Essays in Banking and Monetary Policy

by

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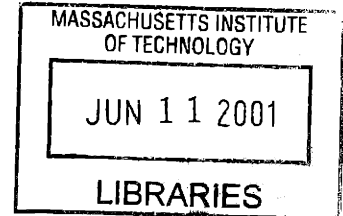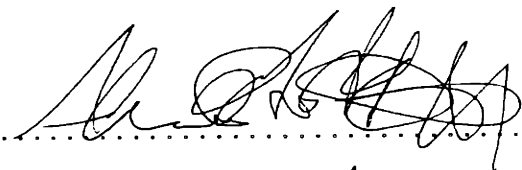
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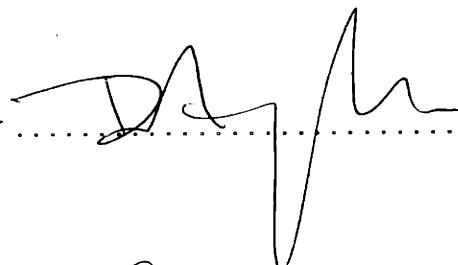
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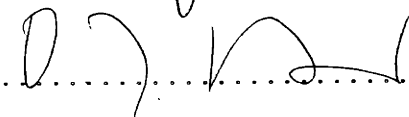
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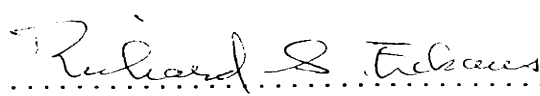
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Abstract

In the first chapter, I demonstrate that banks play a special role in the transmission mechanism of monetary policy, and that this role potentialy explains the excessive sensitivity and asymmetric response of the real economy to small and temporary changes in interest rates. While banks exploit imperfectly-priced deposit insurance in order to ameliorate the underinvestment problem created by financial constraints, open-market operations by the central bank control the aggregate supply of insured deposits, and thus the severity of these constraints. I demonstrate in the second chapter that tougher bank capital requirements did not affect on the banking industry in the 1980s. Banks with relatively low capital raised their capital ratios relative to better capitalized banks well before any tightening of standards, and did not change their behavior following the change in policy. This implies that banks have market-based incentives to hold capital, an important consideration in designing bank regulation. In the third chapter I illustrate that there is very little correlation between how monetary policy affects state output and how the shocks which monetary policy is trying to smooth affect state output. This correlation is weak enough to imply that while monetary policy may have reduced the variance of aggregate output growth over the last 30 years, it has actually increased volatility for a majority of states. This result has important implications in choosing appropriate target variables for the central bank.

Thesis Supervisor: Daron Acemoglu
Title: Professor of Economics

Thesis Supervisor: Olivier Blanchard
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attend my lunches and consistently given me constructive feedback on my work. Daron has challenged me as much as anyone, and has been very supportive of my attempt think hard about causality in my work. He has had an uncanny ability to keep mind of the big picture but not ignore any minute detail. I am in awe of his ability to follow, challenge, and add value during lunches and workshops across very disparate fields. He is a brilliant economist, and will certainly be recognized as such at the end of his career.

Without the kind assistance of Sean May, I would have never learned LATEX (or a number of other software packages that I have not used since he graduated), and would have spent the last few days like poor other souls trying to figure out how the heck to format my thesis in Scientific Word. Sean has been a great friend over the last five years while working together in the lab late at night, watching the Patriots fumble away another game to the Jets, or playing hockey against Wellesley girls. His most important contribution to my thesis over the last year has probably been taking my wife shopping during the weekend so I could get some work done. Sean's brother Craig also did more than his share of shopping, but he goes to Harvard, so is not worth mentioning here.

Campe Goodman has also been a great friend during my time at MIT. He introduced me to his old friend from college who I eventually married. Campe kindly invited us down every summer to spend time unwinding at his mansion in Virginia Beach, and showed me how to productively use my down time playing Yahoo backgammon (while Stata jobs were running of course). Jonathan Guryan was great lunchtime company, and loved baseball enough to sit in the rain with me at Fenway. John Johnson was a father figure, always there to provide support when things weren't going well and to create balance to my otherwise liberal-leaning friends. Eric Bettinger was just an awesome softball player that made our summers a little

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brighter by keeping us in a few games. Steve Bergantino was also pretty good with the bat, but most of us remember him for his econometrics notes which are still passed down on to first-years. I should also thank the bank-inclined Dan Bergstresser and Jonathan Zinman for their comments along the way.

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Chapter 1

Introduction

This thesis is a collection three essays about banks, monetary policy, and the role of banks in the conduct of monetary policy, respectively. The first chapter attemps to answer whether or not banks have a special role in the transmission mechanism with mixed results. There seems to be convincing evidence that the central bank can affect the supply of bank credit, but it is not clear whether or not this matters for real activity. The second paper re-evaluates the importance of changes in bank capital regulation that were implemented by the regulators in the mid-1980s. While several researchers have observed that low capital banks tended to increase their capital ratios relative to better capitalized banks after the policy changes and concluded that tougher adequacy standards prompted banks to increase their capital ratios, I demonstrate such mean-reversion exsited before any change in policy. Banks appear to have market-based incentives to hold capital and thus reverse bad shocks, an important observation when designing bank regulation. The final paper is about the potential distortions created by smoothing aggregate volatility with monetary policy. When the correlation between how policy affects regions and the shocks to be smoothed affect

regions is low, smoothing the aggregate component of shocks can actually increase volatility for some regions. I demonstrate that while monetary policy might have reduced aggregate volatility over the last 30 years, volatility has actually increased for a significant part of the economy. Moreover, even a transition to optimal policy rules involve trade-offs between lower aggregate volatilitiy and higher regional volatility. I conclude that using monetary policy to achieve aggregate targets may not be a great idea.

Economists have long been puzzled by the observed large and lagged response of output to what are generally small and temporary changes in policy interest rates is difficult to reconcile the with the measured weak cost of capital effects on private spending. This excessive sensitivity has prompted some researchers to look for a financial mechanism – often referred to broadly as the credit channel – through which policy-induced changes in short-term interest rates are greatly amplified. The lending channel presumes that monetary policy directly affects bank loan supply, forcing bank-dependent firms to reduce investment. Draining deposits from banks will reduce lending if banks face financial constraints when attempting to smooth these outflows by issuing uninsured debt. When banks have acquired an information advantage over time about the quality of their borrowers, firms may find the credit offered by other banks to be an imperfect substitute. A policy-induced contraction in loan supply thus has much larger effects on investment than is implied by the actual change in interest rates.

The main insight of the first chapter is that there is a very natural source of cross-sectional variation in financial constraints that identifies a lending channel. In particular, I argue that banks affiliated with multi-bank holding companies are much larger than their actual size indicates, at least in terms their ability to smooth policy-induced changes in

insured deposits, due to the presence of internal capital markets. While a small bank faces sharply increasing marginal costs when issuing uninsured debt, a large holding company can raise external funds more cheaply and downstream capital to its subsidiaries. Comparing the response of otherwise similar banks to monetary policy across the size of their affiliated holding company seems to be the right experiment for identifying a shift in loan supply. In contrast to existing research, this strategy plausibly isolates cross-sectional variation in financial constraints and arguably holds constant unobserved differences in the response of loan demand across banks.

This first chapter makes several important contributions to the literature. First, there is convincing evidence that differences in the severity of financial constraints affect the response of individual bank lending to monetary policy. Moreover, differences in the response of loan growth across multi-bank holding company affiliation do not appear to be driven by unobserved differences in customer mix. Second, there is evidence that financial constraints affect the response of equilibrium bank lending to monetary policy. As unconstrained banks are unable to reverse the lending response of constrained banks, the lending channel could play an important part in how monetary policy actually works. The extent to which this shift in equilibrium loan supply actually explains the excessive sensitivity of output to monetary policy is left for future research.

The premise of bank capital regulation is a fear that the presence of imperfectly-priced deposit insurance permits banks to view portfolio and leverage risk as compliments, creating incentives for excessive risk-taking at the taxpayer's expense. While banks certainly would fail in the absence of deposit insurance, the concern is that banks are less likely to carefully reverse bad shocks on their own and are more likely to increase asset risk when they don't

have to pay a default premium on their liabilities to depositors. Bank capital regulation has traditionally tried to curb these incentives either by limiting bank leverage or by tying allowable asset risk to the actual level of capital.

By the end of the 1980s, the aggregate capital ratios of commercial banks increased by 200-300 basis points since formal capital standards were introduced in 1981 and subsequently increased in 1985. How much of this increase in capital ratios was caused by tougher adequacy standards is the crucial question addressed by the second chapter.

The fundamental identification problem is that tougher adequacy standards generally affect all commercial banks so that there is no true control group. A finding that low capital banks generally increased their capital ratios relative to high capital banks after an increase in capital standards is only relevant in answering this question if such mean-reverting dynamics did not exist before the policy change. This possibility is strongly rejected in the paper, which demonstrates that mean-reverting dynamics are present throughout the period. A direct consequence of this result is that any evaluation of tougher capital adequacy standards that simply compares the outcomes of banks by level of capital as measured before the change in overestimates the effects of a policy change. Moreover, an estimator which differences out the pre-existing dynamics between low and high capital banks eliminates all measured effects of tougher standards in 1985.

The only way to properly identify the causal effect of interest is to locate a large group of banks with similar asset powers that are lending in similar markets, and to randomly increase capital requirements for one subset of this group. While such deliberate experimentation by the regulators is generally not possible, it turns out that something pretty close to this occurred by accident in the mid-1980s. In particular, I exploit the plausibly exogenous

elimination of differences by Federal Reserve System membership status in leverage require-

ments for community banks (those with less than $1 billion is assets). In particular, until

early 1985 when leverage requirements were made uniform across the regulators, member

banks effectively had requirements of 7 percent while non-member banks had requirements

of 6 percent. I analyze the 100 basis point increase in minimum leverage requirements by the

FDIC in 1985, using member banks as a control group. Controlling for pre-existing dynamics

across membership status and permitting precautionary behavior, I corroborate the finding

above tougher leverage standards in 1985 had little impact on bank behavior. Moreover, I

find that despite lower minimum capital standards in 1985, non-member community usually

banks raised their capital ratios as much as member banks, suggesting that the level of capi-

tal requirements was also unimportant. In any case, analysis of this natural experiment does

not change the basic message from above: tougher leverage requirements did not matter.

This paper provides important lessons when evaluating the impact of risk-based capital

requirements on bank behavior. Several economists had pointed to the ahistorical portfo-

lio shift from loans into securities that occurred in the early 1990s as evidence that Basle

had important real effects. One problem with this story is that while risk-based capital

requirements have if anything gotten tougher over the last decade, commercial banks have

completely reversed this portfolio shift. Advocates of risk-based capital standards could

reasonably argue that standards have been eroded over time as banks discovered or created

loopholes in them, but there is another interpretation of these facts: tougher standards were

simply not important and that the observed portfolio shift was a response to an ahistorical

level of bank failures.

When banks view FDIC guarantees as a call option on the value of assets, there are

incentives for excessive risk-taking. This implies that any minimum capital requirement is binding as banks seek to maximize their leverage. I interpret the evidence above as a strong rejection of this simple call option model of bank behavior, suggesting that the moral hazard incentives for banks have been largely overstated and that there are possibly market-based incentives for banks to hold capital. Identifying and quantifying these incentives is thus the next important step in properly evaluating the likely effects of past bank regulation and of course when designing regulation for the future.

Monetary policy is the primary tool in advanced economies for smoothing business cycles. In the United States the central bank has been charged under the Federal Reserve Act with the objectives of maximum employment, stable prices, and moderate long-term interest rates. While the Federal Reserve has generally attempted to achieve these objectives by smoothing fluctuations in economic aggregates, it is possible that the aggregate economy is not the right unit of analysis when designing or evaluating monetary policy.

The aggregate economy is made up of potentially heterogeneous regions, each of which has its own response to the policy instrument and to the fluctuations which prompt aggregate smoothing by the central bank. When the correlation between how policy affects a region with how the shocks to be smoothed affect a region is low, a number of regions might not benefit very much – or may even suffer – under aggregate smoothing by the central bank. In this sense a focus by the central bank on economic aggregates.

To fix ideas, consider an economy with two regions. Imagine a shock that affects the Eastern region and a policy instrument that largely operates through the Western region. Any aggregate smoothing of this shock increases volatility in the West and only affects the East indirectly through its linkages with the other region. The inability of the central

bank to channel the impact of monetary policy in the affected region implies that aggregate smoothing actually weakly increases volatility in every region of the economy. This is of course an extreme example, but does illustrate that there could be an important difference between smoothing aggregate and regional volatility. Developing evidence on the possible size of this difference is the primary task of the third chapter.

It turns out that there actually is very little correlation between how shocks that create aggregate volatility affect state output growth with how state output growth response to changes in monetary policy. This small correlation has important implications for when evaluating the performance of actual monetary policy over the last three decades. I demonstrate below that the estimated policy rule seems to have reduced the variance of aggregate output relative to policy of holding interest rates constant. On the other hand, the actual steady-state variance of output has increased for a majority of states representing at least half of the economy, implying that aggregate smoothing has largely been accomplished by generating negative a covariance in output across the states.

When characterizing the set of policies that minimize the steady-state variance of prices and income, macroeconomists have generally found trade-offs between these two objectives. Estimates of the policy rules actually used by the Federal Reserve have generally indicated that these rules are sub-optimal in the sense that the variance of both inflation and output growth could be reduced through a change in policy. As more recently estimated policy rules have seemed to move in this direction, it may seem like central bank performance is improving. I demonstrate, however, that while a shift towards a Taylor rule for monetary policy would certainly reduce the variance of both aggregate output and prices, such a policy change continues to increase state volatility, although most often for state that represent a

small fraction of the economy. I conclude that monetary policy has the potential to create significant distortions when using aggregate volatility as a target variable.

Chapter 2

New Evidence on the Lending Channel

2.1 Introduction

How does monetary policy affect the real economy? The textbook story, often referred to as the interest rate or money channel, is that the Federal Reserve uses open-market operations to enforce a target for the federal funds rate by managing the aggregate supply of commercial bank reserves. The absence of arbitrage requires that changes in policy interest rates induce similar changes in other short-term interest rates. In the presence of sticky prices, these real changes in the cost of capital drive changes in the interest-sensitive components of demand. Consequently the response of real output to monetary policy in this theory simply depends on how far interest rates move and how elastic spending is to interest rates. In practice, the observed large and lagged response of output to what are generally small and temporary changes in policy interest rates is difficult to reconcile the with the measured weak cost of

capital effects on private spending. [1]

The excessive sensitivity of output to monetary policy has prompted economists to look for a financial mechanism – often referred to broadly as the credit channel – through which policy-induced changes in short-term interest rates are greatly amplified. These theories generally involve the presence of asymmetric information that creates financial constraints through an increasing marginal cost of external finance. The balance sheet channel hypothesizes that monetary policy affects loan demand through firm balance sheets. Higher interest rates will erode firm cash flow and reduce net worth. This deterioration in firm creditworthiness increases the external finance premium and effectively reduces firm demand for credit. [2] On the other hand, the lending channel presumes that monetary policy directly affects bank loan supply, forcing bank-dependent firms to reduce investment. Draining deposits from banks will reduce lending if banks face financial constraints when attempting to smooth these outflows by issuing uninsured debt. When banks have acquired an information advantage over time about the quality of their borrowers, firms may find the credit offered by other banks to be an imperfect substitute. A policy-induced contraction in loan supply thus has much larger effects on investment than is implied by the actual change in interest rates. [3]

The main insight of this paper is that there is a very natural source of cross-sectional variation in financial constraints that identifies a lending channel. In particular, I argue

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[1]Bernanke and Gertler (1995) discuss this and related issues in more detail. See Caballero (1997) for a survey of the literature on the sensitivity of investment to the cost of capital, or Cummins, Hasset, and Hubbard (1994) for analysis in the context of a natural experiment.

[2]See Gertler and Gilchrist (1994), Oliner and Rudebusch (1996b), or Kashap, Lamont, and Stein (1994) for evidence consistent with a balance sheet channel of monetary policy.

[3]See Kashyap and Stein (1994,1998), Kishan and Opiela (2000) for evidence consistent with a lending channel of monetary policy. See Farrell and Shapiro (1988) for a model of optimal contracts with lock-in consistent with bank-dependence by firms.

that banks affiliated with multi-bank holding companies are much larger than their actual size indicates, at least in terms their ability to smooth policy-induced changes in insured deposits, due to the presence of internal capital markets. While a small bank faces sharply increasing marginal costs when issuing uninsured debt, a large holding company can raise external funds more cheaply and downstream capital to its subsidiaries. Comparing the response of otherwise similar banks to monetary policy across the size of their affiliated holding company seems to be the right comparision for identifying a shift in loan supply. In contrast to existing research, this strategy plausibly isolates cross-sectional variation in financial constraints and arguably holds constant unobserved differences in the response of loan demand across banks.

The idea that internal capital markets reduce financial constraints is not new. Stein (1997) builds a model where a financially constrained parent company not only has controls rights over the cash flows and collateral of its similarly constrained subsidiaries, but also has better information than the market about their relative profitability. Knowing that the parent is selectively relaxing the financial constraints of the most promising subsidiaries, passive investors are willing to trust the parent with more capital. There is also evidence that bank holding companies actually operate internal capital markets. Houston, James, and Marcus (1997) find that the loan growth of bank subsidiaries is actually more sensitive to the cash flow and capital position of its holding company than the subsidiary bank.

The model developed below demonstrates that when deposit insurance is mispriced, banks can use insured deposits to reduce the underinvestment problem created by the presence of financial constraints. Moreover, banks that face tougher financial constraints should rely more on insured deposits to finance new lending. Using multi-bank holding company affili-

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ation as a measure of constraints, I demonstrate that the loan growth of affiliated banks is much less sensitive to insured deposit growth. When there is no difference between reservable and insured deposits, open market operations operate directly on the ability of banks to reduce existing underinvestment problems, creating a lending channel of monetary policy. Consistent with this prediction I find that the loan growth of affiliated banks is less sensitive to changes in the federal funds rate. There is also evidence that these banks are actually better able to smooth the insured deposit outflows created by a monetary contraction by issuing large time deposits and borrowing federal funds. While it seems unlikely that unobserved differences in the response of loan demand to monetary policy explain these results, I show that these findings are robust to recently available controls for small business loan concentration.

As the lending channel is identified by differences in financial constraints across banks, one might expect that it is much weaker during times when constraints are not binding. I argue below that the monetary expansion that occurred 1990-1993 corresponds to a period when loan growth was not constrained by the supply of insured deposits. There appears to be weak evidence that affiliated banks do less to smooth the impact of monetary policy on lending during this period. This result is difficult to explain in a model where banks don't have a special role in the transmission mechanism, but is predicted by the model of the lending channel developed in the paper. Moreover, there is potentially an asymmetry in the effectiveness of countercyclical monetary policy: increases in the federal funds rate during booms should on average affect real output more than decreases during recessions.

I finally find evidence that financial constraints at the bank level affect the equilibrium response of lending to monetary policy. One might be concerned that affiliated banks use

their greater ability to smooth deposit outflows to pick up any slack in loan supply left by unaffiliated banks. As interstate branching restrictions have historically meant that commercial banks largely operate in the state where chartered, it seems plausible for much of the last 25 years to treat the US as a collection of state economies. [4] Along these lines, I document that aggregate state loan growth becomes less sensitive to changes in the federal funds rate as loan market share of affiliated banks increases. Having identified a shift in equilibrium lending, I attempt to measure the importance of a lending channel in amplifying changes in the funds rate on state output. Unfortunately, I am unable to make strong statements about this number due to the size of standard errors.

While researchers have recently made progress in identifying evidence of a lending channel, there remain some important concerns. Kashyap and Stein (1995,1998) hypothesize that due to tougher financial constraints, smaller banks will be less able to replace insured deposits with insured debt and thus be forced to sell liquid assets to fund loan growth. The authors establish that in response to a monetary contraction, the lending of small banks falls relative to large banks and that the lending of small banks is more sensitive to liquidity than large banks. [5] Since large banks tend to concentrate their lending with large firms, however, it is difficult to distinguish a differential response of loan demand to monetary policy across firm size from a differential response of loan supply across bank size. When firms hold deposits at the same bank where they borrow funds – as is frequently required in the covenants of loan contracts – there are also likely differences in the composition of liabilities.

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[4]See Strahan (2000) or Kane (1996) for a discussion of the political economy behind branching restrictions.

[5]Kishan and Opiela (2000) also argue that increasing bank leverage worsens financial constraints. The authors document in aggregated data that there is a differential response of loan growth across bank equity ratios to monetary policy.

[6] Without evidence that large banks are actually smoothing insured deposit outflows better by issuing uninsured debt, this observation is consistent with smaller banks having larger shocks to liabilities. [7] At the same time, even if the differential response of loan growth across bank size and liquidity reflects financial constraints and not customer mix, this is not evidence that the lending channel plays an important role in the transmission mechanism. Large liquid banks could pick up the slack in lending left by small illiquid ones so there are no aggregate consequences of the lending channel.

This paper makes several important contributions to the literature. First, there is convincing evidence that differences in the severity of financial constraints affect the response of individual bank lending to monetary policy. Moreover, differences in the response of loan growth across multi-bank holding company affiliation do not appear to be driven by unobserved differences in customer mix. Second, there is evidence that financial constraints affect the response of equilibrium bank lending to monetary policy. As unconstrained banks are unable to reverse the lending response of constrained banks, the lending channel could play an important part in how monetary policy actually works . The extent to which this shift in equilibrium loan supply actually explains the excessive sensitivity of output to monetary policy is left for future research.

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[6]It is often argued that one way that banks are able to perform their monitoring function and thus offer finance to firms on better terms than passive investors is by reviewing data on deposit accounts. Loan contracts often contain covenants requiring compensating balances at the bank. Mishkin (1997) argues that compensating balances "make it easier for banks to monitor borrowers more effectively" and thus are an "important credit risk management tool".

[7]While Kashyap and Stein (1994) find the shocks to core deposit growth created by changes in the federal funds rate are not correlated with size class when using aggregated data, this is not true when using bank size in the micro data. There is no evidence in the literature that larger or better-capitalized banks are better able to smooth deposit outflows by issuing uninsured debt. I demonstrate in Ashcraft (2000d) that such evidence is elusive. When exploiting variation in equity ratios it simply does not exist. Larger banks do appear to smooth deposit outflows with large time deposits and federal funds borrowing more than small banks, but only after controlling for differences in the shocks to insured deposits across bank size.

Section 2 demonstrates the role of banks in the transmission mechanism with and without financial constraints. I discuss how internal capital markets work in Section 3, and describe the data and descriptive statistics in Section 4. Evidence that internal capital markets identify a lending channel of monetary policy is discussed in Section 5, and directions for future research are outlined in Section 6.

2.2 Theory

Below I sketch of a model of banks' role in the transmission mechanism of monetary policy in order to provide a solid foundation for empirical analysis that follows. The microfoundations for this reduced-form approach are developed in Ashcraft (2000c). I begin with a frictionless world in order to illustrate the passive role of banks in the simple money channel, and then introduce information problems at the bank level in order to build a lending channel. Finally, I illustrate how the presence of a balance sheet channel creates a serious threat to identification. [8]

2.2.1 Financial intermediation without financial constraints

Banks are firms that extend credit and are largely financed through insured deposits, in contrast to other financial intermediaries – broadly referred to here as non-banks – which are financed completely using uninsured debt and equity. In the absence of information prob-

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[8]Stein (1995) builds a model of the lending channel based on asymmetric information about the value of existing assets. This model is very similar is spirit, and frequently differs more in style and emphasis than substance. The main difference here is in the role of deposit insurance pricing. When the insurer prices deposit insurance in a manner similar to how passive investors price uninsured debt, banks are no longer able to use insured deposits to reduce existing underinvestment problems and the lending channel disappears.

lems that create financial constraints, the loan supply of risk-neutral financial intermediaries does not depend on the fraction of assets financed by insured deposits. While there are institutional factors that might make one form of finance relatively more attractive, the opportunity cost of lending is always the fixed interest rate on the uninsured debt instruments of other intermediaries, and is thus independent of how a particular institution is financed.

Assume that banks have monopoly power in the credit market so that the demand for bank loans is downward-sloping. This monopoly power can be motivated either by the presence of legal restrictions on branching within and across states or the presence of significant switching costs created by lender lock-in. [9] For simplicity, I use the following linear loan demand schedule,

$$L_n^d = a - b * r_l \qquad (2.1)$$

Banks finance new loans (L_n) by using insured deposits (D) and uninsured certificates of deposit (CD), being forced to hold a fraction θ of insured deposits as required reserves (R) on account at the central bank. Deposits pay a zero nominal interest rate while CDs pay an interest rate of $r_{cd} \geq 0$. Banks may also purchase the CDs of other banks. [10] For simplicity,

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[9] For a discussion of evidence of branching restrictions and monopoly power see Gilbert (1984) or Kroszner and Strahan (1999). The necessary assumption here is that some firms are bank-dependent in the sense that the credit of other banks is an imperfect substitute for the credit of its current bank. See Farrell and Shapiro (1989) for a model consistent with lender lock-in, or Sushka, Slovin, and Polonchek (1990) for evidence suggesting that firms can be bank-dependent. I do not formally model this dependence here, taking financial constraints at the firm level and the implications of delegated monitoring by banks as given.

[10] I have choosen to refer to all short-term risky debt by large CDs as Romer and Romer (1990,1992) argue that banks are able to smooth deposit outflows with this specific instrument. I intend for CDs to generally represent any form of unsecured debt that banks can use to replace insured deposits. For example, the cross-holdings of other uninsured CDs across banks possibly corresponds to the federal funds market. As banks are risk-neutral, all properly priced all debt instruments are perfect substitutes. Thus the holdings of

Table 2.1: Bank Balance Sheet	
Assets	Liabilities and Equity
Reserves (R)	Insured Deposits (D)
Uninsured Deposits (CD^-)	Uninsured Deposits (CD^+)
New Loans (L_n)	

the price of deposit insurance is zero. [11] The balance sheet is illustrated in Table (2.1), and

the implied balance sheet constraint is simply.

$$L_n = (1 - \theta)D + CD \tag{2.2}$$

I finally assume that the quantity of bank deposits is given, motivated by the presumption

that this quantity is largely determined by fixed costs in the presence of bank branches that

do not affect our short-run optimization problem here. The bank maximizes profits as follows,

$$\max_{L_n} \pi = L_n * r_l - CD * r_{cd} \tag{2.3}$$

subject to loan demand (2.1) and the balance sheet constraint (2.2). First-order condi-

tions imply that unconstrained lending L_n^* sets the marginal revenue of bank credit equal

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other banks' CDs could also represent government securities. Of course there are differences in the maturities
of these instruments, but making these distinctions does not seem to add much to the model.

[11] Any fixed positive price certainly complicates the analysis, but does not substantively change the results.
While the the presence of unfairly priced deposit insurance is crucial our analysis, this does not seem to be
an unreasonable assumption. Berger, Herring, and Szego (1995) document that the risk premia implied by
the current pricing of deposit insurance is at least an order of magnitude smaller that faced by non-banking
firms. In particular, the difference in risk premia charged by the FDIC for the best-rated to worst-rated (in
terms of bank examiner's CAMEL ratings) banks was around 8 basis points. Differences in risk-premia on
corporate bonds between B- and AAA-rating typically exceed 100 basis points.

to the marginal cost of finance. When insured deposits are insufficient, banks issue CDs so that the marginal cost is r_{cd}. On the other hand, when insured deposits are in surplus, banks have the option of purchasing CDs so that the opportunity cost of lending is r_{cd}. Equilibrium is illustrated in Figure (2-1) for each of high and low levels of loan demand (the figure illustrates corresponding marginal revenue curves). The expression $X(D)$ corresponds to the quantity of insured deposits net of required reserves and existing loans, and is simply $(1 - \theta)D$. Intermediary lending depends on exogenous factors affecting firm demand for credit, the elasticity of loan demand, and the interest rate on uninsured CD's, that last of which has not yet been determined.

The model is closed with a money market. Assume that risk-neutral agents have a fixed amount of wealth allocated between insured deposits and uninsured certificates of deposit (simply money and bonds), which they view as imperfect substitutes. Non-banking institutions are financed entirely by bonds, which may have a different characteristics, but are perfect substitutes for uninsured deposits. The aggregate supply of insured deposits is simply the ratio of required reserves to the required reserve ratio, $\frac{R}{\theta}$, while the aggregate demand for insured deposits is modeled as a linear function of the opportunity cost of holding money, the interest rate on large CDs. [12]

$$D^d = \alpha_0 - \alpha_1 * r_{cd} \tag{2.4}$$

[12]This linear specification is used for simplicity. Any downward-sloping money demand function would work, implying that open-market purchases of bonds correspond to expansionary monetary policy. This requires that the income effects created by changes in interest rates are dominated by substitution effects.
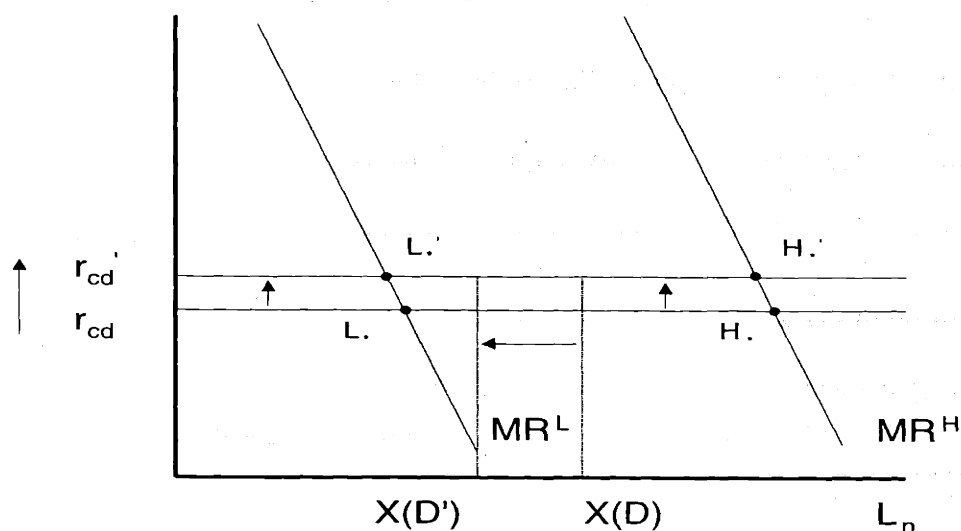
Figure 2-1: Frictionless Response to a Monetary Contraction

The equilibrium interest rate and aggregate quantity of insured deposits determined by the intersection of money demand D^d with money supply. [13]

2.2.2 The role of banks in the money channel

Monetary policy affects banks directly by changing the supply of insured deposits and indirectly by changing the opportunity cost of funds. The central bank can target the inter-bank interest rate r_{cd} using open market operations that affect the aggregate stock of required reserves. For example, a monetary contraction motivated by an open market sale of government bonds by the central bank increases the interest rate and reduces the aggregate supply of

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[13]Note that I have not specified the mechanism through which aggregate deposits are allocated to individual banks. As long as a bank's insured deposits are weakly monotone in the aggregate supply of insured deposits, putting more structure on this mechanism adds little to the main results below.

insured deposits. Figure (2-1) illustrates that the effect of monetary policy generally does not depend on the composition of external finance or the state of loan demand. [14] The only mechanism though which monetary policy affects bank lending is through the interest rate on uninsured CDs. Changes in the aggregate supply of insured deposits are smoothed away by banks by changing their position in uninsured CDs at constant marginal cost. Given that the stock of wealth is constant, this contraction in loan supply is accomplished by increasing the share of uninsured deposits in agents' portfolios, increasing the marginal cost of intermediating new credit by moving along the aggregate money demand curve. One should note that even in the absence of frictions at the bank level, open-market operations affect the supply of bank credit. Of course, monetary policy also affects the supply of non-bank credit as the impact on loan growth does not depend on the composition of finance, so that the relative supply of bank credit is unchanged. In the absence of financial constraints, there is consequently no independent role for banks in the transmission mechanism.

