors (related to the inputs for CAMELS ratings) proxied by various ratios of bank condition. The hypothesis being tested is whether a bank's cost of funding, y_{it}, is affected by the bank's riskiness as measured by the risk-factors, f_{it}: whether the λs correspond to expectations. In effect, this answers the question of whether investors in bank liabilities price sources of bank risk of concern to bank regulators.[8]

A limitation of this approach is that it fails to establish any additional benefit to market monitoring. Evidence to the effect that investors monitor banks' risk-taking merely establishes investors' duplication of regulators' efforts. It is not at all clear why such duplication would be desirable, or if duplication is to be avoided, which monitor—regulator or investor—is preferred.

My approach is to extend the above empirical strategy by incorporating risk-factors beyond simple balance-sheet ratios—ones based on information that is not easy for regulators to act on. Thus, my approach corresponds to the extended specification:

$$y_{it} = \alpha_t + \gamma' x_{it-1} + \lambda' f_{it-1} + \beta' h_{it-1} + \epsilon_{it},$$

where h_{it} represents additional risk-factors potentially employed by the market, but which regulators have a harder time using. If markets properly respond to (i.e. price) these factors, then this suggests that market monitoring in the market for bank liabilities can compliment regulatory oversight. Thus, the focus on my analysis is on the βs.

The dependent variable in my analyses is the bank's cost of funding. If investors in bank liabilities are concerned about a potential bank default, then the probability of default should be reflected through a default premium in the bank's cost of funds.[9]

8. Subject to the caveat that the strategy is effective at identifying causal effects.

9. And to the extent that such a default is correlated with non-diversifiable risk factors, a corresponding risk-premium.

Ideally, cost of funding would be reported separately for each type of bank liability (e.g. "insured transaction account", "large-denomination 1 year CD"), as certain bank liabilities are insured. Unfortunately, such detail is not available, and it is necessary to resort to summary measures. I estimate the overall cost of deposit funding ($CODF_{it}$) from the quarterly deposit interest expense and the interest-bearing deposit balance.[10]

For the standard balance-sheet risk factors, f_{it}, I use measures commonly used in the literature. These proxy for the inputs to regulatory CAMELS ratings (i.e. proxies for: capital adequacy, asset quality, managerial effectiveness, earnings, liquidity, and sensitivity to market risk). These measures are derived from banks' balance sheets and income statements. Capital adequacy is measured by the risk-adjusted Tier 1 Capital ratio, $Capital_{it}$. The ratio of non-performing (90 days or more past due) loans, NPA_{it}, measures asset quality.[11] Liquidity is measured by the ratio of cash and investments to total assets, $Liquid_{it}$. The return on assets, ROA_{it}, is used to measure earnings. For thrifts prior to the crisis, sensitivity to market risk was essentially equivalent to interest rate risk; because regulatory filings offer little visibility on the term-structure of bank assets, I use the ratio of residential mortgage loans to total assets to measure the banks' market risk exposure, $MktRisk_{it}$. Management effectiveness is difficult to measure with balance sheet data, so I do not include it. All measures based on ratios are Winsorized at the 2% level and measured in percentages. Because larger banks are more likely to enjoy implicit government guarantees, I also include dummies for the bank's size tercile, Med_{it}, Big_{it} (the smallest tercile is taken as the baseline) as an additional risk factor. Because many smaller thrifts are mutual benefit

10. This is calculated as

$$CODF_{it} = 400\frac{EDEPDOM_{it}}{.5DEPIDOM_{it} + .5DEPIDOM_{it-1}}$$

where $EDEPDOM_{it}$ and $DEPIDOM_{it}$ are SDI data items "Interest expense: Domestic office deposits" and "Interest-bearing deposits" respectively.

11. The assumption being that portfolios with more performance issues (i.e. sub-prime loans) will exhibit greater performance degradation during economic downturns or financial crises.

organizations ostensibly run for the benefit of the depositors, I also include a mutual dummy, $Mutual_{it}$ to capture potential differences in risk arising from reduced agency conflicts.

A bank's cost of funds may be driven by various other (non-risk) factors. To the extent that these are are correlated with the risk-factors of interest, failing to control for them would lead to biased estimates. Therefore, I include a number of controls likely to play a significant role in the cost of funding. First, the competitive position of a bank may play an important role. Banks with a high market share in their local market(s) may have difficulties expanding deposits (without increasing funding costs), while banks operating in concentrated markets may enjoy pricing power. To control for these effects, I include each bank's share of the deposit market in which it operates, $MktShare_{it}$, as well as the weighted-average Herfindahl-Hirschman index of deposit market concentration faced by each bank, HHI_{it}.[12].

Another potential factor in a bank's cost of funds is the rate at which a bank needs to expand its funding. Banks experiencing rapid growth in assets may need

12. Using the FDIC Summary of Deposits Database, I first calculate each bank's share of deposits within each metropolitan statistical area (MSA):

$$MSAShare_{itm} = \frac{DEPOSITS_{itm}}{\sum_i DEPOSITS_{itm}},$$

where $DEPOSITS_{itm}$ is the dollar deposits bank i's branches located in MSA m, in year t. I then calculate an aggregate market share for each bank by weighting its $MSAShare$s by the level of deposits, to calculate $MktShare_{it}$:

$$MktShare_{it} = \sum_m \frac{DEPOSITS_{itm}}{DEPOSITS_{it}} MSAShare_{itm}.$$

Similar to the calculation of $MktShare_{it}$ described in Footnote 12, I first calculate MSA-level Herfindahl-Hirschman indexes (HHIs) of concentration using the Summary of Deposits database:

$$HHI_{mt} = \sum_i MSAShare_{itm}{}^2,$$

where m indexes over MSAs. I then calculate a bank-specific Herfindahl-Hirschman index, HHI_{it} as the weighted-average HHI of the regions in which the bank has deposits:

$$HHI_{it} = \sum_m \frac{DEPOSITS_{itm}}{DEPOSITS_{it}} HHI_{tm}.$$

to bid aggressively for deposits and consequently face higher costs. Similarly, banks without branch networks and banks using brokered (i.e. non-core) funds should also face higher funding costs.[13] To control for these factors, I include asset growth, $AssetGrowth_{it}$, a dummy variable, $Unit_{it}$, indicating a unit bank (one with no branches), as well as a dummy indicating the use of brokered deposits, $Broker_{it}$.[14].

Due to data limitations, I am unable to obtain separate estimates of deposit prices for insured and uninsured deposits, nor can I obtain separate estimates for deposits of different maturities. This should generally work to weaken my findings as the response of insured depositors to risk factors (verifiable or not) is expected to be attenuated.

I employ three alternative measures of asset-quality (the h_{it}s). The first, local mortgage default risk, $LocalRisk_{it}$ is based on the geographical composition of a bank's mortgage originations and acquisitions. Mian and Sufi (2009) has argued that the Sub-prime Crisis can be traced back to growth of mortgage credit in neighborhoods with stagnant (or declining) income growth. Similarly, Anderson, Capozza, and Van Order (2011) attribute much of the mortgage melt-down to the extension of credit in areas with poor economic fundamentals, potentially resulting from banks' mis-estimation of default risks.[15] The local risk measure I construct attempts to capture this aspect of banks' lending decisions. To construct it, I begin with ZIP-code level metrics from University Financial Associates LLC (UFA) that assess the default risk arising from the local and national economic environment for a loan originated in a given year.[16] I convert the ZIP-code-level data to census-tract-level using

13. A branch network not only increases access to low-cost deposits (i.e. core deposits) but also increases bank charter value, reducing agency conflicts and depositors' risk.

14. The smaller units thrifts tend to be community thrifts, while the larger unit thrifts consist of Internet-based banks (e.g. Netbank, ING Bank FSB) or thrift entities that are a part of a larger bank holding company (e.g. Citicorp Trust Bank FSB, Capital One FSB).

15. See also Murfin (2012), who provide evidence that banks adjusted underwriting standards to recent loan loss experience.

16. The UFA metrics are provided at a monthly frequency. I annualize them by weighing the monthly data by the U.S. Census *New One Family Houses Sold* series. The metrics are multipliers, with 1 corresponding to the average default propensity in the 1990s. Additional details can be found

"crosswalk" mappings provided by the U.S. Department of Housing and Urban Development.[17] Next, I use each bank's annual loan application register (LAR) to construct census-tract portfolio weight-vector for each bank-year.[18] For each bank-year, I use the dollar value of loan originations and purchases in a given census tract to compute the weights. Finally, I multiply the tract-level UFA metrics by this weight vector to obtain a geographic risk measure ($LocalRisk_{it}$) for each bank-year. Local economic conditions are known to play an important role in mortgage defaults (Capozza, Kazarian, and Thomson (1997)); because of this, they may be incorporated into the market assessment of bank risk. Conversely, political consideration may make it difficult for regulators to employ this measure: such pressure may even lead them to encourage lending in imprudent areas.

