# THREE ESSAYS ON BANK BALANCE SHEETS AND DISRUPTIONS IN THE SUPPLY OF INTERMEDIATED CREDIT

by

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DISSERTATION ABSTRACT

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The following dissertation comprises three self-contained chapters that describe several mechanisms by which financial factors can impact banks' ability or willingness to supply credit. Given banks' unique position at the front lines of monetary transmission, it is important for policy makers to fully understand how the financial condition of banks can lead to changes in credit supply that can in turn impact the real economy. Intermediated credit has no reasonable substitute for many firms in the United States. This is especially true for small businesses that make significant contributions to employment and growth and often depend on relationship-based bank credit as an important source of funds.

Chapters II and III help define the role that banks play in the propagation of monetary policy. Deepening the understanding how monetary policy is transmitted through the economy is essential for both evaluating the stance of policy at a given time and assessing the timing and effect of monetary actions. Chapter II presents an empirical test of the balance sheet channel of monetary policy. According to this channel,

monetary policy actions impact the financial position of borrowers, causing banks to withdraw credit. I provide evidence that a subset of banks exhibit a balance sheet channel that can lead to significant reductions in lending to small firms. Chapter III constructs a test for a recently described channel of monetary policy known as the bank capital channel. In this chapter, I demonstrate that the sensitivity of banks' capital positions to monetary policy can be used to explain cross-sectional differences in loan growth. This study not only adds to the scarce capital channel literature but also highlights important interactions between the regulatory and stabilization functions of most modern central banks. Finally, Chapter IV develops a new "early warning" methodology that can be used to help forecast the financial health of banks, which affects their ability to extend credit. Included in the chapter is an application in which I identify some predictors of the severity of stress large banks realized during the height of the subprime mortgage crisis.

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TABLE OF CONTENTS

LIST OF FIGURES

## LIST OF TABLES

Table Page

# CHAPTER I

# INTRODUCTION

In most developed countries, financial institutions occupy a unique place in the fabric of the economy. To the extent that banks play a significant role in the allocation of private credit, bank behavior and attitudes can contain crucial information about future economic growth. Furthermore, since banks (as the proximate counterparty in Federal Reserve policy actions) are at the front lines of the monetary transmission mechanism, it is crucial to understand how banks might facilitate or frustrate the intentions of central bankers. With this in mind, the following essays present expositions of how bank balance sheets can generate potentially important changes in the supply of credit as a result of (1) changes in the stance of monetary policy or (2) severe bank-level financial distress.

At their most basic level, chapters two and three each catalogue a part of the monetary transmission mechanism. These chapters demonstrate that tighter monetary policy impacts the balance sheets of borrowers and lenders in ways that lead to a contraction of the supply of credit. Though chapters two and three catalogue different channels of monetary policy (the credit channel and the capital channel, respectively) they each clarify banks' role in the transmission of monetary policy. Furthermore, each channel seems to operate mostly through small banks. This distributional asymmetry in the transmission of monetary policy should be of concern to policy makers, particularly since the clients of large and small banks differ.

The third chapter also has implications for the interaction between the regulatory and stabilization responsibilities of the central bank. In the wake of the financial crisis, the Federal Reserve's role as a regulator has taken on an increased level of importance. For instance, a new regulatory body has been created within the Fed and the text of the Federal Reserve Act has been altered in a way that stresses the importance of the central bank's regulatory authority. This redoubled regulatory focus represents the overlap between the third and fourth chapters. The fourth chapter constructs a model of bank stress that adds to the "early warning system" literature, which focuses on constructing models of bank failure. The model described below is specifically designed to help alert regulators to financial institutions that may come under significant financial stress even when the ultimate result is not failure. As a bank regulator the Federal Reserve is, ipso facto, interested in the development of an early warning system for bank stress. Moreover, instances of severe stress among banks are associated with disruptions in credit. Since these disruptions can also be important for monetary transmission, central bankers have multiple reasons to take an interest in these models.

The rest of the dissertation is organized into three self-contained essays as follows. Chapter II presents an empirical test of the "balance sheet channel" of monetary policy. A theoretical model of the channel is constructed and results consistent with the predictions of the model are presented for a subset of banks. Chapter III outlines the more recently described "capital channel" of monetary policy and presents two tests that are consistent with its operation through small banks. Chapter IV develops a multiple indicator multiple cause model of bank stress during the 2008-2009 financial crisis. This model not only catalogues the causes of bank stress in this particular crisis but - relative to the existing early warning system literature - also expands the notion of bank distress.

Chapter V provides brief concluding remarks.

## CHAPTER II

## MONETARY POLICY AND BANK LENDING TO SMALL FIRMS

### 1. Introduction

Understanding how monetary policy is transmitted to the real economy is central to the study of macroeconomics. It has been established that the policy induced changes in the cost of capital are insufficient to explain the magnitude, timing, and composition of the economic response.[1] To reconcile this, the traditional "interest-rate view" has been augmented by theoretical and empirical evidence of a so-called credit channel of monetary policy. Models of the credit channel show that financial market imperfections amplify the effects of monetary policy via two distinct sub-channels. As described in Bernanke and Blinder (1988), the "bank lending channel" predicts a decline in the aggregate level of credit extended by banks in response to a monetary tightening. While this channel arises due to lower system-wide reserves, an additional "balance sheet channel" described by Bernanke and Gertler (1989) predicts a disruption in credit extension as a result of procyclical movement in borrowers' financial positions caused by monetary policy. With imperfect information and heterogeneous borrowers, models of

[1] See Bernanke and Gertler (1995) and Hubbard (2000) for a review.

the credit channel predict tighter credit standards that lower the share of loans extended to less credit-worthy firms.[2]

If financial intermediaries do respond to higher real interest rates with a "flight to quality" as argued by Bernanke, Gertler, and Gilchrist (1996), then this compositional shift in banks' loan portfolios is part of the monetary transmission mechanism. The primary purpose of this paper is to present evidence that uniquely identifies the balance sheet channel of monetary policy. Importantly, the method used to identify the balance sheet channel within this paper will be valid even in the presence of both the interest rate and bank lending channels. While there has been relatively strong evidence for a credit channel of monetary policy in recent years (see Mishkin, 2007 for a summary), many papers fail to differentiate between the bank lending and balance sheet hypotheses (e.g. Gertler & Gilchrist, 1994; Kashyap, Lamont, & Stein, 1994; Morgan, 1998). There is also a body of work that finds support for a specific channel, but either uses aggregate data as in Lang and Nakamura (1995) or disaggregate data specific to a single sector (Kashyap, Stein, & Wilcox, 1993; Gertler & Gilchrist, 1994; Oliner & Rudebusch, 1995). Although strong evidence is reported in the aforementioned studies, each limitation presents a disadvantage. First, making use of aggregate data precludes the identification of heterogeneity amongst financial intermediaries and/or borrowers. Secondly, employing individual sectoral data presents a sampling problem. To the extent that a single sector (usually manufacturing) is not representative of the aggregate economy, one must be cautious in making conclusions or policy decisions based on these studies.

[2] For a thorough discussion of the distinction between the balance sheet and bank lending channels see Bernanke and Gertler (1995).

In this paper, I analyze data on virtually all domestic banks to conclude that certain groups of banks exhibit a significant flight to quality in response to a monetary tightening. Using disaggregate data, Kashyap and Stein (1994) show that the composition of bank balance sheets varies significantly across different size classes of banks. In a follow-up paper Kashyap and Stein (2000) go further to show that smaller banks are most likely to behave in a manner consistent with the bank lending channel. I employ a comparable data set and examine a small-business-loan-to-total (SBL) ratio to argue that similar patterns emerge in the propagation of the balance sheet channel. In response to a shift towards tighter monetary policy, banks adjust the composition of their loan portfolios away from small, high-agency-cost borrowers.[3] According to the U.S. Small Business Administration, small businesses employ half of all private sector employees and account for more than half of all private sector output. For this reason, distributional effects of monetary policy manifested in the balance sheet channel are of interest to a host of policy makers, including elected representatives, the U.S. Small Business Administration, and the Federal Reserve.

The remainder of this paper is organized as follows. Section II describes a model motivating a method by which a balance sheet channel may operate alongside an interest rate channel. The strategy used to identify the balance sheet channel is outlined in Section III. Section IV outlines the data used, presents the estimated model, and describes the econometric method employed. Section V contains the results of the estimation, and Section VI concludes.

[3] Much research exists to suggest that small, relatively young firms are likely to have higher agency costs. See, for example Gertler and Gilchrist (1993, 1994) and the references therein. In particular, Hyytinen and Pajarinen (2008) provide evidence that firm age may be a better proxy for measuring agency costs. Since I do not observe borrower age, I identify the balance sheet channel by using borrower size.

## 2. Theory

The balance sheet channel of monetary policy has two requirements. First, monetary policy actions must affect market interest rates.[4] Second, any increase in interest rates must impact the financial positions of borrowers. There are several means by which interest rates may impact firms' balance sheets and income statements. The most obvious way in which rising interest rates can impact a firm's balance sheet is through its financing structure. To the extent that firms are at all reliant on short-term debt (or floating rate debt of longer maturity), higher interest rates reduce net cash flows. Lower profits reduce the net worth of firms relative to an environment with no interest rate shocks. Additionally, since higher interest rates are linked to lower asset prices, higher interest rates will shrink the value of debtor collateral.[5]

If these firm-level responses to monetary policy lead to a reduced access to credit, firms will respond by scaling back production and factor inputs. Before turning to the issue of which firms may find their access to credit markets impaired, I will first motivate the credit channel by presenting a theory that relates higher interest rates to firms' net worth and collateral.

Following the simplifications to Kiyotaki and Moore's (1997) model presented in Bernanke, Gertler, and Gilchrist (1996), suppose entrepreneurs use inputs in period 0 to

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[4] Since many firms use short-term debt to finance their working capital, we only require that Federal Reserve actions impact short-term interest rates.