2.2.3   Financial intermediation with financial constraints

The presence of financial constraints now implies that intermediaries will face increasing marginal costs when issuing uninsured debt, so that the cost of replacing insured deposits with uninsured debt will be larger than the opportunity cost of funds. Non-banks will face a standard underinvestment problem, but the presence of insured deposits implies that banks require less external finance and thus may be able to lend up to the unconstrained level when the supply of insured deposits is adequate.

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[14] If the elasticity of loan demand or money demand changes over the cycle this latter point may not hold. I am unaware of any evidence on either of these points.

Intermediaries issuing uninsured deposits now have to deal with the presence of asymmetric information that drives a wedge between internal and external costs of finance. I use a reduced-form model of financial constraints with the cost function below, representing the excess that banks will pay over $r_{cd} * CD$ to finance CD in external funds. [15]

$$C(CD, k) = k * CD^2 \tag{2.5}$$

The parameter k reflects the severity of financial constraints for a fixed level of borrowing. It may be useful in the analysis here to think of this parameter as an indicator function for banks that are not affiliiated with a multi-bank holding company, so that affiliated banks do not face any financial constraints. This cost function implies that the marginal cost of uninsured CD's is simply $r_{cd} + k * CD$. [16]

Consider how the presence of an external finance premium changes the bank's optimization problem. As all agents are risk-neutral, the finance premium exists in order that the uninsured CD will yield r_{cd} in expected value. This will permit me to treat the price of CDs asymmetrically, with an expected yield of r_{cd} from the perspective of lenders but costing

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[15]I develop microfoundations for this cost function in Ashcraft(2000c). Assume both insured and uninsured depositors have the same seniority, but banks also issue equity. The risk-premium on uninsured debt will be increasing in the amount borrowed as the capacity for loss absorption per dollar of deposits falls. Higher leverage increases both the probability of failure and the losses of uninsured depositors when the bank fails. When a parent company is committed to downstrem capital to a troubled subsidiary or reduces information problems through close monitoring, this risk-premium will increase faster for unaffiliated banks.

[16]It turns out that the functional form is important here. It is possible to re-interpret this model with loan growth as investment and deposit growth as cash flow so that well-known results apply. Given the quadratic production function, a sufficient condition for the loan growth of banks with higher k to be more sensitive to the growth in insured deposits is that this function is increasing, convex and quadradic in the amount borrowed, and well as supermodular in (CD,k). Kaplan and Zingales (2000) point out that more general functional forms generate non-monotonicities in the investment sensitivity of cash flow across k. While I admit that functional forms are crucial in the analysis below, ultimately the question is an empirical one about which there is not convincing evidence.

more from the perspective of borrowers. [17] Banks choose lending to maximize profits

$$\max_{L_n} \pi = r_l * L_n - C(CD, k)1_{CD \geq 0} - r_{cd} * CD \qquad (2.6)$$

subject to loan demand (2.1) and the balance sheet constraint (2.2). Affiliated banks (for whom $k = 0$) do not face financial constraints and always lend at the unconstrained level L_n^* described above. When unaffiliated banks (for whom $k > 0$) have a sufficient quantity of insured deposits $X(D) > L_n^*$, it is not necessary for them to borrow using uninsured CDs so that lending is also equal to the unconstrained level. In the more interesting case, insured deposits are inadequate and financial constraints are binding so lending takes the following form

$$L_n = \phi(k)L^* + (1 - \phi(k))X(D) \qquad (2.7)$$

Constrained lending is a convex combination of unconstrained lending L_n^* and insured deposits net of required reserves $X(D)$. The function $\phi(k)$ is decreasing in k so that when constrained, actual lending depends less on unconstrained lending and more on insured deposits as financial constraints increase. It is useful to think about equilibrium for banks and non-banks separately. As non-banks do not issue any insured deposits so that $X(D) =$

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[17]Implicitly I am assuming that the probability of bank failure is unaffected by loan growth this period. The probability of failure of course could depend on k. Banks only earn profits if they survive or pay fixed bankruptcy costs otherwise.

0, equilibrium lending is always less than the unconstrained level. This is illustrated by the dashed line in Figure (2-2), and the phenomenon is analogous to the underinvestment problem described in Myers and Majlif (1977). Intuitively, underinvestment problems worsen as financial constraints tighten. The equilibrium is a bit more complicated for banks, as when insured deposits are sufficiently large relative to loan demand, banks do not require any external financing and there is no distortion of lending so that $L_n = L_n^*$. When insured deposits are insufficient, however, bank lending is constrained in a manner that increases with a measure k of the degree of information problems. Each of these cases is illustrated in Figure (2-2). It should be clear that insured deposits permit banks to reduce the underinvestment problem. The correlation between the reservability and insurability of insured deposits is what gives life to a lending channel of monetary policy as the central bank relaxes or tightens the financial constraints faced by banks.

Before turning to monetary policy, a simple test for any cross-sectional measure of financial constraints in hidden in Equation (2.7). Affiliated bank lending is never constrained by deposits. On the other hand, unaffiliated lending closely tracks deposit growth when constrained. Differences in the sensitivity of lending to insured deposits across affiliation thus constitutes suggestive evidence that multi-bank holding companies relax the financial constraints faced by subsidiary banks. More generally, there is a monotone relationship between the sensitivity of lending to insured deposits and a continuous measure of financial constraints – like the size of the affiliated holding company. I use this idea below in a test that measures of k are actually correlated with financial constraints. Of course, this test is conceptually equivalent to demonstrating that the the sensitivity of investment is monotone in a measure of financial constraints (like cash flow), and can thus is tied closely to Fazarri,

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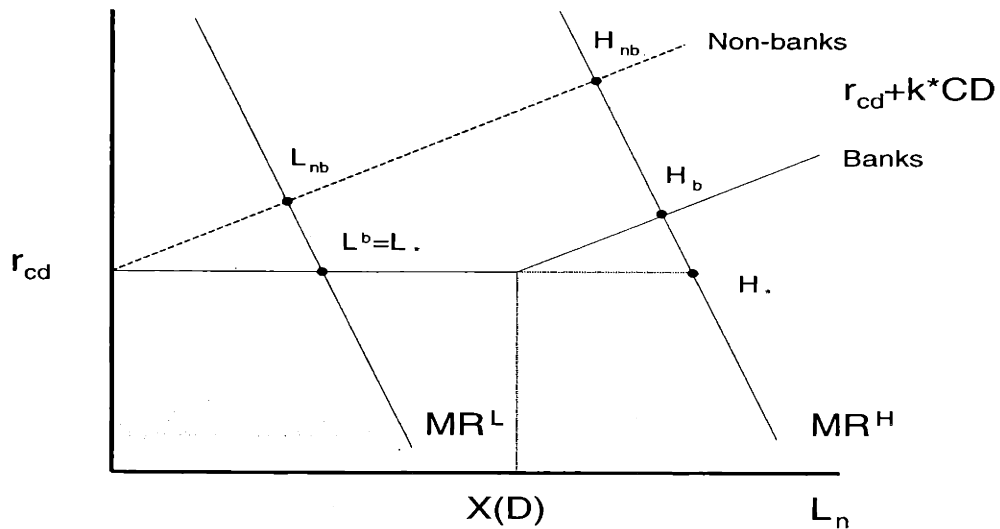
Figure 2-2: Equilibrium for Banks with Financial Constraints

Hubbard, and Peterson (1988). [18]

2.2.4 The role of banks with financial constraints: a lending channel

While equilibrium non-bank lending depends solely on the opportunity cost of funds r_{cd} and conditions in the loan market, equilibrium bank lending also depends on the availability of insured deposits. Open-market operations that affect the aggregate supply of insured deposits can now affect the supply of bank loans through an independent mechanism by improving or reducing the ability of banks to solve any existing underinvestment problems.

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[18] Jayaratne and Morgan (2000) implement this test when using bank leverage as a measure of k, finding that the lending of highly-levered banks is more sensitive to insured deposit growth. These results are replicated below in a broader and much larger sample

Of course when banks are awash in insured deposits so that underinvestment problems do not exist, the lending channel disappears. The presence of financial constraints at non-banks will still imply that the response of loan growth to monetary policy is not unconstrained, and will generally depend on the severeity of financial constraints.

Consider the sensitivity of lending to open-market operations. Again, the contrast between non-banks and banks is instructive. An increase in the federal funds rate reduces the unconstrained level of lending L_n^* as the marginal cost of external funds increases. Equation (2.7) demonstrates that the shift in unconstrained lending prompts non-banks to reduce actual lending, but always less than one-for-one. This effect is illustrated in Figure (2-3), and the change in lending does not vary across the level of loan demand. As contractionary monetary policy is largely accomplished by draining insured deposits from banks through open-market operations, there is potentially a second channel through which banks are affected. Banks that are not constrained by the supply of insured deposits always lend at the unconstrained level, so the response to monetary policy is no different from the economy described above without financial constraints. When binding, draining insured deposits from banks worsens the underinvestment problem, reducing bank lending even further. This second effect is illustrated in Figure (2-4) for the speical case where money and bonds are perfect substitutes so that there is no change in interest rate. Both of these effects reduce bank lending.

The lending channel is ultimately going to be identified by differences in the sensitivity of lending to monetary policy across banks with different marginal costs of external finance – for example, across multi-bank holding company affiliation. Of course when banks are not constrained by insured deposits, there is no differential response across k as each bank is
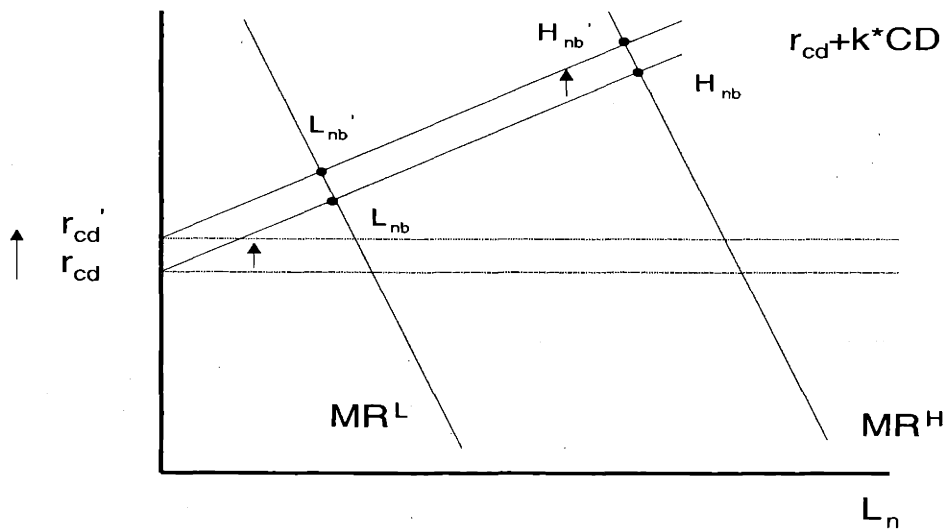
Figure 2-3: Non-bank Response to a Monetary Contraction with Financial Constraints
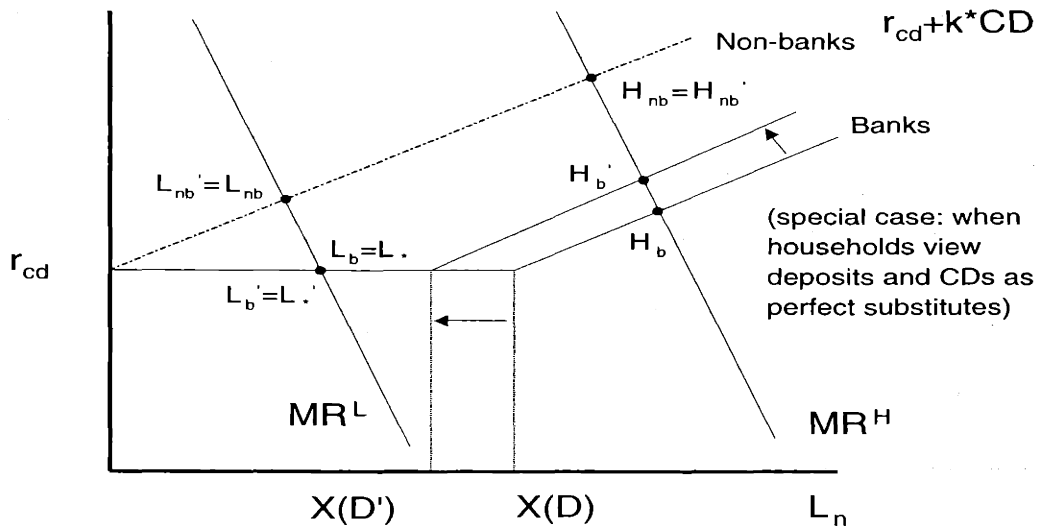
Figure 2-4: Bank Response to a Monetary Contraction with Financial Constraints

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always lending at the unconstrained level. In the more interesting case where intermediaries are constrained, the differential response of lending to monetary policy across k depends on two competing factors. Policy-induced changes in the federal funds rate have a differential effect on lending across k in the absence of insured deposits. As financial constraints tighten, lending becomes less sensitive to unconstrained lending L_n^*. This implies that as k increases, lending actually becomes less sensitive to monetary policy. As this case corresponds to the experience of non-banks, it is illustrated for low k (large or affiliated) and high k (small or unaffiliated) in Figure (2-5). [19] On the other hand, there is another effect that is likely to dominate this first one. As financial constraints worsen, lending also becomes more sensitive to the growth rate of insured deposits as banks are forced to finance a greater fraction of their loans using insured deposits. This second effect implies that as k increases, lending becomes more sensitive to monetary policy. In the case of money and bonds being perfect subsititutes, only this second channel is operational, and it is illustrated in Figure (2-6). While the net effect of tougher financial constraints on the response of lending to monetary policy is in theory ambiguous, it seems likely that the second channel dominates as money demand appears very elastic and investment demand very inelastic. The direct effect of open-market operations on unconstained lending is thus likely very small. [20]

The above framework motivates a simple test of the lending channel. The the lending of high k (unaffiliated) banks should be more sensitive to monetary policy. Moreover, the

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[19] As the correlation between the sensitivity of lending to monetary policy and financial constraints is reversed for non-banks, this might motivate another empirical project on the lending channel. Ludvigson (1998) actually finds evidence consistent with this point in the market for automobile credit, with a stronger response to monetary policy by commercial banks than finance companies.

[20] Of course as monetary policy eventually affects output, there will be lagged effects on unconstrained lending and the supply of insured deposits. The analysis here – and in most of the empirical literature – focuses on the response of lending in the year following a change in policy where there is little measured change in output.
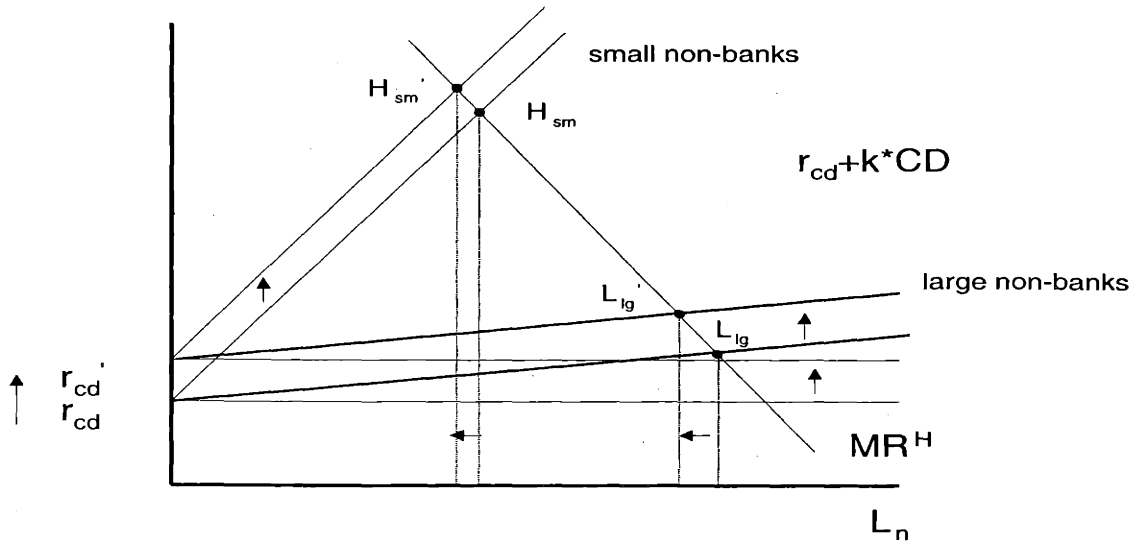
Figure 2-5: Non-bank Response to a Monetary Contraction with Financial Constraints: II
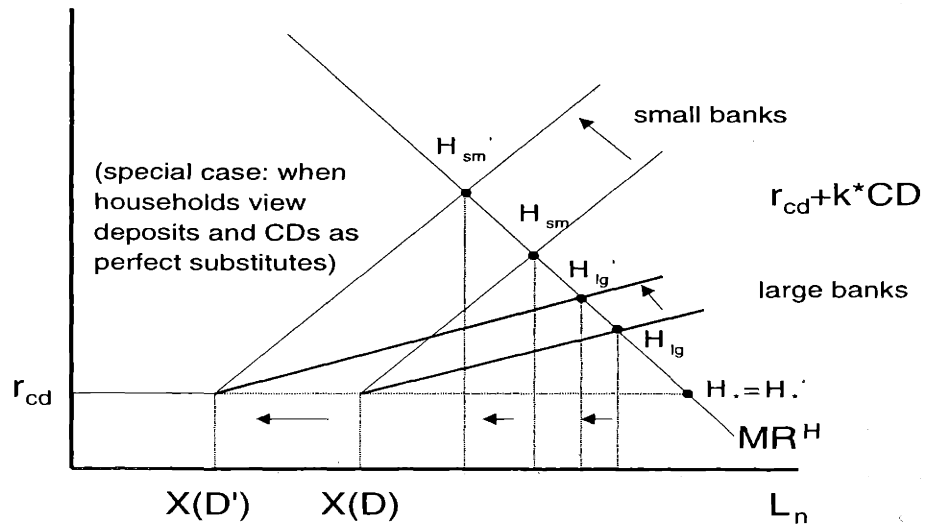
Figure 2-6: Bank Response to a Monetary Contraction with Financial Constraints: II

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mechanism through which low k banks are able to shield loan growth is a lower marginal cost of external funds. Thus we should observe that low k banks actually issue more large CDs and borrow more federal funds in response to a monetary contraction. Both of these hypotheses are tested below.

2.2.5   Threats to identification

Return to the simple model of the money channel outlined above. I model the balance sheet channel by permitting loan demand to depend on the interest rate on uninsured CDs and to depend on the interest rate differently across a measure of firm information problems z. One may think of z as firm size, with the creditworthiness of small firms being more interest-sensitive than large firms. [21]

$$L^d = a - b_0 * r_l - b_1 * r_l * z \tag{2.8}$$

The response of loan growth to monetary policy is now now amplified by the dependence of firm creditworthiness on interest rates. Figure (2-7) illustrates how an increase in the funds rate affects lending for two types of firms over two levels of loan demand. As higher interest rates effectively reduce small firm demand for credit, equilibrium lending to small firms falls by more then large firms. This example demonstrates that it is possible to generate spurious evidence consistent with a lending channel when there is positive correlation between k and

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[21] Gertler and Gilchrest (1994) find evidence that a monetary contraction hurts small manufacturing firms more than large ones.
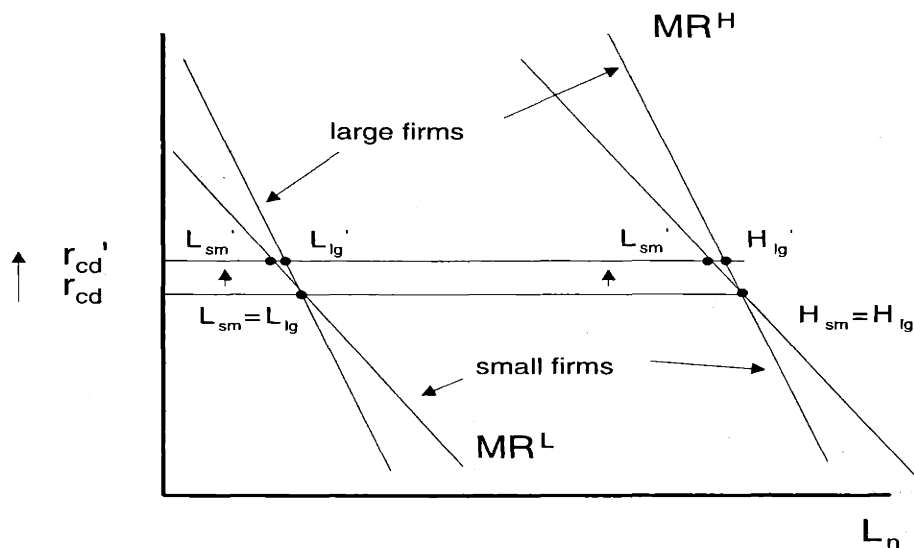
Figure 2-7: Threats to Identification

z – when very financially constrained banks tend to lend to very financially constrained firms. The evidence presented below demonstrates that this concern is very real when using size as a measure of financial constraints but much less of a problem when using multi-bank holding company affiliation. Thus it is going to be important to control as much as possible for differential shifts in loan demand in identifying the lending channel. Note however, that while the lending channel depends on the availability of insured deposits relative to loan demand, the balance sheet channel does not. Using differences in the response of loan growth to monetary policy across bank characteristics k as a measure of the lending channel, a third difference across times when loan supply is unlikely constrained by the supply of insured deposits plausibly eliminates any concern that we are confounding loan demand with loan supply. This idea is implemented as an overidentifying test below.

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2.3   Internal capital markets

The ideal experiment for identifying the lending channel is to somehow change the ability of a commercial bank to smooth any volatility in deposits created by monetary policy without changing its loan portfolio. As indicated below, exploiting variation in bank size and leverage appear to be correlated with differences in the bank loan portfolio so it is difficult to isolate movements in loan supply from those in loan demand. The insight of this analysis is that an individual bank that is affiliated with a multi-bank holding company is really much larger than its actual size indicates – at least with respect to the ease in which it can raise financing to smooth deposits – through the use of internal capital markets by the holding company. In particular, the real size of this bank seems to be better captured by the size of its holding company's assets. Exploiting differences in affiliation with multi-bank holding companies will also permit us to hold the actual size, liquidity, and loan portfolio constant, so that we are comparing banks that are otherwise alike as far as differential movements in loan demand are concerned.

Stein (1997) outlines a model of internal capital markets by assuming binding credit constraints at both the project and headquarters level. In his model, headquarters can create value if given control rights over the cash flows and collateral of its subsidiaries. In contrast to a bank, as an intermediary headquarters can reallocate scarce resources among divisions to pick winners, adding value by relaxing the financial constraints of the most profitable projects. At the same time, through this monitoring function headquarters may be able to increase the amount of overall external financing of the divisions together. The ability to pick winners separates headquarters from a bank as an intermediary. Since the

value of headquarters comes from relative evaluation, it follows that its divisions should all be related so that any evaluation errors are correlated in contrast to a bank which optimally selects a diversified portfolio of projects.

There is ample evidence that holding companies operate internal capital markets. Lamont (1997) documents that investment of the non-oil subsidiaries of oil companies was affected by fluctuations in the price of oil in the 1980s. This excessive sensitivity of subsidiary investment to parent company cash flow is interpreted as evidence of financial constraints that are relaxed through the operation of an internal capital market by the parent company. In a related study, Stein and Stultz (1996) find that investment decisions of small divisions of well-diversified firms depend on the cash flows of other divisions. Houston, James, and Marcus (1997) provide evidence that bank holding companies operated internal capital markets throughout the 1980s. Using a sample of approximately 300 publicly-traded multi-bank holding companies 1981-1989, the authors demonstrate that subsidiary loan growth is more sensitive to the non-bank cash flows of the holding company than the cash flows generated by the subsidiary. Moreover, subsidiary loan growth is more constrained by the capital position of the holding company than that of the subsidiary bank. Finally, the authors provide evidence that subsidiary loan growth is negatively correlated with loan growth of other subsidiaries of the holding company. All of these pieces suggest the operation of an internal capital market where the parent deliberately allocates capital across its subsidiaries.

Furthermore, in looking for plausibly exogenous variation in the amount of subordinated debt, I document in Ashcraft (2000a) that bank holding companies appear to issue debt in a manner to exploit of differences in state corporate income tax rates throughout the company. In particular, while the amount of debt on a subsidiary bank's balance sheet is positively

related to its chartering state's corporate income tax rate, it is negatively correlated with the tax rate of its parent company, conditional on its own tax rate. A similar relationship holds with the amount of subordinated debt on the parent's balance sheet, which is negatively correlated with the subsidiary bank's income tax rate. That holding companies may allocate subordinated debt within the holding company to maximize the tax shield from debt is clear evidence of internal capital markets in action. [22]

2.4 Data

In the analysis below I use December data on the population of insured commercial banks from Call Reports of Income and Condition, available on-line from the Federal Reserve Bank of Chicago starting in 1976. Annual data is used largely due to space constraints, but I don't seem to have any problem in replicating the main features of previous work at this frequency. In order to construct consistent time series, I rely heavily on notes created by Kashyap and Stein (1998) to follow changes in variable definitions. A full discussion of the data employed and variables constructed appears in the Appendix, and program code is available on request.

I merge the call report data with most recent merger file, identifying years in which banks make acquisitions that create jumps in balance sheet variables unrelated to real economic activity. [23] Instead of following the tradition of force-merging banks with their eventual acquirers, I remove all bank-years in which an acquisition occurs. It should be clear that

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[22] Additional evidence that holding companies reduce financial constraints would be to compare the implied risk-premia of uninsured bank debt instruments across affiliation with multi-bank holding companies. I am unaware of any evidence on this point, and leave it for future research.

[23] The merger file has been recently updated retroactively to identify bank acquisitions of several non-bank institutions.

the ability of a bank to smooth deposit outflows depends largely on its current size and affiliation with a multi-bank holding company, and has little to do with being acquired by another bank or holding company in the future. Consistent with Kashyap and Stein (1998), I further remove observations where loan growth is larger than 5 standard deviations from the year-specific mean. [24] Banks are identified as part of a holding company on the basis of having a direct holder identification number, and I identify multi-bank holding companies by counting the number of banks that have the same direct holder. [25]

2.4.1 Base Call Report Data

The first two columns of Table (2.2) describe the main features of the data in 1986 and 1996. Consolidation in the banking industry is readily apparent from the decline by 25 percent in the number of banks, the 35 percent increase in average bank size, and the 33 percent decrease in number of banks unaffiliated with bank holding companies. The nature of much of this consolidation is alluded to in the decline in percentage of banks affiliated with multi-bank holding companies as banks used newfound powers to consolidate their subsidiaries into branches of a larger bank. [26] The dramatic shift in aggregate bank portfolios towards securities in the early 1990s that has been widely documented in the bank capital literature

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[24]New loan growth is measured simply as the percentage change in total loans, net of allowances for loan loss. Peek and Rosengren (1995) discuss how a better measure removes net loan sales, loan charge-offs, and transfers to other real estate owned from this measure, each of which correspond to changes in the stock of loans but not changes in the flow of credit. I have not used this insight in the analysis below due to the disappearance of net loan sales from the Call Reports in the mid-1990s, but concede there is certainly measurement error in what will be one of my main dependent variables.

[25]While matching on the basis of regulatory high holder might identify multi-bank holding companies with more complicated structures, this does not seem to affect results.

[26]In many states banks had been forced to branch throughout a state by chartering new banks. See Jayaratne and Strahan (1996) for a description of bank branch deregulation in the late 1980s and early 1990s.

is not apparent in part because this shift occurred in large banks and in part because it has been completely reversed since. The increase in bank equity ratios, however, is clearly evident. Core deposits represent total deposits less large time deposits, and are as close as we can get to a measure of insured deposits. The bank finance mix is the ratio of core deposits to total deposits plus net federal funds borrowing, and is a measure of the intensity of insured deposits in short-term finance. The first two columns illustrate that almost 90 percent of short-term finance is composed by insured deposits. Finally, internal capital is defined in a manner similar to Houston, James, and Marcus (1998) as the sum of loan loss provisions and net income before extraordinary items relative to total loans.

In 1993 information on the small business lending concentration of a bank's loan portfolio becomes available every June. The data records the aggregate amounts of lending by original loan size for each of commercial and industrial loans and loans secured by farmland, secured by non-farm nonresidential properties, or used to finance agricultural production. While there is not necessarily a perfect correlation between loan and borrower size, there is certainly a precedent set in another literature for making this leap in logic.[27] Banks are asked in each of these four loan categories which on average represent about 50 percent of the loan portfolio to break down the amount of lending by original amount borrowed. I use 250,000 dollars as a cutoff in defining small business loans, and define small business lending concentration as the ratio of loans originated for less than this amount divided by the sum of all loans in each of the four categories surveyed. The second column of Table (2.2) demonstrates that commercial bank loan portfolios are dominated on average with loans to small businesses.

In concert with the introduction of risk-based capital standards, better information on

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[27]See Peek and Rosengren (1997b) for an example.

off-balance sheet activities of banks becomes available starting in 1990. In particular, there is extensive data on unused bank loan commitments and letters of credit. Loan commitments represent promises by commercial banks to make loans to firms at some point in the future, while letters of credit are guarantees that banks write to back other debt instruments of firms like commercial paper. The second column of the table illustrates that loan commitments were on average equal to 20 percent of the outstanding stock of loans while letters of credit were less than one percent. That loan commitments are large relative to both the stock and flow of lending implies that they might play an important role in explaining the behavior of loan growth.

2.4.2 Conventional Measures of k

The third and fourth columns of Table (2.2) describe using 1996 data differences in bank balance sheets across one popular measure of k – bank size. Consistent with Kashyap and Stein (1998), large banks have assets more than the 95th percentile of the national distribution of assets. Larger banks are typically more aggressive than smaller banks, lending out a larger fraction of assets leaving them with less liquidity in the form of securities. The lower equity ratio of large banks is consistent with tougher financial constraints faced by small banks, implying that it is tougher for them to raise equity so they hold a buffer stock. The most striking difference across bank size comes from the apparent differences in customer mix, with small banks largely focusing their loan portfolios with small businesses and large banks having much more extensive off-balance sheet activities, which typically involve larger firms. Note that if the true measure of agency costs is the consolidated size of a bank's

affiliated holding company, on average the agency costs faced by small banks is overstated by an average of seven times, in comparison to about half as much for large banks. Nine percent of small banks are actually misclassified as small when using the size of their affiliated holding company.