Whereas the previously described measure ($LocalRisk_{it}$) captures differences in asset quality arising from banks' exposures to local economic conditions assuming *borrower and loan characteristics are held constant*, my second measure captures differences in asset quality arising from differences in borrower and loan characteristics. It is based on individual banks' relative propensity to approve a *constant-quality loan* and reflects the looseness (or tightness) in a bank's underwriting standards. It is expressed as an *over-approval* multiplier, $OverApproval_{it}$: when the multiplier is unity, a bank is approving the *expected* fraction of its loan applications, when it is 1.5, the bank approves 50% more loans than is expected. To construct this measure, I first fit a loan application approval model based on loan characteristics using loan application data from all banks in my sample. This model estimates the probability that a loan with a given set of observable characteristics would be approved if assigned to a random bank with a probability corresponding to the bank's market share. Using

in the appendix of Anderson, Capozza, and Van Order (2011).

17. These files may be found at `http://www.huduser.org/portal/datasets/usps_crosswalk.html`.

18. The LARs are from the Home Mortgage Disclosure Act filings described in more detail in the subsequent sub-section.

this model, I calculate the *expected* approval rate for the applications received by each bank in a given period. The over-approval measure, $OverApproval_{it}$ is calculated as the ratio of a bank's *actual* approval rate to the *expected* approval rate (i.e. the rate predicted by the model). Further details on the construction of this measure can be found in Chapter IV.

The final measure of asset quality that I consider is based on banks' *future* loan performance. I suppose that investors obtain some unbiased signals about how each bank's loans will perform during unfavorable conditions (i.e. when home prices decline, credit is reduced, etc.); if investors monitoring is present, then the signals should be reflected in investors' pricing of bank liabilities.[19] As such signals are not directly observable, I use a simple proxy: the bank's average *realized* loan delinquencies during the Sub-prime Crisis, or "crisis non-performing assets", $CNPA_i$.[20] To the extent that the noise in these signals is not correlated with the other regressors, the proxy $CNPA_i$ yields unbiased estimates of the signals' impact.

I use standard pooled OLS and fixed-effects models to estimate the coefficients. Pooled OLS has been frequently employed in prior literature despite the implausibility of the required assumption that unobserved bank heterogeneity is uncorrelated with bank characteristics (such as capital ratios and earnings). Thus, the fixed-effects models will be preferred. As bank balance sheets change only slowly, residuals are highly correlated over time; to deal with this, I cluster standard errors at the bank level. Throughout, estimation is based on quarterly data, although some of the asset-quality measures are either cross-sectional ($CNPA_i$), or only vary at the annual frequency ($LocalRisk_{it}$ and $OverApproval_{it}$).

19. Assuming that deterioration in loan performance during a crisis situation increases a bank's default risk.

20. I take the crisis period to begin in the third quarter of 2008 and to end in the second quarter of 2011.

5.3 Data

Data Sources

The core of my sample is based on quarterly regulatory filings—Thrift Financial Reports (TFRs)—filed with the Office of Thrift Supervision (OTS). Balance sheet and income statement data reported in the TFRs are similar to the data reported in commercial banks' Call Report filings. I extract this data from the FDIC Statistics on Depository Institutions (SDI) database which contains TFR filings going back to 1992Q4.[21].

I use branch-level data on deposit balances at all U.S. depository institutions to construct my market structure controls ($MktShare_{it}$, HHI_{it}). This data is available at annual frequency through the FDIC Summary of Deposits database; it goes back to 1994.[22].

To construct my measure of a bank's underwriting, I rely on the bank's *Loan Application Register (LAR)*; the LAR is a loan-level report mandated by the Home Mortgage Disclosure Act (HMDA) for nearly all financial institutions engaged in mortgage lending. It contains detail on borrower and loan characteristics, as well as the disposition of the loan. This data is available for all years starting with 1992 from the Federal Financial Institutions Examination Council (FFIEC).[23]

Sample

In my analysis, I restrict the sample to the "inter-crisis" period that begins with the end of the S&L Crisis and ends just before the Sub-prime Crisis. Because crisis episodes represent break-downs in the status-quo arrangements, they yield little insight as to bank investors' actions during "normal times". In addition, their inclu-

21. The SDI database is found at `http://www2.fdic.gov/SDI/`
22. The Summary of Deposits database is found at `http://www2.fdic.gov/sod`
23. This data can be downloaded / ordered at `http://www.ffiec.gov/HMDA/hmdaproducts.htm`.

sion would complicate the analysis considerably. Thus, my analysis focuses on the 52 quarters beginning with 1994Q1 and ending in 2006Q4. Over this period, a total of 58,253 bank-quarter observations relating to 1,938 distinct thrifts were extracted from the FDIC SDI database.[24]

I eliminate from this sample all bank-quarters where less than $25M in assets or less than $10 million in deposits were reported: banks operating on such small scales are unlikely to be representative. This eliminates approximately five thousand observations. I also eliminate bank-quarters corresponding to each bank's first year and last quarter of operation, as well as quarters in which a bank was involved in a merger. This filter is intended to eliminate observations from quarters during which a bank was undergoing major structural changes. Finally, I eliminate all bank-quarters for which Summary of Deposits are not available. This leaves 51,136 bank-quarters which yield an unbalanced panel with 1,741 banks. All ratios are Winsorized at the 2% level. The resulting subset of observations is summarized in Tables 5.1 and 5.2.

In 1994Q1, filings for 1,668 thrifts were extracted from the SDI database. These thrifts had $785 billion in assets and deposits of $593 billion. Median thrift assets wer $102 million with median deposits of $89 million. By the fourth quarter of 2006, only 838 thrifts remained, with total assets of $1,410 billion and $876 billion in deposits. These figures are representative of the pattern of growth and consolidation of thrifts during the period; Figure 5.1 plots these trends. Along with the consolidation, came increased concentration. Table 5.3 lists the largest thrifts at the end of 1993 and 2006; in 1993, the largest thrift was approximately five times larger than the tenth largest thrift, but by the end of 2006 the largest thrift was *sixteen* times larger than the tenth.

During this period, banks in the thrift population increased their use of uninsured

24. Because reporting is on a consolidate basis, I ignore the approximately one hundred observations relating to thrifts directly owned by another bank; this avoids double-counting. I also ignore a handful of observations with missing values for key balance sheet variables.

deposits. Among all thrifts, the median percentage of uninsured deposits was 2% at the end of 1993; by the end of 2006, it was 12%. In aggregate, use of uninsured deposits increased from 4.7% at the end of 1993, to 22% at the end of 2006. Use of—and growth in—uninsured deposits was correlated with bank size. Figure 5.2 separately plots the median uninsured deposit percentage for small, medium, and large banks (corresponding to asset terciles). For each category, median uninsured deposits exhibited a nearly monotonic increase over the 1993–2006 period. The largest banks were the biggest users of uninsured deposit funding, increasing their use from 3% to 16%, while the smallest banks increased usage from 2% to 9%. The large increase in the use of uninsured deposits among banks in my sample offers some hope of detecting the effects of market discipline.

Figure 5.3 plots the median spread in the cost of deposit funding for small-sized and medium-sized banks (relative to the large banks). Theory suggests that smaller banks should face higher costs of deposits: large banks are less risky because of their larger franchise value, too big to fail guarantees, increased opportunities for diversification, etc. For the most part, this pattern is manifested in the figure: the spread in the cost of funding for small and medium sized banks is generally positive, and spikes during crisis episodes.[25] The figure also exhibits an interesting feature that is harder to account for. Around 2003, the spread on small banks' cost of funding begins to fall, turning negative in 2005, falling as low as -20bp in late 2006. A similar pattern exists in the spreads between banks with high levels of uninsured deposits and those with low levels. This spread is plotted in Figure 5.4: banks with high levels of uninsured deposits faced increasing costs of deposits between 2002 and 2006. Over this period, the spread in funding costs between banks in the high- and low-uninsured terciles increased from approximately -40bp to +30bp. This is consistent

25. In the figure, the spikes occur in 1995, 1998, 2001, and 2008. These are roughly coincident with the Mexican Peso Crisis, the Asian Financial Crisis, the dot-com bubble, and the Sub-prime Crisis.

with uninsured depositors growing increasingly concerned with the risks developing in the residential mortgage sector. [26]

The aggregate patterns are broadly consistent with the hypothesis that uninsured depositors were responsive to bank risk and took note of the brewing problems in the residential mortgage sector. However, they are hardly conclusive. In the next section, I present the results from the micro-level panel analysis.