[5] See Bernanke and Gertler (1995) for a further, "indirect" impact of monetary policy on net cash flows. While this additional impact on downstream customers is likely a significant driver of firm profits it is not important for the model presented here.

produce output of a final good in period 1. There is a single final good, but required inputs are of two types: a fixed factor of production $K$ and a variable factor $v_1$. In period 1, output is produced with the production function $a_1 f(v_1)$ where $a_1$ is some technology parameter and $f(\bullet)$ satisfies the Inada conditions. At this point the fixed factor may be sold for a unit price of $p_1$ and the variable factor of production depreciates fully in use.

Each entrepreneur inherits a cash balance of $a_0 f(v_0)$ and a liability of $r_0 b_0$ from borrowing in previous periods. The entrepreneur completes period 0 by choosing $v_1$ and $b_1$ to maximize net output. Thus, the entrepreneur's maximization problem is:

$$\max_{v_1, b_1} a_1 f(v_1) - (r_1 b_1) \tag{2.1}$$

$$\text{s.t. } v_1 = a_0 f(v_0) + b_1 - r_0 b_0 \tag{2.2}$$

where the price of the variable input has been normalized to one and $r_1$ is the real interest rate applied to borrowed funds that will be paid back in period 1 ($b_1$). Equation (2.2) simply states that the amount of variable input purchased will be equal to the cash flow available to the entrepreneur net of interest payments. The credit constrained entrepreneur then faces the familiar first order condition relating marginal revenues to marginal costs:

$$a_1 f'(v_1) \geq r_1 \tag{2.3}$$

Next, imagine a role for finance similar to that in Bernanke, Gertler, and Gilchrist (1996). If it is costly for a lender to confiscate output of the final good in the event of default, the lender would require that the (easily transferable) fixed factor be posted as collateral for a loan. In this situation the lender will ensure that outstanding debt never exceeds the value of the collateral.[6] This then puts a ceiling on the amount of $b_1$ equal to the market value of the fixed factor in period 1. That is:

$$r_1 b_1 \leq p_1 K \tag{2.4}$$

which – when combined with the constraint (2.2) – gives:

$$v_1 \leq a_0 f(v_0) + \frac{p_1 K}{r_1} - r_0 b_0 \tag{2.5}$$

Equation (2.5) relates an entrepreneur's investment spending to his net worth in period 0. If total net worth is less than the unconstrained value of investment from (2.2), then (2.5) will bind and the entrepreneur will purchase a sub-optimal value of $v_1$.

This model demonstrates the mechanism by which the balance sheet channel should work. If interest rates rise and (2.5) binds, then a borrower will be forced to reduce spending on the input which leads to lower production. In this case, the production effect may be driven by two mechanisms which may operate simultaneously. First, the present value of the fixed (collateralizable) asset decreases in the interest rate. Second, the firm may experience higher financing costs, lowering net cash flow.[7] Both

[6] If this were not the case, the defaulted borrower would have the leverage to re-negotiate a smaller loan with his creditors. See Kiyotaki and Moore (1997).

[7] That is, $r_0 b_0$ could increase if the firm has short term debt it must roll over, or if a portion of the firm's interest obligations are not fixed rate.

of these effects reduce the entrepreneur's net worth and drive the balance sheet channel described above.[8]

**3. Identification**

In order to investigate patterns in the extension of credit to high-agency-cost borrowers, I construct small-business-loan-to-total SBL ratios that measure the proportion of each bank's total commercial loan book invested in loans to small firms. The data contain information on loans to small firms classified as either commercial and industrial (C&I) loans or loans secured by a firm's property, plants, or equipment (hereafter referred to as 'real estate' loans). Using these SBL ratios as the outcome to identify a balance sheet channel is a unique feature of this study. It is in this way that I attempt to directly measure banks' loan portfolio positioning to demonstrate a mechanism by which small firms disproportionately lose access to external funds. Previous studies such as Gertler and Gilchrist (1993, 1994), Oliner and Rudebusch (1996), and Bernanke, Gertler, and Gilchrist (1996) provide evidence of the differential response of high-agency-cost (usually small) firm spending and investment decisions. However, these authors assume intermediate financial frictions that lead to their results while it is the aim of this paper to use bank balance sheets to demonstrate a manifestation of these frictions.[9]

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[8] If (2.5) does not bind, then a rise in $r_1$ leads to a higher hurdle rate for investment projects, reducing spending on $v_1$. This can be easily seen by equation (2.3) and is a manifestation of the standard interest rate channel of monetary policy.

[9] The readjustment of bank loan books described here is likely not the only manifestation of these frictions. The non-price terms of lending are other obvious examples.

Though the SBL ratios here can be viewed as the complement of Lang and Nakamura's (1995) "% safe" variable, I use disaggregate data to test the balance sheet channel on a micro level. As such, I am able to identify any distributional effects of monetary policy across both banks and borrowers. Other studies have made use of similar SBL ratios as outcome variables, but their primary purpose has been to explore the relationship between bank consolidation and its impact on credit extension.[10]

The idea that small borrowers may be more susceptible to monetary policy tightening is not a new one, and dates to Galbraith (1957) and Bach and Huizenga (1960). There are several reasons to expect that the burden of tighter credit standards should fall disproportionately on small firms and thereby generate measurable changes in real activity. First, small firms have lower collateralizable net worth (by definition), leading to greater incentive incompatibility. Secondly, unconditional survival rates are lower for small firms and bankruptcy costs are proportionately larger for small borrowers due to the fixed costs associated with monitoring and evaluation.[11] Finally, smaller firms are less diversified which increases idiosyncratic risk.

As mentioned earlier, the balance sheet channel predicts a reduction in the net supply of loans to less creditworthy borrowers. This of course leads to the question of whether an observed reduction in the *share* of loans to small firms (i.e. a fall in the SBL ratio) may instead be evidence of a shift in demand only. Fortunately, however, much evidence exists to dispute an initial fall in small firm demand for bank loans. Gertler and Gilchrist (1996) and Milne (1991) argue that small firms initially demand more loans in

[10] See Strahan and Weston (1998) and Peek and Rosengren (1998) for examples.

[11] Morgan (1992) contains many references to literature suggesting that bankruptcy costs are proportionately higher for small firms.

the face of a monetary contraction. This is due in part to the sharper decrease in sales small firms experience relative to their larger counterparts. Oliner and Rudebusch (1996) find that small firms become more dependent on internal financing for investment spending in response to a monetary contraction than do large firms. The authors take this result as an indication that small firms experience a scarcity of external financing. Large firms similarly increase their loan demand to smooth the impact of lower sales (and finance higher inventories) with more success than small companies. Gilchrist and Zakrajšek (1996) note that all firms would like to increase their borrowing to smooth the effect of declining cash flows, but only certain firms are able to access the desired funds. In fact, the disproportionately negative effect of tight money on small firm sales demonstrated by Gertler and Gilchrist (1994) would lead one to expect small firms to increase their demand for external funds by a greater amount than large firms. It seems clear that the optimal amount of inventory smoothing, labor hoarding, etc. in response to monetary tightening is not due to a different optimization strategy, but rather arises from an external financing constraint. That is, the stress placed on firms as a result of contractionary monetary policy leads small firm demand for external financing to increase by approximately as much as that of large firms, and perhaps more.

An important difference, however, is that large companies can access financial markets to satisfy some of this demand. Due to the increase in financing premiums induced by tighter monetary policy, Kashyap, Stein, and Wilcox (1993) demonstrate that the proportion of commercial paper to bank loans rises. The authors interpret this shift as a result of a contraction of reserves by the Fed, forcing some borrowers to the commercial paper market. For the purposes of identification in the current study, the important conclusion from Kashyap, et. al. is much more simplistic: large firms have been shown to access financial markets in order to satisfy some portion of their loan demand subsequent to monetary tightening.[12] Small firms, for the most part, do not have the option of tapping financial markets for needed funds and must rely almost exclusively on internal funds and intermediated credit to finance investment (Gertler & Gilchrist, 1996). The authors also show that trade credit extended to small firms actually *decreases* in response to an increase in the FFR, and is therefore not acting as a substitute for bank lending. Indeed, it appears as if the operation of the balance sheet propagation mechanism may also work through large firm management of receivables and payables. This provides yet another reason for small firm loan demand to increase relative to large firms. With fewer financing options, any withdrawal of bank credit should produce a larger economic response in small firms.

Notice that these borrower reactions – the increased demand for loans by small firms and the ability of large firms to substitute away from intermediated credit – work to raise the SBL ratio. That is, the similar increase in loan demand coupled with large firms' propensity to satisfy some portion of this in financial markets serve to *increase* the SBL ratio after a monetary contraction. As a consequence, any decrease in loan portfolio risk (represented by a fall in the SBL ratio) following an increase in the FFR can be viewed as strong evidence of the balance sheet channel of monetary policy.

Given the higher relative liquidity constraints that affect the investment decisions of small firms (Fazzari, Hubbard, & Peterson, 1998; Gilchrist, 1990) and the importance

[12] In fact, using the data described above to regress large firm C&I loan growth on controls (included in later regressions) shows an insignificant to negative change in response to tighter monetary policy. In isolation, this would cause the SBL ratio to increase.

of these small firms to the American economy (Mishkin, 2008), these shifts in bank loan portfolios can be an important source of the observed fluctuation in real activity precipitated by monetary policy. As demonstrated by Bernanke and Gertler (1995), responses of small firms tend to be so large that they can impact entire sectors even if they have a relatively low representation within those sectors. It seems likely that a decline in net new loans to small firms described above may be attributed to the types of credit market imperfections associated with theories of the balance sheet channel.