The fifth and sixth columns of Table (2.2) describe using 1996 data differences in bank balance sheets across another measure of k used in the literature – binding capital requirements. I use banks with a ratio of equity to assets less than six percent as a crude measure of binding standards. The large difference in assets is driven by outliers, with the median assets of banks facing binding requirements less than twice the median assets of everyone else. Note that while large banks focus their lending with large firms, adequately-capitalized banks tend to focus their lending with small firms. As each of these groups conceptually should correspond to banks facing weaker financial constraints, the bias created by differences in unobserved customer mix actually switches sign depending on which strategy is used. This implies one cannot reasonably argue that differences in the small business lending concentration explain why highly-levered banks reduce their lending more in response to a monetary contraction. While exploiting variation across leverage instead of size seems to reduce some of the differences in bank characteristics, there unfortunately is evidence that low capital banks do not face severe financial constraints. In particular, banks with lower equity ratios (and thus higher leverage and k) appear to use core deposits less intensively. These differences are not large, but the sign is inconsistent with the model described above, and is a warning when interpreting any results using this strategy below. [28]

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[28]Houston, James, and Marcus (1997) also conclude that there is little correlation between bank equity ratios and financial constraints.

2.4.3 Holding Company Data

Starting in 1986, I am able to merge information about the parent and consolidated holding company for banks that are part of a bank-holding company. A potentially important sample selection issue is that only holding companies that have at least 150 million dollars in consolidated assets file the consolidated report. [29] Constructing the consolidated balance sheet is unfortunately not as simple as aggregating the parent and subsidiary bank balance sheets. In the analysis below I exploit differences in the consolidated assets of a bank's affiliated holding company. For banks affiliated with a small holding company, I simply use bank assets in place of consolidated assets as a reasonable approximation. Misclassifying some banks as effectively smaller than they really are will only make my life more difficult. [30]

Columns seven and eight of Table (2.2) illustrate that along most dimensions, differences in bank characteristics are small across holding company affiliation even before conditioning on bank size. While large banks are on average 50 times larger than small banks, banks affiliated with multi-bank holding companies are on average only three times larger than those that are not. Banks affiliated with multi-bank holding companies face agency costs (again approximated by size) that are eight times less then indicated by actual bank size. Note that while 90 percent of banks affiliated with multi-bank holding companies are small (compared

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[29]There are some exceptions to this rule. Smaller holding companies that have outstanding debt or are directly or indirectly extending credit using financial leverage are required to file this form as well.

[30]Only banks that in which the parent has at least a 50 percent stake are aggregated on to the consolidated balance sheet. The equity claim of other parties in these subsidiaries is reported as a liability under minority interest in consolidated subsidiaries. The parent's stake in other banking subsidiaries is simply recorded as an investment on the asset side of the balance sheet. My attempts to approximate consolidated assets using information using information on the parent's stake in the bank and parent assets have so far failed miserably, with the measurement error systematically understating true consolidated assets.

to 96.5 percent for unaffiliated banks), only 56.4 are effectively small when using the size of their affiliated holding company. Note that there are also evidence that this affiliation relaxes financial constraints as affiliated banks use insured deposits less intensively than do other banks, although these differences are small. More importantly for our purposes is the large narrowing in customer mix across holding company affiliation, with the difference going from 48 to 8 percentage points, and elimination of the gap in off-balance sheet behavior. The last two columns condition on the small size class, noting that differences are even smaller across MBHC affiliation. Overall, the strategy of exploiting affiliation with large holding companies looks promising relative to strategies that exist in the literature.

I have also used data from parent company balance sheets in order to look for differences in gross flows within a holding company across consolidated holding company size. Although not reported here, I construct the ratio of cash flows to total consolidated loans for a variety of categories. Long-term cash flows account for the category investments and loans to subsidiaries on the parent company's balance sheet. This category includes equity and debt investments, and represents the main source of gross flows. Short-term cash flows include the sum of receivables due to and from all subsidiaries on the parent's balance sheet. Cash deposits refer to cash deposited by the parent at subsidiary banks. There appears to be evidence that gross flows are larger as the consolidated size of a holding company increases.

2.4.4 The Federal Funds Rate and Monetary Policy

Following Bernanke and Blinder (1988), I use the federal funds rate as a measure of monetary policy. [31] Figure (2-8) illustrates the path of the federal funds rate since 1976. Contractionary monetary policy in the early 1980s due to the Volker disinflation pops out of the figure. Note the 300 basis point reduction in the funds rate during the most recent recession, and the large increase in the funds rate in early 1994 when the central bank observed the unemployment rate falling to what was then thought to be the natural rate. That the federal funds rate might be a good indicator of monetary policy is illustrated in Figure (2-9) by the strong negative correlation with the share of insured deposits in total short-term finance. Changes in monetary policy thus appear to be highly correlated with changes in the composition of bank finance in the right direction, even during Regulation Q years. Increases in the federal funds rate seem to be correlated with a reduction in share of insured deposits in short-term finance, consistent with banks relying more on uninsured debt. As the theory described above indicates that the lending channel operates through changes in the mix of insured deposits in bank liabilities, the federal funds rate seems like exactly the right measure of monetary policy to use in the analysis below. [32]

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[31]Kashyap and Stein (1998) document that the funds rate is highly correlated with other measures of monetary policy like the Bernanke-Mihov measure or Boshen-Mills index.

[32]Moreover, concerns that a lending channel might be weaker when there are ceilings on interest rates may be unfounded. What matters for the lending channel (as illustrated in the model above) is the supply of insured deposits relative to loan demand. To the extent that changes in the federal funds rate are well-correlated with open-market operations, which appears to be the case in the figure, there is no reason why the funds rate can't be used throughout the entire period as a measure of monetary policy.
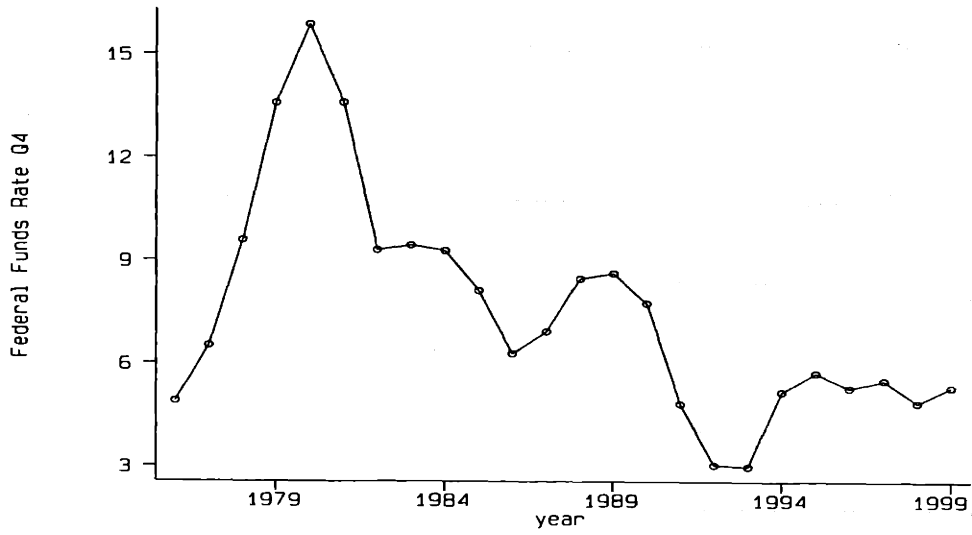
Figure 2-8: Federal Funds Rate
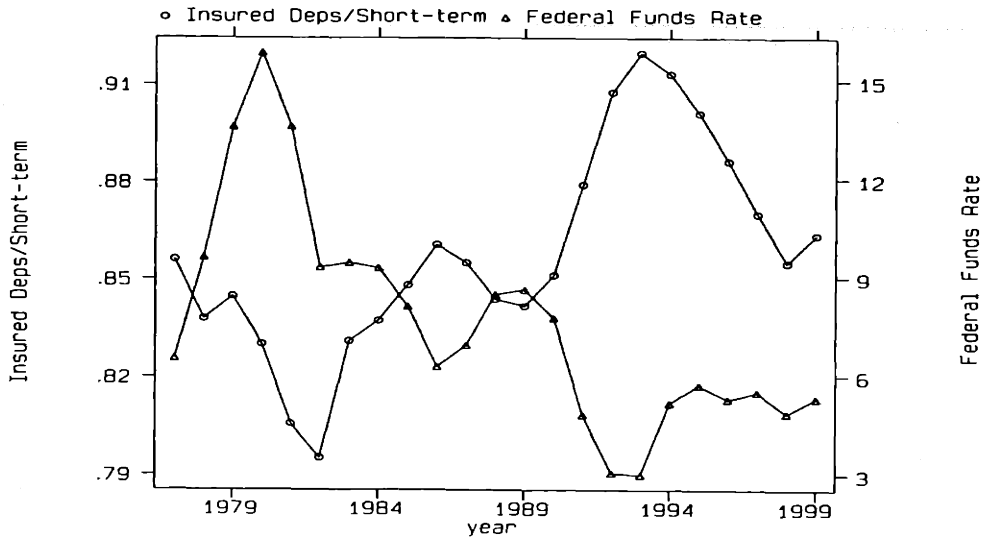
Figure 2-9: Bank Short-term Finance Mix Versus the Funds Rate

2.5 Internal Capital markets and the Lending Channel

This section contains the core results of the paper. I first present evidence that a multi-bank holding company appears to reduce the financial constraints faced by its subsidiary banks. Next, I demonstrate that affiliated banks are better able to smooth deposit outflows and shield loan growth from a monetary contraction. These results are robust to recently available controls on small business lending concentration. I then demonstrate that the lending channel appears to be much weaker when loan demand is plausibly unconstrained by the supply of uninsured deposits, a result difficult to explain without a lending channel. Finally, I demonstrate that financial constraints at the bank level matter for the equilibrium response of lending to monetary policy.

Two measures of information problems k are considered as a proxy for access to internal capital markets in the analysis that follows: affiliation with a multi-bank holding company and the log of consolidated assets of the affiliated holding company. The second measure is somewhat more attractive as it can be better compared to a strategy of using the log of asset size. Using consolidated assets is also more restrictive, requiring larger holding companies to smooth more than smaller holding companies. On the other hand, by construction this variable will systematically overstate the information problems faced by banks affiliated with small bank holding companies. [33] The differencing implicit when using affiliation with a multi-bank holding company is also very transparent, making it very easy to understand the variation exploited in estimation. To keep things simple, I only discuss results when

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[33] Recall that the consolidated assets of small bank holding companies without publicly traded debt is not available in the Bank Holding Company data. I have approximated the agency costs faced by banks affiliated with these companies by using bank assets, which surely understates the size of the consolidated holding company.

exploiting variation in multi-bank holding company affiliation below.

2.5.1 Preliminary evidence

The first hypothesis motivated from the theory above is consistent with the approach of Fazarri, Hubbard, and Peterson (1988), who test the sensitivity of firm investment to cash flow across a priori measures of financial constraints. This test is also a validation of findings by Houston, James, and Marcus (1997) in a slightly different context and in a much broader and longer sample.

Hypothesis 1

Loan growth becomes less sensitive to insured deposit growth when banks are affiliated with a multi-bank holding company or as the log of consolidated assets of the affiliated holding company increases.

As any measure of financial constraints is weakened, including access to internal capital markets, the model above predicts that banks should be better able to shield loan growth from volatility in insured deposits. Evidence that this is actually the case is described in Table (2.3), examining the relative sensitivities of loan growth to core deposit growth across several measures of the degree of information problems. I exploit annual data 1986-1999. The first column of the table demonstrates that the loan growth of banks affiliated with multi-bank holding companies is less sensitive to core deposit growth. The presence of interactions of core deposit growth with other bank characteristics reduces the likelihood that this result is driven by unobserved variables that are correlated with holding company affiliation. The column also illustrates that bank liquidity, equity ratio among well-capitalized banks, and internal additions to capital all significantly reduce this sensitivity while binding capital

standards increase the sensitivity. Each of these observations is certainly consistent with out priors about how these measures are correlated with financial constraints. Using the log of consolidated assets in place of MBHC affiliation yields qualitatively similar conclusions in the second column. Moreover, the effect of bank size is much larger than that of the holding company. One log dollar of bank assets reduces the sensitivity of loan growth to insured deposit growth by more than one log dollar of holding company assets. This latter observation is plausible given the capital controls that exist within a holding company that do not exist within a bank of similar size. [34] The evidence is certainly consistent with the hypothesis that affiliation with a large holding company reduces financial constraints.

2.5.2 Baseline evidence

We are of course not interested in the sensitivity of loan growth to any variation in deposits, but rather how loan growth responds to the volatility in insured deposits created by monetary policy. When there is little meaningful difference between reservable deposits and insured deposits – as is currently the case in the US banking system – a monetary contraction effectively reduces the aggregate supply of licenses to issue insured deposits. Banks will have a differential ability to replace outflows of insured deposits by issuing uninsured CDs and borrowing federal funds due to financial constraints. As the evidence above suggests that affiliation with a multi-bank holding company seems correlated with financial constraints, it seems natural to look for a differential response of lending to changes in the funds rate across affiliation. This leads us to consider the following hypothesis.

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[34]Houston, James, and Marcus (1997) discuss the restrictions faced by bank holding companies in operating full-scale internal capital markets.

Hypothesis 2

Loan growth is less responsive to changes in monetary policy when banks are affiliated with a multi-bank holding company or as the log of consolidated assets of the affiliated holding company increases.

I employ annual data on the population of insured commercial banks over 1986-1999. Baseline results are reported in Table (2.4). Each dependent variable is regressed against the one-year change in the federal funds rate, aggregate nominal output growth, inflation measured by the consumer price index, and the interactions of these variables with measures of the lending channel. In addition to affiliation with a multi-bank holding company, these measures include the log of total bank assets, the liquidity ratio, and equity ratio in the spirit of the discussion above. The interaction of each measure with aggregate output growth is in place to capture differential changes in loan demand across banks in response to any change in output. The second column adds information about the banks' loan portfolio composition and internal capital generation, and interacts this with each of the three aggregate variables. The table reports coefficients and standard errors on the interaction variables, and all standard errors are corrected for heteroskedasticity and clustering at the bank level. [35]

The first two columns of Table (2.4) demonstrate that being affiliated with a multi-bank holding company generally reduces the response of loan growth to changes in the federal funds rate when comparing banks of equal size, capital position, liquidity, and internal capital. The second column demonstrates that these results are not driven by differences

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[35] I have also experimented with weighting regressions by the inverse of the number of banks in each year to ensure that the earlier time period (when there were many more banks) does not receive relatively more weight in estimates, as there is no a priori reason to allow such a weighting, but this does not seem to affect results qualitatively or statistically. The regressions in table are unweighted.

in portfolio shares across MBHC affiliation. In the context of a 100 basis point funds rate hike, internal capital markets seem to reduce the response of loan growth by about 20 basis points. (how large is this. check relative to the dependent mean)

When shocks to insured deposits are accompanied by differential shocks to loan demand or liabilities across the severeity of financial constraints, it is not clear that differences in the response of loan growth identify a lending channel. Moreover, the model above predicts that the mechanism through which effectively larger banks are able to shield loan growth from monetary policy is through a greater ability to issue uninsured deposits. Without evidence that banks facing weaker financial constraints are actually able to more easily issue uninsured deposits, it is difficult to interpret evidence of a differential response to loan growth across some measure of agency costs as consistent with a lending channel. The absence of evidence in the literature that large banks actually do smooth insured deposit outflows by issuing large CDs is worrisome. This leads us to consider the following hypothesis.

Hypothesis 3

The growth of uninsured debt is more sensitive to changes in monetary policy when banks are affiliated with a multi-bank holding company or as the log of consolidated assets of the affiliated holding company increases.

That banks are able to smooth insured deposit outflows is illustrated by the second two columns, tracking the growth rate of total-short term finance, itself comprised of total deposits and federal funds borrowing. The latter four columns break out the response of short-term finance by the growth rate of insured deposits in columns five and six and by the growth rate in uninsured deposits and federal funds borrowing in columns seven and eight. While banks affiliated with multi-bank holding companies appear to be better able to more

easily issue external finance during a monetary contraction, one might be concerned about the observed response of core deposits. I have three points to make on this issue.

First, the response of core deposit growth could reflect internal capital markets. A sizeable portion of gross flows with the parent holding company correspond to the parent company's deposits in subsidiary banks. It is certainly possible that the mechanism through which internal capital markets work is for the parent to channel funds raised by the holding company to subsidiary banks through insured deposits. A parent company can downstream funds to a subsidiary through short-term loans, buying uninsured CDs issued by the subsidiary, or placing insured deposits. Which method is actually employed might vary across holding companies and over time depending on the needs of the parent and tax issues involved. Second, there is also no positive correlation of the state loan market share of banks affiliated with multi-bank holding companies and the response of state output growth. This implies that it is unlikely that this strategy is simply capturing differential policy-induced shocks to insured deposits. Finally, controlling for core deposit growth does not qualitatively change our results, although the size of coefficients are smaller, but still significant.

2.5.3 Small Business Evidence

While the ability to compare banks that are observationally equivalent except for their affiliation with a multi-bank holding company should reduce the likelihood that this strategy exploits unobserved variation in bank customer mix, I replicate the analysis above using small business loan concentration controls available starting in 1993 in Table (2.5). The first two columns demonstrate that the reduced-form effect of MBHC-affiliation is much stronger

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in the recent data, and if anything are strengthened by controlling for previously unobserved differences in small business loan concentration. Columns three and four illustrate qualitatively similar results for the growth rate of short-term finance, although this variable is not as sensitive to the controls for customer mix.

Interestingly, the sign on the interaction of small business lending with the change in federal funds rate is positive and significant, implying that the response of total loan growth to monetary policy is actually weaker as small business loan concentration increases. As banks affiliated with multi-bank holding companies generally lend less on average to small businesses (see descriptive statistics above), this explains why the coefficient on loan growth increase in column (2). On the other hand, the sign on small business lending is entirely inconsistent with previous literature on the balance sheet channel. Looking at the path of the funds rate in Figure (2-8) above, there certainly appears to be enough variation in monetary policy with a 300 basis point increase starting in 1994. One possible explanation is that this increase in the funds rate was not correlated with a slowdown in output growth. Previous research on the balance sheet channel uses Romer dates, where a shift towards contractionary montary policy is usually followed by a recession. [36] Strong economic growth may have ameliorated any balance sheet effects. In any case, what is important is that differences in customer mix do not seem to explain why the response of loan growth to monetary policy is much weaker across MBHC affiliation, ruling out the main threat to identification.

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[36]See Gertler and Gilchrist (1994) for example.

2.5.4 Overidentifying evidence

The model outlined above predicts that the lending channel is identified by the differential response of loan growth across the severity of measures of financial constraints. The above analysis largely exploited cross-sectional variation in agency costs, but time-series variation in the strength of financial constraints might provide overidentifying evidence that this strategy exploits changes in loan supply and not loan demand. In particular, the above model hinted at an asymmetry in the lending channel between expansionary and contractionary policy when monetary policy is largely countercyclical. Actual lending is not only constrained by insured deposits, but also by the unconstrained level of lending implied by loan demand and the opportunity cost of lending r_{cd}. During a rapid expansion, contractionary monetary policy would seem to almost always to have a differential effect across k, but during a recession expansionary monetary policy may not have any differential effect if loan demand is sufficiently low relative to available insured deposits. This point is an important contrast relative to an economy without financial frictions, where the impact of monetary policy does not depend on the availability of insured deposits. Moreover, taking this third difference seriously (the response of loan growth to changes in the funds rate across affiliation with a multi-bank holding company differenced across times of surplus insured deposits) should eliminate any remaining doubts that a measure of financial constraints is uncorrelated with the response of loan demand to monetary policy. Such evidence is also difficult to explain without an important role for banks in the transmission mechanism. This motivates the following hypothesis,

Hypothesis 4

The lending channel is weaker when loan growth is unconstrained by insured deposit growth.

Figure (2-10) plots seasonally adjusted growth rates for M1 as a proxy for insured deposits and nominal GDP as a proxy for loan demand. The figure demonstrates that starting in the early 1990s, loan growth does not appear to be constrained by insured deposits. This increase on money growth corresponds to the start of the recession which prompted the Federal Reserve to dramatically reduce the federal funds rate. That banks had more than enough insured deposits to finance desired loan growth is suggested in Figure (2-11) which plots the aggregate share of securities in bank assets. Note that securities holdings are increasing until 1994, implying that banks are holding back on loan growth. There is actually a large literature describing the credit crunch that occurred during this period. [37] Both of these points seem to indicate that the period 1990-1993 corresponds to a time when bank lending is not constrained by insured deposits, and is a natural candidate for testing the prediction of our model above.

Table (2.6) reports the results of taking another difference in the size of the lending channel across the time period 1989-1993. Note that the point estimates on MBHC affiliation interacted with the change in funds rate for loan growth in the first two columns are much larger than when estimated over the entire period. That our control time period includes years before and after the time period of slow demand implies that this analysis is not simply picking up a trend in the size of the lending channel. Moreover, the triple interactions indicate that loan growth during the slow demand period was much less sensitive to monetary policy

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[37]See Bernanke and Lown (1991) for a discussion of the credit crunch.
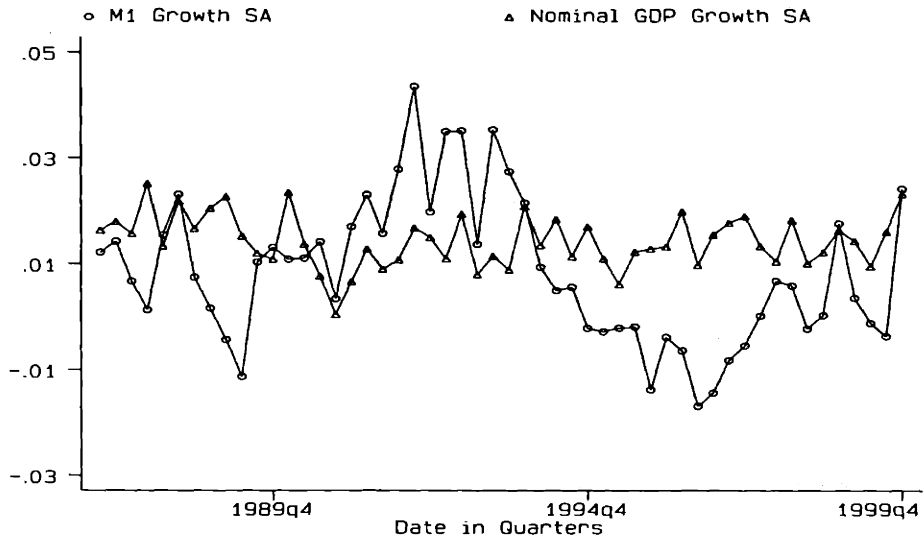
Figure 2-10: Commercial Bank Financial Constraints
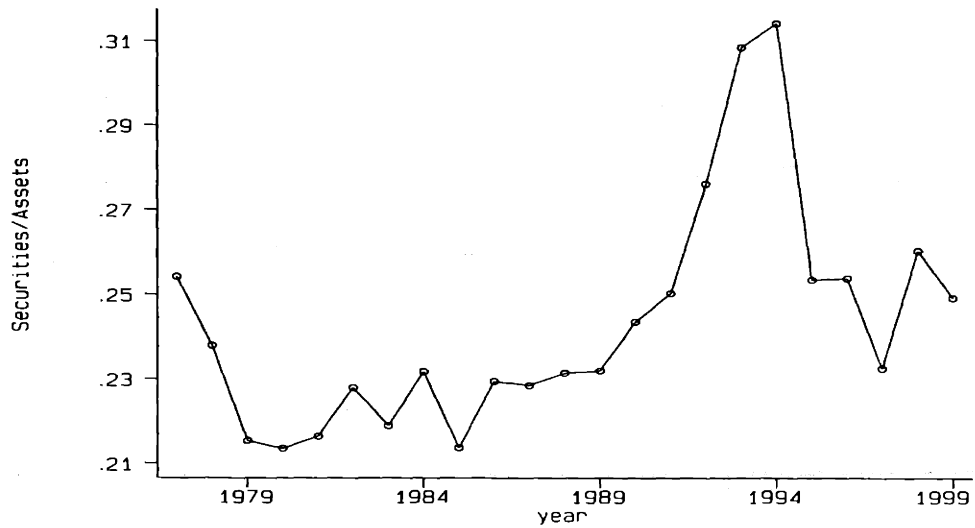
Figure 2-11: Aggregate Securities Holdings and the Credit Crunch

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across MBHC affiliation, although the coefficients are not significant. The effects for short-term finance are qualitatively similar but statistically stronger. Overall, I interpret this as weak overidentifying evidence that internal capital markets identify differential shifts in loan supply in response to monetary policy.

2.5.5 Aggregate Evidence

Having identified evidence of differential responses to bank loan supply to changes in the federal funds rate, the next step is to identify whether or these correspond to changes in aggregate loan supply and eventually affect the investment decisions of bank dependent firms. On one hand, it is plausible that banks affiliated with multi-bank holding companies issue uninsured debt in order to pick up the slack in lending created other banks so that the observed difference in bank loan growth across access to internal capital markets corresponds to no change in aggregate lending. [38] On the other hand, it is not clear that changes in monetary policy don't have qualitatively similar but quantitatively smaller effects on other types of banks, as banks affiliated with multi-bank holding companies could also struggle to smooth loan growth (although by not as much as unaffiliated banks) so that the bank-level analysis actually underestimates the aggregate importance of the lending channel. These issues are crucial when evaluating the importance of the lending channel in the transmission mechanism of monetary policy. Without evidence that financial constraints for banks

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[38]It is certainly possible that other firms pick up any slack in lending through trade credit or the slack in output. These possibilities are less plausible given the convincing evidence described by Peek and Rosengren (1997a) that plausibly exogenous changes in the loan supply of US branches of Japanese banks seem to have affected output in the real estate industry. Thus I feel that the real gap in our understanding is whether or not monetary policy actually induces shifts in the aggregate supply of bank credit (relative to the supply non-bank credit).

actually affect the response of equilibrium lending to monetary policy, it is possible these frictions play no role in amplifying the response of real output to changes in the federal funds rate.

Identifying convincing evidence of a distinct lending channel in the aggregate data has been extremely difficult. While Bernanke and Blinder (1992) document that changes in aggregate lending usually lag changes in monetary policy, it is not clear if these changes are caused from the supply side by the presence agency problems in banks or from the demand side by firms reacting directly through the more traditional money channel. There is strong evidence of a balance sheet channel that amplifies changes in interest rates by affecting firm cash flow and net worth, which in turn affects firm creditworthiness. Gertler and Gilchrest (1994) document that among manufacturing firms, smaller firms bear the brunt of a decline in activity and slowdown in inventory demand. [39] Weaker firm balance sheets effectively reduce the demand for credit, implying that a lagged decline in bank lending in response to tighter monetary policy could plausibly be caused either through the balance sheet or lending channel. Kashyap and Stein (1993) attempt to solve this identification problem through the observation that while higher interest rates should reduce the demand for all types of credit through the balance sheet channel, the supply of bank credit is reduced and demand for non-bank credit it increased through the lending channel. The lending channel is consequently identified by changes in the aggregate mix of bank and non-bank credit following changes in the stance of monetary policy. Moreover, the authors demonstrate that the aggregate credit mix is an important explanatory variable in several traditional investment equations.

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[39]See Hubbard (1994) for a complete discussion of the balance sheet and lending channels.

[40] Friedman and Kuttner (1993) unfortunately find in a VAR framework that any shock that reduces aggregate output also tends to increase the mix, implying these changes in the mix may not have anything to do with the lending channel. [41]

The absence of convincing evidence in existing aggregate studies motivates the following hypothesis.

Hypothesis 5

The presence of bank-level financial constraints amplifies the equilibrium response of lending to monetary policy.

In order to test that changes bank lending are actually corresponding to changes in equilibrium lending and output, I aggregate up bank behavior to the state level to look for differences in the response of state loan and output growth across the loan market share of banks affiliated with multi-bank holding companies. Interstate branching restrictions have historically meant that commercial banks largely operate in the state where chartered, so for much of the last 25 years it seems plausible to treat the US as a collection of state economies. As with the microdata analysis above, it is possible to difference the response of loan growth across the loan market share of banks affiliated with multi-bank holding companies, holding constant all other characteristics of a state's banking industry constant. Included as controls are aggregated state banking assets, liquidity, equity ratio, internal capital, fraction of banks

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[40]A closer look at what is driving changes in the mix, however, is less persuasive. As small firms have little access to nonbank credit, variation in the aggregate mix is driven by the large firm mix and allocation of bank debt across firm sizes. While there appears to be a shift in the mix for large firms, Calomiris, Himmelberg, and Wachtel (1994) find that any increase in non-bank credit (measured by commercial paper) does not appear to occur in the same firms that have bank lending reduced.

[41]When including trade credit in nonbank lending, Oliner and Rudebusch (1996a) find much of the variation in the aggregate mix is driven by changes in the large firm share of bank debt, although these facts and their implications for the lending channel are disputed in Kashyap and Stein (1996). The crucial issue is whether or not there are changes in the terms on which credit is extended to firms, combined with how sensitive firm output is to these terms.

with low capital ratios, and portfolio composition shares. I also control for the loan market share of small banks, and in the later data control for the small business lending concentration of banks affiliated with MBHCs and small banks separately.

Descriptive statistics are presented in Table (2.7). Note that despite all of the consolidation that occurred in the banking industry over the last 20 years,the average state loan market share of small banks only fell by around 4 percentage points. The trend increase and in the loan market share of banks affiliated with multi-bank holding companies combined with the trend decrease in fraction of affiliated banks described above is consistentwith much of this consolidation occuring as large holding companies merge and consolidate their subsidiary banks into branches. The table also illustrates that there are large differences in customer mix across the loan market share of mall banks at this intermediate level of aggregation. Moreover, differences in customer mix across multi-bank holding company affiliation are actually larger than they appeared in the micro data.

I should note that the implications of unobserved customer mix for identification may be different at the state level than the bank level. If the composition of small firms in a state is fixed after controlling for state industrial structure, exploiting differences in the loan market share of either small or affiliated banks may mechanically induce variation in aggregate customer mix. The presence of important balance sheet channel effects at the bank level make identification at the state level much more difficult. [42] Of course the data above suggest that over the period when small loan concentration controls are available, accounting

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[42]There does appear to be a significant negative correlation between the loan market share of multi-bank holding companies and their small loan concentration, even with a full set of state-level controls. While the question of whether or not this is causal is a matter of lively debate, only the correlation is relevant here. See Peek and Rosengren (1997b) for a recent discussion.

for differences in customer mix only strengthens the lending channel. In any case, I think a much more careful treatment of these issues is necessary, and view these aggregate results only as suggestive.

This strategy is implemented in Table (2.8). Panel A is estimated over the full time period 1976-1999 while Panel B is estimated over a more recent period when better controls are available. The first column simply regresses state loan growth on a lag of loan growth, main effects for changes in the funds rate, nominal aggregate output growth, inflation, small bank loan market share, and the loan market share of MBHCs, in addition to interactions of the latter two variables with macro variables. The second column adds state controls state bank capitalization, asset size, and liquidity, each also interacted with macro variables. Finally, the third columns adds ten state industry share controls, and interacts these with macro variables. The first row indicates that the state impulse response of loan growth to a change in the federal funds rate is actually mitigated by the loan market share of MBHCs. In the context of a 100 basis point increase in the federal funds rate, an increase in the loan market share of MBHCs from zero to 100 percent reduces the response of loan growth by 50 basis points. The results in Panel B are generally larger but statistically weaker. The increase in size of the lending channel over time is consistent with the bank-level results. Small loan concentration controls are added with the other state-level controls in the second. The whole set of state-level bank controls weakens the sign on loan growth, but it is only with the inclusion of the industry shares that the result becomes statistically insignificant.

This evidence suggests that there are differential shifts in loan supply across a measure of state-level financial constraints. The big question of course is whether or not these translates into differential movements in state output, and is the final hypothesis tested in this paper.

Hypothesis 6

The presence of bank level financial constraints amplifies the equilibrium response of real output to monetary policy.