5.4 Results

Balance Sheet Factors in the Cost of Funds

I begin by examining the effect of balance-sheet-based risk factors on a bank's cost of funds. This represents a common approach taken in the earlier literature on bank monitoring and which is based on the following regression specification:

$$y_{it} = \alpha_t + \gamma' x_{it-1} + \beta' f_{it-1} + \epsilon_{it},$$

where f_{it} and x_{it} are vectors of balance-sheet derived risk-factors and controls. Table 5.4 presents the estimates of the above specification.

The first column of Table 5.4 corresponds to pooled estimates without the market structure controls, while the second includes them. The results from these two pooled specifications do not offer especially compelling evidence for the monitoring hypothesis. As expected under the hypothesis, banks with higher earnings (ROA_{it-1}) do pay less for funding. However, the effect of capital ($Capital_{it-1}$) goes the wrong way: banks with higher capital levels have *higher* funding costs. This is surprising given that capital serves as a buffer against liability-holders' losses and reduces

26. From 2000 to 2002, the spread exhibited a pronounced decline into negative territory. A plausible interpretation is that banks which depositors perceived to be safe (i.e. larger banks) saw an influx of deposits following the 2000–2001 dot-com bubble and the uncertainty created by the World Trade Center attacks. The perceived safety of these banks allowed them to offer lower deposit rates.

equity-holders' incentives to take excessive risks. Non-performing assets (NPA_{it-1}), and bank size (Med_{it}, Big_{it}) also appear to have no statistically significant effect on funding costs. Exposure to market risk ($MktRisk_{it-1}$), liquidity ($Liquid_{it-1}$) and organization as a mutual bank ($Mutual_{it-1}$) have the expected signs, but the effect of liquidity, and mutual bank organization do not survive the introduction of the market-structure controls (column (2)).

While the risk-factors offer a mixed picture, the market-structure controls are much more consistent. Except for market-share ($MktShare_{it-1}$), all the controls are statistically significant. They also have the expected signs: high asset growth ($AssetGrowth_{it-1}$), low deposit market concentration (HHI_{it-1}), unit banking ($Unit_{it-1}$), and use of brokered deposits ($Broker_{it-1}$) are associated with higher costs of funds. The inclusion of these controls does not materially affect the estimates on the risk-factors, although the mutual benefit organization dummy ($Mutual_{it-1}$) looses significance.

The previous estimates are biased if there exist omitted variables correlated with both the risk-factors and the cost of deposit funding. This may explain why bank capital ($Capital_{it-1}$) does not have the expected effect; for example, bank-level variation in risk-appetite may lead "risky" banks to choose higher capital levels in order to attract funding. Omitted variables that do not exhibit significant variation over time (e.g. bank-level risk-appetite, reputation, or ownership) can be controlled for through fixed-effect estimation. In the third column of Table 5.4, I present estimates from such a fixed-effects model. Now, the estimate of the coefficient on bank capital ($Capital_{it-1}$) takes on the expected sign: controlling for bank-level heterogeneity, higher capital levels are associated with a lower cost of funding. However, the estimate is very small: a one percent increase in capital leads to an 0.3 basis point reduction in funding cost. The effect of return on assets (ROA_{it-1}) is reduced in the fixed-effects model: a one percent increase in the return on assets leads to a 6.6

basis point reduction in the cost of funds. The effect of exposure to market risk ($MktRisk_{it-1}$) is again highly significant and in the expected direction. Contrary to expectations, liquidity ($Liquidity_{it-1}$), non-performing assets (NPA_{it}), and the size dummies (Med_{it-1}, Big_{it-1}) now have statistically significant effects that run counter to the monitoring hypothesis.

The above analyses of balance-sheet risk-factors is not especially consistent with the hypothesis that depositors monitor bank risk. In particular, under the fixed-effects specification, asset quality—as measured by non-performing loans (NPA_{it-1})—does not have the expected effect: banks holding more delinquent loans appear to enjoy a lower cost of funding. To the extent that portfolios with higher rates of delinquency (i.e. sub-prime portfolios) are more susceptible to further deterioration in bad states, this appears inconsistent with liability investors' monitoring of banks' asset quality. On the other hand, it may reflect shortcomings in the asset quality measure. In particular, high levels of delinquencies need not be associated with appreciably increased risk of default *most of the time*: it is only when economic or financial conditions deteriorate that these sub-prime portfolios start to pose a risk.

Time-variability in the Role of Loan Quality

To examine whether the effect of loan performance on banks' cost of funds is obscured by variability along the time dimension, I augment the fixed-effects model of Table 5.4, Column 3 with interactions between the time dummies (α_ts) and non-performing assets (NPA_{it-1}). The coefficient estimates from this regression are presented in Table 5.5, with the time-varying coefficient estimates on the NPA_{it-1} variable plotted in Figure 5.5.

Figure 5.5 shows that throughout my sample period loan performance had no appreciable (or statistically significant) impact on the cost of funding, although the estimates appear to decline toward the latter half of the period. If anything, it seems that as the crisis approached, investors in bank liabilities took less of an interest in loan performance.

These results suggest that banks' past loan performance experience had no appreciable impact on their cost of funding in the pre-crisis period. This could potentially be explained by the oft-repeated adage that real estate markets are driven primarily by local factors: perhaps investors were more concerned with lurking local risks in banks' loan portfolios rather then their contemporaneous performance characteristics?

Local Risk and the Cost of Funds

To test whether investors took account of variation in the geographical compositions of banks' loan portfolios and the consequent differences in exposure to local risk factors, I augment the fixed-effects analysis of Figure 5.4, Column 3, with the measure of local economic risk exposure, $LocalRisk_{it}$, described in Section 5.2. As before, I allow for time-variation in the effect of this risk exposure by including interactions with time dummies. The coefficient estimates from this model are presented in column (2) of Table 5.5 with the time-varying coefficients on the standardized $LocalRisk_{it}$ variable plotted in Figure 5.6.[27]

The estimates reveal a striking pattern. Prior to 2001, a bank's exposure to risks stemming from local mortgage market conditions was not reflected in its cost of funds—the estimates are generally statistically indistinguishable from zero. Starting in 2001 however, the cost of exposure to local risk spikes to approximately 6 basis points[28], and continues to increase throughout the year, reaching a peak of approximately 15bp. Coincidentally, the UFA National Default Risk Index (which measures national mortgage default risks arising from economic conditions) began to deteriorate around the same time (2001–2002) after approximately seven years of improvement.

27. The $LocalRisk_{it}$ variable is standardized by its sample standard deviation.

28. That is, a one standard deviation increase in a bank's local risk exposure results in a 6 basis point increase in the cost of funds.

While the cost associated with a bank's local risk exposure spiked around 2001, it did not persist through the pre-crisis period: after spiking, it began a gradual and nearly uninterrupted decline. By mid-2005, the cost of local risk exposure had declined to levels statistically indistinguishable from zero. A literal reading of this pattern would suggest that investors quickly grew concerned about the geographical composition of banks' holdings in mid-2000 (shortly after the dot-com bubble), but that this concern gradually eroded over the next five years.

Over-approval Rates and the Cost of Funds

The declining impact of local economic risk on the pricing of bank liabilities over the 2001–2006 period raises doubts about monitors' appreciation of the impending problems in the mortgage market. To explore this further, I examine their reactions to another aspect of loan quality: underwriting standards. I repeat the previous analysis but consider instead the time-varying coefficients on the over-approval rate, $OverApproval_{it-4}$. Again I estimate a fixed-effects model and interact the measure with time dummies to obtain a time series of coefficient estimates, on the standardized $OverApproval_{it-4}$ variable, which I plot in Figure 5.7.

The effect of the over-approval rate on a bank's cost of funds bears a similarity to the pattern for local risk exposure. Prior to 2001, a bank's over-approval rate had no obvious effect on the cost of funding. Again, around 2001 the estimates spike to approximately 3 basis points per one standard deviation change in the over-approval rate. Unlike the estimated effect of local risk exposure, the estimated effect of over-approvals persists a bit longer and declines more precipitously in 2003: at its nadir in mid-2006, it is firmly in negative territory. Again, it appears that concerns about the safety of bank liabilities declined considerably while problems in banks' mortgage books were mounting.