## 4. Data and Empirical Method

### *4.1. Data*

The data used here are taken from the Consolidated Report of Condition and Income (also known as the Call Reports). Detailed balance sheet and income statement data are available within these reports for all banks regulated by the Federal Reserve System, the Federal Deposit Insurance Corporation, and the Comptroller of the Currency. Though Call Reports are filed at the individual bank level, a case might be made for aggregating the data up to the holding company level (see Houston, James, & Marcus, 1997 and Ashcraft, 2007). However, analysis at the bank level is supported by the findings of Berger, Kashyap, and Scalise (1995) who show that the majority of banks are unaffiliated with a holding company. Furthermore, holding companies of all sizes tend to be dominated by a single bank. As a robustness check of the results presented below, individual banks were aggregated to the holding company level. Such an adjustment does not alter the conclusions reached below, so all tables are reported at the individual bank level.[13]

To measure each bank's exposure to less credit-worthy borrowers, observations are made annually beginning in 1993Q2 and ending in 2008Q2.[14] Several exclusion criteria are imposed to remove those banks with limited relevance or presence in the data. First, banks that file a Call Report in no more than two years are excluded. A second filter removes those bank-quarters that have missing values for either total assets or total loans. In most instances this filter removes banks that are out of business due to failure or merger (the loans of merged banks are counted on the books of the acquirer). As a robustness check, a third filter was applied to remove banks for which C&I loans comprise less than five percent of the total loan book. Since it is immaterial to the main findings, this exclusion criterion was not included in the tables presented below.

The net result of these filters is a data set that contains 129,291 bank-quarters across 10,634 individual banks. The assets for various bank size classes are summarized in Table 2.1. Panel A of Table 2.1 reports descriptive statistics for the groups as of 1993Q2. Panel B contains identical summary statistics as of 2008Q2. There are several patterns worth noting. First, the distribution of banks by total assets is highly skewed; containing many more small banks than large ones. Second, all banks – especially small ones – maintained a much higher balance of cash and securities relative to total assets in the 1993 sample than in the 2008 sample. Finally, small banks invest more of their

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[13] For further discussion on the issue of bank aggregation, see Kashyap and Stein (2000).

[14] Banks began reporting loans to small businesses in their second quarter Call Report pursuant to the Federal Deposit Insurance Corporation Improvement Act of 1991.

balance sheet in loans to small businesses. It appears that banks below the 98th percentile shifted into loans and out of cash and securities during the sample period.

Bernanke and Mihov (1998) and Christiano, Eichenbaum, and Evans (2000) provide discussions of various potential measures of monetary policy used in recent years. As mentioned, the most important driver of the balance sheet channel is the real interest rate, which should be influenced by the stance of monetary policy if prices are sticky. Since alternative measures of monetary policy mentioned above provide similar results (see Appendix A), my primary measure of monetary policy will be the real federal funds rate (FFR) as in Bernanke and Blinder (1992) and Gertler and Gilchrist (1993). Note that the sample period here skirts the common criticism of employing the FFR as a measure of monetary policy during the Volcker years.[15]

Two primary SBL ratios are calculated and used as dependent variables. Descriptive statistics for the SBL ratios are included in Panels A and B of Table 2.1. SBL1 represents small C&I loans as a percent of all C&I loans. The second SBL ratio - SBL2 - measures the ratio of small C&I and commercial real estate (CRE) loans to all C&I and CRE loans. Since all loans less than one million dollars are classified as loans to small businesses in the Call Reports I calculate a second set of SBL ratios analogous to SBL1 and SBL2 that consider only those commercial loans less than $250,000 to be small business loans. The results reported below are very similar when the alternative SBL measures are used (see Appendix A). Given the relative ease of taking delivery of collateral posted as a condition of real estate lending, one might expect real estate loans to exhibit a lesser sensitivity to monetary tightening relative to C&I loans.

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[15] See Walsh (2003) for a comprehensive review.

**Table 2.1.** Descriptive statistics for key variables by bank size (grouped by percentile ranks).

| Panel A - Bank Balance Sheet Summary Statistics by Asset Class (1993 Q2) | | | | | | |
|---|---|---|---|---|---|---|
| | < 90th | | 90th - 98th | | > 98th | |
| Number of banks | 8161 | | 580 | | 151 | |
| Mean assets (millions of 2008 $) | 115.09 | | 1,367.65 | | 20,212.32 | |
| Median assets (millions of 2008 $) | 79.99 | | 987.46 | | 9,604.50 | |
| Fraction of system wide assets | 0.20 | | 0.17 | | 0.64 | |
| *Fraction of total class assets* | | | | | | |
| Cash + Securities | 0.40 | | 0.35 | | 0.28 | |
| Total loans | 0.55 | | 0.59 | | 0.59 | |
| *Fraction of total class loans* | | | | | | |
| Small business loans | 0.17 | | 0.17 | | 0.07 | |
| Commercial real estate | 0.09 | | 0.09 | | 0.03 | |
| C & I loans | 0.08 | | 0.09 | | 0.04 | |
| Mean loans (millions of 2008 $) | 63.56 | | 807.30 | | 11,862.44 | |
| Median loans (millions of 2008 $) | 41.33 | | 579.29 | | 6,056.03 | |
| Fraction of system wide loans | 0.19 | | 0.17 | | 0.64 | |
| | < 90th | | 90th - 98th | | > 98th | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Liquidity | 0.38 | 0.16 | 0.32 | 0.15 | 0.27 | 0.13 |
| Net Interest Margin | 0.02 | 0.00 | 0.02 | 0.01 | 0.02 | 0.01 |
| SBL1 | 0.39 | 0.47 | 0.55 | 0.33 | 0.28 | 0.21 |
| SBL2 | 0.39 | 0.46 | 0.51 | 0.30 | 0.29 | 0.21 |
| SBL1 (<250K) | 0.29 | 0.37 | 0.32 | 0.24 | 0.14 | 0.14 |
| SBL2 (<250K) | 0.25 | 0.33 | 0.23 | 0.17 | 0.13 | 0.11 |

**Table 2.1.** (continued)

| Panel B - Bank Balance Sheet Summary Statistics by Asset Class (2008 Q2) | | | |
|---|---|---|---|
| | < 90th | 90th - 98th | > 98th |
| Number of banks | 5921 | 548 | 97 |
| Mean assets (millions of $) | 196.60 | 2,142.38 | 94,303.54 |
| Median assets (millions of $) | 136.29 | 1,506.74 | 25,348.66 |
| Fraction of system wide assets | 0.10 | 0.10 | 0.80 |
| *Fraction of total class assets* | | | |
| Cash + Securities | 0.23 | 0.22 | 0.19 |
| Total loans | 0.70 | 0.71 | 0.55 |
| *Fraction of total class loans* | | | |
| Small business loans | 0.24 | 0.16 | 0.06 |
| Commercial real estate | 0.15 | 0.09 | 0.03 |
| C & I loans | 0.10 | 0.07 | 0.03 |
| Mean loans (millions of $) | 138.43 | 1,522.27 | 52,243.49 |
| Median loans (millions of $) | 91.13 | 1,099.61 | 14,251.00 |
| Fraction of system wide loans | 0.12 | 0.12 | 0.75 |

| | < 90th | | 90th - 98th | | > 98th | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Liquidity | 0.20 | 0.14 | 0.18 | 0.12 | 0.15 | 0.12 |
| Net Interest Margin | 0.02 | 0.00 | 0.02 | 0.01 | 0.02 | 0.01 |
| SBL1 | 0.72 | 0.32 | 0.51 | 0.23 | 0.26 | 0.22 |
| SBL2 | 0.66 | 0.31 | 0.41 | 0.19 | 0.28 | 0.22 |
| SBL1 (<250K) | 0.43 | 0.26 | 0.25 | 0.16 | 0.14 | 0.19 |
| SBL2 (<250K) | 0.30 | 0.21 | 0.14 | 0.10 | 0.12 | 0.19 |

| Panel C - Key Bank-Invariant Covariates | | |
|---|---|---|
| | Mean | Std. Dev. |
| GDP | 2.85% | 0.62% |
| Unemployment | 5.27% | 0.74% |
| BAA - AAA Spread | 0.84% | 0.24% |
| Federal Funds Rate | 4.01% | 1.78% |
| Inflation (Core CPI) | 2.40% | 0.48% |

It should be noted that the stock of loans is observed in the Call Reports rather than the flow. Any changes in the stock of loans are then a net result of loan contracts expiring without renewal, charge-offs, and the issuance of new credit extension. Rather than measuring changes in the flow of new credit extension - which is arguably preferable - I proxy for this by using the change in the stock of loans as is common in the literature (Bernanke & Lown, 1991). On the other hand, since observations are made annually it is plausible to view the variation in the SBL ratio as a bank choice.

### *4.2. Empirical Method*

In order to estimate the effects of the FFR on the share of banks' loans to small firms as a proportion of their total loans, it is necessary to employ dynamic panel data estimation techniques. This is due to the possibility of serial correlation in the error terms. Intuitively, one would expect a regression explaining loan book composition to exhibit a moderate degree of serial correlation given the quasi-contractual nature of these assets. For instance, in response to a shock to monetary policy, Bernanke and Blinder (1992) observe a substantial delay in the expected decrease in loans on a banks' balance sheets. Though the evidence presented by the authors applies more to the bank lending channel, they argue that the reason for the substantial delay has its roots in the inherent stickiness of loans as an asset.

Recent innovations in dynamic panel data estimation have concentrated on providing optimal linear Generalized Methods of Moments (GMM) estimators while imposing relatively weak assumptions with respect to the exogeneity of the covariates.[16] The typical approach is to first-difference the equation to eliminate any permanent unobserved heterogeneity and use lagged levels of the series as instruments for any

[16] See Blundell, Bond, and Windmeijer (2000) for a review of the recent literature.

predetermined and endogenous variables as in Arellano and Bond (1991). However, Blundell and Bond (1998) show that the instruments in the Arellano-Bond estimator become weak as the autoregressive process becomes persistent. The Blundell-Bond GMM estimator makes use of additional instruments to provide significant efficiency gains.[17] Additionally, this estimator easily accommodates models with weakly exogenous covariates. Considering the serial correlation as well as the presence of weakly exogenous regressors exhibited in the model I estimate below, the Blundell-Bond estimator is preferred.