The final three columns of Panel A in Table (2.8) demonstrate that over the full period, there is no such evidence. The response of gross state product growth to monetary policy is not significantly weakened by the loan market share of banks affiliated with multi-bank holding companies. Controlling for the small loan concentration of affiliated and small banks in Panel B does little to change this result, although the coefficients are much larger. While there results are not positive, they certainly cannot be described as negative. Note that confidence intervals on the interaction coefficients include implied elasticities of state output growth to loan growth of up to nearly one, much larger than has been found elsewhere. [43] Moreover, it should be noted that this approach at best identifies a lower bound on the size of the lending channel. If banks that are affiliated with multi-bank holding companies also struggle to replace insured deposits in a qualatatively similar but quantatively similar fashion as unaffiliated banks, this strategy understates the response of equilibrium lending to monetary policy. There is also a more subtle issue of timing to consider. The measured response of aggregate output to an innovation in the funds rate is very small in the first four quarters. As the peak effect on output does not occur until after eight to twelve quarters, limiting the analysis to the first year might not be the best thing to do. I am currently investigating these issues in greater detail. [44] For now, I conclude that there is evidence that monetary policy affects equilibrium lending, but little can be said about whether or not this

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[43]Driscol (1998) uses money demand shocks to conclude that changes in lending have small and economically insignificant effects on state output.

[44]See Christiano, Eichenbaum, and Evans (1998) for a full discussion.

affects real output.

2.6 Conclusions

At the end of the day, there is convincing evidence that changes in monetary policy affect the aggregate supply of bank credit. Banks affiliated with multi-bank holding companies face weaker financial constraints. Moreover, these banks appear better able to smooth deposit outflows and shield loan growth from a monetary contraction. Finally, there is evidence that financial constraints at the bank level affect the equilibrium response of lending to monetary policy.

More work certainly needs to be done documenting exactly how holding companies are able to downstream funds to their subsidiaries through internal capital markets. I have been working with the bank holding company data in identifying the gross flows of funds within a holding company, trying to identify the right correlations across holding company size and across changes in the federal funds rate.

I presented evidence above there there might be important asymmetries when implementing countercyclical monetary policy. If the lending channel plays an important role in amplifying the response of output to interest rates, expansionary monetary policy will be much weaker than contractionary monetary policy as bank-level financial constraints do not bind when loan demand is low relative to the supply of insured deposits. This claim is consistent with observations that the economy was slow to respond to prodding by the Federal Reserve in the early 1990s, and has important implications for the conduct of monetary policy if borne out by future research.

I also presented new evidence on the operation of a balance sheet channel in more recent data. Using small business loan concentration information, I demonstrated that the loan growth of banks that concentrate their lending with small firms was actually less responsive to changes in the federal funds rate since 1993. This result might be explained by the fact that the monetary contraction that occured in 1994 was not accompanied by a slowdown in output. It is also possible that there were other shocks to the profitability of small firms that offset this increase in the cost of capital. In any case, it seems prudent to update research on the balance sheet channel with more recent data, and perhaps new methods. There is no reason why the source of cross-sectional variation in financial constraints exploited here – internal capital markets in holding companies – couldn't be used to identify balance sheet effects in firm micro data.

The largest task of future research, however, is to document the extent to which these changes in loan supply actually amplify the response of output to monetary policy. I presented weak results above when differencing the response of output growth to monetary policy across the loan market share of multi-bank holding companies. Standard errors were consistent with a wide range of hypotheses about the aggregate importance of the lending channel. I believe that the most convincing evidence will probably come from matching firm micro data with the Call Reports, either directly with confidential data or geographically with the public use files. In any case, there is still much work to do.

Table 2.2: Descriptive Statistics

	All Banks		Size		Leverage		Multi-bank holding company affiliation			
	1986	1996	Small	Large	Low	High	One-bank	MBHC	One-bank	MBHC
Assets	189	255	80	3,615	213	2,975	167	534	75	95
Loans	51.7	57.7	57.4	62.1	57.6	60.1	56.8	60.6	56.6	60.2
Small loans		75.9	77.9	29.7	76.2	56.0	77.9	69.6	79.3	73.1
Securities	35.3	34.2	34.5	28.2	34.2	29.1	35.1	31.2	34.2	31.9
Core deposits	78.6	76.2	76.8	65.4	76.3	73.7	76.3	75.8	76.8	76.9
Equity	8.6	10.4	10.4	9.0	10.5	5.4	10.6	9.6	10.7	9.7
Finance mix	87.6	87.2	87.6	76.7	87.2	82.3	87.4	86.3	87.8	87.1
Loan losses	1.6	1.6	1.6	1.8	1.6	1.7	1.6	1.6	1.6	1.5
Internal capital	7.0	6.0	5.89	9.4	6.1	4.2	5.8	6.8	5.7	6.6
Loan commitments		19.2	16.6	76.9	19.3	16.9	18.5	21.4	16.0	18.8
Letters of credit		0.9	0.7	4.9	0.9	1.8	0.8	1.2	0.7	0.7
Holding company	68.2	77.2	76.6	89.5	77.2	77.2	70.0	100	69.6	100
Multi-bank company	29.0	24.0	22.9	45.8	23.9	30.9	0	100	0	100
Consolidated assets	1,106	1,224	590	13,400	1,028	13,900	220	4,396	87	2,283
Small bank	95.0	95.0	100	0	95.3	75.6	96.5	90.5	100	100
Small holding company	83.0	86.5	91.0	0	86.8	65.0	96.1	56.4	99.6	62.2
Binding leverage	14.1	1.5	1.2	7.5	0	100	1.4	2.0	1.3	1.1
Loan growth	5.6	12.3	12.3	12.4	12.2	16.1	12.5	11.7	12.4	11.9
Core deposit growth	10.6	7.6	7.6	7.6	7.5	12.0	7.8	6.9	7.8	7.0
Number of insured banks	12,823	8050	7650	400	7927	123	6114	1936	5897	173

Table Notes: Data refer to the population of insured commercial banks. Assets and consolidated holding company assets are reported in millions while all other variables are reported in percentage terms. Loans, securities, core deposits, and equity are measured relative to assets. Small loans are measured relative to total loans covered the small business loan supplement. The finance mix is the ratio of core deposits to the sum of total deposits and net federal funds borrowing. Loan losses, internal capital, loan commitments, and letters of credit are measured relative to total loans. Small banks and small bank holding companies are defined at the 95th percentile of the national distribution of bank assets. Binding leverage standards are approximated by an equity ratio of less than six percent.

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Table 2.3: Sensitivity of Loan Growth to Core Deposit Growth

	(1)	(2)
Δ ln(deposits)	1.6331	1.6429
	(0.0743)	(0.0737)
ln(assets)	0.0012	0.0015
	(0.0004)	(0.0007)
MBHC affiliated	0.0025	
	(0.0010)	
ln(consolidated assets)		-0.0002
		(0.0005)
Securities	0.0951	0.0952
	(0.0040)	(0.0040)
Capital Surplus	0.1107	0.1044
	(0.0247)	(0.0249)
Binding leverage	-0.0413	-0.0412
	(0.0022)	(0.0022)
Internal capital	-0.0005	-0.0006
	(0.0005)	(0.0005)
ln(assets)$*\Delta$ ln(deposits)	-0.0859	-0.0589
	(0.0065)	(0.0088)
MBHC affiliated$*\Delta$ ln(deposits)	-0.0745	
	(0.0165)	
ln(consolidated assets)$*\Delta$ ln(deposits)		-0.0284
		(0.0061)
Securities$*\Delta$ ln(deposits)	-0.1268	-0.1235
	(0.0526)	(0.0521)
Capital surplus$*\Delta$ ln(deposits)	0.1121	0.1556
	(0.1320)	(0.1330)
Binding leverage$*\Delta$ ln(deposits)	0.1269	0.1331
	(0.0219)	(0.0221)
Internal capital$*\Delta$ ln(deposits)	-0.0068	-0.0066
	(0.0024)	(0.0023)
R^2	0.31	0.31
Observations	130,194	130,194

Table Notes: The table refers to a regression of annual loan growth on core deposit growth, various measures of financial constraints, and the interaction of these measures with core deposit growth. The interactions have been properly scaled so the the main effects are evaluated at mean deposit growth. The data refer to the population of insured commercial banks 1986-1999. The table reports coefficients on the main effects and interactions, as well as their standard errors which have been corrected for heteroskedasticity and clustering at the bank level.

Table 2.4: Internal Capital Markets: MBHC Affiliation

	Loans		Short-term Finance		Insured Deposits		Uninsured Short-term	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
$MBHC*\Delta r_t$	0.0020	0.0018	0.0015	0.0018	0.0023	0.0024	0.0018	0.0021
	(0.0010)	(0.0010)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
$ln(A)*\Delta r_t$	0.0004	0.0009	0.0009	0.0010	-0.0003	0.0005	0.0007	0.0011
	(0.0004)	(0.0005)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0004)
$Surplus*\Delta r_t$	-0.0516	-0.0403	0.0358	0.0335	0.0157	0.0057	0.0202	0.0203
	(0.0305)	(0.0307)	(0.0228)	(0.0223)	(0.0205)	(0.0203)	(0.0190)	(0.0189)
$Bind*\Delta r_t$	0.0056	0.0058	-0.0008	-0.0009	-0.0030	-0.0025	-0.0010	-0.0008
	(0.0025)	(0.0025)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0018)	(0.0019)
$Secs*\Delta r_t$	0.0092	0.0085	-0.0281	-0.0278	-0.0253	-0.0273	-0.0302	-0.030
	(0.0035)	(0.0037)	(0.0026)	(0.0029)	(0.0028)	(0.0031)	(0.0027)	(0.0029)
$Cash*\Delta r_t$		-0.0046		0.0021		0.0069		0.0010
		(0.0053)		(0.0024)		(0.0037)		(0.0041)
Portfolio	No	Yes	No	Yes	No	Yes	No	Yes
R-sq	0.165	0.167	0.179	0.182	0.162	0.165	0.167	0.169
obs	123,882	123,882	123,882	123,882	123,881	123,881	123,882	123,882

Table Notes: The table refers to a regression of each dependent variable (listed by column) on one lag of the dependent variable, various measures of financial constraints, the one-year change in the federal funds rate, aggregate output growth, inflation, and each measure of financial constraints interacted with each macro variable. These dependent variables include (reading across) loan growth, total short-term finance growth, core deposit growth, uninsured deposit and federal funds borrowing growth. The second column for each dependent variable adds controls for loan portfolio composition and interacts these portfolio shares with the macro variables. Each regression is estimated over the population of insured commercial banks 1986-1999. The table reports coefficients on the interactions of measures of financial constraints with the change in federal funds rate and their standard errors, which have been corrected for heteroskedasticity and clustering at the bank level.

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Table 2.5: Internal Capital Markets with More Recent Data: MBHC Affiliation

	Loans		Short-term Finance	
	(1)	(2)	(1)	(2)
$MBHC * \Delta r_t$	0.0046	0.0057	0.0040	0.0039
	(0.0017)	(0.0017)	(0.0013)	(0.0013)
$ln(A) * \Delta r_t$	-0.0026	0.0015	0.0002	0.0008
	(0.0008)	(0.0011)	(0.0006)	(0.0009)
$Surplus * \Delta r_t$	-0.0019	0.0078	0.0047	-0.0086
	(0.0384)	(0.0327)	(0.0412)	(0.0411)
$Bind * \Delta r_t$	0.0178	0.0208	0.0101	0.0102
	(0.0067)	(0.0066)	(0.0057)	(0.0056)
$Secs * \Delta r_t$	0.0275	0.0206	-0.0269	-0.0269
	(0.0065)	(0.0066)	(0.0049)	(0.0049)
$Cash * \Delta r_t$		0.0031		0.0069
		(0.0038)		(0.0043)
$Commitments * \Delta r_t$		-0.0020		-0.0001
		(0.0016)		(0.0005)
$SmallLoans * \Delta r_t$		0.0271		0.0101
		(0.0044)		(0.0035)
Portfolio	No	Yes	No	Yes
R-sq	0.153	0.172	0.195	0.208
obs	57,724	57,506	57,724	57,506

Table Notes: The table refers to a regression of each dependent variable (listed by column) on one lag of the dependent variable, various measures of financial constraints, the one-year change in the federal funds rate, aggregate output growth, inflation, and each measure of financial constraints interacted with each macro variable. These dependent variables include (reading across) loan growth and total short-term finance growth. The second column for each dependent variable adds controls for loan portfolio composition and intereacts these portfolio shares with the macro variables. Each regression is estimated over the population of insured commercial banks 1993-1999. The table reports coefficients on the interactions of measures of financial constraints with the change in federal funds rate and their standard errors, which have been corrected for heteroskedasticity and clustering at the bank level.

Table 2.6: Internal Capital Markets Differenced Across Slow Loan Demand: MBHC Affiliation

	Loans		Short-term Finance	
	(1)	(2)	(1)	(2)
$MBHC * \Delta r_t$	0.0067	0.0067	0.0072	0.0073
	(0.0018)	(0.0018)	(0.0013)	(0.0013)
$MBHC * Slow * \Delta r_t$	-0.0026	-0.0027	-0.0048	-0.0046
	(0.0023)	(0.0023)	(0.0017)	(0.0017)
$ln(A) * \Delta r_t$	-0.0058	-0.0052	-0.0003	-0.0003
	(0.0008)	(0.0008)	(0.0006)	(0.0007)
$ln(A) * Slow * \Delta r_t$	0.0062	0.0060	-0.0012	-0.0013
	(0.0010)	(0.0010)	(0.0008)	(0.0008)
$Surplus * \Delta r_t$	-0.0341	-0.0225	0.0321	0.0295
	(0.0314)	(0.0316)	(0.0230)	(0.0225)
$Bind * \Delta r_t$	0.0037	0.0039	0.0002	0.0000
	(0.0025)	(0.0025)	(0.0019)	(0.0019)
$Secs * \Delta r_t$	0.0064	0.0061	-0.0287	-0.0285
	(0.0035)	(0.0037)	(0.0027)	(0.0029)
$Cash * \Delta r_t$		-0.0050		0.0021
		(0.0054)		(0.0024)
Portfolio	No	Yes	No	Yes
R-sq	0.17	0.172	0.184	0.186
obs	123,882	123,882	123,882	123,882

Table Notes: The table refers to a regression of each dependent variable (listed by column) on one lag of the dependent variable, various measures of financial constraints, the one-year change in the federal funds rate, aggregate output growth, inflation, a dummy variable for the time period 1989-1993, and all of the interactions of these variables.. These dependent variables include (reading across) loan growth and total short-term finance growth. The second column for each dependent variable adds controls for loan portfolio composition and intereacts these portfolio shares with the macro variables. Each regression is estimated over the population of insured commercial banks 1986-1999. The table reports coefficients on the interactions of measures of financial constraints with the change in federal funds rate, as well as the third interaction with dummy for the time period 1989-1993, and their standard errors, which have been corrected for heteroskedasticity and clustering at the bank level.

Table 2.7: State Descriptive Statistics

	1980	1990	1995
Small bank loan market share	0.46	0.41	0.42
	(0.28)	(0.28)	(0.27)
MBHC-affiliated loan market share	0.33	0.55	0.52
	(0.28)	(0.22)	(0.25)
Small bank small loan concentration			0.61
			(0.15)
Large bank small loan concentration			0.24
			(0.14)
MBHC-affiliated small loan concentration			0.33
			(0.20)
MBHC-unaffiliated small loan concentration			0.53
			(0.22)
State loan growth	0.03	0.01	0.10
	(0.04)	(0.08)	(0.06)
Nominal Gross State Product growth	0.09	0.06	0.05
	(0.06)	(0.03)	(0.02)

Table Notes: Data refer to the population of insured commercial banks. Small banks and small bank holding companies are defined at the 95th percentile of the national distribution of bank assets. Small loan concentration refers to the fraction of loans with original principal of 250,000 dollars or less in total loans surveyed by the small business supplement.

Table 2.8: Aggregate State Loan and Output Growth

A. 1976-1999

	$\Delta ln(L_s)$ (1)	$\Delta ln(L_s)$ (2)	$\Delta ln(L_s)$ (3)	$\Delta ln(GSP_s)$ (1)	$\Delta ln(GSP_s)$ (2)	$\Delta ln(GSP_s)$ (3)
$\theta^{mbhc} * \Delta r_t$	0.0099	0.0053	0.0053	-0.0005	-0.0006	0.0000
	(0.0046)	(0.0029)	(0.0030)	(0.0021)	(0.0021)	(0.0020)
$\theta^{small} * \Delta r_t$	0.0090	0.0022	-0.0006	0.0101	-0.0034	-0.0047
	(0.0033)	(0.0034)	(0.0036)	(0.0025)	(0.0030)	(0.0033)
Covariates	No	Yes	Yes	No	Yes	Yes
Industry	No	No	Yes	No	No	Yes
R-sq	0.328	0.875	0.897	0.403	0.555	0.659
obs	1122	1122	1122	969	969	969

B. 1993-1999

$\theta^{mbhc} * \Delta r_t$	0.0416	0.0205	0.0168	0.0047	0.0112	0.0128
	(0.0183)	(0.0120)	(0.0114)	(0.0078)	(0.0098)	(0.0121)
$\theta^{small} * \Delta r_t$	0.0095	-0.0171	-0.0172	-0.0067	-0.0188	-0.0102
	(0.0125)	(0.0204)	(0.0247)	(0.0065)	(0.0171)	(0.0149)
Covariates	No	Yes	Yes	No	Yes	Yes
Small loans	No	Yes	Yes	No	Yes	Yes
Industry	No	No	Yes	No	No	Yes
R-sq	0.141	0.839	0.879	0.29	0.581	0.784
obs	306	297	297	204	200	200

Table Notes: The table refers to a regression of each dependent variable (listed by column) on one lag of the dependent variable, various measures of state-level financial constraints, the one-year change in the federal funds rate, aggregate output growth, inflation, and each measure of financial constraints interacted with each macro variable. These dependent variables include (reading across) aggregate state loan growth and state gross-state product growth. State-level covariates include aggregate banking assets, liquidity, equity ratio, internal capital, fraction of banks with low capital ratios, and portfolio composition shares. Each regression is estimated over the population of insured commercial banks 1993-1999. The small loans covariates control for the small loan concenetration of small and MBHC-affiliated banks, also interacted with changes in macro variables. Industry controls include the state income shares for each of ten industries, also interacted with macro variables. The table reports coefficients on the interactions of the loan market share of MBHC-affiliated banks and small banks with the change in federal funds rate and their standard errors, which have been corrected for heteroskedasticity and clustering at the state level.

Chapter 3

Do Tougher Bank Capital

Requirements Matter?

New Evidence from the Eighties

Requirements that banks have sufficient capital are another way to change the banks incentives to take on less risk. When a bank is forced to hold a large amount of equity capital, the bank has more to lose if it fails and is thus more likely to pursue less risky activities. *Frederic Mishkin, 1997*

Like safe sex, safe banking requires effective precautions. *Economist, April 1996*

A study by the London Business School last year found that the annual direct costs of financing regulators' activities was almost $140 million; in America it was $795 million. The American Bankers Association has estimated the cost of [footing the bill for the paperwork that regulators demand] at $14 billion a year.

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Economist, April 1996

Empirical evidence on the effectiveness of capital regulation suggests that regulations have had a significant impact on most banks' capital ratios in the period since the 1981 numeric guidelines were imposed. *Wall and Peterson (1996)*

3.1 Introduction

The premise of bank capital regulation is a fear that the presence of imperfectly-priced deposit insurance permits banks to view portfolio and leverage risk as compliments, creating incentives for excessive risk-taking at the taxpayer's expense. While banks certainly would fail in the absence of deposit insurance, the concern is that banks are less likely to carefully reverse bad shocks on their own and are more likely to increase asset risk when they don't have to pay a default premium on their liabilities to depositors.[1] Bank capital regulation has traditionally tried to curb these incentives either by limiting bank leverage or by tying allowable asset risk to the actual level of capital.

Formal leverage requirements in the United States were introduced by the regulators for all but the largest banks in 1981, and then for the multi-nationals in response to the Latin American debt crisis in 1983. Differences in these requirements across regulators and bank size were eliminated in 1985. Since 1988 the centerpiece of commercial bank regulation in developed countries has been the Basle Accord, an international agreement by bank regulators in G-7 countries as to what constitutes bank capital and bank capital adequacy.[2]

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[1]There is a large theoretical literature on bank capital regulation. See Dewatripont and Tirole (1993), Keeley and Furlong(1990), Kim and Santomoero (1988), Gennotte and Pyle (1991), Avery and Berger (1991), and Gan(1999).

[2]The banking agencies also retained pre-existing leverage requirements, but eliminated the inclusion of

Basle was not only important in eliminating most differences in standards across countries that put U.S. banks at a disadvantage in their own market, but also was fundamental in its attempt to limit the ability of banks to transfer risk off the balance sheet. Congress supplemented risk-based capital requirements in 1989 by requiring the banking agencies to take prompt corrective action when banks fail these standards, presumably increasing the regulatory costs of inadequacy, to convince institutions of the need to carefully reverse bad shocks. [3] There were certainly other important reforms, in particular the introduction of risk-based deposit insurance premiums by the FDIC, but it is fair to say that the safety and soundness of commercial banks over the last two decades has been largely guarded through the regulation of bank capital. [4]

The time series of aggregate capital ratios for commercial banks is illustrated in Figure 3-1, which describes a 200 basis point increase in the ratio of equity to assets and almost a 300 basis point increase in the primary capital ratio since formal capital standards were introduced and subsequently increased. How much of this increase in capital ratios was caused by tougher adequacy standards is the crucial question of this paper. While the analysis below focuses on changes in leverage requirements and not directly on an admittedly more interesting policy change like the implementation of risk-based capital, it is certainly

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loan loss allowances in core capital and varied the minimum ratio based an overall rating of capital adequacy, management quality, earnings, and liquidity by bank examiners.

[3]Research has not been kind in evaluating either of these initiatives. Jones and King (1995) find little would have changed if prompt corrective action provisions had been in place during the 1980s while Kuester and O'Brien (1990) report that the default premia implied by risk-based pricing of deposit insurance are inadequate.

[4]While G-7 countries may be the ones pioneering new techniques in bank capital regulation, the stakes are even larger for economies with less developed financial markets. The June 1997 issue of the Economist claims that "regulators in emerging markets are becoming increasingly aware that capital adequacy rules are the most effective item in their toolbox."
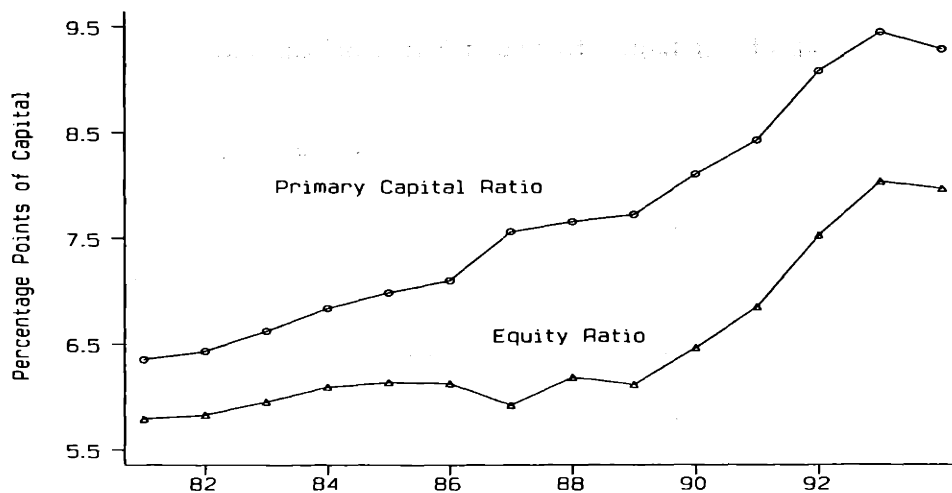
Figure 3-1: Aggregate Capital Ratios

relevant to any evaluation of the Basle Accord. [5] Baer and McElravey (1993) estimate that

the capital shortage created by the 1985 increase in standards was similar in magnitude to

that created by the introduction of risk-based capital [6] In addition, several strategies that

have been employed to evaluate the Accord were developed when economists evaluated these

earlier standards. In a recent survey of the literature, Jackson et. al. (1999) claim that at

best researchers have reached a broad consensus that in the 1980s and 1990s, relatively low

capital banks tended to increase their capital ratios more than better capitalized banks.

Early studies by Keeley (1988) and Shrieves and Dahl (1992) reach exactly this conclu-

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[5]This is not to say changes in leverage requirements are uninteresting. They are perhaps the cleanest test of models of the optimal bank capital structure that treat fixed-rate deposit insurance as a put option on the value of bank equity.

[6]For those believing that the Basle Accord prompted a credit crunch, perhaps 1985 is the recession that didn't happen. The authors estimate that pre-existing financial weaknesses and the recycling of assets each created capital shortages equal in magnitude to tougher adequacy standards in 1989.

sion for large commercial banks and Bank Holding Companies in the first half of the 1980s. Wall and Peterson (1987) claim that changes in capital ratios are better explained by a regression model with regulatory variables than one containing information possessed by the market. Using similar methods, Jacques and Nigro (1994) and Wall and Peterson (1994) reach similar conclusions about risk-based capital. The main limitation of these studies is their failure to appropriately use data before the policy change, implicitly focusing on identifying consequences of the level of standards and not the effect of tougher capital regulation. This latter question really is the only one identified in the data, as the former presumes that there is some way of mapping the observed outcomes of high capital banks subject to leverage standards to the counterfactual outcomes of (federally-insured) low capital banks in the absence of capital regulation. I find this a difficult place to start given a concern about weakly capitalized banks gambling with taxpayers money is the motivation for capital regulation.[78]

It is worth stating explicitly that this paper evaluates how much of the change in capital ratios after 1985 can be attributed to tougher capital regulation, and does not attempt to evaluate pre-existing capital standards. The fundamental identification problem is that tougher adequacy standards generally affect all commercial banks so that there is no true control group. A finding that low capital banks generally increased their capital ratios rela-

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[7]Only Berger and Udell (1995) and Aggarwal and Jacques (1996), in the context of risk-based capital and FDICA respectively, appropriately focus their identification on the change in regulation. The main limitation of these studies is in their treatment of precautionary behavior. There is no such study evaluating these earlier changes in leverage standards.

[8]The most convincing work on bank capital is done by Peek and Rosengren (1995), who exploit changes in the Nikkei to identify the effect of changes in the capital of Japanese banks on the lending behavior of their US branches. This is certainly strong evidence that large market-driven changes in bank capital can have real effects, but it has little to say about how much relatively smaller regulator-driven changes in adequacy standards matter.

tive to high capital banks after an increase in capital standards is only relevant in answering this question if such mean-reverting dynamics did not exist before the policy change. This possibility is strongly rejected in Figure 3-2, which graphs for the population of insured commercial banks the regression-adjusted one-year change in the primary capital ratio given last year's capital ratio. Mean-reverting dynamics are present throghout the period. A direct consequence of this result is that any evaluation of tougher capital adequacy standards that simply compares the outcomes of banks by level of capital as measured before the change in overestimates the effects of a policy change. As the capital ratios of low capital banks rise over time relative to high capital banks, presuming any differences between these groups is fixed implicitly assumes away the presence of mean-reversion and loads the natural adjustment of low capital banks on top of any effects from the change in policy. Moreover, an estimator which differences out the pre-existing dynamics between low and high capital banks eliminates all measured effects of tougher standards in 1985.

There are at least two potential problems with this strategy. First, relatively high capital banks are being used as a control group to identify what would have happened to low capital banks in absence of a policy change. If the control group also reacts to tougher standards in the same direction by increasing capital ratios, we will be underestimating the consequences of the policy change on the low capital group. [9] The time-series in Figure 3-2 generally support this concern, illustrating that the capital ratios across the entire distribution of banks seem to increase after each policy change. Second, identification is based on the absence of time-varying factors that affect the adjustment of low versus high capital banks.

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[9]This potentially explains the absence of observed effects on lending of risk-based capital. Using data before the Accord to properly control for pre-existing dynamics across initial leverage, Berger and Udell (1995) find risk-based capital standards did not affect bank lending.
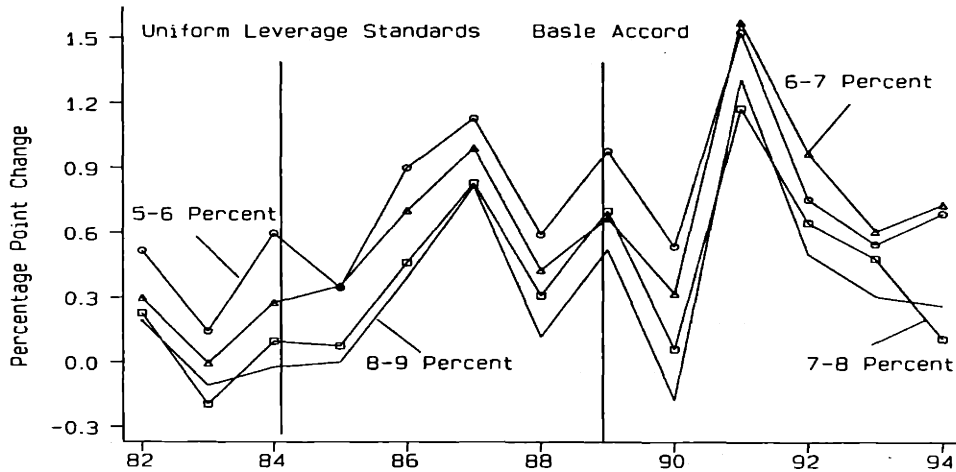
Figure 3-2: Annual Change in Capital Ratio by Lagged Ratio

If low capital banks adjust primarily by increasing capital growth and relatively higher capital banks adjust primarily by reducing asset growth, as appears to be the case in the data below, time-series variation in the cost of external finance or loan opportunities could affect these groups differently. Moreover, I argue in the analysis below that when bad shocks temporarily reduce bank capital, there is a change in the composition of low capital banks toward banks with higher target capital ratios. [10] When changes in capital regulation are either prompted by or accidently timed near these shocks, exploiting differences in initial leverage to identify the likely effects of regulation is especially dubious.

The only way to properly identify the causal effect of interest is to locate a large group

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[10]In the context of a simple partial adjustment model where the actual adjustment of bank capital depends on the difference between target and actual leverage, bad shocks will increase the average target capital ratio of low capital banks. This implies that low capital banks will tend to increase their capital ratios faster than they normally did, but this is driven by the abnormal presence of banks with high target capital ratios.

of banks with similar asset powers that are lending in similar markets, and to randomly increase capital requirements for one subset of this group. While such deliberate experimentation by the regulators is generally not possible, it turns out that something pretty close to this occurred by accident in the mid-1980s. In particular, I exploit the plausibly exogenous elimination of differences by Federal Reserve System membership status in leverage requirements for community banks (those with less than $1 billion is assets). In particular, until early 1985 when leverage requirements were made uniform across the regulators, member banks effectively had requirements of 7 percent while non-member banks had requirements of 6 percent. I analyze the 100 basis point increase in minimum leverage requirements by the FDIC in 1985, using member banks as a control group. Controlling for pre-existing dynamics across membership status and permitting precautionary behavior, I corroborate the finding above tougher leverage standards in 1985 had little impact on bank behavior. Moreover, I find that despite lower minimum capital standards in 1985, non-member community usually banks raised their capital ratios as much as member banks, suggesting that the level of capital requirements was also unimportant. In any case, analysis of this natural experiment does not change the basic message from above: tougher leverage requirements did not matter.