Crisis Loan Performance and the Pre-crisis Cost of Funds

The evidence thus far suggests that markets began to penalize banks exposed to local economic risk and banks with loose underwriting standards around 2001–2002. However, the subsequent years saw a decrease in these penalties—as the sub-prime crisis neared banks exposed to local risks and those with looser lending standards did not pay more for their funding. Thus, it appears that participants in the market for bank liabilities were unaware of banks' exposures. An alternate possibility is that my measures of local risk exposure and underwriting standards were playing an ever smaller role in investors' assessments of bank risk. Perhaps investors had *better* information?

To explore this possibility, I examine when a bank's *crisis exposure* was reflected in its cost of funds. I assume that banks exhibit *cross-sectional* heterogeneity in their exposure to a crisis scenario: certain banks pursue strategies that perform badly in a crisis, while others pursue strategies that perform (relatively) well.[29] If investors monitor, and if they receive signals about banks' crisis exposures, then these signals should affect a banks' cost of funding. Moreover, the signals' impact on the cost of funds should be proportional to investors' assessments of the probability of a crisis occurring.

A bank's realized performance during a crisis scenario—here, crisis non-performing assets ($CNPA_i$)—is used as a proxy for unbiased signals about crisis exposure. Because banks' crisis exposures have been assumed to be constant, it is not possible to identify an overall crisis exposure effect in a fixed-effects model; however, time-series variation in the effect can be identified.[30] To this end, I begin with the fixed effects regression specification of column two in Figure 5.4 where I regresses cost of deposit funding ($CODF_{it}$) on the usual lagged balance-sheet risk-factors and controls. To

29. Of course, banks may have adjusted their strategies over time. For the purposes of identification, I assume this away.

30. The overall effect is indistinguishable from bank-level heterogeneity in a fixed effects model.

control for the effects of *historical* asset quality, I include interactions between the time dummies and asset quality (NPA) as in Figure 5.5; in addition, I include lagged growth in non-performing assets to capture readily observable trends. To identify time-series variation in the crisis exposure effect, I include interactions between the time dummies and crisis non-performing assets ($CNPA_i$). Coefficient estimates for these interactions are plotted in Figure 5.8, while the non-time-varying coefficient estimates are reported in column (3) of Table 5.5. These estimates correspond to *differences* from the baseline period (the beginning of 1994) with the overall crisis exposure effect unidentified.

The plot of coefficient estimates in Figure 5.8 reveals a pattern very different from that of the contemporaneous risk measures. Prior to 2005, a bank's crisis exposure was most often statistically indistinguishable from zero, with brief spikes (into statistically significant positive territory) in 1995–1996, 1997, and 2000-2001. By mid–2001 the effect is again indistinguishable from zero, but starting in 2003 a consistent upward trend emerges. By mid-2005, crisis-exposure is again reflected in banks' cost of funding, and by the end of 2006, a one percent increase in the crisis delinquency rate is associated with an additional 5 basis points in the cost of funding funding.

5.5 Discussion

The results presented here are somewhat mixed. On the one hand, in the years preceding the Sub-prime Crisis the markets for bank liabilities seem to have gradually lost interest in the quality of banks' assets, banks' exposures to local risk factors, and banks' underwriting standards (Figures 5.5, 5.6, and 5.7 respectively). On the other hand, starting as early as 2003 banks' crisis exposure seems to have played an increasing role in banks' cost of funding (Figure 5.8).[31]

31. Although statistically significant deviations from the baseline crisis exposure effect (i.e. the effect in the beginning of 1994) are not observed until 2005, a nearly uninterrupted upward trend begins in early 2003.

An explanation consistent with the monitoring hypothesis is that the market for bank liabilities was focused on an observable aspect of banks' risk-taking not captured by my analysis. My sample covers a period that witnessed significant changes in banks' underwriting practices: starting around the mid-1990s, banks grew increasingly reliant on automated underwriting systems in which credit scores served as a key input.[32] Unfortunately, the HMDA loan application registers do not contain borrowers' credit scores; consequently, my measure of underwriting standards, $OverApproval_{it}$, may not adequately capture important aspects of banks' propensity to "over-approve" loans. Variation in banks' underwriting standards based on unreported characteristics may nonetheless have been common knowledge and used by investors; the increasing "effect" of crisis loan performance on a bank's pre-crisis funding cost could have been due to investors applying increasing scrutiny to banks with a reputation for "working with the borrower" a little too much.

Alternatively, the "effect" of a bank's crisis exposure on its cost of funds may not be a causal effect at all. One possibility is reverse causality: if banks faced heterogeneous shocks to their cost of funding, it could be that banks subject to positive shocks increased investment in higher-yielding assets in a "search for yield". The yield came at a price, one which was not fully revealed until the crisis. Another possibility is the existence of an omitted factor that simultaneously increased (some) banks' funding cost and decreased their future loan performance: shocks to local economic conditions may be one such factor.

It remains to be seen whether better measures of banks' underwriting standards will provide an explanation in which the observed association between banks' performance in the crisis and their pre-crisis cost of funds reflected market monitoring. While the results presented here are consistent with some (yet unidentified) form of complimentary market monitoring, the present analysis does not fully exclude the al-

32. Straka (2000) provides an account of the shift toward automated underwriting systems.

ternative explanations. However, it does appear that such monitoring—to the extent that it was present—did not take account of banks' exposures to the local economic conditions affecting their mortgage borrowers: although banks' local risk exposure was a significant factor in banks' performance during the crisis, its effect on the cost of funds was *declining* prior to the crisis. This provides further evidence that such exposures were either misunderstood or mis-estimated.

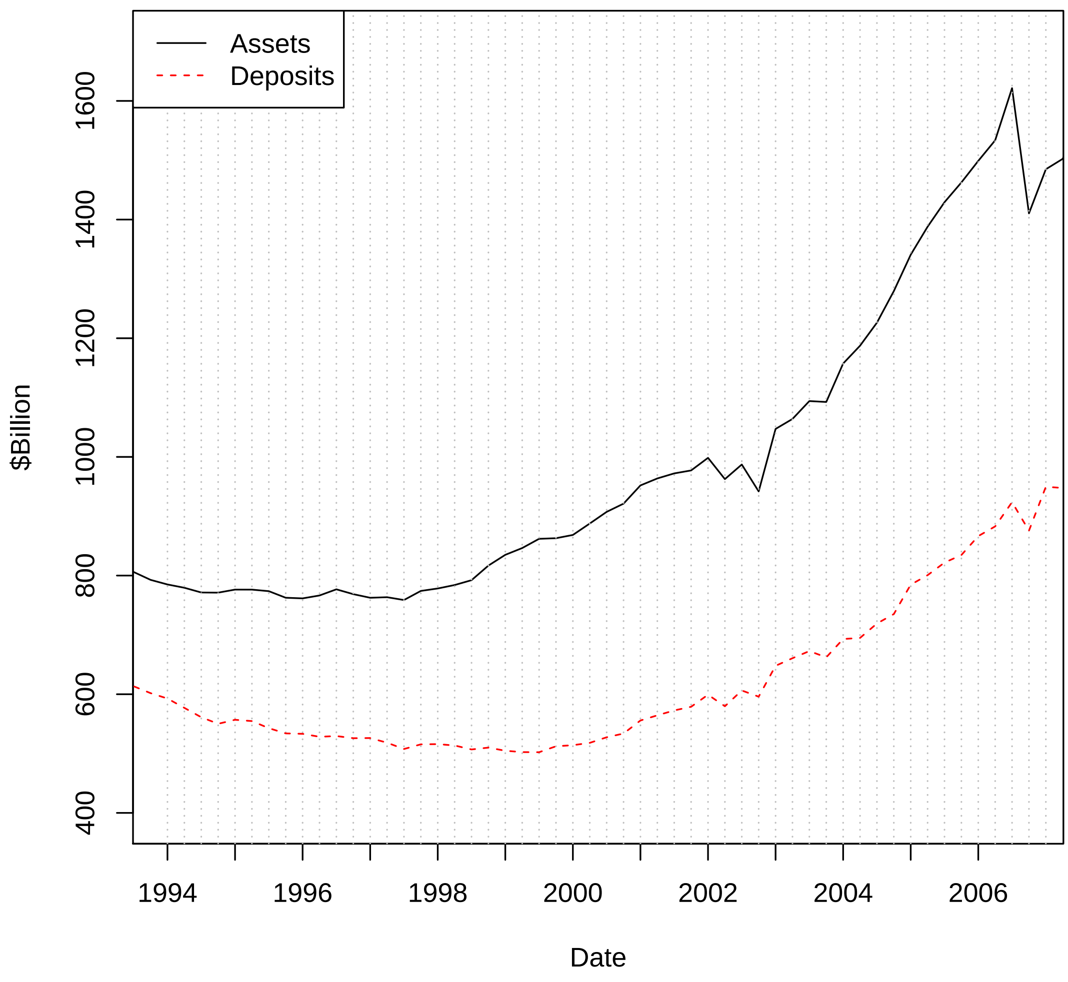

Figure 5.1: Asset and deposit growth in the thrift sector.