Suppressing the constant term, the dynamic panel data model to be estimated here takes the form

$$y_{it} = \sum_{j=1}^{L} \alpha_j y_{it-j} + \gamma FFR_t + \beta' x_{it} + u_{it} \qquad (2.6)$$

$$u_{it} = \eta_i + \upsilon_{it} \qquad (2.7)$$

for $i$ = 1, …, $N$ banks and $t$ = 2, …, $T$, where $\eta_i + \upsilon_{it}$ is the usual "error components" decomposition of the error term. For the data set used in this study $N$ is large, $t$ takes a maximum value of sixteen, and $\alpha_j < 1$ where $L$ is chosen to produce white noise residuals. In equation (2.6) $\gamma$ is the key coefficient and $x_{it}$ is a column vector of

[17] Specifically, the Blundell-Bond estimator uses moment conditions in which lagged differences are used as instruments for the level equation in addition to the moment conditions of lagged levels as instruments for the differenced equation.

covariates described below. The dependent variable *y* represents a measure of the proportion of total loans extended to high-agency-cost borrowers[18]

$$y_{it} = \frac{\text{total "small" loans}_{it}}{\text{total loans}_{it}} \qquad (2.8)$$

Again, the key independent variable is the real FFR since this is an appropriate measure of the stance of monetary policy over the sample period. The inflation rate used to determine the real FFR is the trailing twelve month inflation rate as measured by the core CPI. The results reported below are robust to alternate measures of inflation, such as shorter trailing averages and the median expected price change as reported in the University of Michigan's Survey of Consumers.[19] Since the real FFR increases as monetary policy tightens, a negative coefficient on this regressor is consistent with the theory of the balance sheet channel as described in the previous section. A positive coefficient, on the other hand, would imply that banks increase the portion of their loan portfolio exposed to less creditworthy (small) businesses. The latter scenario would not necessarily refute the existence of the balance sheet channel. Instead, it could be the case that the upward pressures on the SBL after a monetary tightening described in Section 3 dominate any shift in a change in banks' loan preferences.

The covariate vector $x_{it}$ is comprised of eight additional regressors. In all regressions (except as indicated in the robustness checks found in Appendix A) a time trend and a dummy variable for 2008 are included to remain consistent with the literature.

[18] For the purposes of the regressions below, a transformation of this ratio is used as the dependent variable. The results are not changed if observations at the extremes are omitted.

[19] Another measure of expected inflation constructed using the procedure in Mishkin (1981) produced similar results. See Appendix A for results produced using different measures of expected inflation.

The 2008 dummy is meant to capture the effects associated with the early stages of the credit crunch. Although Appendix A considers dropping the time trend or replacing it with time fixed effects, it should be noted that panel-level unit root tests on the dependent variable strongly indicate stationarity.[20] Other controls used to explain bank-level variation in exposure to small borrowers are compiled as follows. For a measure of bank-level liquidity, I follow Kashyap and Stein (2000) and use the ratio of securities plus federal funds sold to total assets. Cash is excluded as it largely represents required reserves and therefore does not contribute to a bank's liquid assets. It appears from Table 2.1 that bank size may influence the proportion of risky loans kept on the books. To control for this, the log of each bank's overall assets is included as an explanatory variable. As a measure of real activity, a forecast of GDP growth is used.[21] To remain consistent with the literature I also include a forecast of the unemployment rate. Both forecasts are taken from the Survey of Professional Forecasters. Since bank profits may affect the willingness of a bank to alter its risk structure – Mishkin (2007) contains a good summary – I include the net interest margin as a measure of bank profits. It may be the case, however, that banks with a larger share of loans to small firms have a higher net interest margin to compensate for risk and agency costs. The net interest margin is calculated by subtracting interest expense from interest revenue and dividing by total assets less property, plant, equipment, and intangibles.

[20] See Choi (2001) and Im, Pesaran, and Shin (2003) for descriptions of the multiple panel unit root tests employed.

[21] The results are robust to the use of trailing averages of GDP growth (at both the state and national levels).

The final component included in $x_{it}$ is a measure of the credit risk-premium. The reason to include this control is to ensure that any variation picked up by the coefficient on the FFR does not merely reflect the change in the market price of credit risk. A widely accepted measure of credit risk is the spread of the yield on Baa rated bonds above the yield on Aaa bonds. To smooth short term fluctuations, the average spread over the prior six months is used. The results below are not altered significantly by substituting either the trailing twelve month average spread or the real-time spread.[22] To avoid potential endogeneity issues I follow the literature and lag all bank-specific covariates. Summary statistics for these variables can be found in Table 2.1 Panels A, B, and C.

Lastly, it is natural to raise the question of whether there may be disparate effects of the balance sheet channel across banks of different sizes. It is unclear whether one should expect, a priori, different types of lending behavior across large and small banks. The work of Kashyap and Stein (1994, 2000) suggests that large banks are less responsive to the effects of the credit channel. However, Black and Rosen (2008) also control for loan maturities and debtor size, and obtain contradictory results that are consistent with the model presented in Stein (2002). In Stein's model, large banks have a greater sensitivity to the balance sheet channel (compared to small banks) as a result of relatively higher information gathering costs. In light of this unresolved debate, the sample of banks in this analysis will be divided into size classes based on percentile ranks of total assets in each year. Given the skewness of the size distribution, I assign each bank to one of three groups. The *small* group contains all banks below the 90$^{th}$

[22] The argument can be made that the Baa-Aaa spread is endogenous. The Appendix contains results under an alternative specification that relaxes the strict exogeneity of this variable.

percentile, while the *medium* group consists of banks between the 90th and 98th percentiles. *Large* banks will be defined as those above the 98th percentile. All regressions in Section 5 are reported at the system-wide and group levels.[23]

**5. Results**

The results - presented in Table 2.2 - are very similar for both SBL ratios, so I limit the discussion here to SBL1 (C&I loans only).[24] Several points regarding the last column of Table 2.2 (Panel A) are worth noting. The first concerns the sign and significance of the coefficient on the real federal funds rate. Recall that this is the key independent variable as it best captures systematic changes in the stance of monetary policy. The negative sign on this coefficient for the entire banking system indicates that increases in the real effective federal funds rate induces banks on the whole to shift their C&I loan book away from smaller firms. For all banks, a coefficient of -0.229 on a log-odds transformation of the dependent variable is economically meaningful. A change of just twenty-five basis points in the real FFR implies that loans to small firms as a percent of banks' commercial loan books falls by approximately four percent over the course of a year, all else equal. In dollar terms, that would imply a nearly $16 billion reduction in small C&I credit (as of Q2 2008). Since the results are driven by a subset of banks, it is instructive to estimate the impact based on the -0.291 coefficient associated with the smallest ninety percent of banks. For these banks, an increase of twenty-five basis points

[23] See Appendix B for a discussion of more formally derived size class divisions.

[24] The reported results are for *L* (the number of lags of the dependent variable) equal to one since additional autoregressive terms do not change the primary findings reported here.

in the real FFR leads to an annual drop in C&I credit of approximately $5.5 billion, or seven percent of 2008 small bank C&I credit to small firms. Similarly, taking into account the autoregressive parameter implies a "total" (two-year) effect of $10 billion or nearly thirteen percent. Welch tests on the FFR coefficients easily reject the null hypothesis of equality across each size group.

**Table 2.2.** Baseline estimation of equation (2.6). Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. The coefficients on the trend term, as well as the 2008 dummy are suppressed.

| Panel A - Dependent Variable: SBL1 (Share of C&I Loans to Small Firms) | | | | |
|---|---|---|---|---|
| Coefficient | < 90th percentile | 90th - 98th percentile | > 98th percentile | All Banks |
| FFR | **-0.291** | **0.073** | -0.117 | **-0.229** |
| | *0.000* | *0.069* | *0.552* | *0.001* |
| GDP growth | **0.667** | 0.039 | 0.238 | **0.537** |
| | *0.000* | *0.596* | *0.335* | *0.000* |
| Unemployment | **-0.439** | 0.179 | -0.418 | **-0.350** |
| | *0.002* | *0.102* | *0.163* | *0.005* |
| Liquidity | **-12.2** | 0.694 | 7.26 | **-11.7** |
| | *0.000* | *0.600* | *0.118* | *0.000* |
| Baa-Aaa | **0.867** | 0.115 | 0.450 | **0.789** |
| | *0.001* | *0.446* | *0.329* | *0.001* |
| ln(Assets) | **-2.37** | **-0.722** | -0.430 | **-2.00** |
| | *0.000* | *0.000* | *0.181* | *0.000* |
| Net Interest Margin | **4.36** | -0.448 | 0.689 | **3.18** |
| | *0.001* | *0.495* | *0.334* | *0.005* |
| AR(1) | **0.471** | **0.223** | 0.183 | **0.468** |
| | *0.000* | *0.000* | *0.114* | *0.000* |
| Observations | 95299 | 7996 | 1724 | 105019 |
| Wald Statistic | 4296.25 | 214.05 | 17.58 | 4334.51 |
| Banks | 9720 | 1308 | 254 | 10484 |
| $FFR_{Tight}$ | **-0.326** | 0.068 | -0.163 | **-0.262** |
| | *0.000* | *0.134* | *0.489* | *0.000* |
| $FFR_{Easy}$ | **-0.394** | 0.058 | -0.234 | **-0.327** |
| | *0.001* | *0.457* | *0.444* | *0.002* |