This paper provides important lessons when evaluating the impact of risk-based capital requirements on bank behavior. Several economists pointed to the ahistorical portfolio shift from loans into securities that occurred in the early 1990s as evidence that Basle had important real effects. Figure (3-3) documents this shift 1989-1994, which is clearly too large to be explained by the recession when differencing across 1980-1982. On the other hand, there is a clear problem with this interpretation in more recent data. While risk-based capital requirements have if anything gotten tougher over the last decade, commercial
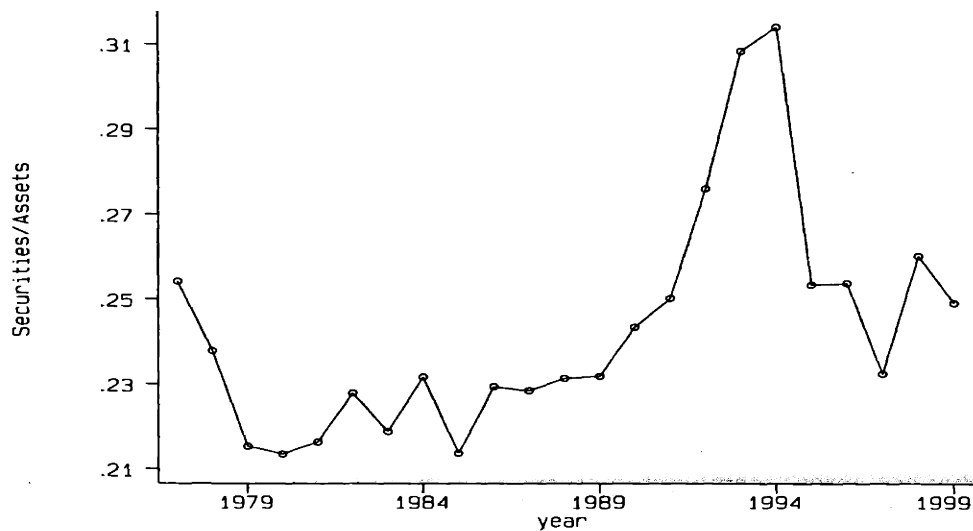
Figure 3-3: Aggregate Securities Holdings of Commercial Banks

banks have completely reversed this portfolio shift. While advocates of risk-based capital standards could reasonably argue that standards have been eroded over time as banks discovered or created loopholes in them there is another interpretation of these facts: tougher standards were simply not important and that the observed portfolio shift was in response to an ahistorical level of bank failures. [11]

When banks view FDIC guarantees as a call option on the value of assets, there are incentives for excessive risk-taking. This implies that any minimum capital requirement is binding as banks seek to maximize their leverage. I interpret the evidence above as a strong rejection of this simple call option model of bank behavior, suggesting that the moral hazard

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[11] The Accord actually reduced leverage requirements to 4 percent, and seemed to have the greatest impact on banks that had relied excessively on loan loss allowances as capital or had significant off-balance sheet activities. I reevaluate the impact of the Accord on bank behavior in Ashcraft (2001).

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incentives for banks have been largely overstated and that there are possibly market-based incentives for banks to hold capital. Identifying and quantifying these incentives is thus the next important step in properly evaluating the likely effects of past bank regulation and of course when designing regulation for the future.

Section 2 describes what constitutes bank capital and bank capital adequacy for those unfamiliar with these concepts. Institutional details are provided in Section 3 and the data employed is described in Section 4. Analysis of the 1985 standards is performed in Section 5, of differential changes across membership status in Section 6. Directions for future research are outlined in Section 7.

3.2   What is bank capital?

In order to motivate a discussion of what constitutes bank capital, a hypothetical bank balance sheet is shown in Table (3.1). Note that the all of the bank's assets are financed through the issue of deposits, debt, and stockholder's equity, the last of which mostly includes proceeds from the sale of stock and cumulative retained earnings. This equivalence is not a coincidence and reflects an identity that must always hold. As equity simply is the difference between assets and liabilities, what the bank owns and what it owes to outsiders, it is a measure of the owners' stake in the bank.

Bank regulators typically are concerned with the book value of equity, requiring banks to periodically revalue assets that have deteriorated in quality. In fact, an important part of the bank examination process is a careful review of the bank's loan portfolio to ensure bank managers are properly identifying and revaluing problem loans. On the other hand banks

are generally not required to revalue loans due to changes in interest rates. Once a bad loan has been identified, its revaluation always requires an off-setting transaction to preserve the balance sheet identity.

The most direct method of writing-off a bad loan is to reduce owner's equity by the same amount. The book value of equity thus serves the purpose of loss absorption, which is actually the primary determinant of what defines bank capital. It turns out that banks realize lending is a risky business and in order to smooth fluctuations in earnings, will regularly expense a fraction of their loan portfolio through loan loss provisions before bad loans are actually identified. The stock of loan loss provisions from all previous periods is referred to as allowances for loan loss. [12] When bad loans are actually identified, they are written off against these allowances so the net effect on assets is zero. Since these allowances clearly serve a loss absorption function, they too are included in the definition of bank capital. [13] The sum of book equity and loan loss allowances is referred to here as primary capital, consistent with convention in the mid-1980s.

In the event of a bank failure the holders of a bank's subordinated debt are last creditors in line to collect on their claims. Their interests are subordinated to those of depositors, so as far as the taxpayer is concerned, they too serve a loss absorption function and thus constitute regulatory capital. While subordinated debt does not really contribute to capital in any

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[12] These provisions do not involve any cash outflows but reduce profits. If all a banks revenues and other expenses are settled in cash, the balance sheet evolves over time as follows: equity increases by profits (ignoring dividends), cash increases by revenues less all expenses except loan loss provisions, and loans are reduced by the amount of loan loss provision. This is done by reporting loans on the balance sheet net of allowances for loan loss, essentially reducing the book value of the loan portfolio by expected losses.

[13] There has frequently been debate between the regulators as to whether or not loan loss allowances should constitute capital, as they are allowances for expected losses, implying a more narrow definition of capital is the capacity to absorb unexpected losses. The measure of core capital (Tier 1) under the Basle Accord actually excludes these allowances, but permits a limited amount as secondary capital.

Table 3.1: Hypothetical Commercial Bank Balance Sheet

Assets		Liabilities and Equity	
Cash	80	Deposits	900
Securities	350	Subordinated Debt	2
Loans	500	Stockholder's Equity	80
Less Allowances	5		
Other Assets	75	Other Liabilities	18
Total Assets	1000	Total Liabilities and Equity	1000

economic sense and the issue was often debated between the agencies in the early 1980s, bank regulators eventually became interested in the potential discipline that subordinated debt holders might impose on the bank. [14] The sum of primary capital and subordinated debt is referred to as total capital, and is the broadest measure of loss absorption from the taxpayer point of view.

Capital adequacy is generally measured relative to assets or loans under a regime of leverage requirements or relative to risk-weighted assets in a regime of risk-based capital, where the risk weights are proportional to underlying credit risk of various asset categories. In our hypothetical bank the equity ratio is 8 percent, primary capital is 8.5 percent, and total capital is 8.7 percent when measured relative to assets net of loan loss allowances. A very simple measure of risk-based capital is the ratio of primary capital to loans, important as many state-chartered banks had legal loan limits tied to the level of capital. Given a loan ratio of 0.5 and a 100% weight on loans, a measure of risk-based capital is 17 percent. This example illustrates an important point, that for banks with very few off-balance sheet assets, a minimum leverage requirement of 7 percent will be more binding than a risk-based capital

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[14]There have always been minimum maturity restrictions on limited life instruments to qualify for capital. The actual regulations in Basle are quite complex, and this discussion only highlights some of the more basic conceptual issues.

requirement of 7 percent as risk weighted assets are usually less than total assets. [15]

3.3 Institutional Background

Commercial banks can be chartered in the United States at either the state or federal level. National banks are regulated by the Office of the Comptroller of the Currency, are required to have federal deposit insurance and be members of the Federal Reserve System, and have their powers limited by the laws of the US Congress. On the other hand, state-chartered banks have their powers limited by the state legislature, generally have the choice of federal deposit insurance and Federal Reserve membership, and are regulated by their state banking authority. All federally-insured banks are also regulated by the FDIC, and all member banks are regulated by the Federal Reserve Board. In practice, the banking agencies have attempted to avoid overlapping jurisdictions in the bank examination process, so that the Board is the primary regulator of state member banks, the Comptroller is the primary regulator for national banks, and the FDIC is the primary regulator of the state non-member banks. As the analysis below exploits differential changes in minimum leverage requirements across the regulators, it is important to understand why these regulations were different in the first place. The following discussion of the evolution capital adequacy standards closely follows that of Davison (1997).

During the 1970s there were no formal capital requirements, and the banking agencies

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[15] In the Basle regulations, risk-weighed assets not only include the classes of assets which appear on the balance sheet, but also off-balance sheet items such as letters of credit and obligations to conduct foreign exchange transactions. Risk-based capital requirements were in part designed to contain the growing off-balance sheet activities of larger banks. The communty banks considered in the analysis below are on average much closer to the hypothetical bank above than those prompting proposals for risk-based capital in the mid 1980s.

simply set target capital ratios for commercial banks based on the capital levels of a particular bank's peer group. As these standards were enforced only by the regulators power to approve mergers or new lines of business, they were largely ignored. A decline in capital ratios over the decade and the failure of a few large banks prompted the establishment of an inter-agency task force in 1979 to develop proposals for minimum capital adequacy standards. The regulators failed to agree on the specifics of the formal requirements as the FDIC strongly protested inclusion of limited life instruments as regulatory capital and to opposed any proposal that gave lower capital requirements to larger banks.

Unable to agree on uniform capital adequacy standards, the regulators eventually decided to issue different regulations. In December 1981 the Board and Comptroller of the Currency jointly announced formal total capital requirements for community banks of 7 percent, seemingly easing up on their earlier practices. The new regulations actually created three size classes for commercial banks. The multinationals, having assets greater than 15 billion dollars, were not subject to formal capital requirements but were expected to reverse a decline in capital levels. Regional banks, those having assets greater than 1 billion dollars, were subject to a minimum total capital ratio of 6 percent, while the aforementioned community banks have assets less than 1 billion dollars. [16]

Shortly after the joint announcement by Board and Comptroller, the FDIC announced a formal capital adequacy standard of 6 percent regardless of bank size. As the FDIC had a long-standing position against the inclusion of limited life instruments counting towards capital adequacy, these minimums applied only to primary capital. The analysis below focuses

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[16]It is important to note that most researchers have looked at the 1981 capital regulations as a tightening in capital adequacy standards. This is probably only true for regional banks.

Table 3.2: Leverage Standards for Community Banks in the 1980s

Ratio	Member		Non-member	
	Primary	Total	Primary	Total
A. 1981 Standards				
Zone 1	6.5	7	6	X
Zone 2	6.0	6	6	X
Zone 3	Less	Less	5	X
B. 1985 Standards				
Zone 1	6.5	7	6.5	7
Zone 2	5.5	6	5.5	6
Zone 3	Less	Less	Less	Less

Table Notes: These regulations are described in Davison(1997) and the Federal Reserve Bulletin (1982,1985).

on community banks, so any differences with the Board regulation as to what constituted capital turns out to be unimportant as small institutions generally had more limited access to external forms of finance. [17]

In 1983 the agencies started to overcome their reluctance to toughen up capital standards when the Comptroller's authority to impose formal capital guidelines was upheld in court. Congress also helped out with language in the International Lending Supervision Act, enacted in response to concerns about the safety and soundness of the banking system that were in turn prompted by the LDC debt crisis. The law directed each agency to ensure banks held adequate capital levels, and decreed that the failure to do so was an unsafe and unsound practice. In the next two years the regulators began to work towards uniform capital standards. While the Board and OCC seemed to press for a modest one percentage point

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[17]While this may appear to be an opportunity to examine the impact of reducing minimum leverage requirements, it has been difficult to ascertain whether or not the FDIC policy simply formalized earlier requirements or was also a loosening its earlier informal policy. Conversations with researchers at the FDIC have not been able to clarify this point. Since capital requirements before 1981 were informal and often ignored by banks, it is difficult to find evidence for any view of what actually happened here. The inability to clarify these institutional details is the primary reason analysis of this change in standards is not included in the paper. Another important concern includes the enactment of fairly significant banking legislation in 1979 and 1982 which may have affected banks differentially by Federal Reserve System membership status, making it extremely difficult to isolate the impact of lower capital requirements for member banks.

increase in requirements for large institutions, the FDIC began to press for a 9 percent lever-age requirement that included a 3 percent subordinated debt requirement. The FDIC also changed its position on limited-life instruments in the hope that sophisticated debt holders would impose greater discipline on bank risk-taking, and its proposal was actually endorsed by Paul Volker and the Treasury. At the same time, the Board and OCC were prepared to abandon regulations that treated banks differently by size, perhaps learning from the LDC debt crisis that larger banks were not necessarily safer. This slow convergence in regulatory philosophies eventually permitted a compromise between the regulators in early 1985.

The next significant regulatory change for community banks occurred when the FDIC de-cided to toughen up capital regulations for all its banks, increasing minimum leverage ratios to 7 percent. The Board and Comptroller also raised requirements for regional and multina-tional banks to the same number, finally creating a substantial degree of uniformity across the regulators in capital regulation. While all large banks faced tougher adequacy standards – the focus of much research to date – only non-member banks faced tougher standards after 1985. Regulations for community banks are describe in Table (3.2) For banking institutions operating in the first zone, capital is considered adequate if it is above the minimum level and acceptable to the regulator, but the agencies claimed to intensify analysis and action when unwarranted declines in capital ratios occurred. In Zone 2, it is presumed that the bank is undercapitalized, and the regulators will engage in extensive contact and discussion with management, requiring submission of an acceptable capital restoration plan. The intensity of monitoring supposedly increased. Banking institutions in Zone 3 are undercapitalized. In addition to frequent discussion and contact with management, the bank must also submit an acceptable capital augmentation plan and tolerate continuous analysis, monitoring, and

supervision.

In summary, differences in adequacy standards across bank size and membership status were eliminated in early 1985. The creation of uniform standards generally toughened the standards faced by multi-national and regional banks while only strengthening the standards faced by non-member community banks.

3.4 The Data

This paper employs the Call Report Data available on-line at the Federal Reserve Bank of Chicago, relying heavily on documentation developed by Jeremy Stein and Anil Kashyap (1998) on forming consistent time series. The microdata includes complete financial information regarding the financial condition and income of commercial banks on a quarterly basis since 1976. It is the population of banks and not a random sample. This analysis will make use of annual data on the subset of federally-insured, commercial banks at least two years old, recorded as of December 1984. Exploiting the quarterly frequency might provide more data, but it is not costless as this data also much more variable. The age restriction is consistent with the regulation, and is employed to not confound the change in regulation with changes in bank chartering policies by the regulators in the early 1980s. [18]

I choose six years for a window of analysis, three years before and three after the increase in capital requirements. Including earlier years might be problematic as Garn-St. Germain expanded the asset powers of national banks, and member community banks appeared to have their minimum leverage requirements cut by one percentage point in December 1981.

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[18]Since the analysis below will focus on banks with between 5 and 9 percent primary capital ratios, the age criterion is unimportant and does not affect any of the results.

Table 3.3: The Commercial Banking Industry, December 1984

	Community	Regional	Multinational	All
A. Number				
Members	5747	213	17	5977
Non-members	8476	50	0	8526
Total	14223	263	17	14503
B. Market Share				
Members	18.7	28.2	31.1	68.0
Non-members	17.8	4.2	0.0	22.0
Total	36.5	32.4	31.1	100.0

Table Notes: Data is taken from the balance sheets of all insured commercial banks as reported in December 1984. Market share is measured using bank assets. Community banks have less than $1 billion in assets while Regional banks have between $1 and $15 billion in assets and Multinational banks have more than $15 in assets.

Looking after 1987 may confound any differential effects of the Basle Accord across member status, particularly if regulators differed in their attitudes towards off-balance sheet assets.

A breakdown of how insured commercial banks break down into size classes and membership status is described in Table 3.3. Community banks have less than $1 billion in assets, while regional banks have up to $15 billion in assets, while the multinationals are even larger. The table first illustrates the extreme skewness in the distribution of assets, with less than 300 banks owning over 60 percent of industry assets in December 1984. Our sub-population of community banks owns the rest, having a fairly significant 36.5 percent themselves, equally distributed across membership status. Also note that community banks are more numerous than other size classes, representing over 98 percent of all institutions. The large number of banks makes it easier to directly compare banks across membership status and the distribution of capital, the two main sources of variation exploited in this analysis.

Before turning to more rigorous analysis, it is worth taking a naive look at the data. The

change in aggregate primary capital ratios is decomposed across time and by initial leverage in Table 3.4. Panel A corresponds to the three years preceding the change in adequacy standards, December 1981-1984, while Panel B describes the three years following, December 1984-1987. The table examines how the behavior of banks that existed in the first year of each period contributed to the change in aggregate capital ratio. The first column reports simply the three year change in the primary capital ratio for surviving banks weighted by final period assets. Note that in both time periods there is a monotonic relationship between the change in capital ratio and each of bank size and initial leverage so that low capital banks tend to increase their capital ratios relative to high capital bank across the entire distribution of capital. Moreover, the increase in bank capital seems larger in the second period for all banks. The second column corresponds to the final year market share of surviving banks, and is used in creating the third column, the change in aggregate primary capital broken up by initial leverage and bank size.[19] The residual column is approximately the change in market share weighted by lagged leverage, and exists because the weighted change in primary capital is not the same as change in weighted primary capital. Low capital banks generally lose market share to higher capital banks. Large and low capital banks, those targeted by tougher standards, seem to be driving the increase in aggregate capital ratio. On the other hand, capital ratios seem to be increasing faster across the entire distribution of initial capital and bank size, and the change in adjustment for the least capitalized banks is about the same as the change in adjustment for the highest capitalized banks. [20] The

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[19] An important element in explaining these dynamics for small and high capital banks is that new banks begin with capital ratios of 100% which fall over time as the bank grows. While their market share is small, they are important in the overall picture due to the size of their change in capital ratios.

[20] For example, banks with nine percent or more primary capital ratios increased their average three-year change in capital by around 60 basis points, as much as the banks targeted by the new adequacy standards

main point taken away from this table is that it is certainly possible for an increase in capital adequacy standards to have no effect on banks but for the aggregate capital ratio to increase. Shocks that improve the capital ratios of all banks equally will tend to increase the aggregate capital ratio when the asset market share of low capital banks is relatively large.

In any panel study there is attrition, and Table 3.4 also illustrates that our sub-population of insured community commercial banks decreases over time as banks fail and merge out of the data set. I feel both merger and failure are outcomes, so eliminating banks requires conditioning on endogenous variables while the tradition of forcing banks which eventually merge to do so immediately is in appropriate and requires too much guesswork. [21] Consequently, I leave banks in the sample until they exit so that parameter estimates reported below are interpreted as the impact of tougher capital requirements on surviving banks, which seems to be the policy parameter of interest.

3.5   Tougher Leverage Standards in 1985

The analysis begins by setting up some notation needed to discuss the details of identification and to develop the empirical model. Using only data after the policy change, I implement standard empirical strategies to replicate results from the literature for large banks and demonstrate that estimates for small banks using these methods are similar. These results are falsified using data before the policy change, and a plausible correction for pre-existing

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in the 5-7 percent region.

[21] Tougher leverage standards might not only affect the level of capital, potentially affecting the probability of forced merger or failure for banks at the bottom of the distribution. The FDIC also often removes problem assets from a failed bank before recycling the other assets to a purchaser, so force-merging could create large jumps in the time series.

Table 3.4: Decomposing the Change in Aggregate Primary Capital Ratios

	$\Delta(C/A)_t$	Market Share	$\Delta^a(C/A)_t$	Residual	Total	Number	Pr(Failure)	Pr(Merger)
A. 1981-84								
0-5%	1.05	30.5	0.32	-0.17	0.15	163	6.1	5.5
5-6%	0.60	18.3	0.11	-0.04	0.07	451	4.7	9.5
6-7%	0.06	15.7	0.01	0.09	0.10	1376	1.2	8.0
7-8%	-0.07	13.2	-0.01	0.06	0.05	2919	1.0	6.1
8-9%	-0.42	9.1	-0.04	0.04	0.00	3298	0.7	5.6
9+%	-1.97	11.8	-0.24	0.19	-0.05	6361	0.6	5.6
< $0.1	-0.54	19.0	-0.10	0.11	0.01	12676	0.9	5.7
$0.1 - 1	-0.45	20.6	-0.09	0.12	0.03	1678	0.8	9.2
> $1+	0.60	59.0	0.35	-0.06	0.30	214	0.5	3.3
New	X	1.5	X	0.17	0.17	1109	X	X
	X	100.0	0.16	0.34	0.50	15677	0.9	5.6
B. 1984-87								
0-5%	1.87	5.0	0.09	-0.08	0.01	157	21.7	12.1
5-6%	1.14	33.5	0.38	-0.00	0.38	472	4.4	14.0
6-7%	0.62	26.1	0.16	0.03	0.19	1787	2.9	13.0
7-8%	0.13	14.7	0.02	-0.02	-0.01	2927	3.0	9.5
8-9%	-0.02	7.0	0.00	-0.02	-0.02	2832	2.5	6.6
9+%	-1.12	12.1	-0.13	0.13	0.00	6317	1.6	6.0
< $0.1	-0.46	15.5	-0.07	0.01	-0.06	12028	2.8	7.2
$0.1 - 1	0.26	19.8	0.05	-0.03	0.02	2184	1.5	12.5
> $1+	0.85	63.2	0.54	0.05	0.58	280	0.4	5.7
New	X	1.6	X	0.18	0.18	851	X	X
	X	100.0	0.52	0.21	0.73	15343	2.4	7.6

Table Notes: All numbers are reported in percentage terms, except for the number of banks. The three year change in aggregate primary capital ratio is decomposed by initial capital ratio and bank size in billions of dollars. The first column corresponds to the average change in the capital ratio at different points in the distribution of capital and size. The second column describes the market period market share of banks for each category of initial characteristics. The third column is the product of the first two, corresponding the contribution from each category to the change in aggregate primary capital. The fourth column is a residual, corresponding to changes in bank market share over time, while the fifth column represents the total change in aggregate capital generated for each group. The number of each banks initially in each category along with attrition through failure or merger is reported in the final three columns.

dynamics eliminates all measured impact of the tougher capital standards on bank behavior.

3.5.1 The Empirical Model

I am interested how changes in bank leverage requirements affect a sequence of bank-specific outcomes over time $\{Y_{it}\}$. In the analysis below these outcomes will alternatively include the capital ratio, the growth rates of capital, assets, and loans, and the level of both asset risk and the risk-based capital ratio. For simplicity, this analysis focuses on the primary capital ratio, as it presumably the driving force behind all other outcomes.

Let C_i be an indicator function for a particular bank having a one percentage point increase in capital requirements at time $t = 0$, where Y_{i0} is the bank's initial capital ratio. It is possible to describe the potential outcomes of each bank by defining $\{Y_{it}^N\}$ as the sequence of outcomes with no increase in leverage requirements $C_i = 0$ and defining $\{Y_{it}^C\}$ as the sequence of outcomes with a policy change $C_i = 1$. The observed sequence of bank outcomes is a simple linear function of these potential outcomes.

$$Y_{it} = Y_{it}^N + (Y_{it}^C - Y_{it}^N) * C_i \tag{3.1}$$

The object of interest is the causal effect on the sequence of average bank outcomes of a one-percentage point increase in leverage requirements given the initial capital ratio $Y_{i0} = k$. In terms of the notation developed above, this is simply a sequence of conditional expectations for $t = 1, 2, ..., T$, where T is the last period of interest.

$$\gamma_t^k = E[Y_{it}^C - Y_{it}^N | Y_{i0} = k, C_i = 1] \tag{3.2}$$

A complete model of bank behavior would likely suggest that a bank's target capital ratio is a markup μ over the minimum leverage requirement, where μ probably depends on the risk preferences of the bank's owners, the wedge between internal and external forms of financing, the regulatory costs of capital inadequacy, and perhaps the level of the requirement itself Y_{it}^{min}. [22]

$$Y_{it}^* = \mu(X_{i0}, Y_{it}^{min}) + Y_{it}^{min} \tag{3.3}$$

The empirical literature generally proceeds by introducing functional form restrictions in the form of an error-correction model, where the expected change in capital ratio depends on the distance between the target and actual capital ratios.

$$E[\Delta Y_{it} | Y_{i0}, Y_{it}^*] = \beta(Y_{it}^* - Y_{i0}) \tag{3.4}$$

Writing down this equation is implicitly a model of potential outcomes. In particular, the

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[22]Some of these basic conjectures readily appear in the data. For example, many small family-owned banks have capital ratios around 9 percent presumably because these firms do not have access external forms of finance while the largest banks tend to have the smallest markups over regulatory minimums. On the other hand, empirical evidence, discussed in Jackson et. al. (1999), suggests informal capital requirements may have had little impact on bank capital ratios, consistent with low regulatory costs.

implied sequence of capital ratios for banks with and without capital standards, respectively, is as follows,

$$Y_{it}^N = \beta[\mu(X_{i0}, Y_{i0}^{min}) + Y_{i0}^{min}] + (1 - \beta)Y_{i0} \tag{3.5}$$

$$Y_{it}^C = \beta[\mu(X_{i0}, Y_{i0}^{min} + 1\%) + Y_{i0}^{min} + 1\%] + (1 - \beta)Y_{i0} \tag{3.6}$$

The sequence of implied causal effects of tougher standards is simply a multiple of the change in target capital ratios ΔY_{it}^*.

$$\gamma_t^k = \beta[\mu(X_{i0}, Y_{i0}^{min} + 1\%) - \mu(X_{i0}, Y_{i0}^{min}) + 1\%] \tag{3.7}$$

As written, this model cannot be implemented in the data given that the target capital ratio Y_{it}^* is not observed. Researchers have typically overcome this problem by implicitly assuming that it is a linear function of observable variables.

$$E[\mu(X_{i0}, Y_{it}^{min})|Y_{i0}, X_{i0}] = \theta_1 Y_{i0} + \theta_2 X_{i0} + [\theta_3 Y_{i0} + \theta_4 X_{i0}]1_{C_i=1} + \sum_t \eta_t 1_t \tag{3.8}$$

The model permits the markup to depend on bank-specific covariates X_{i0}, initial leverage Y_{i0}, each of these variables interacted with a dummy for tougher standards, and aggregate economic conditions η_t. A crucial assumption for the implementation of existing strategies

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below, which compare the impact of tougher standards across the distribution of initial leverage, is that the markup of low capital banks responds more strongly to an increase in capital standards. [23] Without differential changes in the markup across initial leverage, it is impossible to identify how tougher leverage requirements that impact all banks affect behavior. [24]

In any case, it is not obvious why this is a reasonable assumption. The claim is essentially that following a policy change, the average target capital ratio of low capital banks increases more than for high capital banks. Changes in the distribution of target capital ratios of low capital $Y_{it}^*|Y_{i0} = k$ over time could easily be mistaken for a response to policy. For example, a bad shock to bank earnings (like the LDC debt crisis) reduces capital ratios, but plausibly increases the target capital ratios of low capital banks. One might expect following bad shocks for low capital banks to actually increase their capital ratios by more than during normal times as there is a change in the distribution of target capital ratios. When leverage requirements are enacted in response to bad shocks (as appeared to be the case with multi-national banks in the discussion above), exploiting differences in initial capital to identify the likely consequences of the policy change seems especially dubious. While the natural experiment analyzed below is immune this problem, for now I ignore it and proceed as in the literature.

Inserting the model of the markup in Equation (3.8) into Equation (3.4) and writing

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[23] In principle, any differential effect across bank characteristics X_{i0} would also identify the effect of the policy change. In practice, however, these policy changes generally affect all banks, so these variables are used to capture a change over time in the response of capital to bank characteristics unrelated to the policy change.

[24] Some researchers include measures of the change in asset risk and asset quality as determinants of the change in the capital ratio. These are treated as endogenous, instrumented for with lags of asset risk and quality. I exclude these variables from the equations estimated below, skeptical that the instruments are valid and that the variables even belong there in the first place.

$Y_{it}^{min} = Y_0^{min} + 1_{C_i=1}$ generates the empirical model.

$$E[\Delta Y_{it}|Y_{i0}, X_{i0}] = \beta[\theta_1 Y_{i0} + \theta_2 X_{i0} + (1 + \theta_3 Y_{i0} + \theta_4 X_{i0})1_{C_i=1} + \sum_t \eta_t 1_t + Y_0^{min} - Y_{i0}] \quad (3.9)$$

In the analysis below, I consider variations on a slightly more general model described in Equation (3.10), removing the linearity assumptions on normal adjustment and effect of policy across initial leverage ratios. [25]

$$E[\Delta Y_{it}|Y_{i0} = k, X_{i0}] = [\beta^k + \gamma^k 1_{C_i=1}] + \sum_t \eta_t 1_t + [\theta_2 + \theta_4 1_{C_i=1}]X_{i0} \quad (3.10)$$

The immediate problem for evaluating changes in capital requirements is that these policy changes generally affect all banks, so that the counterfactual sequence of outcomes in absence of the policy change is not observed for subset of banks. Comparing bank outcomes before and after the change in adequacy standards potentially confuses the effects of policy with other time-varying factors affecting bank behavior, making a convincing identification strategy elusive. Conventional strategies have attempted to circumvent this problem through the assumption that tougher standards should have differential affects across the distribution of initial leverage ratios, so that it is possible to infer an effect on relatively lower capital banks through a comparison with relatively higher capital banks.

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[25] The dummy for $1_{C_i=1}$ is subsumed in the time effects when all banks are affected by the policy change, while Y_0^{min} is a constant.

3.5.2 Conventional Analysis

This analysis focuses alternatively on the sub-population of non-member community and large banks, ignoring any differential changes in leverage requirements across membership status or size class, and only exploits cross-sectional differences in bank leverage after the policy change. Studies similar in methodology to this approach include Shrieves and Dahl (1992), Brinkman and Horowitz (1993), Haubrich and Wachtel (1992), and Jacques and Nigro (1995). [26]

Identification is achieved by first assuming that high capital banks are unaffected by the change in policy and well-represent the counterfactual outcomes of lower capital banks. In the notation, there exists some Y_{i0}^* such that

$$E[Y_{it}^C - Y_{it}^N | Y_{i0} > k^*, C_i = 1] = 0 \tag{3.11}$$

This assumes no precautionary behavior by high capital banks, but is really only halfway towards properly identifying the sequence of causal effects. To simplify matters, consider only two possible ranges for the initial distribution. Let $Y_{i0} = L$ correspond to banks with initial capital ratios that were made inadequate the change in policy while $Y_{i0} = H$ represents banks which had higher capital ratios, and thus were not directly forced to change their behavior. Identification is achieved through the restriction that high capital banks are unaffected by the policy change $E[Y_{it}^C | Y_{i0} = H] = E[Y_{it}^N | Y_{i0} = H]$, so that they can potentially serve as a

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[26]None of these studies actually assumes the absence of precautionary behavior by well-capitalized banks, which is done below. I find this approach much more transparent, but is at the end of the day not very different from previous methodology.

control group.