Figure 5.1 total assets (solid line) and deposits (dashed line) in the thrift industry over the sample period.

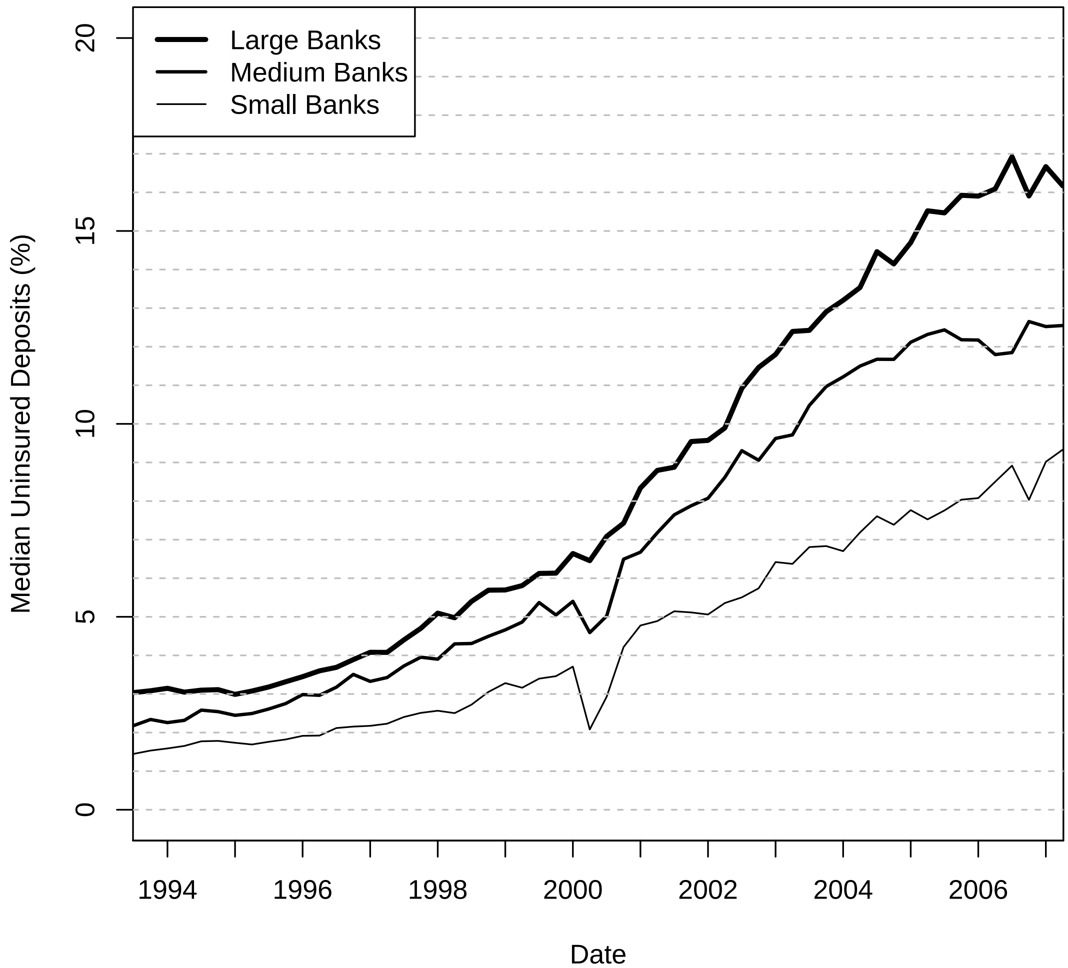

Figure 5.2: Uninsured deposits.

Figure 5.2 plots the fraction of deposits not covered by explicit government guarantees for the banks (i.e. thrifts) in my sample. The median percentage of uninsured deposits is plotted separately for banks in each size tercile.

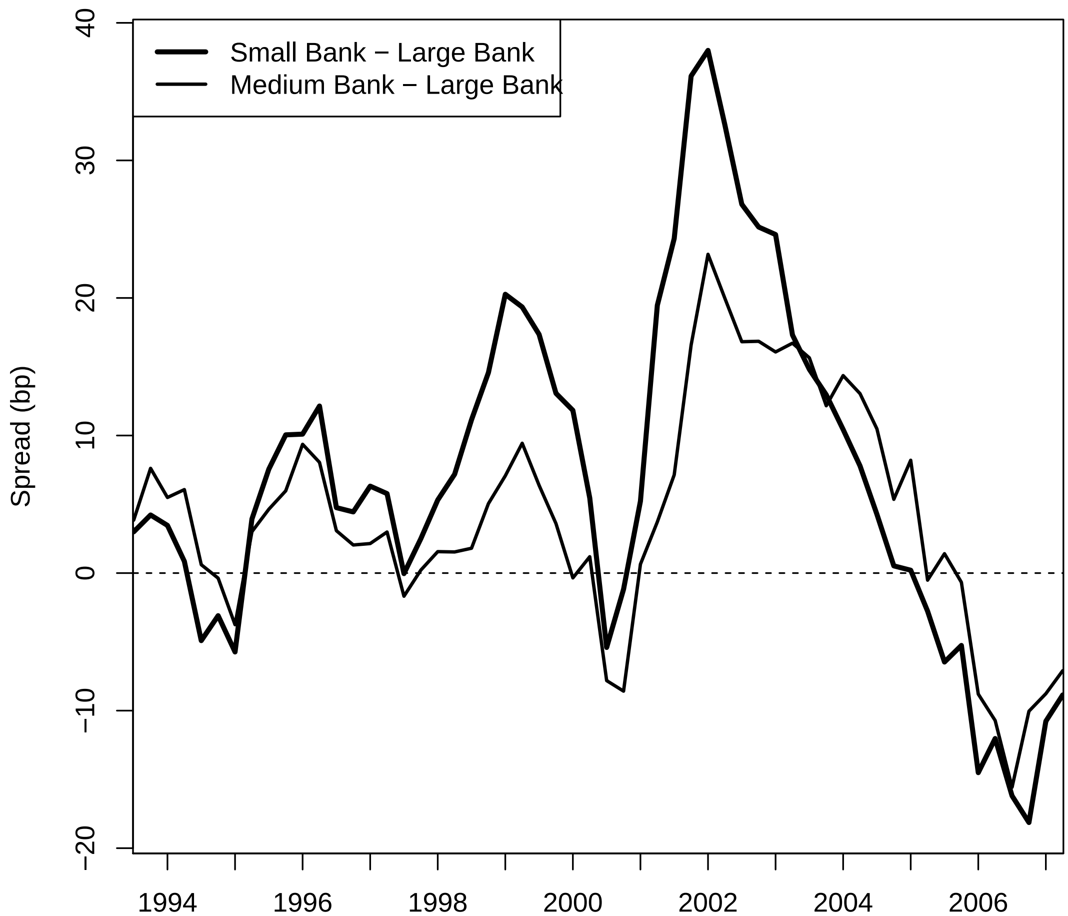

Figure 5.3: Cost of funds (by bank size).

Figure 5.3 plots the difference in funding cost between banks in the small and large size terciles, as well the difference in funding cost between banks in the medium and large size tercile.