**Table 2.2.** (continued)

| Panel B - Dependent Variable: SBL2 (Share of C&I and CRE Loans to Small Firms) | | | | |
|---|---|---|---|---|
| Coefficient | < 90th percentile | 90th - 98th percentile | > 98th percentile | All Banks |
| FFR | **-0.289** | -0.014 | -0.150 | **-0.237** |
| | *0.000* | *0.650* | *0.334* | *0.000* |
| GDP growth | **0.564** | 0.009 | 0.018 | **0.418** |
| | *0.000* | *0.853* | *0.919* | *0.001* |
| Unemployment | **-0.440** | 0.013 | **-0.448** | **-0.363** |
| | *0.001* | *0.875* | *0.100* | *0.002* |
| Liquidity | **-8.59** | 0.836 | 8.57 | **-8.48** |
| | *0.000* | *0.441* | *0.227* | *0.000* |
| Baa-Aaa | **0.786** | 0.018 | 0.554 | **0.669** |
| | *0.002* | *0.880* | *0.236* | *0.004* |
| ln(Assets) | **-1.85** | **-0.304** | **-0.694** | **-1.53** |
| | *0.000* | *0.043* | *0.013* | *0.000* |
| Net Interest Margin | **4.68** | 0.985 | -0.018 | 3.29 |
| | *0.000* | *0.271* | *0.980* | *0.001* |
| AR(1) | **0.471** | **0.215** | 0.156 | **0.469** |
| | *0.000* | *0.000* | *0.165* | *0.000* |
| Observations | 97388 | 8187 | 1768 | 107343 |
| Wald Statistic | 4216.17 | 253.79 | 13.78 | 4266.73 |
| Banks | 9851 | 1331 | 260 | 10619 |
| $FFR_{Tight}$ | **-0.312** | -0.012 | -0.207 | **-0.254** |
| | *0.000* | *0.738* | *0.263* | *0.000* |
| $FFR_{Easy}$ | **-0.358** | -0.005 | -0.301 | **-0.287** |
| | *0.001* | *0.938* | *0.213* | *0.003* |

It is also interesting to investigate whether the balance sheet channel exhibits asymmetry across different types of monetary actions. To accomplish this, I interact the measure of monetary policy with dummies indicating whether monetary policy has tightened or eased over the prior year. Though the time dimension is relatively short - ten of the years saw tighter monetary policy while six saw easing - the results of these terms substituted into the regression are reported at the bottom of each panel of Table 2.2. The point estimates (which were estimated without restrictions) are larger and estimated more precisely for periods of tight monetary policy. For all cases in which the estimates of either $FFR_{Tight}$ or $FFR_{Easy}$ are statistically significant, I can reject the hypothesis that the balance sheet effect observed here is the same across different policy stances at the 5% level. Of course, this result cannot be considered conclusive given the relatively short time series used.[25]

The second feature of Table 2.2 that deserves mention is the measures of real activity. The coefficients on forecasts of both GDP and the unemployment rate indicate loans to small firms are procyclical. The positive sign on GDP growth and the negative relationship with the unemployment rate are consistent with priors regarding banks' willingness to take on risk in a worsening macroeconomic environment. Robustness checks uphold this conclusion, but occasionally only one measure of real activity maintains a standard level of statistical significance. This result supports the notion that banks are forward looking when making loans.

In regards to bank liquidity, the negative relationship between liquidity and the portion of loans extended to risky borrowers may be a reflection of bank managers' general risk aversion. Of course, more information on the terms of the loans would be needed to make a convincing case that these patterns are in fact a manifestation of risk aversion. Furthermore, the results for liquidity are not particularly robust. The negative coefficient on bank size indicates that the relationship between loans to small businesses and bank size exhibited in Table 2.1 persists within size classes.

[25] The question of whether the balance sheet channel exhibits asymmetries across the business cycle is taken up in Appendix C.

Finally, the coefficient on the net interest margin has a positive influence on investment in small firm loans. It is conceivable that this represents a means by which the balance sheet channel may manifest itself through banks' balance sheets. According to the theory of the balance sheet channel, monetary policy's influence on net cash flow can worsen balance sheets and hinder access to credit. It appears that a bank's willingness to invest in loans to small firms depends not only on the borrower's balance sheet, but also on the bank's own cash flow. This fact, in conjunction with the fact that the smallest banks are driving the results, leads to the possibility that the effect found here can be driven by balance sheet channel effects working on the banks themselves in addition to borrowers. The impact of monetary policy on bank balance sheets and this potential for knock-on effects is an area for future research.

To help shed some light on the question, however, I consider an alternate division of the sample of banks by importance of small business lending to total lending. A priori, one might expect that banks heavily invested in loans to small businesses would exhibit a higher sensitivity to monetary tightening since they stand to lose proportionately more. Table 2.3 reports the FFR coefficient for those banks that have the highest SBL (top quartile) and lowest SBL (bottom quartile) along with median 2008 assets. The top quartile of banks by SBL ratio consists of very small banks, as suggested by Table 2.1. On the other hand, median assets for banks in the bottom SBL quartile are (as of 2008) less than $260 million. Even though many banks in this quartile are very small they do not exhibit the balance sheet channel effect observed in the top quartile. This result therefore suggests that the dominant effect is a balance sheet effect working on borrowers rather than lenders.

**Table 2.3.** Baseline estimation of equation (2.6) with banks sorted according to their proportion of assets invested in C&I loans (SBL1) and C&I plus CRE loans (SBL2). Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. All coefficient estimates are suppressed except for that of the Federal Funds Rate. Median assets are measured in millions of 2008 dollars.

| Groupings based on importance of small business lending | | | | |
|---|---|---|---|---|
| | Dependent Variable: SBL1 | | Dependent Variable: SBL2 | |
| Coefficient | Top Quartile | Bottom Quartile | Top Quartile | Bottom Quartile |
| FFR | **-0.989** | -0.144 | **-1.420** | 0.060 |
| | *0.000* | *0.278* | *0.000* | *0.639* |
| Median assets | 74.9 | 255.4 | 84.8 | 207.8 |
| Observations | 23699 | 27285 | 25797 | 27326.00 |
| Wald Statistic | 2646.71 | 1170.66 | 3089.53 | 1015.21 |
| Banks | 6837 | 5867 | 6728 | 5925 |

**6. Conclusions**

The existence of channels for monetary policy operating beyond the interest-rate channel has been reasonably well documented in recent years. Although the credit channel has been singled out as an additional transmission mechanism, the means by which it operates have been more difficult to determine. The evidence presented here suggests that a balance sheet channel of monetary policy is in operation and has an economically significant impact. Furthermore, the operation of this mechanism is shown irrespective of whether a bank lending channel operates simultaneously. This differentiation is in contrast to previous studies that find support for a credit channel but fail to differentiate between the bank lending and balance sheet hypotheses. The present paper also casts a wider net than studies that focus analysis on relatively small samples of banks or borrowers from narrowly defined sectors.

This study provides support for the existence of a balance sheet channel that works through many different banks' loan books. Specifically, the smallest ninety percent of banks appear to shift their loan portfolios away from small firms in response to tighter monetary policy. Small banks are a major source of credit for small businesses and, as these results show, monetary policy has a substantial impact on the willingness of small banks to extend this credit. With respect to the impact on the business cycle, the results for the C&I loans in particular are very compelling since C&I loans are used to carry inventories and finance investment. These findings demonstrate a manifestation of the types of financial frictions that are assumed by previous studies to generate asymmetry in firm spending/investment decisions after a monetary tightening. Thus, by demonstrating banks' movement out of loans to small businesses in response to monetary tightening, this paper adds to the growing catalogue of empirical research on monetary transmission.

## CHAPTER III

## NEW EVIDENCE ON THE BANK CAPITAL CHANNEL OF MONETARY POLICY

### 1. Introduction

Over the last thirty years, the regulation of financial institutions has become an increasingly active subject of academic and policy research in the United States. After the 1970s a combination of declining bank capital, macroeconomic weakness, and a higher incidence of bank failures triggered a regulatory response that featured explicit capital adequacy standards. In the years since, capital adequacy has been an important consideration - if not the centerpiece - of major regulations affecting financial intermediaries.[26] The recent financial crisis has underscored the importance of prudential regulation and sparked renewed interest in the regulation of financial intermediaries. In a striking example of the regulatory response to the crisis, the 111th Congress of the United States passed the Dodd-Frank Wall Street Reform and Consumer Protection Act that requires the Presidential appointment of a "Vice Chairman for Supervision" to serve on the Federal Reserve Board of Governors. In addition, the Dodd-Frank Act amends the Federal Reserve Act to explicitly ensure that, "The Board of Governors may not delegate . . . its functions for the establishment of policies for the supervision and regulation of . . . financial firms." This type of legislation serves to strengthen the link between the

[26] See Wall and Peterson (1996) for a good summary of major changes to capital regulations through the publication date.

regulatory and stabilization functions of the Federal Reserve. One goal of this study is to investigate this link between the Federal Reserve's dual responsibilities of monetary policy and prudential regulation.

The implications for the monetary/regulatory link presented here, however, are a consequence of the primary goal of this paper: to further define the role of banks in the transmission of monetary policy. Recently, the credit channel view has been developed and tested to show that the role of financial frictions in the transmission of monetary policy to the real economy is nontrivial (Bernanke & Blinder, 1988; Bernanke, Gertler, & Gilchrist, 1996). Conspicuously absent from the recent work in theories of monetary transmission, though, is an explicit role for bank equity (Van den Heuvel, 2009; Friedman, 1991). This paper focuses on empirically demonstrating a recently described transmission mechanism known as the bank capital channel, which depends critically on bank equity.[27] Van den Heuvel (2009) constructs a dynamic model in which bank lending decisions are influenced by their current and expected capital positions. If a monetary tightening adversely impacts banks' capital adequacy, this might lead to a reduction in credit extension. Since there is no explicit role for bank deposits in the model, this transmission mechanism falls outside of the more familiar bank lending channel.