Given a group of banks unaffected by the policy change, it is necessary to develop a mapping of these outcomes to the counterfactual outcomes of those banks where the causal effect is nonzero, here the low capital banks. The empirical model constructed in Equation (3.10) above suggests the following,

$$E[\Delta Y_{it}|Y_{i0} = L] = E[\Delta Y_{it}|Y_{i0} = H] + \beta^L - \beta^H \qquad (3.12)$$

The adjustment in capital of low capital banks that would have occurred in absence of the policy change is simply the adjustment of high capital banks less the normal difference in adjustment of capital ratios between these banks. As all strategies examining tougher leverage standards only exploit data after the policy change, I initially ignore potential differences in dynamics across the initial capital ratio, requiring $\beta_L = \beta_H$. Imposing these restrictions on Equation (3.10) and inserting them into Equation (3.2) motivates the following estimator,

$$\hat{\gamma}_t^L(H, 1) = E[Y_{it}|Y_{i0} = L] - E[Y_{it}|Y_{i0} = H] - (L - H) \qquad (3.13)$$

The notation $\hat{\gamma}_t^L(H, 1)$ represents our estimate of the causal effect for non-member banks with initial primary capital $Y_{i0} = L$ using a control group with initial primary capital $Y_{i0} = H$

and treatment status $C_i = 1$. [27] Given the initial capital ratios, it is possible to interpret this estimator as a simple difference across the initial leverage ratio in the adjustment of capital since the change in regulation, motivating a differences-in-differences strategy implemented in Table (3.5) below.

$$\hat{\gamma_t^L}(H, 1) = E[\Delta Y_{it} | Y_{i0} = L] - E[\Delta Y_{it} | Y_{i0} = H] \tag{3.14}$$

The differences-in-differences estimates reported in Table 3.5 generally confirm well-known results. Panel A includes only non-member community banks while Panel B includes all banks with assets greater than \$100 million, consistent with the existing approach. The analysis is broken up into three points of the distribution for initial primary capital ratios, corresponding to L in the notation above. For each point in the distribution, I alternatively use two control groups: banks with 1-2% more initial primary capital ratios and banks with 8-9% primary capital. Each regression employs data from 1982-1987, except for the primary and risk capital ratios that use only 1984-1987. [28] The coefficients should be interpreted as the average effect of the policy on each outcome in the three years after the policy change, and are all in percentage terms.

The table indicates that tougher leverage standards affect both large and small banks across the entire distribution of initial capital. Overall, primary and risk-based capital ratios

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[27]Note in this section all banks are affected by the policy change so every possible control bank has $C_i = 1$. In the context of the natural experiment below, $C_i = 1$ for member community banks that were unaffected by any policy change.

[28]Note the relative trend before the policy change for capital ratios, suggesting the need for a model of outcomes with both a fixed effect and lagged dependent variable. Given this strategy eventually fails a falsification exercise, I only use the last pre-treatment year as a control year here as an approximation.

Table 3.5: Differences-in-Differences Across Initial Leverage Ratios

Initial Capital	5-6 Percent		6-7 Percent		7-8 Percent
Control Banks	6-7%	8-9%	7-8%	8-9%	8-9%
A. Community Non-member Banks					
Capital Ratio	0.13	0.87	0.45	0.58	0.11
	(0.19)	(0.09)	(0.11)	(0.12)	(0.06)
Asset Growth	-1.11	-2.91	-1.41	-1.81	-0.51
	(1.36)	(1.45)	(0.76)	(0.71)	(0.54)
Capital Growth	1.32	8.59	3.71	5.56	1.39
	(4.01)	(1.92)	(2.29)	(2.41)	(0.67)
Loan Growth	-1.37	-3.64	-1.62	-1.82	-0.51
	(1.66)	(1.87)	(1.02)	(1.03)	(0.77)
Asset Risk	-0.60	1.21	0.72	1.56	0.89
	(0.69)	(0.64)	(0.39)	(0.38)	(0.30)
Risk Capital Ratio	0.30	1.12	0.48	.056	0.04
	(0.22)	(0.16)	(0.14)	(0.15)	(0.09)
B. Large Banks					
Capital Ratio	0.22	0.96	0.35	0.47	0.18
	(0.11)	(0.09)	(0.09)	(0.10)	(0.09)
Asset Growth	0.25	-1.86	-2.74	-0.31	2.42
	(0.99)	(1.23)	(1.10)	(1.14)	(1.61)
Capital Growth	1.16	1.70	0.39	0.59	0.75
	(1.64)	(1.90)	(1.09)	(1.55)	(1.09)
Loan Growth	0.32	-4.10	-3.79	-3.96	-0.52
	(1.79)	(1.56)	(0.89)	(1.28)	(1.28)
Asset Risk	10.22	6.22	3.14	1.59	-1.29
	(2.88)	(1.36)	(1.91)	(1.14)	(1.22)
Risk Capital	-0.01	1.14	0.36	0.62	0.32
	(0.14)	(0.14)	(0.14)	(0.15)	(0.19)

Table Notes: Standard errors are corrected for heteroskedasticity and are clustered at the bank level. Each of the 60 regressions is weighted by bank assets, and the table reports the interaction of low capital in 1984 with a dummy for year after 1984 in percentage point terms. The first regression includes only community non-member banks with between 5-7% primary capital in 1984, and concludes that banks with between 5-6% capital increased their capital ratios by 0.13 more than banks with initially between 6-7% capital.

as well as primary capital growth and asset risk increase while asset and loan growth are generally slower. High capital banks seem to rely more on lower asset growth while low capital banks seem to increase primary capital growth. A warning flag is raised, however, as the estimated effect of the policy change is significantly different across differently leveraged control groups. These differences indicate that something may be wrong with our exclusion restrictions.

Recall that identification required both similar adjustment across initial leverage ratios and no precautionary behavior in the control group. After a little algebra, the difference between the parameter of interest and our estimator using banks with x more primary capital as a control group reduces to the following,

$$\hat{\gamma}_t^L(L+x, 1) = \gamma_t^L + \beta^L - \beta^{L+x} - \gamma_t^{L+x} \tag{3.15}$$

It is plausible that banks closer to the old leverage standard are affected more by the tougher standards so $\hat{\gamma}_t^{L+x} > \hat{\gamma}_t^{L+x+z}$ for $z > 0$. In addition, low capital banks may adjust faster relative to banks further away from their initial capital ratio, implying $\beta^L - \beta^{L+x} > \beta^L - \beta^{L+x+z}$ for $z > 0$. In either scenario, the estimated effects of tougher standards increase as the initial capital ratio of the control group also increases. As the absence of precautionary behavior by high capital banks is the key to identification, there is little to be said about evidence on this possibility until I analyze differential changes in leverage standards. On the other hand, mean-reversion between low and high capital banks is easily detected through a falsification exercise.

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Table 3.6: Falsification Exercises for the Primary Capital Ratio

Policy Change	1982:4			1984:4		
Model	(1)	(2)	(3)	(1)	(2)	(3)
A. Community Banks						
5-6%	0.41	0.37	0.36	0.26	0.33	0.34
	(0.11)	(0.11)	(0.11)	(0.09)	(0.10)	(0.11)
6-7%	0.21	0.25	0.26	0.23	0.29	0.29
	(0.07)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
7-8%	-0.07	0.07	0.10	0.03	0.16	0.16
	(0.12)	(0.07)	(0.06)	(0.05)	(0.04)	(0.04)
B. Large Banks						
5-6%	0.18	0.13	0.12	-0.02	0.05	0.05
	(0.06)	(0.12)	(0.12)	(0.10)	(0.09)	(0.09)
6-7%	0.12	0.15	0.15	0.21	0.29	0.30
	(0.05)	(0.05)	(0.05)	(0.08)	(0.09)	(0.09)
7-8%	-0.12	-0.02	-0.01	0.07	0.17	0.17
	(0.14)	(0.06)	(0.06)	(0.10)	(0.11)	(0.12)

Table Notes: Standard errors are corrected for heteroskedasticity and are clustered at the bank level. The first column is simple differences-in-differences in the level of capital with standard covariates, while the second model estimates differences in the change in capital in an attempt to reduce any bias from attrition. The third model additionally conditions on the change in the capital ratio in the year before the policy change.

A simple check on this possibility is to pretend the increase in leverage requirements happened earlier, implemented in Table 3.6. Focusing on the capital ratio, I compare the one-year effect of a false policy change in December 1982 with the one-year effect of the real policy change. The first specification is differences-in-differences in the level of the capital ratio while the second model simply compares differences across initial leverage in the one-year change in capital ratio to in an attempt to reduce any bias from the attrition of low capital banks from the sample. Except for the top of the distribution, it appears that low capital banks usually increase their capital ratios relative to banks with initially more primary capital. The third model for each policy change conditions on the previous change in primary capital ratio in an attempt to compare banks with similar shocks to capital. A difference across policy changes for a particular model could be interpreted as the causal effect of the policy change under the assumption that the adjustment of low capital non-member relative to high capital member banks is fixed over time. I hesitate to do this here as the choice of 1982 is arbitrary as a false policy change, but this idea generally motivates a fix for the conventional strategy.

I remain agnostic as to the probable driving forces behind this mean-reversion. It is certainly possible that low capital banks are increasing their capital ratios in an attempt to avoid any regulatory costs associated with violating existing leverage requirements. This view would indicate that while changes in capital requirements may not have large effects due to pre-existing mean reversion, capital adequacy standards as a whole may be very effective by creating those dynamics in the first place. While a plausible story, it is important to note there are other factors to keep in mind. In particular, if banks are seeking to avoid bankruptcy costs or the event of failure, they will choose finite levels of leverage and will

likely reverse bad shocks that create departures from the target capital ratio.

3.5.3 Accounting for Pre-Existing Dynamics

The above strategy has failed a falsification exercise, succumbing to robust mean-reverting dynamics between banks with different initial capital ratios. Under the assumption that the relative dynamics between low and high capital banks are fixed in absence of the policy change, easily identified from the relative dynamics between these two groups before 1985, it is possible to repair the above estimates and recover the parameter of interest. In the context of the notation above, the exclusion restriction on precautionary behavior is maintained, but now assume $\beta^L - \beta^H$ is fixed for a given difference in initial capital ratios and time t years since the false policy change. In other words, the estimates suggest that banks with initially 6-7% primary capital increase their capital ratios by 20 basis points over the first year relative to banks with 7-8% primary capital. Proper identification requires this number is approximately constant over time.

Figure 6a: Change in Primary Capital for Small Banks
Uniform Capital Standards

Percentage Points of Primary Capital

5-6 % Capital

6-7 % Capital

7-8 % Capital

8-9 % Capital

1.0
0.75
0.5
0.25
0.00
-0.25

82   84   86   88
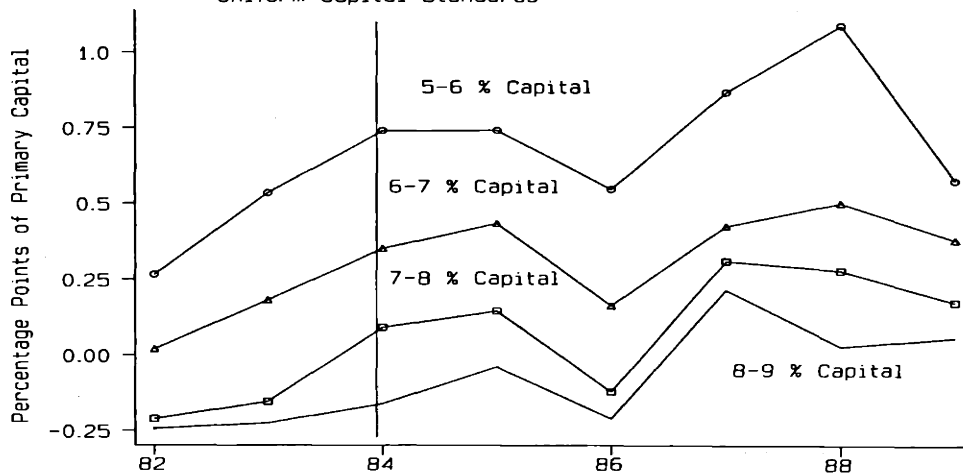
Figure 6b: Change in Primary Capital Ratio for Large Banks
Uniform Capital Standards

Percentage Points of Primary Capital

5-6 % Capital

6-7 % Capital

7-8 % Capital

8-9 % Capital

0.8
0.4
0.0
-0.4

82   84   86   88
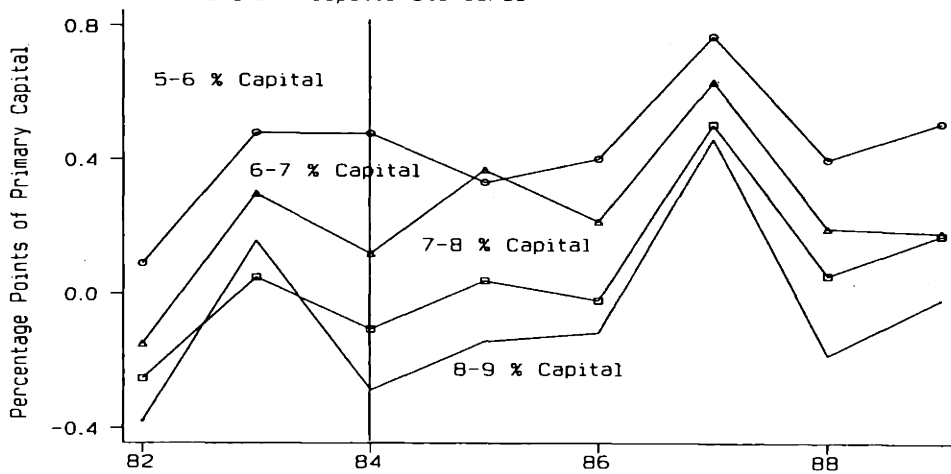
A graphical description of this strategy is illustrated in Figure 6 for both non-member

community banks in Panel A and large banks in Panel B across the distribution of initial

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capital. I select a panel of insured commercial banks which in a given year either non-member community banks or have at least $100 million in assets. Given the previous year's capital ratio, I regress the annual change in primary capital ratio on dummies for initial capital ratio interacted with time and an exhaustive list of covariates. Recall these controls include Census sub-region and sub-region by year dummies as well as one-year lags of balance sheet and condition measures. Several points jump out of the picture. All of the series appear to move together, implying that high capital banks may have some value as a control group. Banks with lower capital always seem to increase their capital ratios more than banks with relatively higher capital, consistent with a concern about mean reversion. The fixed effects assumption requires that the distance between the target group and control group is approximately constant before the policy change. This claim does not appear unreasonable. Finally, there does not seem to be a widening in the adjustment of low versus high capital banks after 1984, indicating the policy may not have done much to affect bank capital.

Invert equation (3.12) to solve for the usual mean-reversion of community non-member banks identified from a false policy change occurring T periods before the actual increase in leverage standards.

$$\beta^L - \beta^{L+x} = E[\Delta Y_{i(t-T)}^N | Y_{i0} = L] - E[\Delta Y_{i(t-T)}^N | Y_{i0} = L + x] \qquad (3.16)$$

Combine the above model for mean-reversion of high versus low capital banks t periods after the false policy change with our model of potential outcomes in equation (3.12) to construct a triple differences-in-differences estimator. The parameter of interest is identified

Table 3.7: Triple Differences Across Initial Leverage

Initial Capital	5-6%		6-7%		7-8%
Control Banks	6-7%	8-9%	7-8%	8-9%	8-9%
A. Small Banks					
LowCapital	0.36	0.57	0.27	0.38	0.08
	(0.05)	(0.15)	(0.03)	(0.07)	(0.05)
Low * 1(t > 84 : 4)	-0.07	0.04	-0.04	-0.03	0.03
	(0.09)	(0.14)	(0.04)	(0.07)	(0.06)
B. Large Banks					
LowCapital	0.24	0.50	0.21	0.26	0.09
	(0.05)	(0.13)	(0.04)	(0.07)	(0.06)
Low * 1(t > 84 : 4)	-0.15	-0.02	0.01	0.03	0.02
	(0.07)	(0.12)	(0.05)	(0.08)	(0.07)

Table Notes: Standard errors are corrected for heteroskedasticity and are clustered at the bank level. Each of the 10 regressions is weighted by banks assets and employs data 1982-1987.

by comparing the change in capital (1st difference) of low versus high capital banks (2nd difference) before versus after the policy change (3rd difference).

$$\hat{\gamma}_t^L(L + x, 1) = E[\Delta Y_{it} | Y_{i0} = L] - E[\Delta Y_{it} | Y_{i0} = L + x] -$$

$$E[\Delta Y_{i(t-T)} | Y_{i0} = L] + E[\Delta Y_{i(t-T)} | Y_{i0} = L + x] \quad (3.17)$$

I again focus on the one-year adjustment parameter, using the three changes in the primary capital ratio 1981-1984 to identify typical mean-reversion. For each of the three points in the annual distribution of primary capital, I regress the change in primary capital on a dummy for low capital interacted with time dummies and the covariates employed in constructing Figure 6. Several important points emerge from the results displayed in Table 3.7. The low capital main effects are almost always positive and significant, and represent the estimate of usual adjustment of low capital relative to the higher capital control group.

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The higher capital control group is typically associated with a stronger estimate of mean-reversion, confirming what appears in Figure 6. Moreover, after controlling for these pre-existing dynamics, the estimated causal effect of the policy change on adjustment is zero regardless of control group leverage. The only exception is a negative and significant effect on large banks with initially low capital. Confidence intervals never reach more than 20 % of the pre-existing adjustment and always include zero.

A potential problem explaining the estimated zero effect is that the exclusion restriction on the causal effect for high capital banks could be false, the consequences of which are straightforward to demonstrate. Assume that the causal effect is nonzero. A little algebraic manipulation indicates that if this is the correct model, the estimation strategy will actually recover the following.

$$\hat{\gamma}_t(L + x, 1) = \gamma_t^L - \gamma_t^{L+x} \qquad (3.18)$$

The one bit of evidence on this point in the non-experimental framework is to compare the estimates of the causal effect across differently leveraged control groups. Under the assumption that banks with higher capital are less affected by the policy change, employing a higher capital control group should increase the estimated effect of the policy change. While the estimates from Table 3.7 seem to increase a little when using the 8-9% capital control group, the differences are not statistically significant.

Overall, the conclusion in the non-experimental framework is that tougher leverage standards do not seem to matter, with the crucial element missing in previous work being a

proper accounting for mean-reversion. Understand that the result is not that capital adequacy standards are unimportant, just that tougher standards have little if any affect on bank behavior.

3.6 Differential Changes in Leverage Requirements in 1985 for Community Banks

It is this second change in capital requirements that appears to be a unique opportunity to investigate the effect of an increase in capital requirements on non-member community banks, using member banks as a control group. [29] Previous studies have ignored these differential changes in minimum leverage requirements across the regulators by focusing exclusively on the increase in capital requirements for larger banks. The premise of this paper is that these differential changes in standards present an opportunity to better understand the impact of increasing bank capital on bank lending and risk-taking behavior. Exactly how these differential changes actually translate into an empirical strategy is described below.

What is important to take from the above discussion is that the differential increase in leverage requirements was in some sense exogenous. In particular, the validity of the analysis below rests on the claim that there were no other factors that led non-member banks to increase their target capital ratios relative to member banks around December 1985. The first step in thinking about the plausibility of this claim is to be sure that the

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[29]This increase in adequacy standards at first glance is very interesting because the FDIC also relaxed its stance on subordinated debt, which might have been an opportunity to collect evidence on the current proposal for minimum subordinated debt requirements. Unfortunately, these banks do not have significant amounts of debt, and there is little change over time. Even for the larger non-member banks, the ratio of subordinated debt to assets does not change much relative to member banks after 1985.

policy change itself was not designed as a reaction to other factors that would have changed target capital ratios differently by membership status. The above discussion should make it clear that the reason for differential changes leverage requirements by size before 1985 had more to do with the slow convergence in principled differences by the regulators than other factors affecting community banks differentially by membership size.

One immediate objection to membership status as a source of plausibly exogenous variation is that membership in the Federal Reserve is in part chosen by the bank. Since late 1981 member banks had minimum leverage requirements of 7 percent while non-member banks had requirements of 6 percent. If a significant number of member banks left the Federal Reserve System in pursuit of lower capital requirements, or policy evaluation could be contaminated. While this scenario seems unlikely, as the historical determinant of membership has been bank size, the proof is in the data. Looking at the sub-population of insured commercial community banks, 44 joined the system while 7 member banks left in 1983. In the following year 41 banks joined while 20 banks left. The median primary capital ratio of banks renouncing membership was 8.68 percent, far above the 7 percent minimum, and these banks increased their median primary capital ratios after leaving the system. This appears to be suggestive evidence that banks did not seem to choose minimum leverage requirements via membership.

Descriptive characteristics of community banks by primary capital ratio and membership status are reported in Table 3.8. It should be clear that there are some important differences between banks with different levels of capital. Low capital banks have a much higher ratio of loans to assets and have a much smaller fraction of agriculture loans. They are also much less profitable, grow much more quickly, and much larger than banks with high capital levels.

Table 3.8: Background Characteristics of Community Banks, December 1984

Primary Capital	Non-member Banks						Member Banks					
	5-6 percent		6-7 percent		7-8 percent		5-6 percent		6-7 percent		7-8 percent	
Cash	10.01	(6.17)	9.66	(6.51)	9.21	(5.61)	13.25	(7.54)	11.32	(7.61)	10.22	(6.04)
Securities	18.12	(9.49)	22.67	(10.79)	24.79	(10.99)	17.48	(10.07)	19.44	(9.44)	24.41	(10.81)
Federal Funds Sold	5.40	(6.63)	5.03	(5.88)	4.58	(5.09)	7.21	(6.73)	6.66	(7.90)	5.49	(6.02)
Total Loans	63.90	(12.06)	59.68	(11.81)	58.44	(11.37)	58.99	(13.51)	60.00	(12.86)	57.24	(10.94)
Equity Ratio	4.98	(0.50)	5.89	(0.41)	6.85	(0.45)	4.91	(0.48)	5.87	(0.50)	6.82	(0.44)
Subordinated Debt	0.34	(0.53)	0.25	(0.42)	0.15	(0.43)	0.42	(0.54)	0.30	(0.51)	0.13	(0.29)
Minority Interest	0.00	(0.01)	0.00	(0.03)	0.00	(0.01)	0.00	(0.01)	0.00	(0.00)	0.00	(0.01)
Agriculture Loans	2.06	(7.42)	2.09	(6.86)	5.31	(11.29)	1.37	(4.49)	2.45	(6.12)	4.56	(9.09)
Real Estate Loans	39.15	(14.63)	38.38	(13.58)	37.51	(14.29)	33.10	(14.80)	34.66	(13.24)	35.80	(13.46)
C & I Loans	28.79	(13.31)	29.57	(13.22)	29.78	(15.08)	32.89	(15.41)	33.07	(13.97)	29.00	(13.45)
Loan Quality	1.67	(2.23)	1.68	(1.89)	1.77	(1.83)	1.64	(2.03)	1.74	(1.83)	1.78	(2.12)
Loan Income	11.73	(1.33)	11.85	(1.17)	12.08	(1.22)	11.58	(1.30)	11.55	(1.27)	11.76	(1.10)
Asset Risk	75.05	(8.86)	72.16	(8.95)	71.24	(8.62)	71.67	(9.98)	72.15	(9.45)	70.04	(8.12)
Return on Assets	0.33	(1.18)	0.69	(0.79)	0.77	(0.69)	0.49	(1.00)	0.65	(0.80)	0.79	(0.70)
Δ Primary Capital	-0.38	(0.86)	-0.10	(0.81)	-0.08	(0.90)	-0.42	(1.12)	-0.12	(0.86)	-0.03	(0.79)
Assets	350	(291)	314	(274)	188	(201)	427	(303)	361	(272)	280	(265)
Asset Growth	15.56	(14.32)	11.72	(11.40)	9.86	(9.79)	15.93	(15.13)	16.67	(11.18)	8.55	(9.27)
Capital Growth	10.00	(15.34)	11.55	(13.69)	10.32	(23.10)	11.21	(14.21)	9.96	(12.12)	8.94	(10.91)
Loan Growth	26.11	(21.55)	21.76	(17.10)	17.53	(15.40)	25.41	(19.60)	20.38	(18.09)	18.35	(15.41)
Number	210		884		1684		167		754		1155	
Market Share	2.66		10.34		12.33		3.10		12.58		12.96	

Table Notes: Standard deviations are reported in parenthesis. All balance sheet items are measured in percentage terms relative to assets while components of the loan portfolio, loan yield, and loan quality are measured relative to total loans. Asset risk is simply a measure of risk-weighted assets (including selected off-balance sheet assets) to total assets. The change in primary capital is in percentage terms for the previous year. Assets are reported in millions, and the market share is relative to the assets of all commercial banks.

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Also notable is the trend in the primary capital ratio one year before the change in regulation, with low capital banks losing over 30 basis points while high capital banks hardly changing at all. While there are large discrepancies across membership status unconditionally, the conditioning on the initial capital ratio appears to make member banks reasonably similar to non-member banks in most dimensions of interest.

The change in aggregate community bank primary capital ratios is decomposed across time and by initial leverage in Table 3.9. The first column reports simply the three year change in the primary capital ratio for surviving banks weighted by final period assets, and is the object of interest in most of the analysis below. Of interest is the variation across initial leverage as low capital banks always increase their capital ratios more than high capital banks and across time periods as all banks seem to increase their capital ratios more in the second time period. The second column corresponds to the final year market share of surviving banks, and is used in creating the third column, the change in aggregate primary capital broken up by initial leverage. Note that high capital banks are generally decreasing their capital ratios, and the behavior of these high capital banks is more important in explaining the aggregate change given the distribution of market share. The residual column is approximately the change in market share, and exists because the weighted change in primary capital is not the same as change in weighted primary capital. [30] Low capital banks generally lose market share while high capital banks gain it. The next column is simply the sum of the previous two. A naive comparison across time periods indicates that the aggregate capital ratio increased approximately 25 basis points after the policy change.

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[30]This is distinct from the change in assets, which would be reflected in the leverage ratio. The residual reflects relative asset growth.

Table 3.9: Decomposing the Change in Aggregate Community Bank Primary Capital Ratios

	$\Delta(C/A)_t$	Market Share	$\Delta^a(C/A)_t$	Residual	Total	Number	Pr(Failure)	Pr(Merger)
A. 1981-84								
0-5%	1.52	1.5	0.02	-0.02	0.00	125	7.2	4.8
5-6%	0.96	6.2	0.06	-0.08	-0.02	383	2.6	7.0
6-7%	0.29	17.0	0.05	-0.15	-0.10	1310	0.6	5.8
7-8%	-0.13	27.1	-0.03	-0.04	-0.07	2897	0.4	3.8
8-9%	-0.36	21.0	-0.08	0.05	-0.03	3288	0.3	3.2
9+%	-1.91	27.0	-0.52	0.41	-0.11	6353	0.2	3.6
New	X	3.0	X	0.38	0.38	1105	X	X
	X	100.0	-0.49	0.54	0.05	15461	0.4	3.6
B. 1984-87								
0-5%	3.51	0.9	0.03	-0.02	0.01	255	23.6	11.8
5-6%	1.11	5.8	0.06	-0.08	-0.02	389	5.4	15.9
6-7%	0.64	22.4	0.14	-0.19	-0.05	1674	3.1	13.4
7-8%	0.21	24.4	0.05	-0.12	-0.07	2880	3.1	9.6
8-9%	-0.02	18.0	0.00	-0.01	-0.01	2825	2.5	6.7
9+%	-1.19	28.5	-0.34	0.37	0.03	6303	1.7	6.0
New	X	3.2	X	0.24	0.42	843	X	X
	X	100.0	-0.05	0.36	0.31	15058	2.5	7.6

Table Notes: All numbers are reported in percentage terms, except for the number of banks. The three year change in aggregate primary capital ratio is decomposed by initial capital. The first column corresponds to the average change in the capital ratio at different points in the distribution of capital and size. The second column describes the market final period market share of banks for each category of initial characteristics. The third column is the product of the first two, corresponding the contribution from each category to the change in aggregate primary capital. The fourth column is a residual, corresponding to changes in bank market share over time, while the fifth column represents the total change in aggregate capital generated for each group. The number of each banks in each category along with attrition through failure or merger is reported in the final three columns.

3.6.1 Identification with the Natural Experiment

Return to the error-correction model from Equation (3.4). Crucial to the analysis is the ability to condition on a bank's target capital ratio. While unobserved, it is plausible that there are at most fixed differences in the target capital ratios across membership status for banks with similar leverage, perhaps after conditioning on variables X_{i0}.

$$E[Y_{it}^*|Y_{i0}, C_i, X_{i0}] = \sum_k (\alpha^k + \gamma^k 1_{t \geq 0}) C_i 1_{Y_{i0}=k} + \sum_t 1_t \eta_t + \theta X_{i0} \qquad (3.19)$$

As non-member banks initially had easier leverage standards, the differential adjustment across membership status given initial leverage is captured by α^k. The effect of tougher standards for non-member banks at different points in the initial distribution of leverage is represented by the parameters γ^k. The model also permits time effects η_t and conditioning variables X_{i0}. Inserting this restriction into Equation (3.4), and relaxing the linearity assumption on adjustment given initial leverage motivates the empirical model considered in the analysis of differential changes in leverage standards.

$$E[\Delta Y_{it}|Y_{i0}, X_{i0}, C_i] = \sum_k [\beta^k + (\alpha^k + \gamma^k 1_{t \geq 0}) C_i] 1_{Y_{i0}=k} + \sum_t \eta_t 1_t + \theta X_{i0} \qquad (3.20)$$

For simplicity, the unit interval over which the capital ratio is defined has been discretized. The average adjustment of member banks given initial leverage $Y_{i0} = k$ is represented by β^k.

Identification is achieved here by the assumption that membership status in 1984, equiv-

alent here to $(1 - C_i)$, is independent of potential outcomes Y_{it}^N and Y_{it}^C given the initial capital ratio Y_{i0} and perhaps other variables X_{i0}. In other words, I am assuming that the only reason why non-member bank capital ratios change relative to member banks after 1984 is due to tougher leverage requirements for non-member banks. Given that member banks were unaffected by the policy change, it is necessary to develop a mapping of these banks' behavior to the counterfactual outcomes of non-member banks. This is done using our empirical model described in Equation (3.20) above.

If leverage requirements create regulatory costs that affect bank behavior, it seems plausible that banks with the same primary capital ratio may respond differently to the initial differences in these requirements across membership status. This suggests the following mapping of potential outcomes from member banks to non-member banks with similar capital,

$$E[Y_{it}^N|Y_{i0} = k, C_i = 1] = E[Y_{it}^N|Y_{i0} = k, C_i = 0] + \alpha^k \qquad (3.21)$$

This strategy permits different dynamics across membership status for banks with similar capital ratios, but uses the absence of changes in regulation for member banks to claim that these differential dynamics would be fixed in absence of the policy change. Identification in this framework relies on the presumption that the only thing changing the willingness and ability of non-member banks to adjust their capital ratios relative to member banks is the increase in capital adequacy standards for non-member banks. The potential weakness of this strategy is that other changes in policy across membership status that would potentially be confounded with the change in capital standards.