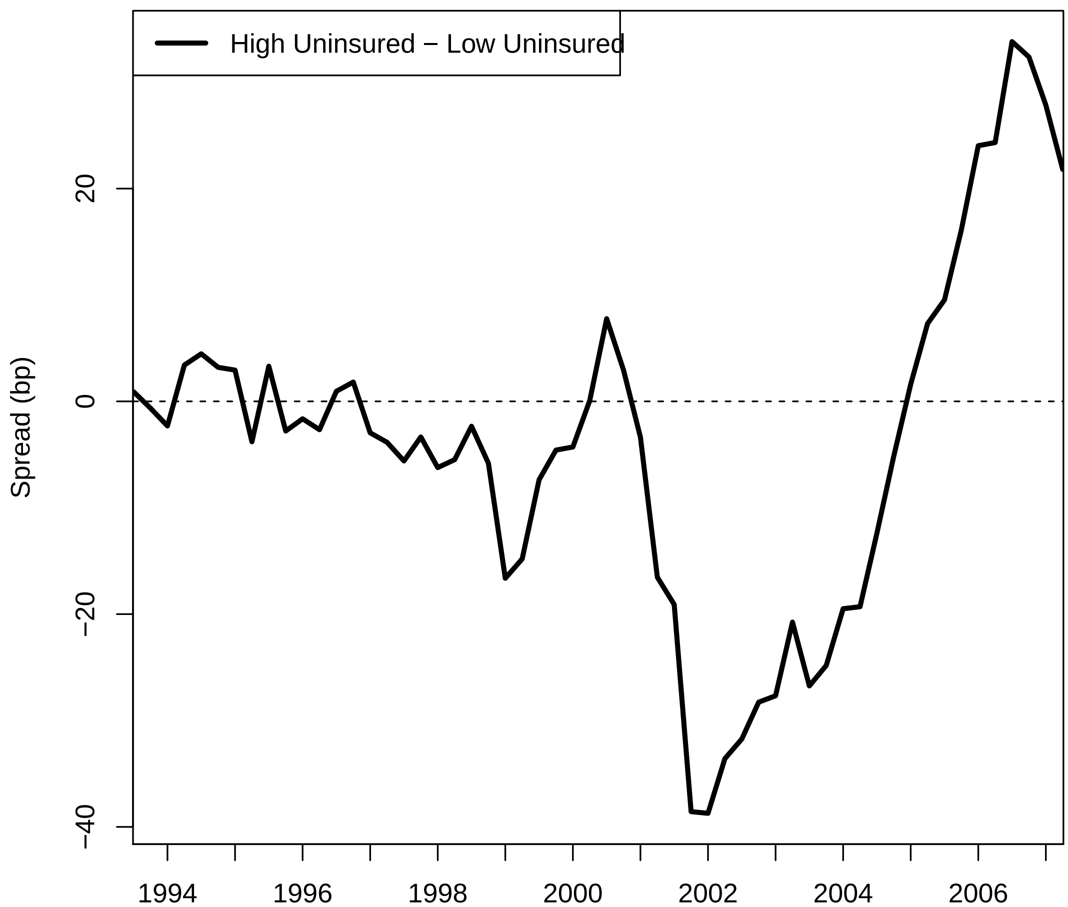

Figure 5.4: Cost of funds (by uninsured percentage).

Figure 5.4 plots the difference in funding cost between banks in the high and low percentage of uninsured deposits tercile.

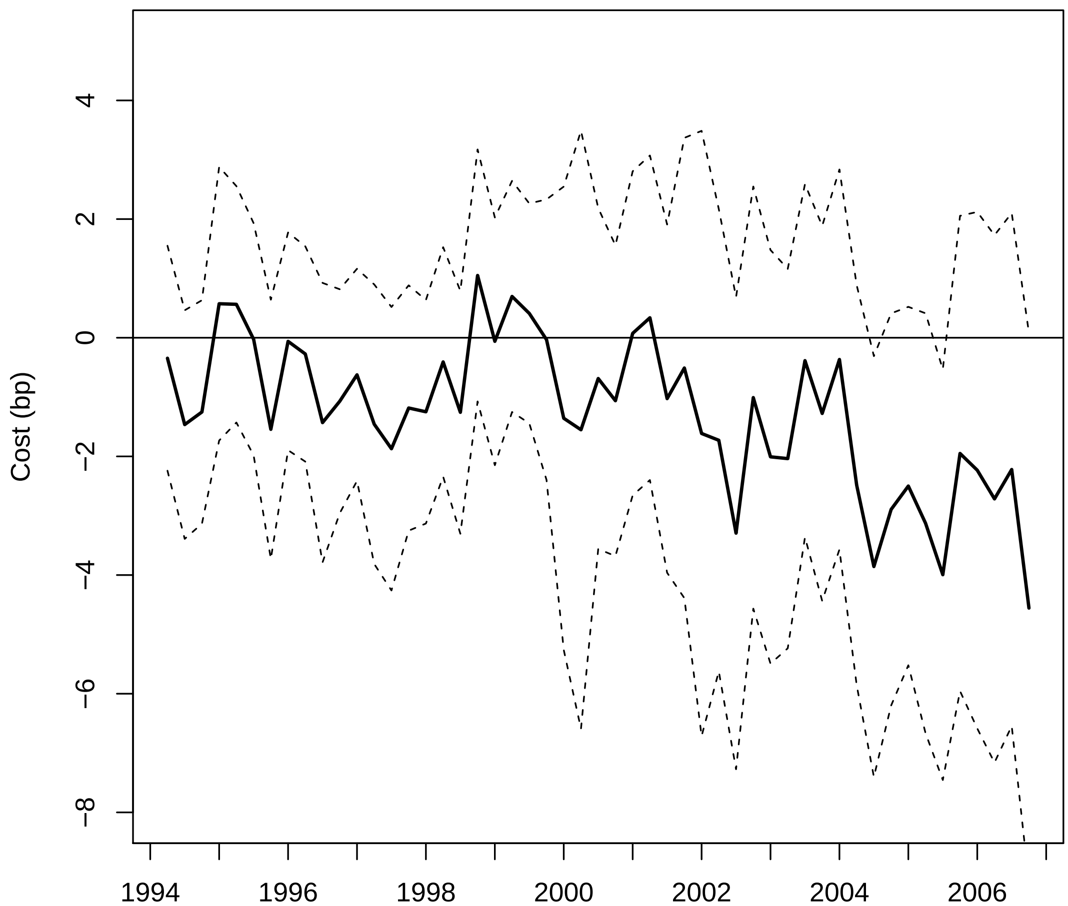

Figure 5.5: Time-varying effects of non-performing assets on the cost of funding.

Estimates for the time-varying impact of non-performing assets, NPA_{it-1}, on the cost of banks' funding. The estimate is obtained from the fixed-effects model:

$$CODF_{it} = \alpha_t + \eta_i + \theta_t NPA_{it-1} + \boldsymbol{\gamma}'\boldsymbol{x}_{it-1} + \boldsymbol{\beta}'\boldsymbol{f}_{it-1} + \epsilon_{it},$$

where the balance-sheet risk-factors, $\boldsymbol{f}_{it-1}$, and the controls, $\boldsymbol{x}_{it-1}$, are the same as in the model described in Table 5.4, Column 3. The thicker solid line is a plot of the estimates of the θ_ts; the lighter dashed lines plot the 95% confidence interval.

Figure 5.6: Time-varying effects of local risk on the cost of funding.

Estimates for the time-varying impact of local mortgage default risk, $LocalRisk_{it-4}$, on the cost of banks' funding. The estimates are obtained from the fixed-effects model:

$$CODF_{it} = \alpha_t + \eta_i + \theta_t LocalRisk^{\star}_{it-4} + \boldsymbol{\gamma}'\boldsymbol{x}_{it-1} + \boldsymbol{\beta}'\boldsymbol{f}_{it-1} + \epsilon_{it},$$

where the balance-sheet risk-factors, $\boldsymbol{f}_{it-1}$, and the controls, $\boldsymbol{x}_{it-1}$, are the same as in the model described in Table 5.4, Column 3. The $LocalRisk_{it-4}$ variable is standardized by the sample standard deviation (denoted by *). The thicker solid line is a plot of the estimates (the θ_ts); the lighter dashed lines plot the 95% confidence interval.