By examining the uneven distribution of monetary policy actions, this paper builds on previous explorations of the link between banks, capital, and the real economy which began in earnest during the 1990-91 recession. The Federal Reserve's dual role as a monetary authority and banking regulator necessitates a keen interest in these studies.

[27] I will use the terms *equity* and *capital* interchangeably except where explicitly noted.

Indeed, much of the early work in this area was produced by the Federal Reserve's staff.[28] In an early exposition of the role of capital in the 1990-91 recession, Syron (1991) characterizes the apparent decrease in the supply of bank credit during the 1990-91 recession as a "capital crunch." In his view, the reduction in the supply of credit was a uniquely capital issue. As evidence for this, he points to the unusual reduction of dividends as well as the outsized capital losses in the Northeast region (which experienced especially tight credit standards). Bernanke and Lown (1991) perform more rigorous tests of this hypothesis and find support for Syron's capital crunch. Unlike Syron, however, Bernanke and Lown entertain – and find support for – the idea that changes in bank regulation may have contributed to the capital crunch. Separately, Furlong (1992) finds that bank leverage ratios predict loan growth when controlling for other supply and demand factors. These findings – in conjunction with anecdotal reports – marked the beginning of an empirical literature that examines the link between the credit crunch of the 1990-91 recession and the risk-based capital requirements implemented by the Basel Accord.[29]

Shrieves and Dahl (1995) provide evidence that capital considerations and changing regulatory conditions were responsible for the lending slowdown that occurred during the implementation of the Basel Accord. Thakor (1996) finds that borrowers see abnormal increases in their stock prices if they are able to secure a loan from a bank subject to risk based capital requirements. This positive reaction is even greater if the bank is more capital constrained, which is consistent with the notion that capital

[28] See, for instance, Syron (1991), Furlong (1992), Baer and McElravey (1993), and Wall and Peterson (1996).

[29] Both the senior loan officer survey (Dec 1989) and the American Bankers Association survey (Jan 1992) contain anecdotal evidence of a change in bank behavior in response to Basel.

considerations can play an important role in credit extension. Other studies such as Peek and Rosengren (1995) and Baer and McElravey (1993) present evidence consistent with a capital crunch following the implementation of capital adequacy requirements. Alternatively, Berger and Udell (1994) find evidence that capital plays a part in bank behavior, but downplay the role of new capital regulations.

These studies do not, however, test how monetary policy affects bank loan growth for a given capital position. For the purposes of the present study though, this body of literature studying the link between changing regulatory conditions and bank asset management is important for several reasons. First, a significant amount of evidence is provided to support the hypothesis that bank behavior changes in response to fluctuations in capital and capital adequacy. Specifically, it appears that low levels of capital adequacy may be associated with a reduction in the supply of credit. As suggested by the capital channel, the link between bank equity and the real economy may thus be an important one. Secondly, the studies detail the significant changes in regulatory capital requirements during the 1980s and early 1990s.[30] Since it appears that the impact of bank capital may have been changing dramatically with the regulatory requirements, the empirics presented here will focus on the period following the announcement of the Basel I Accord and the FDICIA. Finally, this literature draws a distinction between lending effects generated by capital and those generated by a drawdown of deposits as in the bank lending channel. In this way, this strand of literature lays the foundation for a channel of monetary transmission that works through bank balance sheets alongside the credit channel.

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[30] For a summary of regulatory changes see Baer and McElravey (1993) and Wall and Peterson (1996).

While the effects of capital on lending may be debated in a regulatory environment that lacks capital adequacy standards, the theory linking lending and capital in the presence of capital regulations is stronger. In the extreme case, a bank facing a binding capital requirement would be prohibited from expanding assets and/or loans if it cannot easily issue equity. Additionally, risk-based capital requirements (such as those established in the Basel Accord) effectively act as a tax that is larger on assets carrying higher risk weights. Banks would be expected to substitute out of risky assets (such as commercial loans) and into safer assets with low risk weights. Essentially, risk weighted capital standards restrict lending in a similar way to some restrictive covenants in debt contracts.

In Van den Heuvel (2009), the author constructs a dynamic model that incorporates risk-based capital requirements and an imperfect market for bank equity.[31] The former assumption is manifested in regulations such as the Basel accord, while the latter is supported by a lemons premium generated by asymmetric information (Stein, 1998). Empirically, Asquith and Mullins (1986) find that issuing new equity results in a sizable dilution of current equity. The large cost associated with raising equity therefore limits a bank's ability and willingness to augment its capital via share offerings. Furthermore, companies are much more reluctant to cut dividends than to increase them.

As a result of the aforementioned assumptions, the model shows that it may be optimal for a low-capital bank to forego profitable lending opportunities even if capital regulations are not momentarily binding. The reason for this is that banks wish to lower

[31] Although I summarize the model here and below, I refer the reader to Van den Heuvel (2009) for the formal presentation. Additional features and implications of the model will be mentioned as warranted throughout the paper.

the potential for current and/or future regulatory violations. Thus, any negative shock to a bank's current or expected future capital position could lead to tighter credit. It is this aspect of the model in which capital enters as a transmission mechanism of monetary policy. A monetary tightening raises short-term interest rates that – along with the asset transformation service performed by banks – leads to lower retained earnings and, thus, capital. This impact of monetary policy on bank loans works through bank equity and is therefore referred to by Van den Heuvel (2002a, 2009) as "the bank capital channel." In a sense, the bank capital channel can be thought of as a shift in the supply of credit resulting from the balance sheet channel (Bernanke & Gertler, 1995) working on lenders subject to capital adequacy regulations.[32]

Despite the demonstrated importance of bank capital, empirical tests of the capital channel have been scarce. Among the studies that have been conducted, Van den Heuvel (2002b) uses state-level data to show that output growth in states with poorly capitalized banks is more sensitive to changes in monetary policy. After controlling for the bank lending channel by including measures of bank liquidity, this evidence is consistent with a bank capital channel for monetary policy. In a subsequent paper, Van den Heuvel (2007) uses bank-level data to obtain a similar conclusion. Hubbard, Kuttner, and Palia (2002) use a matched sample of lenders and borrowers to show that banks with low capital appear to reduce loan supply disproportionately during monetary contractions - a result consistent with the capital channel. It is worth emphasizing, however, that the bank lending channel (in conjunction with a failure of the Modigliani-Miller theorem)

[32] I should note that the model detailed in Van den Heuvel (2009) implies that *any* negative profit shock – not just one brought on by a monetary tightening – should have detrimental effects on loan supply for those banks concerned about their current or future capital position.

also predicts that poorly capitalized banks will exhibit increased lending sensitivity in response to monetary tightening. This result arises as banks attempt to raise funds to offset a fall in reserves induced by the monetary authority. Those banks with higher levels of capital will be faced with lower asymmetric information costs when attempting to issue, for instance, large denomination time deposits. This effect somewhat equivocates the findings in several of the papers mentioned above.

Kishan and Opiela (2000, 2006) present evidence that the strength of a bank's lending response to monetary policy varies inversely with capital adequacy. Although the authors interpret their findings in the context of the bank lending channel, the results are consistent with the implications of the capital channel. These studies help to illuminate the connection between regulatory and monetary responsibilities highlighted in this paper. Finally, Gambacorta and Mistrulli (2004) use an empirical strategy similar to Kashyap and Stein (1995) to find that the lending response of Italian banks to monetary policy depends critically on capital adequacy considerations in a manner consistent with the capital channel. Importantly, the authors cleverly control for the dependence of the bank lending channel on banks' capital position described above.

This paper contributes to the aforementioned literature in several ways. First, I estimate the loan supply using disaggregate data rather than simple aggregates. Besides serving to deepen the identification strategies, bank-level data are more useful for identifying the types of banks important to the operation of the capital channel. Second, as formulated in Van den Heuvel (2009), the model predicting a capital channel has several implications. By presenting results consistent with two separate implications of the capital channel, I am able to limit the interpretation of the findings. Third, I attempt to adequately control for credit channel effects that might otherwise obfuscate the interpretation of the results. Fourth, I discuss the likely impact of several recent regulatory proposals on the operation of the capital channel. Finally, Gambacorta and Mistrulli (2004) point out that the link between bank capital and risk taking behavior (including lending decisions) is still controversial. This paper provides evidence to help clarify this debate by reporting results consistent with a capital channel - a potential monetary transmission mechanism which has remained largely unexplored.

The remainder of the paper proceeds as follows. Section 2 describes the primary data used throughout the paper. Section 3 discusses empirical tests constructed to identify the capital channel and presents results. Section 4 presents several policy considerations and concludes.

## 2. Data

The primary data used in this study are taken from the Report of Condition and Income data collected by the FFIEC. These data (also known as the Call Reports) are sampled on a yearly basis for all individual banks regulated by the Federal Reserve System, Federal Deposit Insurance Corporation, and the Comptroller of the Currency. Given the significant changes in prudential regulation in the 1980s, obtaining a currently meaningful relationship between lending and capital should focus on the period after the announcement of significant legislation impacting this relationship. I follow Kishan and Opiela (2006) and begin my sample in the third quarter of 1990, a date by which all parts of both the FDICIA and Basel Accord were either announced or enacted. Using this start date excludes years in which capital regulations and their enforcement were in a state of flux while also including the variation associated with 1990-91 recession.

Several criteria are used to remove banks with limited presence or relevance in the data. First, bank-quarters are dropped if the institution reports no assets, equity, or loans. Secondly, any institution reporting for less than two years is dropped along with any institution that does not report continuously between the time it enters and exits the sample. Finally, all Edge Act corporations are excluded from the sample. Applying these filters to Call Reports between 1990Q3 and 2008Q3 yields a panel of 190,181 bank years. Dropping bank years containing a merger (as in Kashyap & Stein, 2000) has a negligible effect on the results reported in Section 3, so these observations are included.