Consider an estimator that uses member banks with initially similar primary capital as a control group. Simple differences-in-differences for the level of primary capital across membership status for banks with initially similar capital ratios will be biased unless $\alpha^k = 0$,
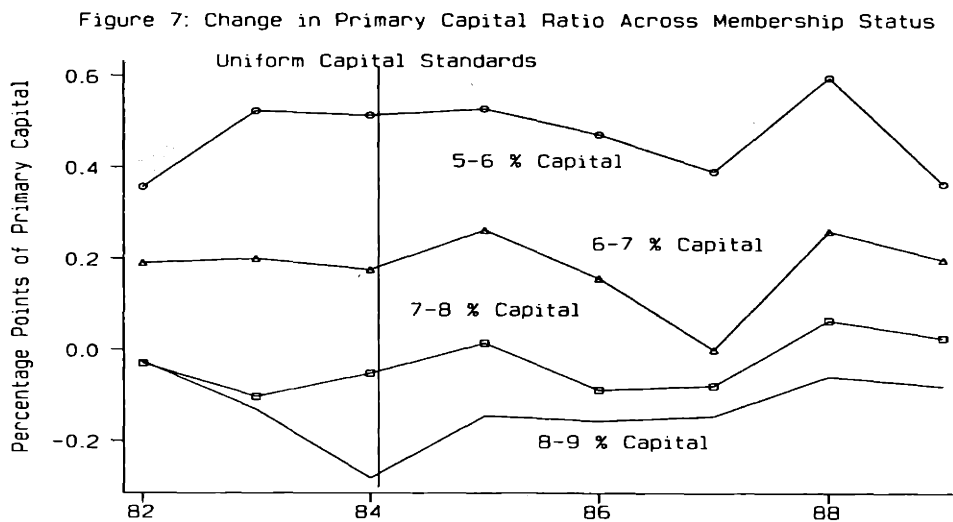
$$\hat{\gamma}_t^k(k,0) = \gamma_t^k - \alpha^k \qquad (3.22)$$

Given the absence of any change in leverage standards for member community banks, it is plausible that in absence of the change for non-member banks the relative adjustment of banks with initially similar capital ratios would have been fixed, which is what I assume below. The crucial point for identification is that in absence of the policy change the adjustment dynamics across membership status after 1984 would look similar to these dynamics before the policy change. These dynamics are estimated by inverting equation (3.21) for α_{kt},

$$\alpha^k = E[\Delta Y_{i(t-T)}^N | Y_{i0} = k, C_i = 1] - E[\Delta Y_{i(t-T)}^N | Y_{i0} = k, C_i = 0] \qquad (3.23)$$

The parameter of interest is finally identified by comparing the change in capital (1st difference) of low versus high capital banks (2nd difference) before versus after the policy change (3rd difference).

$$\hat{\gamma}_t^k(k,0) = E[\Delta Y_{it}|Y_{i0} = k, C_i = 0] - E[\Delta Y_{it}|Y_{i0} = k, C_i = 1] -$$

$$E[\Delta Y_{i(t-T)}|Y_{i0} = k, C_i = 0] + E[\Delta Y_{i(t-T)}|Y_{i0} = k, C_i = 1] \quad (3.24)$$

Figure 7: Change in Primary Capital Ratio Across Membership Status

A graphical description of this strategy is illustrated in Figure 7 across the distribution of initial capital. I select a panel of insured commercial non-member community banks, and break the panel up into four sub-samples, selecting banks depending on the previous year's capital ratio. For each sub-sample, I regress the annual change in primary capital ratio on dummies for FDIC-regulated interacted with time and an exhaustive list of covariates. The graph plots the interaction coefficients from each of the four regressions. Several points jump out of the picture. For non-member banks with 5-8% capital, a fixed effect model with member banks appears appropriate, implying that high capital banks may have some

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Table 3.10: Triple Differences Across Membership Status

Initial Capital	5-6 Percent		6-7 Percent		7-8 Percent	
A. Fixed Difference Model						
$FDIC$	0.11	0.11	0.06	0.06	-0.02	-0.02
	(0.07)	(0.07)	(0.03)	(0.03)	(0.02)	(0.02)
$FDIC*1(t>84)$	0.03		-0.05		0.03	
	(0.13)		(0.05)		(0.04)	
$FDIC*1(t=85)$		0.09		0.00		0.13
		(0.15)		(0.07)		(0.05)
$FDIC*1(t=85)$		-0.12		-0.01		-0.04
		(0.26)		(0.00)		(0.06)
$FDIC*1(t=85)$		0.08		-0.14		0.02
		(0.15)		(0.09)		(0.05)
B. Lagged Dependent Variable Model						
$FDIC$	0.09		-0.02		-0.01	
	(0.09)		(0.04)		(0.03)	

Table Notes: Standard errors are corrected for heteroskedasticity and are clustered at the bank level. Each of the 9 regressions is weighted by banks assets, and the table reports the interaction of FDIC-regulated in 1984 with a dummy for year after 1984.

value as a control group. Troubling is that non-member banks always seem to increase their capital ratios more after one-year than member banks with initially similar capital, inconsistent with these banks having easier adequacy standards before 1985. It is possible that given adequacy standards, the FDIC was a tougher regulator than either the OCC or Board before the policy change. Given that the FDIC is the insurer of commercial banks this is certainly plausible, but more evidence on this point is discussed below.

I again focus on the one-year adjustment parameter, using the three changes in the primary capital ratio 1981-1984 to identify the usual dynamics across membership status for similarly leveraged banks. For each of the three points in the annual distribution of primary capital, I regress the change in primary capital on a dummy for FDIC-regulated interacted with time dummies and the covariates employed in constructing Figure 7. Several

important points emerge from the results displayed in Table 3.10. The FDIC main effect is positive at the low end of the distribution, confirming the visual point that despite tougher standards before 1985, member banks did not increase their capital ratio as much as non-member banks. Moreover, after controlling for these pre-existing dynamics, the estimated causal effect of the policy change on adjustment is zero across the distribution of initial capital. To check for temporary effects, I break out the effect by post year. Standard errors increase, but except in 1985 for very high capital banks, there is no evidence of significant temporary effects. Instead of a fixed effect across membership status, an alternative model of outcomes is reported in Panel B. Here I regress the change in capital ratio for 1985-1987 of the same interaction effects and covariates, but also condition on each of the three changes in the capital ratio for each bank 1981-1985. While this model is inappropriate if there really are fixed differences in the dynamics across membership status, the results to not change significantly. [31]

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[31] Another successful robustness test completed but not reported is triple differences across membership status for the five other outcomes in Table (3.5) above.

Figure 8: Mean Examination Interval by Regulator
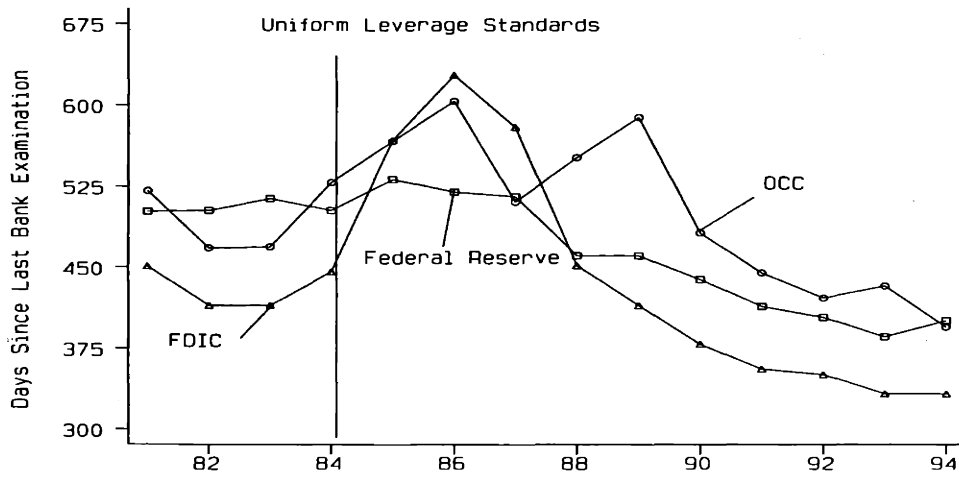
3.6.2 Robustness: Checking for Differential Trends in Regulator Resources

While the estimates in Table 3.10 are consistent with the non-experimental estimates above, as a validation exercise I exploit the existence of two control groups in an attempt to evaluate whether or not differential trends in other forms of regulatory pressure are important. In particular, these regulators had quite different histories during the 1980s as Reagan instituted a hiring freeze at the federal banking agencies, reducing resources available to the FDIC and OCC. The independence of the Federal Reserve, however, protected the Board from reducing its number of bank examiners. These policies led to significant relative changes in mean examination frequency across the agencies at the time of the policy change, as illustrated in Figure 8. While all of the banking agencies began stretching out examination

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frequencies greater than once a year in the early eighties, the Board changed much less than the other agencies and reverted to annual examinations in 1985. In 1986 there were almost 2000 commercial banks that the FDIC had not examined in the past three years.

In order to investigate these concerns, I break up the estimates of the policy change by control group, reporting results in Table 3.11. The concern here is that my analysis potentially confounds to policy changes, an increase in leverage requirements for non-member banks and a reduction in the resources available to the FDIC. These may offset each other and explain the estimated zero. The OCC had a similar reduction in its workforce relative to the FDIC while the Board actually increased its examination efforts. Consequently, the estimated effect of the policy should be larger using the OCC as a control group than the Board if these changes in regulator resources affect bank behavior. The results in Table 3.11 reject this argument for banks near the top of the distribution, and while the ordering of the estimates is consistent with this argument for banks with 5-6% primary capital, the differences are not significant. The large effect (16 basis points) for high capital banks relative to Board banks is curious, but not corroborated by other evidence in this paper. Overall, I conclude cautiously that tougher leverage requirements had little effect on bank behavior in 1985.

3.6.3 Robustness: Differences in Attrition Across the Regulators

One explanation for the absence of estimated effects across membership status or across different control groups with quite different histories in the eighties is perhaps that tougher standards affect attrition and have little impact on capital ratios. This possibility is examined

Table 3.11: Triple Differences Across Membership Status by Regulator

Initial Capital	5-6 Percent		6-7 Percent		7-8 Percent	
Regulator Control	FRB	OCC	FRB	OCC	FRB	OCC
A. Fixed Difference Model						
FDIC	0.07	0.04	0.04	0.07	-0.02	-0.02
	(0.12)	(0.07)	(0.04)	(0.04)	(0.03)	(0.03)
$FDIC * 1(t > 84 : 4)$	-0.10	0.01	-0.02	-0.06	0.16	0.00
	(0.23)	(0.13)	(0.07)	(0.06)	(0.06)	(0.04)
B. Lagged Dependent Variable Model						
FDIC	-0.12	0.10	-0.03	-0.02	0.07	-0.02
	(0.19)	(0.10)	(0.06)	(0.04)	(0.05)	(0.03)

Table Notes: Standard errors are corrected for heteroskedasticity and are clustered at the bank level. Each of the 18 regressions is weighted by banks assets, and the table reports the interaction of FDIC-regulated in 1984 with a dummy for year after 1984.

Table 3.12: Attrition from the Sample as an Outcome

Outcome	Failure			Merger		
Initial Capital	5-6 %	6-7 %	7-8 %	5-6 %	6-7 %	7-8 %
Dependent Mean	3.37	1.02	0.70	7.64	5.07	2.80
FDIC	1.17	0.13	0.01	2.80	0.60	-0.68
	(0.67)	(0.14)	(0.13)	(1.56)	(0.89)	(0.64)
$FDIC * 1(t > 84)$	-1.12	0.08	0.13	-3.11	-0.91	-0.24
	(0.93)	(0.19)	(0.19)	(2.81)	(1.26)	(0.91)

Table Notes: Coefficients are in percentage terms and standard errors are corrected for heteroskedasticity and are clustered at the bank level. Each of the 6 regressions is weighted by banks assets, and the table reports both a main effect for FDIC-regulated and its interaction with a dummy for year after 1984.

in Table (3.12) through regression-adjusted differences-in-differences, here with the event of failure or merger as an outcome instead of the capital ratio, using the same sample and covariates as in the triple differences approach above.

Results from Table (3.12) are comforting. The FDIC appeared to be a tougher regulator before the change in standards, illustrated in the main effects for exit being positive (although significant only the bottom of the distribution of initial leverage). Except for the banks with the least initial capital, the estimated coefficients are small relative to their means after 1984.

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Moreover, there does not appear to be any significant change in these rates of exit across membership status after the policy change, indicating that the effect of policy is certainly not on this margin.

3.7 Concluding Remarks

Tougher bank leverage requirements don't seem to matter much for bank behavior, certainly not as much as has been previously thought. I have shown that there are some fairly robust mean-reverting dynamics between banks with different absolute levels of capital, and that failing to account for these dynamics leads to large overestimates of the consequences of a policy change. Using the plausibly exogenous elimination of differences in leverage requirements for community banks in 1985, I am unable to reverse this conclusion, finding only weak evidence of precautionary behavior by high capital banks. While it is possible that other factors affecting the adjustment of banks across membership status are making it harder for non-member banks to increase capital ratios, I am able to rule out an obvious problem: a differential changes in regulatory pressure created by different trends regulator resources during the 1980s. The final conclusion is a cautious zero for the consequences of tougher leverage standards on non-member community banks. Combined with the descriptive evidence of pre-existing dynamics between low and high capital banks since 1981 and of precautionary behavior after 1989 presented in Figures (3-2) and (3-3), the paper should provide sufficient motivation for another careful evaluation of the Basle Accord before thinking seriously about radical changes in bank regulation. Moreover, these results are possibly explained by bank having market-based incentives to hold capital so that existing regulatory

capital requirements weren't binding. Identifying and quantifying these incentives is thus the next obvious step for research if this claim is to be taken seriously. [32]

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[32] As one potentially strong incentive is the protection of future monopoloy rents, exploiting differential changes in bank branching restrictions across states may generate plausibly exogenous changes in monopoly power which in turn should affect bank leverage and risk choice. Bergstresser (2000) has actually found preliminary evidence that greater competition created by the removal of branching restrictions actually reduces bank equity ratios and increases portfolio risk. This is clear evidence that there exist market-based incentives for banks to hold capital.

Chapter 4

On the Economic Distortions of Smoothing Aggregate Volatility with Monetary Policy

4.1   Introduction

Monetary policy is the primary tool in advanced economies for smoothing business cycles. In the United States the central bank has been charged under the Federal Reserve Act with the objectives of maximum employment, stable prices, and moderate long-term interest rates. While the Federal Reserve has generally attempted to achieve these objectives by smoothing fluctuations in economic aggregates, it is possible that the aggregate economy is not the right unit of analysis when designing or evaluating monetary policy.

The aggregate economy is made up of potentially heterogeneous regions, each of which has its own response to the policy instrument and to the fluctuations which prompt aggregate

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smoothing by the central bank. When the correlation between how policy affects a region with how the shocks to be smoothed affect a region is low, a number of regions might not benefit very much – or may even suffer – under aggregate smoothing by the central bank. In this sense a focus by the central bank on economic aggregates.

To fix ideas, consider an economy with two regions. Imagine a shock that affects the Eastern region and a policy instrument that largely operates through the Western region. Any aggregate smoothing of this shock increases volatility in the West and only affects the East indirectly through its linkages with the other region. The inability of the central bank to channel the impact of monetary policy in the affected region implies that aggregate smoothing actually weakly increases volatility in every region of the economy. [1] This is of course an extreme example, but does illustrate that there could be an important difference between smoothing aggregate and regional volatility. Developing evidence on the possible size of this difference is the primary task of this paper.

One might think that this issue is irrelevant in an economy as integrated as the United States. In the context of European integration, Frankel and Rose (1998) have argued that the large observed differences in the transmission mechanism of monetary policy across countries will become irrelevant as financial institutions converge over time. It's also likely that the free flow of goods and factors across borders facilitates the transmission of shocks across regions. On the other hand, integration could lead to specialization within regions that creates differences in industrial structure. [2] There is evidence that early monetary unions such at Italy, Germany, and the US have been correlated with increasing industrial

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[1] By creating a negative covariance between the two regions, volatility can actually increase in each region while aggregate volatility falls.

[2] See, for example, Dornbush, Fisher, and Samuelson (1980).

specialization. [3] Differences in industrial structure alone could generate differences in the transmission mechanism and in regional response to shocks.

Carlino and Defina (1998) have in fact documented that there are significant differences in the response of state income growth to changes in the federal funds rate and that much of the cross-sectional variation in this response is explained by differences in state industrial structure. The simple existence of variation across regions in the response to monetary policy is not enough by itself, however, to break the link between aggregate and regional smoothing. Differences in the response of regional output to policy may simply reflect differences in the sensitivity of regional output to the aggregate economy so that the smoothing of aggregate and regional volatility are one and the same. When either monetary policy or the shocks that monetary policy is smoothing have differential effects on regional growth directly, independent of any differences in the sensitivity to aggregate growth, there is no longer necessarily a connection between the smoothing of aggregate and regional volatility.

It turns out that there actually is very little correlation between how shocks that create aggregate volatility affect state output growth with how state output growth response to changes in monetary policy. This fact is illustrated in Figures (4-1) and (4-2), which plot the four quarter response of state income to the federal funds rate versus the response to an innovation in commodity prices or versus the response to an innovation in consumer confidence, respectively. [4] Commodity prices were chosen given their uncanny correlation

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[3]See Grauwe and Vanhevebeke (1994) and Krugman and Venables (1996).

[4]The system includes the log of commodity prices, the federal funds rate, the log of aggregate income, the log of consumer prices, the consumer confidence index, and the log of income for U.S. states. This system is identified through the assumptions that the funds rate affects other variables only with a lag, confidence affects every variable except the funds rate with a lag, and commodity prices do not respond immediately to other variables. Moreover, I assume that state income depends only on aggregate variables and own lags so that spillovers across states are channeled through aggregate income.
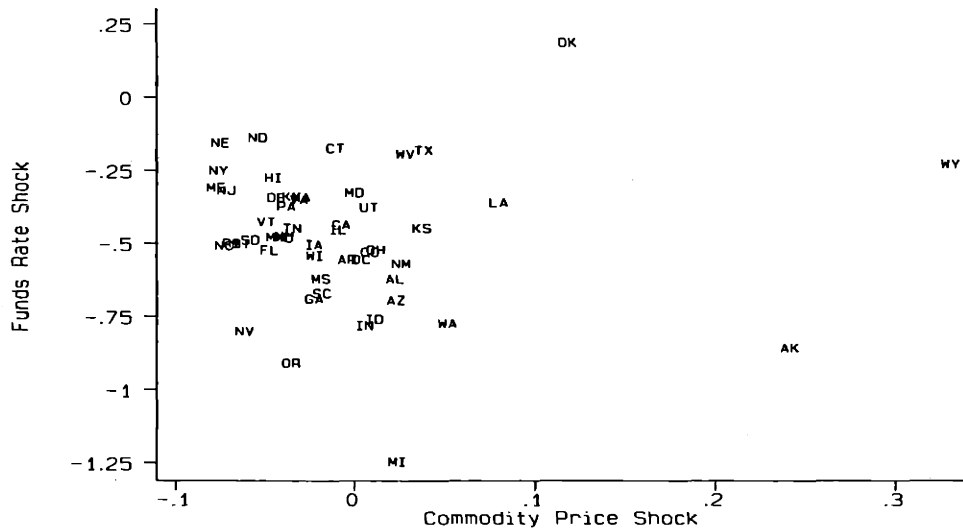
Figure 4-1: Response of State Income to Funds Rate versus Commodity Price Shock

with fluctuations while consumer confidence was chosen in accordance with a private theory

of business cycles. It is clear the correlation between how state output growth responds to

innovations in either consumer confidence or commodity prices with the response to monetary

policy is nearly zero. [5]

This small correlation has important implications for when evaluating the performance of

actual monetary policy over the last three decades. I demonstrate below that the estimated

policy rule seems to have reduced the variance of aggregate output relative to policy of

holding interest rates constant. On the other hand, the actual steady-state variance of

output has increased for a majority of states representing at least half of the economy,

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[5]The correlation of state income response to the funds rate versus commodity price innovations is -0.02 while the correlation versus consumer confidence is 0.16. These difference persist at longer lags, being 0.08 and 0.15 after 8 quarters.
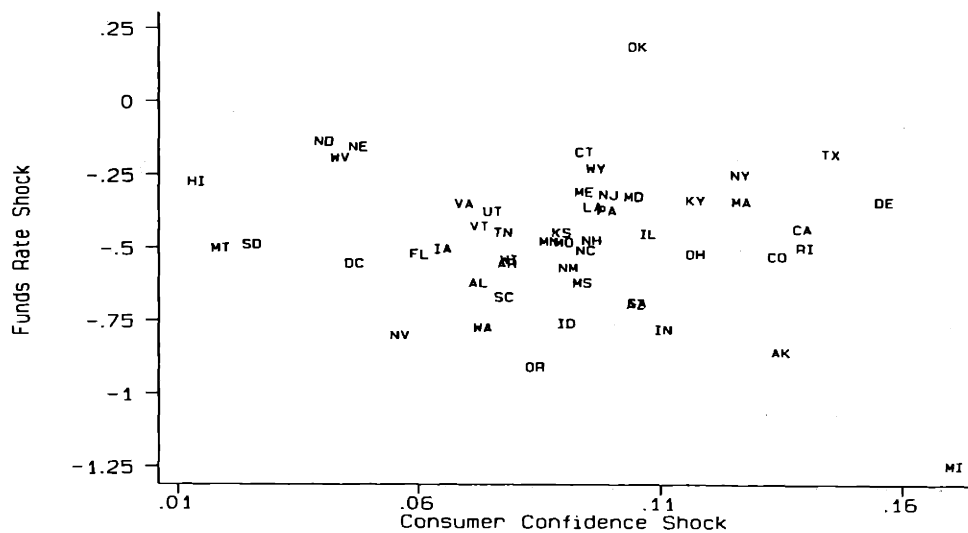
Figure 4-2: Response of State Income to Funds Rate versus Consumer Confidence Shock

implying that aggregate smoothing has largely been accomplished by generating negative a covariance in output across the states.

When characterizing the set of policies that minimize the steady-state variance of prices and income, macroeconomists have generally found trade-offs between these two objectives. [6]. Estimates of the policy rules actually used by the Federal Reserve have generally indicated that these rules are sub-optimal in the sense that the variance of both inflation and output growth could be reduced through a change in policy. As more recently estimated policy rules have seemed to move in this direction, it may seem like central bank performance is improving. [7] I demonstrate, however, that while a shift towards a Taylor rule for monetary

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[6]For example, see Taylor (1979) and Defina, Stock, and Taylor (1996)

[7]Taylor (1993) illustrates that the federal funds rate in the 1980s closely tracked a simple optimal policy rule, while Taylor(1996) documents the mistakes of policy in the 1960s and 1970s.

policy would certainly reduce the variance of both aggregate output and prices, such a policy change continues to increase state volatility, although most often for state that represent a small fraction of the economy. All optimal rules are not equal in the severity of distortions they create, however, as those that place more weight on price volatility tend to increase the volatility of state income for a significant fraction of the economy. I conclude that monetary policy has the potential to create significant distortions, but need not do so.

Section 1 outlines the economic model and VAR estimation, while Section 2 outlines some reduced-form evidence. Section 3 characterizes the central bank's optimization problem and solution. Section 4 highlights results under the barest of assumptions, while Section 5 explores the robustness of these results in several dimensions.

4.2 Reduced-Form Evidence

The analysis below is going to require me to put a great deal of structure on the data, so I am going to take a quick look at some correlatoins from a very reduced-form point of view to start. I first demonstrate there is a correlation times when monetary policy is actively used and the dispersion of state income gaps and then demonstrate that there is also a correlation between the time series volatility of state income gaps and the use of monetary policy. While I do not interpret either of these correlations as casual, they illustrate the the first-order correlations exist to back up the main message of this paper: monetary policy has the potential to create serious real distortions.

If the response of state income to monetary policy as poorly correlated with the response to other types of shocks as was suggested above, it seems plausible that monetary policy

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should increase the dispersion of state income. I look for this correlation in Table (4.1) through a regression of the state income gap, measured as state income growth minus its period mean, on current and lagged measures of the use of monetary policy. As both increases and decreases the funds rate should increase the dispersion, I use as a regressor alternatively the absolute value of changes in the funds rate and the squared change in the funds rate. In order to control for other time-series shocks that might be correlated with the use of monetary policy, I include current and lagged values of aggregate income growth. The table clearly indicates that the use of monetary policy seems to increase the dispersion of state income gaps using either measure at all lags. F-tests for the joint significance of the monetary policy variables reject the hypothesis that they are zero at conventional significance levels.

That monetary policy increases the dispersion of income gaps is troubling, but would not be important if it was simply reducing the volatility of all state income gaps, but in an asymmetric manner. Estimating counterfactual income volatility is especially difficult without putting more structure on the data, but as a first-pass I split the sample into 16 eight-quarter time periods. I regress the time-series volatility of state income gaps on the measures of changes in monetary policy over the time period. I use the sum of absolute value of the changes in the funds rate or the sum of squared changes in the funds rate alternatively. I control for a time trend and for aggregate income gap volatility. The table is clear, demonstrating that the use of monetary policy is correlated with higher volatility in state income gaps. I should restate that this should not be interpreted in a causal sense, as monetary policy could simply be used in times when state income volatility is high. The sample is embarrasingly small as well, but is the best I can do without putting more structure on the data, which is what I turn to next.

Table 4.1: Monetary Policy and the Dispersion of State Output Gaps

X	$|\Delta r_f|$	$\sqrt{V(\Delta lnY_t^s)}$ $(\Delta r_f)^2$
X_t	0.0740	0.9400
	(0.0572)	(1.1807)
X_{t-1}	0.0153	0.1219
	(0.0457)	(0.8446)
X_{t-2}	0.0363	1.2436
	(0.0421)	(0.6220)
X_{t-3}	0.1122	2.3221
	(0.0284)	(0.3535)
X_{t-4}	0.0345	0.7365
	(0.0376)	(0.6777)
ΔlnY_t^a	-0.0907	-0.0937
	(0.0572)	(0.0569)
$\Delta lnY_t^a - 1$	-0.0117	-0.0289
	(0.0344)	(0.0389)
$\Delta lnY_t^a - 2$	0.0498	0.0372
	(0.0257)	(0.0268)
$\Delta lnY_t^a - 3$	0.0425	0.0326
	(0.0283)	(0.0243
$\Delta lnY_t^a - 4$	0.0041)	-0.0045
	(0.0364)	(0.0335
Constant	0.0086	0.0099
	(0.0005)	(0.0004)

Table Notes: The table reports coefficents and standard errors from a regression of the cross-sectional standard deviation of state income gaps on current and lagged values of changes in monetary policy and aggregate income growth. The first column exploits the absolute value of changes in the funds rate while the second column uses the squared change in the funds rate.

Table 4.2: Monetary Policy and State Income Volatility

| | | $\sqrt{V(\Delta ln Y_t^s)}$ |
X	$|\Delta r_f|$	$(\Delta r_f)^2$
$\sqrt{V(\Delta ln Y_t^a)}$	0.5749	0.5792
	(0.0377)	(0.0375)
X_t	0.0099	0.2749
	(0.0061)	(0.1344)
t	-0.0002	-0.0002
	(0.0001)	(0.0001)
Constant	0.0081	0.0085
	(0.0008)	(0.0006)

Table Notes: This analysis splits the sample period into 16 eight-quarter time periods. The table reports coefficents and white standard errors from a regression of the eight-quarter time-series standard deviation of state income gap on the eight-quarter standard deviation of aggregate income gap, measures of changes in monetary policy, and a time trend. The first column exploits the absolute value of changes in the funds rate while the second column uses the squared change in the funds rate.

The regressions above are only suggestive, but indicate the use of monetary policy is at least correlated with more disperse and more volatile state income gaps.

4.3 Model and Estimation

Consider an economy described by the economic variables z_t which include at first the log of aggregate income, the log of prices, and the log of income for each of 51 states. [8] The central bank has at its disposal one policy instrument x_t which will be either the federal funds rate in the spirit of Bernanke and Blinder (1992) or the log of money supply . I assume throughout this paper that these instruments cannot be used simultaneously as the primary mechanism

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[8]I understand that the District of Columbia is not, and will probably never be a state, but will refer to it as such for convenience.

though which the central bank exercises control over the funds rate – intervention in the reserves market – is the same one through which it exerts pressure on the money supply. [9]

Volatility in non-policy variables is generated by a sequence of serially and mutually uncorrelated innovations v_t^z. For the analysis below I define Y_t as the vector of economic variables $\begin{pmatrix} z_t & x_t \end{pmatrix}'$ and v_t as the vector of shocks $\begin{pmatrix} v_t^z & v_t^x \end{pmatrix}'$. Innovations in policy v_t^x occur in practice, and are in fact necessary to identify the effect of policy on the economy, but should not occur when the optimal rule is employed. [10]

I assume that the economy has a linear structure, described by the following system of equations, [11]

$$[I - A]Y_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \pi_3 Y_{t-3} + \pi_4 Y_{t-4} + \pi x_t + v_t \tag{4.1}$$

Note that the coefficient on x_t in the vector of coefficients π is zero. When $[I - A]$ is

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[9]This is not strictly true in more recent years as banks' required reserves have fallen sharply over the last decade as banks have swept reservable deposits into non-reservable accounts overnight and banks' holdings of vault cash (which count towards required reserves) have increased greatly to stock ATMs. These developments have weakened control over the money supply considerably, but have not affected the ability of the Federal Reserve to control the funds rate. See Bennett and Peristiani (2001) for a recent discussion.

[10]This ignores the well-studied problem of time-inconsistency in Kyland and Prescott (1977) and Calvo (1978). In a nutshell, the optimal policy rule can't be implemented because there are incentives to cheat at every point along the optimal path. Following Taylor (1979), the presumption here is that there is some mechanism through which policy-makers are able to commit to long-run objectives. The assumption of an infinite time horizon with no discounting in the loss function of the central bank below is consistent with this view.

[11]While the variables in this economy are written only as linear functions of current and lagged variables, this formulation is consistent with a model where agents have rational expectations as in Taylor (1979a). Expectations of future variables are predicted on the basis of current information that includes both current and past variables, imposing cross-equation restrictions on the coefficients. The presence of rational expectations is potentially important when conducting counterfactual policy exercises like the ones implemented below. Sargent and Wallace (1975) argue that monetary policy is irrelevant when agents have rational expectations, while Taylor (1979b) shows that with fixed contracts and rational expectations monetary policy can have real effects.

invertible this economy has the following quasi-reduced form representation,

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \phi_4 Y_{t-4} + \phi_0 x_t + e_t \qquad (4.2)$$

Without further restrictions on economic structure, there is correlation across equations in e_t as each of the reduced-form residuals is a linear function of all of the structural shocks. [12] While $Y_{t-1}...Y_{t-4}$ are predetermined variables, x_t is potentially endogenous due to a correlation with e_t. In order to identify ϕ_0, the immediate impact of monetary policy on non-policy variables, I follow Christiano, Eichenbaum and Evans (1996) with the assumption that monetary policy only affects non-policy variables with a lag but can react immediately to current non-policy variables. This assumption is convenient because it implies that the quasi-reduced form in equation (4.2) can be estimated directly by OLS. [13] Given consistent estimates of ϕ, the central bank can simply use equation (4.2) to trace out the future path of policy and non-policy variables in response to a vector of innovations e_t even without

[12] For those that are thinking too far ahead, the policy variable x_t is included in Y_t at this point only to estimate the actual policy rule used by the central bank over the sample period, and will be removed from the system below when formulating the optimal policy rule.

[13] If there was an underlying structural model of the economy complete with rational expectations, there would be restrictions across equations on the coefficients that could be exploited in estimation. While imposing these restrictions could improve efficiency over OLS if the model is correct, the estimator could be inconsistent if the underlying model is incorrect. This is of course the perfect environment in which to evaluate a structural model through a Hausman specification test. For some reason, the literature has avoided testing these restrictions. There is of course an unfortunate Catch-22 here. If these restrictions matter in the sense that the estimated parameters vary greatly from those estimated from OLS, the underlying structural model can be rejected. On the other hand, if the restrictions don't matter in this sense then OLS equation by equation is not such a bad thing to do and a structural model is unnecessary. While Taylor (1979a) imposes these cross-equation restrictions to impose rational expectations on the data, there is really no need to do so, and imposing these restrictions may yield biased estimates if exectations are not rational or the underlying macro model not specified correctly. Given the large costs of imposing potentially false restrictions on the data and the relatively small benefits of doing so, I prefer to ignore these restrictions and thus do not specify a structural model.

knowledge of the underlying structural parameters of the economy. Note that this is a minor departure from existing research on optimal policy rules which typically identifies each of the structural equations in (4.1). I have only assumed that the central bank understands how monetary policy affects the economy, but does not have any other information about the structure of the economy, and thus cannot observe structural shocks v_t. Any additional knowledge of economic structure is largely irrelevant for the purposes of formulating optimal policy.