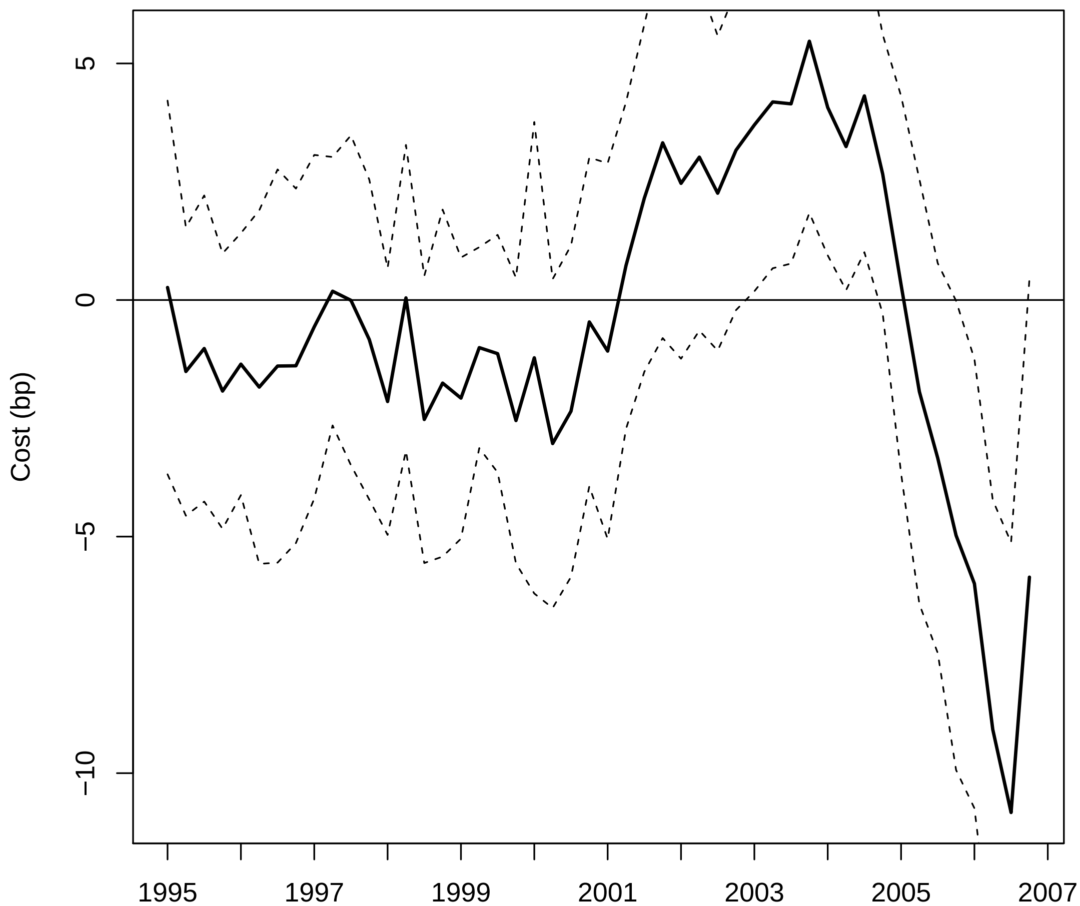

Figure 5.7: Time-varying effects of the over-approval rate on the cost of funding.

Estimates for the time-varying impact of local risk, $OverApproval_{it-4}$, on the cost of banks' funding. The estimates are obtained from the fixed-effects model:

$$CODF_{it} = \alpha_t + \eta_i + \theta_t OverApproval^{\star}_{it-4} + \boldsymbol{\gamma}'\boldsymbol{x}_{it-1} + \boldsymbol{\beta}'\boldsymbol{f}_{it-1} + \epsilon_{it},$$

where the balance-sheet risk-factors, $\boldsymbol{f}_{it-1}$, and the controls, $\boldsymbol{x}_{it-1}$, are the same as in the model described in Table 5.4, Column 3. The $OverApproval_{it-4}$ variable is standardized by the sample standard deviation (denoted by *). The thicker solid line is a plot of the estimates (the θ_ts); the lighter dashed lines plot the 95% confidence interval.

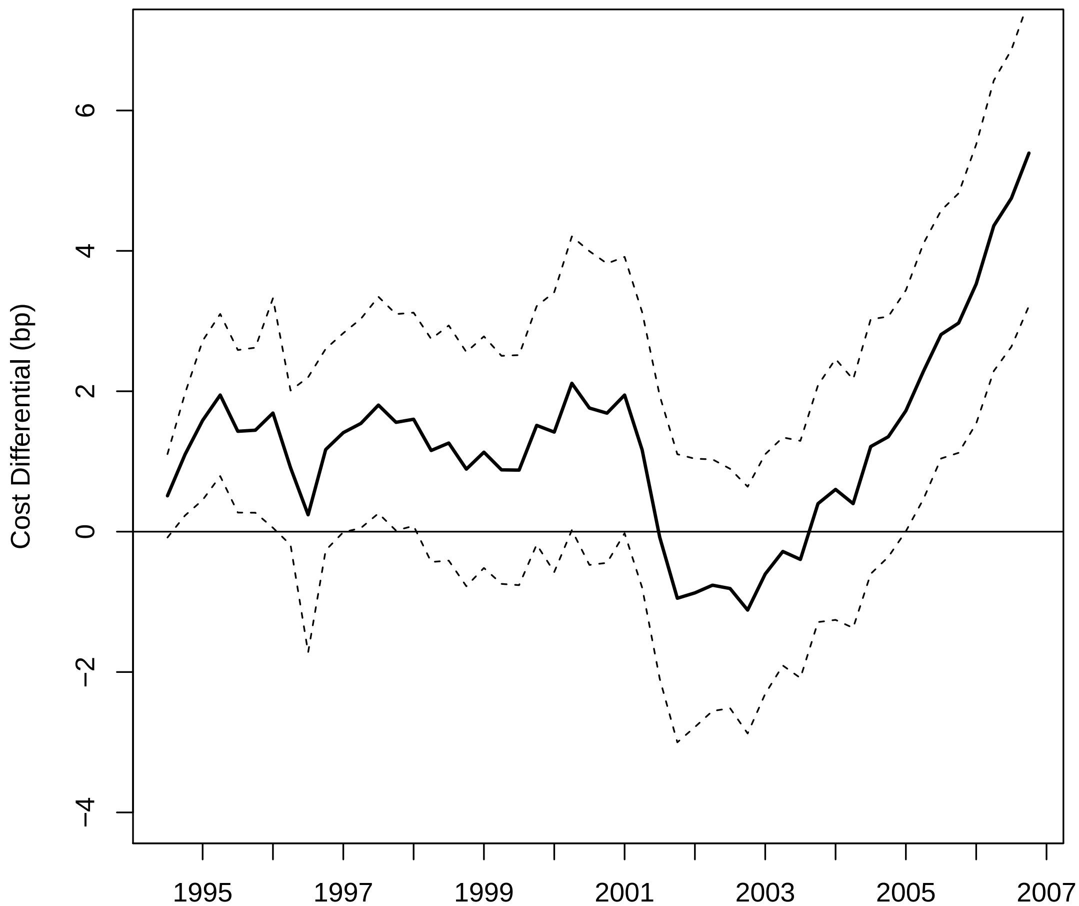

Figure 5.8: Time-varying effects of crisis loan performance on the cost of funding.

Estimates for the time-varying impact of a bank's crisis loan performance, $CNPA_i$, on the banks' pre-crisis cost of banks' funding. The estimates are obtained from the fixed-effects model:

$$CODF_{it} = \alpha_t + \eta_i + \theta_t CNPA_i + \boldsymbol{\gamma}' \boldsymbol{x}_{it-1} + \boldsymbol{\beta}' \boldsymbol{f}_{it-1} + \epsilon_{it},$$

where the balance-sheet risk-factors, $\boldsymbol{f}_{it-1}$, and the controls, $\boldsymbol{x}_{it-1}$, are the same as in the model described in Table 5.4, Column 3. The thicker solid line is a plot of the estimates (the θ_ts); the lighter dashed lines plot the 95% confidence interval. Because crisis loan performance is measured at the bank-level (there's no time variation), the estimates correspond to *differences* in cost in each time period—the total impact of crisis loan performance cannot be identified in a fixed-effects model.

Table 5.1: Summary of variables (averages).

Variable	Average 1994Q1	Average 2006Q3	Description
N_t	1449	747	Number of banks.
ROA_{it}	0.86	0.66	Net income after taxes and extraordinary items (annualized) as a percent of average total assets.
$Capital_{it}$	19.19	20.92	Tier 1 (core) capital as a percent of risk-weighted assets as defined by the OTS for prompt corrective action during that time period.
NPA_{it}	1.13	0.70	Total noncurrent loans and leases, loans and leases 90 days or more past due plus loans in nonaccrual status, as a percent of gross loans and leases.
$Liquid_{it}$	32.09	23.72	Liquid assets; sum of cash, Fed Funds lent, and securities divided by total assets.
$MktRisk_{it}$	60.39	63.54	Exposure to market (interest-rate) risk; ratio (percent) of residential loans to total loans.
$AssetGrowth_{it}$	3.33	5.77	Quarter-to-quarter growth in assets (annualized).
$Unit_{it}$	0.22	0.27	Indicator for banks with a single branch.
$Mutual_{it}$	0.45	0.39	Indicator for banks organized as mutuals.
$Broker_{it}$	0.12	0.33	Indicator for use of brokered deposits.
Med_{it}	0.37	0.36	Indicator of a medium-sized bank.
Big_{it}	0.36	0.36	Indicator of a big-sized bank.
$MktShare_{it}$	1.59	1.41	Market share of deposits; calculated as the weighted-average market share from each MSA in which the bank has a branch.
HHI_{it}	0.07	0.10	Herfindahl-Hirschman Index of deposit market concentration; calculated as the weighted-average HHI from each MSA in which the bank has a branch.
$LocalRisk_{it}$	0.97	1.68	Exposure to local mortgage default risks; calculated as the average ZIP-code level life-of-loan default multiplier for originated (and purchased) loans.
$OverApproval_{it}$	1.09	1.07	Over-approval ratio (multiplier); the bank's realized approval rate divided by the predicted approval rate.
$FNPA_i$	2.80	2.94	Crisis non-performing-assets; calculated as the average non-performing assets in the Sub-prime crisis period.