Summary statistics for the beginning and end of the sample are reported in Table 3.1.[33] Given the potential for capital effects to differ across size classes (Bernanke & Lown, 1991; Kishan & Opiela, 2000, 2006; Van den Heuvel, 2007) these data are summarized by size groups. Several patterns exhibited in Table 3.1 are worth mentioning. First, small banks are much more liquid than large banks. In addition, over the course of the sample, small banks tend to hold more capital per dollar of assets than large banks. Looking at changes over time, one can see that the skewness of market share (as measured by assets) has increased during the sample. Furthermore, the smallest 98% of banks have increased their investment in loans, mostly at the expense of liquid securities. Presumably, at least part of this shift is due to the increase in liquidity of loans themselves during the sample as well as the housing bubble. The housing bubble also

[33] Although the data run through 2008, statistics are reported as of 2007. The hope is to give the reader a sense of the predominant changes over the sample period without introducing noise from the financial crisis. I should also note that excluding 2008 from the sample does not materially impact the findings reported in section III.

helped crowd out C&I loans between 1990 and 2007.[34] Finally, small banks have come to finance a much larger percentage of their assets with large denomination time deposits than do large banks. This could indicate that small banks have a more difficult time raising equity, as one might expect.

It should be noted that (even with the benefit of these descriptive statistics) it is unclear a priori whether one should expect the capital channel to be more or less prominent in large banks. Large banks hold less equity, presumably because of their lower non-leverage risks such as diversification. This fact might lead to a stronger capital channel since a given shock to capital would be more likely to put large institutions in danger of facing regulatory penalties. However, as mentioned earlier, it is generally easier for large banks to issue equity (or equity substitutes like subordinated debt) when the need arises. Additionally, it is easier for large banks to hedge interest rate risk, which would further dampen any capital channel. Therefore the question of whether large or small banks experience a stronger capital channel effect is ultimately an empirical one. There is currently a conflict in the literature regarding this question. Van den Heuvel (2007) finds that the capital channel is not operative in small banks, while the results presented in Kishan and Opiela (2000, 2006) and Gambacorta and Mistrulli (2004) indicate that capital channel type effects are stronger in small banks.

[34] Indeed, the data show that real estate loans as a percent of total loans increased during the sample period by 21 percentage points for small banks, 19 for medium sized banks, and 15 points for large banks.

**Table 3.1.** Descriptive statistics for key variables by bank size (grouped by percentile ranks).

| Balance sheet characteristics by size class | | | |
|---|---|---|---|
| | < 90th percentile | 90th - 98th percentile | > 98th percentile |
| *As of 1990 Q3* | | | |
| Median Assets (Millions of 2007 $) | $65.99 | $717.65 | $7,335.67 |
| Securities / Assets | 0.29 | 0.20 | 0.14 |
| Loans / Assets | 0.56 | 0.65 | 0.64 |
| C&I Loans / Loans | 0.20 | 0.21 | 0.32 |
| Large Time Deposits / Assets | 0.11 | 0.12 | 0.11 |
| Median Capital/Assets % | 8.5% | 7.2% | 6.1% |
| % of System-wide Assets | 18.8% | 17.1% | 64.1% |
| *As of 2007 Q4* | | | |
| Median Assets (Millions of $) | $113.91 | $1,208.90 | $10,310.38 |
| Securities / Assets | 0.19 | 0.17 | 0.15 |
| Loans / Assets | 0.70 | 0.72 | 0.56 |
| C&I Loans / Loans | 0.14 | 0.17 | 0.22 |
| Large Time Deposits / Assets | 0.17 | 0.14 | 0.08 |
| Median Capital/Assets % | 10.2% | 9.5% | 10.0% |
| % of System-wide Assets | 10.5% | 8.5% | 81.0% |

## 3. Methods and Results

Before introducing the empirical tests of the capital channel, it is useful to summarize the theoretical model of Van den Heuvel (2007) in which monetary policy impacts bank lending via its influence on bank capital. In this model, banks maximize shareholder value each period by choosing the desired amount of new loans, marketable securities, and dividend payments. Each bank faces capital requirements similar to those imposed in the Basel Accord, an imperfect market for its equity, and uncertainty regarding the fraction of loans that default each period.

Finally, it is assumed that banks finance some portion of their assets with debt (including deposits) at a cost influenced by the short-term interest rate. The monetary authority's influence over the short rate - in conjunction with banks' maturity transformation function - implies that monetary policy actions influence bank profits. If banks cannot substantially lower dividends, lower profits resulting from a monetary tightening will reduce bank capital over time. Facing lower levels of equity, the bank will restrict lending because of capital requirements and the high cost of issuing new equity. Since the model is constructed in a dynamic setting, momentarily binding capital requirements are not necessary for banks to forgo profitable lending opportunities if they are concerned about the possibility of future capital adequacy violations.

Tests of the capital channel - which may operate alongside the standard interest rate channel of monetary policy - are described below in Sections 3.1a and 3.2a.

### *3.1a. Methods: "One-Step" Approach*

As a first test of the capital channel I use the framework outlined in Kashyap and Stein (2000). To form a testable hypothesis, I consider how two banks with different capital positions respond to monetary policy shocks. Suppose two banks differ only with respect to their capital adequacy. If each is faced with a contractionary monetary shock, both banks' asset transformation business will be less profitable as net interest margins are compressed. Each bank will then realize lower retained earnings and capital vis-à-vis a state with no short-term rate increase. Since they are both subject to capital adequacy regulations and consequences of violation, the bank with the lower capital position has more reason to be concerned about a current and/or future regulatory violation. Therefore, the managers of a bank in a worse capital position would be more likely to shrink their loan portfolio (or grow it less quickly) in response to a monetary policy shock.

The testable implication is $\delta^2 L_{it} / \delta C_{it} \delta MP_t > 0,$ where *L* is a bank-level measure of lending activity, *C* is the bank-level capital-asset ratio, and MP is a measure of monetary policy measured such that higher values are associated with tighter policy. The cross-sectional derivative $\delta L_{it} / \delta C_{it}$ captures the degree to which lending is capital constrained at any time *t*. The hypothesis is that this constraint is intensified during monetary contractions. Alternatively, taking the time series derivative first it is hypothesized that $\delta L_{it} / \delta MP_t$ - the sensitivity of lending volume to monetary policy for bank *i* - is greater for banks with a weaker capital position. That is, loan growth following a monetary contraction should fall by more as capital decreases.

Of course, other channels of monetary policy can be influenced by capital as well. Specifically, the strength of the bank lending channel (BLC) should depend on capital. Since an economically meaningful BLC hinges on banks' inability to raise non-reservable liabilities as reserves are withdrawn, the BLC depends on banks' access to funding markets. Banks that are less leveraged (i.e. those with a higher capital asset ratio) should be able to replace the lost deposits more easily. As such, banks with more capital should experience a smaller BLC *as well as* a smaller capital channel. This observation highlights the necessity for a good control for the BLC. Any coefficient on capital in a regression excluding a BLC control variable will produce dubious results due to omitted variable bias. Adding a good control for the BLC is required to avoid this alternate interpretation.

With this in mind, I test the hypothesis above using a regression analogous to Kashyap and Stein's (2000) "One-Step" approach:

$$\begin{aligned}\Delta\log(L_{it}) = \mu_i + \alpha\Delta\log(L_{it-1}) + \beta\Delta MP_t + C_{it-1}\left[\gamma + \delta\Delta MP_t\right] + \\ \Delta\log(D_{it-1})\left[\eta + \lambda\Delta MP_t\right] + \Gamma\Phi_{it} + \varepsilon_{it}\end{aligned} \tag{3.1}$$

with $i$ = 1, . . ., $N$ ($N$ = number of banks) and $t$ = 1, . . ., $T$ ($t$ = year) and where:

$L_{it}$ commercial and industrial (C&I) loans of bank $i$ in year $t$,

$MP_t$ monetary policy indicator,

$C_{it-1}$ capital-asset ratio of bank $i$,

$D_{it-1}$ measure of bank deposits,

$\Phi_{it}$ control variables.

When measuring the response of lending to monetary policy, it is not uncommon to focus on C&I loans. This is because C&I lending is often uncollateralized and of relatively short maturity. Furthermore, under risk-based-capital regulatory regimes C&I loans carry a high risk-weight. These features make C&I loans likely to be more responsive to monetary policy changes than other types of loans. To measure monetary policy, I use the Bernanke-Mihov (1998) indicator multiplied by negative one so that a positive change indicates tighter policy.

The primary indicator of capital adequacy, $C_{it-1}$, is a standard leverage ratio defined as the ratio of bank capital to assets normalized by the mean over the entire sample. This measure is preferred for several reasons. First, it explicitly appears in capital regulations in the United States and is used by regulators to help determine the degree of a bank's capital adequacy. Second, as Shrieves and Dahl (1995) note, it appears that the leverage ratio (vis-à-vis other capital adequacy measures) is the primary driver of bank behavior. Finally, Estrella, Park, and Peristiani (2000) report that simple leverage ratios are as good as Basel-style risk-weighted capital ratios in predicting short run failure. $D_{it-1}$ measures bank level demand deposits. Note that - as is common practice - all bank-specific controls are lagged one period to avoid endogeneity issues.

The set of control variables $\Phi_{it}$ includes real GDP growth and CPI-based inflation to help capture cyclical movements and loan demand effects. Also included in the set of controls is a measure of bank liquidity, defined as securities plus federal funds sold to total assets, and an indicator of bank size given by the log of total assets. The size control is normalized with respect to the mean in each year as in Gambacorta and Mistrulli (2004) to remove trends in size. Finally, the liquidity indicator is normalized by the mean over the entire sample. Additional controls include a financial crisis dummy and a dummy indicating whether or not a bank is critically undercapitalized.