The first step is to estimate the quasi-reduced form system from equation (4.2) above using OLS. The estimation exploits quarterly data starting in 1969.1 through 1999.4. I use aggregate and state personal income provided by the Bureau of Economic Analysis deflated by the Consumer Price Index as a measure of real output. I also use a time series on the federal funds rate as an instrument of monetary policy, available from the Federal Reserve Bank of St. Louis. Finally, I use time series on the money stock measured by M1 from the Board of Governors of the Federal Reserve. Monthly data has been averaged by quarter, and none of the series have seasonally adjusted. Instead, I choose to include four quarterly dummies in each of the regressions below. The main data constraint is the availability of state personal income, which only goes back to the first quarter of 1969.

The baseline system of equations includes the federal funds rate, the log of aggregate real personal income, the log of prices, and the log of real personal income for 51 states. Without any restrictions it is not possible to estimate this system as there are more parameters than observations. When including four lags of each variable, each equation requires at least 216 parameters. I simplify this problem greatly through the assumption that aggregate variables are functions only of aggregate variables and that state variables are functions of
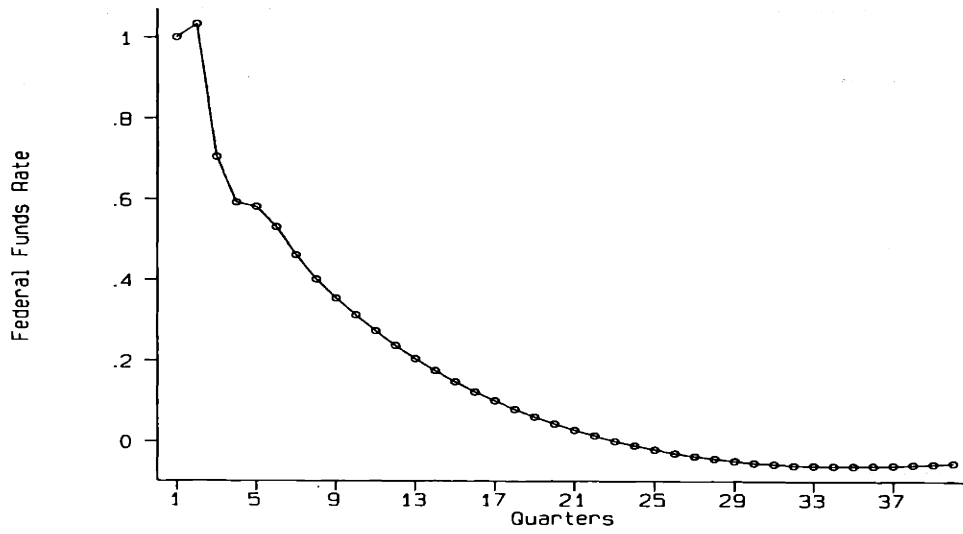
Figure 4-3: Response of Funds Rate to 100 Basis Point Funds Rate Innovation
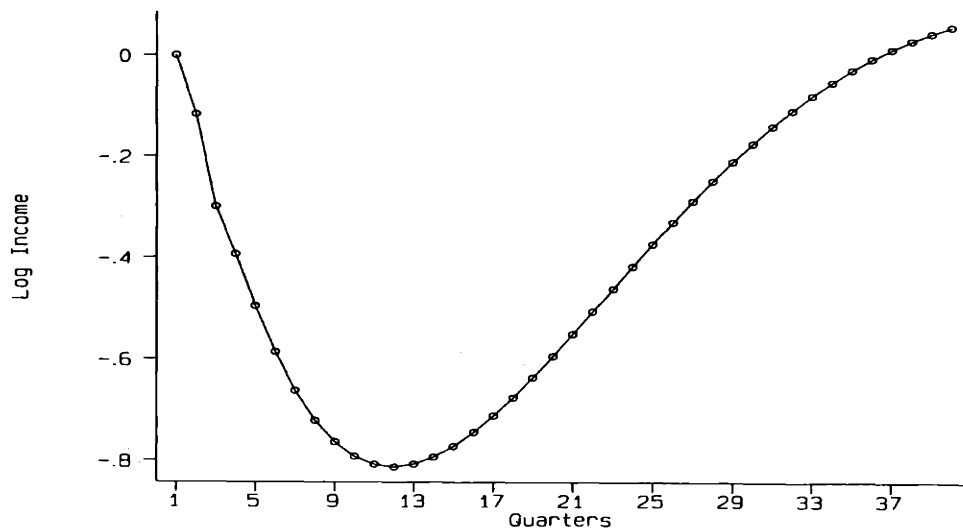

Figure 4-4: Response of Aggregate Income to 100 Basis Point Funds Rate Innovation

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aggregate variables and lags of only own state personal income. [14] In this formulation there is an equation for the funds rate that requires only 11 parameters (current and three lags of prices and aggregate income plus three lags of the funds rate) while the aggregate non-policy block requires 12 parameters (four lags of all aggregate variables). The state block requires 16 parameters per equation, with the additional parameters coming from the own lags on output growth.

I have performed unit root tests on each of the 54 variables included in this system, finding each one is integrated of order one and that log prices has two unit roots. Discuss de-trending decisions. Despite these unit roots, I choose to keep the system in levels to ensure monetary policy is neutral in the long run in the simplest manner possible. [15] I also use four lags of each variable in the system, finding that this is sufficient to eliminate any first-order serial correlation in the estimated residuals. I finally use the residuals of the estimated equations in order to estimate the covariance matrix V of u_t, imposing the identifying assumption that the innovation to monetary policy is uncorrelated with other residuals.

The response of the funds rate and aggregate income to a 100 basis point innovation is illustrated in Figures (4-3) and (4-4). The peak response on aggregate income is about 80 basis points after three years and monetary policy is neutral after about 10 years. Figure (4-5) illustrates the differences in how the funds rate affects state income over time. The

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[14]State income could depend on non-policy aggregate variables contemporaneously, but in transforming the system from (4.1) to (4.2) these variables do not appear in the estimating equation.

[15]Carlino and Defina (1998) have done most of their related work by taking appropriate differences, but permit monetary policy to have long-run effects on the real economy. I feel this is an unfair place to start in a paper trying to gauge the size of distortions created by monetary policy. Moreover, this differencing is not necessary for consistency of OLS, but may affect inference. See Hamilton (1994) for a full discussion of this issue. While it is possible to impose long-run restrictions on the impulse responses a la Blanchard and Quah (1988), I stick with what is simple for now.
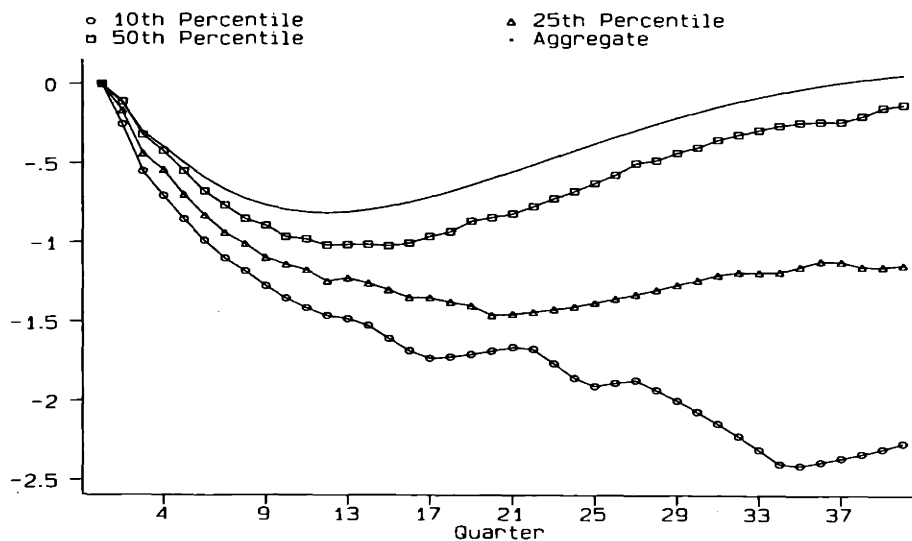
Figure 4-5: Response of State Income to 100 Basis Point Funds Rate Innovation

aggregate response is displayed with the series of circles, and the response at each of the

50th, 25th, and 10th percentiles is illustrated by triangles, squares, and a line, respectively.

What is striking about the figure is that states at or below the 25th percentile react very

differently from other states. This monetary contraction has still reduced state income by 1

percent after 10 years at the 25th percentile while the effect at the 50th percentile then is

basically zero. This is a crucial point which probably drives many of the results below.

4.4 Optimal Monetary Policy

The problem for the central bank is to choose a sequence for the policy variable that min-

imizes its loss function. In order to reduce the algebraic complexity of the optimization

problem described below, it is convenient to re-write this system in first-order autoregressive

form.

$$W_t = B * W_{t-1} + c * x_t + u_t \tag{4.3}$$

This is simply equation (4.2) stacked above a vector of equations requiring $Y_{t-j} = Y_{t-j}$ for $j = 1, 2, 3$. Under the assumption that monetary policy affects other variables with a lag the policy instrument x_t is either the lag of the funds rate or the log of lagged money supply. The coefficient matrix B consistent with this system has the following form,

$$B = \begin{bmatrix} \phi_1 & \phi_2 & \phi_3 & \phi_4 \\ I & 0 & 0 & 0 \\ 0 & I & 0 & 0 \\ 0 & 0 & I & 0 \end{bmatrix} \tag{4.4}$$

Note that these coefficients in the first row can be partitioned into policy and non-policy components. The coefficients ϕ_j^{xz} and ϕ_j^{xx} described the actual policy rule above used by the central bank to choose instruments x_t. As we are interested in the behavior of non-policy variables under alternative policy rules, I remove the actual policy rule from the above system of equations. This is done by replacing each of $\begin{pmatrix} \phi_j^{xz} & \phi_j^{xx} \end{pmatrix}$ with a vector of zeros and ϕ_0^{zx} with the identity matrix. These replacements simply construct the equation $x_t = x_t$.

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$$\phi_j = \begin{pmatrix} \phi_j^{zz} & \phi_j^{zx} \\ \phi_j^{xz} & \phi_j^{xx} \end{pmatrix} \text{ for } j = 1..4 \tag{4.5}$$

The vector W_t is simply the vector $\begin{pmatrix} Y_t & Y_{t-1} & Y_{t-2} & Y_{t-3} \end{pmatrix}'$ while the coefficient vector c contains the elements $\begin{pmatrix} \phi_0 & 0 & 0 & 0 \end{pmatrix}'$ and u_t is just the vector $\begin{pmatrix} e_t & 0 & 0 & 0 \end{pmatrix}'$. In addition, any innovation to the policy rule is eliminated through the restriction $e_t^x = 0$, affecting the covariance matrix of e_t and thus u_t.

Optimal monetary policy by the central bank is described by the sequence of instruments x_t that minimize the central bank's loss function, described by the quadratic form below.

$$\min_{x_t}(W_t - W^*)'Q(W_t - W^*) \tag{4.6}$$

The vector W^* describes the central bank's target for each of the elements of W_t, while the matrix Q describes the bank's preferences over the autocovariances of the vector W_t. For a diagonal weighting matrix Q, the central bank is interested in minimizing the weighted variance of non-policy and/or policy variables around the target vector W^*. The solution to this problem is described in Chow (1975). Optimal policy is set as a function of lagged policy and non-policy variables.

$$x_t = GW_{t-1} + g \tag{4.7}$$

If a steady-state exists, the optimal policy rule converges as follows,

$$G = -(c'Hc)^{-1}c'HBH = Q + (B + cG)'H(B + cG) \tag{4.8}$$

In practice, given estimates of c and B this solution is derived through an initial guess for H (Q works fine), and iterating until G converges to steady-state.

Plugging this solution into the equation above describes the behavior of non-policy variables under optimal policy.

$$W_t = (B + cG)W_{t-1} + cg + u_t \tag{4.9}$$

Define the covariance matrix of u_t as $V = E[u_t u_t']$. The steady-state covariance matrix of W_t, defined here as $\Sigma = E[W_t W_t']$, is the solution to the following equation.

$$\Sigma = V + (B + cG)\Sigma(B + cG)' \tag{4.10}$$

In a manner similar to the above, given estimates of B, c, and V and the solution G

above, the steady-state covariance is derived through an initial guess for Σ (V works fine) and iterating until Σ converges. Note that the steady-state variance of W_t is independent of its mean, which will be W^*.

It is of course not only possible to describe the steady-state behavior of our economy under the optimal rule using equation, but actually to do so under any rule. For example, defining the vector G^a as $\begin{pmatrix} \phi_1^x & \phi_2^x & \phi_3^x & \phi_4^x \end{pmatrix}$, the steady-state variance of our economy following the actual policy rule would be the solution to this equation.

$$\Sigma_a = V + (B + cG^a)\Sigma_a(B + cG^a)' \tag{4.11}$$

Existing studies typically compare the actual variance of non-policy variables each the target vector W^*. [16] From equation (4.11), the steady-state variance of economic variables under the optimal policy clearly does not depend on the central bank's target W^* these variables. On the other hand, it is conventional to compare steady-state variance under the optimal policy to the actual variance of economic variables around the target W^*. This latter calculation obviously requires an assumption about the central bank's target. I find this approach unattractive as one could make very different conclusions about the performance of actual policy simply by using different assumptions about what the central bank's target might have been. [17]

Moreover, the actual variance of the economy is different from the steady-state variance

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[16] See Taylor (1979a, 1993) and Defina, Stock, and Taylor (1996).

[17] Taylor (1979a) found that a constant growth rate for the real money supply did not dominate actual policy (in terms of output growth and inflation variance), but admitted this result depended on the targets for output growth and inflation attributed to the central bank.

of the economy under the actual policy rule for two reasons: innovations in the actual policy rule and any transition time to the new steady-state. This implies that even if the bank is following an optimal rule, the actual variance of the economy might be greater than the optimal variance. It thus seems appropriate to either compare the steady-state variances of the two policy rules or to simulate the actual variance of optimal policy given initial conditions over the sample period. As this latter approach requires fewer assumptions, I choose to compare the steady-state variance of the economy across policy rules in the analysis below.

It is also possible to examine the implications of no feedback rules on steady-state variance by simply replacing G in equation (4.10) with a matrix of zeros. I also explore the implications of a random policy - where the steady-state variance of the policy instrument is equal to the steady-state variance of the instrument under the actual policy rule, but this variance is distributed randomly. This is done simply through appropriate adjustments to the diagonal elements of policy variables in the covariance matrix V of u_t. Under optimal policy these elements were of course set to zero as random innovations to the optimal policy rule are sub-optimal.

4.5 Results

I first consider the simple system described above using the federal funds rate as the instrument of monetary policy, then explore a more complicated economy in order to better control for omitted variables that could potentially bias our estimates.

4.5.1 Baseline Economy

Given estimates of the VAR from above, it is straightforward to use the equation (4.10) in order to compute the steady-state variance of each variable under the optimal policy rule. Table (4.3) summarizes the performance of our baseline economy under actual and naive rules for monetary policy. Panel (a) reports the steady-state standard deviation of the federal funds rate, log aggregate income, and the log price level when following the optimal and alternative policy rules. The first reports the steady-state standard deviation of these variables under the estimated policy rule with variance of innovations to this rule set to zero, while the second column simply inserts the estimated variance of estimated innovations into the covariance matrix of u. The final two columns illustrate the impact of two feedback rules, with a deterministic nominal funds rate in and a random funds rate (with variance equal to that under the actual policy rule), respectively.

The first interesting fact from the table is that monetary policy appears to have been somewhat successful in smoothing the volatility of aggregate output. This standard deviation under the actual policy rule without innovations falls by around 7-8 percent relative to deterministic and random rules and by only about 1-2 percent when including departures from the actual rule. This success appears to have been accomplished at the expense of higher price variance by around 12-25 percent depending on the counterfactual rule.

Given that actual policy appears to have reduced the variance of aggregate output relative to naive policy rules, it is natural to consider what has happened to state output in making a similar shift. This exercise is illustrated in panel (b) of Table (4.3). I construct the percentage change in steady-state standard deviation of state income from a shift in policy from a nave

to actual rule. The first two columns report percentiles of the distribution of percentage changes corresponding to a shift from a deterministic rule to actual the policy rule with and without innovations, respectively. A shift from a fixed to simple policy rule increased the standard deviation of state income by around 16 percent at the 90th percentile and reduced it by about 10 percent at the 10th percentile. The final two columns represent a similar shift, but from a random rule. Each of these exercises indicates that the benefits of aggregate smoothing have not been distributed equally among the states, usually increasing volatility in the median state. The final panel summarizes the magnitude of these asymmetries. The first row counts up the number of states that have greater volatility while the second row reports the share of these states in aggregate income. These numbers are extremely large, with much of the economy experiencing greater volatility. For the shift from a fixed rule to the actual rule without noise described above, 33 states representing almost three-fourths of the economy actually have greater volatility.

Table (4.4) summarizes optimal policy rules. Each of the first seven columns in the table vary the weight of aggregate income variance in a loss function that also a function of price variance, while the last column reports results for the actual policy rule without noise. As in the previous table, panel (a) describes the behavior of aggregate variables, indicating that there are generally trade-offs between the steady-state standard deviation of prices and aggregate output in the class of optimal policies. Moreover, actual policy lies far above the optimal frontier. Finally note that optimal policies ultimately work by increasing the steady-state standard deviation of the funds rate, and that the actual standard deviation is smaller than every point along the optimal policy frontier.

Panel (b) documents the percentiles of percentage change in standard deviation across

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states from the actual policy rule without noise to each point on the optimal frontier. The first two rows of panel (c) report statistics similar to the table above on the number of states having higher volatility and their share in aggregate income. A move from actual policy toward optimal policy with equal weights on the variance of prices and aggregate output could reduce the standard deviation of output by almost 30 percent, but such a shift increases volatility by almost 30 percent at the 90th percentile in the distribution of states. The bottom panel reports statistics similar to the previous table, demonstrating that even in the best of cases such a transition involves increasing the output volatility of at least a dozen states representing at one-fourth of the economy.

4.5.2   Another Weighting Matrix

It is possible that there are differences between the variance of aggregate income growth and the variance of aggregate income growth implied by the variances and covariances of state income growth. In order to ensure the consistency of the central bank's preferences, I complicate the objective function, recognizing the presence of both aggregate and state income in the vector W_t. In order to ensure preferences are consistent, I impose additional restrictions on the form of Q. Note that the log of aggregate income can be written as a weighted sum of the log of state income.

$$\Delta \ln Y_t^a = \theta' \Delta \ln Y_t^s \tag{4.12}$$

The vector θ corresponds to the state share of aggregate income while the vector $\Delta ln Y_t^s$

corresponds to state output growth. For simplicity, I assume that this share is constant, and write the variance of aggregate output growth as a quadratic form in state output growth and a matrix of state output shares θ. As our system above is written in levels, we need an identity relating the log of aggregate income to the log of state income. To accomplish this I write the difference in logs relative to a base year so that $\Delta \ln Y_t^s = \ln Y_t^s - \ln Y_0^s$ and $\Delta \ln Y_t^a = \ln Y_t^a - \ln Y_0^a$. This normalization permits the above equation to be rewritten as,

$$\ln Y_t^a = \ln Y_0^a - \theta' \ln Y_0^s + \theta' \ln Y_t^s \tag{4.13}$$

The first term on the right-hand side of this equation is a constant, which will disappear when writing the variance of the log of aggregate income as an income-share-weighted sum of the variances and covariances of state income.

$$V(\Delta ln Y_t^a) = E[(\Delta ln Y_t^s)' \theta \theta' (\Delta ln Y_t^s)] \tag{4.14}$$

It follows that the upper left block of Q must have the following form with a weight of α on the variance of aggregate growth.

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$$Q_1 = \begin{bmatrix} \frac{1}{2}\alpha & 0 & 0 & 0 \\ 0 & \frac{1}{2}\alpha\theta\theta' & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{4.15}$$

One should note that the optimal policy rule could be quite complex given the number of variables in the system. In what follows, even though aggregate variables are unaffected by state variables in the VAR, the optimal policy rule will generally be a function of both aggregate and state variables when using this weighting matrix.

It turns out that results are no different from those in the previous table, implying that there is no difference between the actual and implied aggregate variance in the exercises above. This strengthens the result above that monetary policy has been able to reduce the volatility of aggregate income growth only by reducing the correlation between state income gaps.

4.5.3   A Larger VAR

One potentially serious problem with the estimation strategy above the presence of important omitted variables in the system above. As the dynamic response of aggregate and state income to policy generally depends on all of the parameters in the system, a bias created by omitted variables for any one parameter could radically change the conclusions above. In fact, it is well-known that the absence of commodity prices from the above system biases the response of prices to monetary policy such that a monetary contraction actually increases

prices. This is one important reason to expand the system.

I simply add commodity prices and consumer confidence to the system above, making only the assumption that confidence and commodity price shocks respond to policy only with a lag. While this seems natural for commodity prices that are determined in large international markets, consumer confidence is in part based on expectations of the future. Changes in the stance of monetary policy plausibly affect those expectations, and could in principle have an immediate effect on confidence through this mechanism. In practice, however, I am skeptical that innovations in the policy rule have much of a direct impact on consumer spending decisions.

I exploit the producer price index for fuel, related products, and power as a measure of commodity prices and the University of Michigan Survey of Consumer Sentiment as a measure of consumer confidence. Both of these series are available on-line at the Federal Reserve Bank of St. Louis. I also choose to use the weighting matrix described in the previous section to ensure that the implied aggregate volatility of state income matches actual aggregate volatility.

Table (4.5) describes the steady-state performance of our new economy. Little has changed qualitatively from before, as policy continues to reduce the volatility of aggregate income and increase the volatility of prices and interest rates. What is new is that actual policy has greatly increased volatility in consumer confidence and commodity prices. The lower panel of the table illustrates that the asymmetric impact of this aggregate smoothing appears to be much smaller after expanding the VAR by two variables. At its worst actual policy increases the volatility of income for 30 states representing about half of aggregate income, down from 44 states representing over 90 percent of income above. Note the significant

differences between the actual policy rule with and without noise, however. The implication here is that innovations in the policy rule have actually reduced aggregate performance and exacerbated the distortions of policy relative to naive policy rules.

The optimal policy rule is characterized in this new economy in Table (4.6). As above, each of the first seven columns corresponds to different weights of aggregate income in the weighting matrix, with the final column representing the actual policy rule without noise. There are again trade-offs between income and price variance, but the second-order Phillips curve is much flatter in (income-price volatility space). The bottom panel confirms what the previous table hinted at – that the distortions across states of aggregate smoothing are much smaller than measured above. A transition from the actual rule without noise to eliminating all of the volatility possible in aggregate income would reduce the standard deviation of aggregate income by two-thirds, but would still increase volatility in eight states representing just under 5 percent of aggregate income.

An interesting point on the optimal frontier exists where the central bank weights output volatility by 10 percent. A shift from the actual policy rule without noise would still reduce the steady-state standard deviation of income by around one-third with a small reduction in price volatility, but such a policy would actually increase income volatility for a majority of states representing almost one-third of aggregate income. This underscores an important result that appeared in each of the tables above: the distortions in state income volatility created by a shift from actual policy to Taylor rules that only improve aggregate performance will increase as the central bank substitutes a reduction in income volatility for price volatil-ity. This is an important empirical fact given the recent observations by Boivin (2001) that the Federal Reserve appears to have increased the sensitivity of the funds rate to prices over

the last 15 years relative to prior policy. Overall I conclude that actual monetary policy has created significant distortions, but need not do so – and that the class of optimal monetary rules are not equal in the severity of distortions they create on state income volatility.

4.6   Conclusions

This work has two main messages. While actual monetary policy appears to have reduced the volatility of aggregate income and prices, it seems to have actually increased the volatility of income for a majority of states representing half of aggregate income. Interestingly, the class of policy rules that minimize the weighted average of price and aggregate income volatility also appear to increase state income volatility, but the distortions appear to be much smaller than those created by actual policy. All optimal rules are not equal in the severity of distortions that they create on the volatility of state income, however, as those that place more weight on price volatility could actually increase the volatility of income for states representing about one-fourth of aggregate income. I conclude that while monetary policy has in the past created severe distortions and has the capacity to do so in the future, it need not do so.

Table 4.3: Performance of the Baseline Economy

A. Standard Deviation of Aggregate Income

| | Actual Policy | | Naive Policy | |
	Simple	+ Noise	None	Random
R_f	0.55	1.16	0.00	0.55
$\ln(Y^a)$	1.00	1.02	1.01	1.02
$\ln(P)$	0.41	0.41	0.34	0.35

B. Percentiles of the Percentage Change in Standard Deviation of State Income

| To | Actual: Simple | | Actual: + Noise | |
From	None	Random	None	Random
90th	4.01	2.59	8.36	6.02
75th	1.70	0.58	4.99	3.52
50th	0.36	-0.43	2.30	1.38
25th	-1.96	-3.17	0.38	-0.56
10th	-3.72	-4.98	-1.38	-2.33
Worse	29	19	40	36
Share	59.98	31.17	73.23	66.12

Table Notes: Panel (a) of the table reports the steady-state standard deviation of the funds rate, aggregate income, and price level under actual and naive policies. The first column uses only the estimated policy rule while the second column adds the variance of innovations to this rule. The third column is a policy of smoothing volatiilty in the funds rate while the fourth column is a policy of changing the funds rate randomly with standard deviation equal to that implied by the actual rule without noise. Panel (b) describes the percentiles of the percentage change in steady-state standard deviation in state income created by a change in policy. The first two columns describe a shift from each naive policy to the actual rule without innovations, while the latter two columns describe a shift to the actual rule with estimated noise. The bottom panel describes the number of states that actually have increased volatility in response to such a policy shift and the share that these states have in aggregate income.

Table 4.4: Optimal Performance of the Baseline Economy

	Optimal Rule (weight on income)							Actual
	0	10	25	50	75	90	100	Simple
R_f	0.74	0.73	0.80	0.96	1.04	1.11	1.12	0.55
$\ln(Y^a)$	0.97	0.94	0.92	0.91	0.91	0.90	0.90	1.00
$\ln(P)$	0.26	0.26	0.27	0.28	0.30	0.31	0.31	0.41

Percentages of the Percentage Change in Standard Deviation of State Income

	0	10	25	50	75	90	100	Simple
From	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
To	0	10	25	50	75	90	100	Simple
From	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
90th	3.30	1.22	0.16	0.22	0.17	0.20	0.21	
75th	1.12	0.08	-0.89	-1.56	-1.58	-1.08	-1.09	
50th	-1.77	-3.28	-4.52	-4.88	-5.10	-5.16	-5.17	
25th	-4.66	-6.60	-7.47	-7.65	-7.52	-7.21	-6.99	
10th	-6.12	-7.97	-8.95	-8.99	-9.25	-9.17	-9.10	
Worse	20	14	8	6	6	6	6	29
Share	22.56	9.39	6.18	3.89	12.88	12.88	12.88	

Table Notes: The top panel of the table reports the steady-state standard deviation of the funds rate, aggregate income, and price level under actual and naive policies. The first column corresponds to a weight of 100 percent on the volatility of prices in the central bank's loss function, and this weight declines to 0 percent in the next six columns. The bottom panel describes the percentiles of the percentage change in steady-state standard deviation in state income created by a change in policy from the actual rule without noise to each of the optimal policies described in the top panel. The bottom panel describes the number of states that actually have increased volatility in response to such a policy shift and the share that these states have in aggregate income.

Table 4.5: Performance of the Full Economy

A. Standard Deviation of Aggregate Income				
	Actual Policy		Naive Policy	
	Simple	+ Noise	None	Random
R_f	0.69	1.17	0.00	0.69
$\ln(Y^a)$	0.97	0.99	1.01	1.03
$\ln(P)$	0.43	0.44	0.33	0.34
$\ln(P^c)$	2.23	2.25	2.06	2.09
CC	4.83	4.95	4.72	4.80

B. Percentiles of the Percentage Change
in Standard Deviation of State Income

To	Actual: Simple		Actual: + Noise	
From	None	Random	None	Random
90th	7.41	5.52	10.76	7.46
75th	4.78	3.09	6.92	5.19
50th	2.07	0.63	4.02	2.04
25th	-1.04	-2.31	0.72	-1.14
10th	-3.19	-4.83	-1.13	-3.11
Worse	36	29	40	6
Share	70.24	65.65	73.77	70.24

Table Notes: Panel (a) of the table reports the steady-state standard deviation of the funds rate, aggregate income, and price level under actual and naive policies. The first column uses only the estimated policy rule while the second column adds the variance of innovations to this rule. The third column is a policy of smoothing volatiilty in the funds rate while the fourth column is a policy of changing the funds rate randomly with standard deviation equal to that implied by the actual rule without noise. Panel (b) describes the percentiles of the percentage change in steady-state standard deviation in state income created by a change in policy. The first two columns describe a shift from each naive policy to the actual rule without innovations, while the latter two columns describe a shift to the actual rule with estimated noise. The bottom panel describes the number of states that actually have increased volatility in response to such a policy shift and the share that these states have in aggregate income.

Table 4.6: Optimal Performance of the Full Economy with Better Weighting Matrix

	Optimal (weight on income)							Actual
	0	10	25	50	75	90	100	Simple
R_f	0.74	0.73	0.82	0.99	1.37	1.20	1.26	0.69
$\ln(Y^a)$	1.05	0.96	0.91	0.89	0.88	0.88	0.88	1.03
$\ln(P)$	0.25	0.26	0.28	0.31	0.32	0.33	0.33	0.34
$\ln(Pc)$	2.00	1.93	1.92	1.95	1.99	1.99	2.01	2.09
CC	4.86	4.79	4.81	4.89	4.97	5.01	5.05	4.80

Percentages of the Percentage Change in Standard Deviation of State Income

To	0	10	25	50	75	90	100
From	Simple	Simple	Simple	Simple	Simple	Simple	Simple
90th	8.30	2.62	0.89	1.18	5.50	1.39	1.77
75th	3.34	-0.29	-2.00	-2.37	-0.70	-2.13	-1.96
50th	-1.44	-4.23	-5.33	-6.04	-5.75	-5.56	-5.45
25th	-5.40	-9.37	-10.59	-10.62	-9.32	-9.51	-9.38
10th	-9.72	-12.59	-13.81	-13.52	-12.02	-12.62	-12.30

Worse	22	13	7	6	12	8	9	36
Share	36.47	25.27	15.85	15.54	21.81	16.35	17.53	

Table Notes: The top panel of the table reports the steady-state standard deviation of the funds rate, aggregate income, and price level under actual and naive policies. The first column corresponds to a weight of 100 percent on the volatility of prices in the central bank's loss function, and this weight declines to 0 percent in the next six columns. The bottom panel describes the percentiles of the percentage change in steady-state standard deviation in state income created by a change in policy from the actual rule without noise to each of the optimal policies described in the top panel. The bottom panel describes the number of states that actually have increased volatility in response to such a policy shift and the share that these states have in aggregate income.

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