Table 5.1 summarizes the variables in the panel. Averages are reported for the first and last quarter. All ratios are winsorized at the 2% level.

Table 5.2: Summary of variables (standard deviations).

Variable	Std. Dev. 1994Q1	Std. Dev. 2006Q3	Description
ROA_{it}	0.60	0.62	Net income after taxes and extraordinary items (annualized) as a percent of average total assets.
$Capital_{it}$	9.54	11.86	Tier 1 (core) capital as a percent of risk-weighted assets as defined by the OTS for prompt corrective action during that time period.
NPA_{it}	1.09	0.83	Total noncurrent loans and leases, loans and leases 90 days or more past due plus loans in nonaccrual status, as a percent of gross loans and leases.
$Liquid_{it}$	17.35	16.79	Liquid assets; sum of cash, Fed Funds lent, and securities divided by total assets.
$MktRisk_{it}$	18.46	17.83	Exposure to market (interest-rate) risk; ratio (percent) of residential loans to total loans.
$AssetGrowth_{it}$	15.33	16.20	Quarter-to-quarter growth in assets (annualized).
$MktShare_{it}$	0.02	0.02	Market share of deposits; calculated as the weighted-average market share from each MSA in which the bank has a branch.
HHI_{it}	0.05	0.06	Herfindahl-Hirschman Index of deposit market concentration; calculated as the weighted-average HHI from each MSA in which the bank has a branch.
$LocalRisk_{it}$	0.25	0.74	Exposure to local mortgage default risks; calculated as the average ZIP-code level life-of-loan default multiplier for originated (and purchased) loans.
$OverApproval_{it}$	0.19	0.22	Over-approval ratio (multiplier); the bank's realized approval rate divided by the predicted approval rate.
$FNPA_{i}$	3.42	3.50	Crisis non-performing-assets; calculated as the average non-performing assets in the Sub-prime crisis period.

Table 5.2 summarizes the standard deviations of the variables in the panel. Standard deviations are reported for the first and last quarter. All ratios are winsorized at the 2% level.

Table 5.3: The ten largest and ten smallest banks in the panel.

Bank Name	Assets ($ million)
Home Savings of America, FSB	50367
Great Western Bank, A FSB	34989
World Savings and Loan Association, A Federal Savings and Loan Associati	28394
American Savings Bank, F.A.	17154
Glendale Federal Bank, Federal Savings Bank	16351
First Nationwide Bank, A FSB	15088
California Federal Bank, A FSB	14955
Citibank, Federal Savings Bank	12944
Standard Federal Bank	10643
Washington Mutual, A FSB	9438
	.
	.
	.
Greater South Texas Savings Bank	25
First Federal Bank for Savings	25
First Trust Savings Bank, FSB	25
Clover Federal Savings and Loan Association	25
Sun World Federal Savings Bank	25
First Northern Savings and Loan Association	25
Cambria County Federal Savings and Loan Association	25
First Federal Savings and Loan Association of Hammond	25
Southwestern Savings and Loan Association of Hugoton	25
North Side Federal Savings and Loan Association of Chicago	25

Table 5.4: Effects of balance-sheet risk-factors on banks' cost of funds.

	(1) OLS	(2) OLS	(3) FE
ROA_{it-1}	-0.103	-0.105	-0.066
	(0.023)***	(0.020)***	(0.013)***
$Capital_{it-1}$	0.005	0.004	-0.003
	(0.001)***	(0.001)***	(0.001)***
NPA_{it-1}	0.018	0.012	-0.010
	(0.011)	(0.011)	(0.006)*
$Liquid_{it-1}$	-0.005	-0.003	0.004
	(0.002)**	(0.002)	(0.001)***
$MktRisk_{it-1}$	0.004	0.005	0.005
	(0.002)**	(0.002)***	(0.001)***
Med_{it-1}	-0.027	0.034	0.066
	(0.029)	(0.027)	(0.022)***
Big_{it-1}	-0.019	0.045	0.094
	(0.032)	(0.034)	(0.035)***
$Mutual_{it-1}$	-0.051	-0.018	-0.015
	(0.025)**	(0.025)	(0.020)
$AssetGrowth_{it-1}$		0.002	0.001
		(0.000)***	(0.000)***
$Unit_{it-1}$		0.267	0.057
		(0.028)***	(0.031)*
$Broker_{it-1}$		0.202	0.072
		(0.027)***	(0.016)***
$MktShare_{it-1}$		0.007	0.033
		(0.005)	(0.014)**
HHI_{it-1}		-0.527	0.213
		(0.229)**	(0.231)
Year Fixed Effects	Yes	Yes	Yes
N	48057	46159	46159
R^2	0.786	0.804	0.913

Table 5.4 shows the results of panel regressions of a bank's cost of funding, $CODF_{it}$ on balance-sheet based risk-factors:

$$CODF_{it} = \alpha_t + \boldsymbol{\gamma}'\boldsymbol{x}_{it-1} + \boldsymbol{\beta}'\boldsymbol{f}_{it-1} + \epsilon_{it},$$

where $\boldsymbol{f}_{it}$ and $\boldsymbol{x}_{it}$ are vectors of balance-sheet derived risk-factors and controls, respectively. Columns (1) and (2) correspond to pooled OLS estimates, while Column (3) presents estimates from a model with with bank-level fixed-effects. The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

Table 5.5: Effects of risk-factors on banks' cost of funds (time-varying coefficients).

	(1) FE	(2) FE	(3) FE
ROA_{it-1}	-0.066	-0.055	-0.080
	(0.013)***	(0.016)***	(0.020)***
$Capital_{it-1}$	-0.003	-0.003	-0.005
	(0.001)***	(0.001)**	(0.001)***
$Liquid_{it-1}$	0.004	0.006	0.007
	(0.001)***	(0.002)***	(0.002)***
$MktRisk_{it-1}$	0.005	0.007	0.008
	(0.001)***	(0.001)***	(0.002)***
Med_{it-1}	0.062	0.074	0.032
	(0.022)***	(0.032)**	(0.030)
Big_{it-1}	0.089	0.097	0.070
	(0.035)**	(0.043)**	(0.047)
$Mutual_{it-1}$	-0.016	-0.029	0.009
	(0.020)	(0.025)	(0.028)
$AssetGrowth_{it-1}$	0.001	0.001	0.001
	(0.000)***	(0.000)***	(0.000)***
$Unit_{it-1}$	0.057	0.076	0.060
	(0.032)*	(0.041)*	(0.045)
$Broker_{it-1}$	0.076	0.066	0.070
	(0.016)***	(0.020)***	(0.023)***
$MktShare_{it-1}$	3.473	4.136	3.810
	(1.405)**	(1.139)***	(2.239)*
HHI_{it-1}	0.209	0.112	0.351
	(0.232)	(0.259)	(0.275)
NPA_{it-1}	Fig. 5.5		
$LocalRisk_{it-4}{}^{\star}$		Fig. 5.6	
$OverApproval_{it-4}{}^{\star}$		Fig. 5.7	
$CNPA_i$			Fig. 5.8
Time Fixed Effects	Yes	Yes	Yes
N	46301	28690	26456
R^2	0.912	0.919	0.933

Table 5.5 shows the estimates of the panel regressions described in Figure 5.5 (column (1)), Figures 5.6 and 5.7 (column (2)), and Figure 5.8 (column (3)). The standard errors (in parentheses) are clustered by bank, allowing for heteroskedasticity and arbitrary within-bank correlation. ***, **, and * denote statistical significance (of two-sided tests) at the 1%, 5%, and 10% levels, respectively.

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