To reiterate, I choose to use annual data to estimate (3.1). The reasons for doing so are similar to those discussed in Ashcraft (2006). Equation (3.1) is estimated using the GMM estimator suggested by Arellano and Bond (1991) which is preferred given this dynamic panel. This method ensures efficiency and consistency provided that the model is not subject to serial correlation of order two or higher and that the instruments used are valid. Furthermore, with the sample period used here, computational memory limitations preclude the estimation of (3.1) with quarterly data unless one wishes to either sacrifice a significant number of covariates, dramatically reduce the number of instruments used, or both. Additionally, it is worth pointing out that the failure to estimate equations similar to (3.1) with dynamic panel estimators represents a deficiency of some previous empirical studies of the capital channel. Additionally, high-frequency observations of bank-level lending activity can produce counterintuitive results owing to factors beyond the bank's control.

Before presenting the results, I note that testing the null hypothesis that monetary policy effects are equal across banks with varying degrees of capital adequacy is equivalent to testing the significance of the $\delta$ coefficient. I control for the BLC effects described above by including deposit growth, the interaction of deposit growth with monetary policy, and bank capital. In addition, the bank liquidity regressor provides another measure of BLC control. This is because (as outlined in Kashyap & Stein, 2000) banks with a high degree of liquidity have a built-in shock absorber between lower reserves and loans.

### *3.1b. Results: "One-Step" Approach*

Table 3.2 summarizes the key coefficient estimates from (3.1) for each size class.[35] As expected, tighter monetary policy is associated with a decrease in C&I lending for the smallest ninety percent of banks. The degree to which lending is capital

[35] The coefficients reported are the "long-run" values, and the associated p-values are computed using the delta method.

constrained is displayed in the second line of coefficient estimates. The third line of estimates in Table 3.2 reports the estimate of $\delta$. A significantly positive value of this coefficient implies that lending of banks with a weak capital position exhibits a greater sensitivity to monetary policy - just as predicted by the capital channel. Next, the coefficients for the bank lending channel are reported. Neither of the deposit measures are significantly different from zero, but lending growth is positively related to bank-level liquidity as in Kashyap and Stein (2000).[36]

For larger banks, the significance of the capital channel coefficient evaporates. This distributional asymmetry across bank sizes is consistent with the findings of Kishan and Opiela (2000). In their study, the authors perform a test of bank sensitivity to monetary actions based on capital adequacy and find capital considerations appear to influence the lending behavior of small banks only. However, these findings are contrary to Van den Heuvel's (2007) study wherein he finds that the capital channel works mostly through large financial intermediaries. Finally, the macroeconomic/loan demand controls each show a significant impact on loan growth.

For the real economy, this distributional effect can have important implications since small banks tend to lend to small businesses that are hotbeds of process and product innovations. In fact, the loans of small banks are sometimes referred to as "high powered" loans (Hancock & Wilcox, 1998) because a dollar decline in small bank loans has a larger economic impact than an equivalent decline in large bank loans. Another important implication of this distributional asymmetry is that commercial loans to small

[36] For robustness, large denomination time deposits were used in place of demand deposits. This yielded significance of the deposits measure at the 10% level, and all other coefficients were very similar to those reported in Table 2.

bank customers - mostly small firms - decline disproportionately as a result of capital considerations. If these small borrowers face switching costs, they are likely to bear the largest burden of the capital channel in times of tight monetary policy.

**Table 3.2.** Baseline estimation of equation (3.1). Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. The dummy identifying critically undercapitalized banks and the financial crisis dummy are suppressed.

| | Dependent Variable: C&I Loan Growth | | | |
|---|---|---|---|---|
| | All Banks | < 90$^{th}$ percentile | 90$^{th}$ - 98$^{th}$ percentile | > 98$^{th}$ percentile |
| $\Delta MP_t$ | **-0.144** | **-0.152** | **-0.021** | **-0.022** |
| | *0.000* | *0.000* | *0.573* | *0.879* |
| $C_{t-1}$ | **0.632** | **0.925** | 0.729 | -0.255 |
| | *0.001* | *0.001* | *0.540* | *0.796* |
| $C_{t-1} \Delta MP_t$ | **1.948** | **2.413** | -0.888 | -2.925 |
| | *0.002* | *0.002* | *0.791* | *0.483* |
| $D_{t-1}$ | 1.332 | 1.358 | 0.929 | 1.083 |
| | *0.731* | *0.731* | *0.637* | *0.264* |
| $D_{t-1} \Delta MP_t$ | -0.776 | -0.700 | -0.755 | -0.765 |
| | *0.779* | *0.779* | *0.069* | *0.360* |
| $Liquidity_{t-1}$ | **-0.001** | **-0.001** | **0.001** | **0.013** |
| | *0.000* | *0.000* | *0.000* | *0.000* |
| $\ln(Assets_{t-1})$ | **-0.083** | **-0.043** | **-0.326** | **-0.420** |
| | *0.000* | *0.000* | *0.000* | *0.000* |
| $GDP_t$ | **0.004** | **0.003** | **0.010** | **0.016** |
| | *0.072* | *0.072* | *0.009* | *0.016* |
| $CPI_t$ | 0.004 | 0.003 | **0.020** | **0.039** |
| | *0.815* | *0.815* | *0.016* | *0.051* |
| *Observations* | 136,896 | 123,825 | 10,410 | 2,661 |
| *MA(2)* | 0.33 | 0.15 | 0.23 | 0.13 |
| *Wald Stat* | 2,682 | 2,138 | 365 | 175 |

*3.2a. Methods: Interest Rate Risk Approach*

As a final test, I attempt to identify a prediction that is more unique to the capital channel. The capital channel hinges crucially on the asset transformation function of banks. If a bank's liabilities reprice more quickly than its assets, a monetary policy tightening will lead to a margin compression as banks pay more for their short term financing both now and in the future. In addition, if a bank is marking assets and liabilities to market, an increase in interest rates will lead to a larger fall in the value of the longer-dated assets. As a matter of accounting, this would erode bank equity. In this way, a monetary tightening impacts bank profits and capital positions. Furthermore, this tightening increases the chances that a bank may violate regulatory capital requirements in the future. Thus, the capital channel should exist even for banks that do not find the capital requirement momentarily binding.

Identifying the capital channel along the lines of the strategy outlined above requires a measure of the sensitivity of bank assets relative to liabilities. Though it would be ideal to obtain the weighted average duration of a bank's assets and liabilities measured in each period, this information is not publicly disclosed for most banks. However, a good proxy for weighted average duration is weighted average maturity. Subtracting the average maturity of liabilities from the average maturity of assets to produce a "maturity gap" measures the extent to which a bank engages in asset transformation. The capital of a bank with a large maturity gap would be expected to suffer more from a monetary tightening since a large maturity gap indicates assets reprice much less frequently than liabilities.[37]

Beginning in 2006, it is possible to extract maturity information for most assets and liabilities from the memoranda of the Call Reports. From this, I use a cross-sectional regression to predict a bank's maturity gap based on bank-level characteristics observable throughout the sample. Regressors can include organization type and balance sheet information such as the ratio of real estate loans to assets, the ratio of deposits to total liabilities, etc.[38] The coefficients on each of the regressors are very stable across quarters over which the regression can be run, though there is no guarantee that this method predicts the maturity gap for the entire sample period with a high degree of accuracy. Mitigating this concern, however, is that the method described below requires only that the *relative* maturity gaps are predicted to a reasonable degree. For this purpose, it is much easier to have confidence in the "maturity gap prediction" approach. For instance, a negative coefficient on the amount of deposit-based finance and a positive coefficient on real estate loans will at least yield a consistent ordering (if not the actual maturity gap).

I then test for the capital channel using a method similar to Kishan and Opiela (2000) by running the following regression on subsets of banks grouped by maturity gap:

$$\begin{aligned}\Delta \log(L_{it}) = \mu_i + \alpha\Delta \log(L_{it-1}) + \beta\Delta MP_t + \\ C_{it-1}\left[\gamma + \delta\Delta MP_t\right] + \Gamma\Phi_{it} + \varepsilon_{it}\end{aligned} \qquad (3.2)$$

[37] In addition, maturity is closely correlated with duration. Thus, besides providing insight into net interest margin effects, the maturity gap is also a good measure of interest rate risk.

[38] The reader is referred to Appendix D for a more detailed treatment of the maturity gap regressions.

with all variables as defined previously. Sorting banks by the maturity gap is equivalent to sorting based on the cost a bank bears as a result of tighter monetary policy owing to its maturity transformation function. In response to tighter monetary policy, banks with higher maturity gaps are expected to face increased deterioration in current and future capital positions. Thus, as a result of the capital channel, banks with a high maturity gap would be expected to have a lower $\beta$ (higher in absolute value) than those banks with a comparatively low degree of maturity transformation.

### *3.2b. Results: Interest Rate Risk Approach*

Table 3.3 reports selected long-run coefficients from the estimation of (3.2) for commercial banks organized as stock corporations within each size class.[39] The first column of Panel A shows that - after controlling for credit channel and demand effects - those banks with the lowest maturity gaps (< 10$^{th}$ percentile) respond about half as forcefully to monetary policy than those banks with the highest maturity gaps (sixth column). Looking at the second and fifth columns, the results are just what one would expect if the capital channel is operative among these banks. With less margin compression and interest rate risk than the top decile, the banks with a top quartile maturity gap (fifth column) experience a weaker response to monetary policy on average. Finally, the monotonicity is violated by the above- and below-median cohorts, but a portion of this small difference is due to the slightly different AR(1) terms used to calculate the long-run coefficients. I should also note that the point estimates reported in

[39] The results are robust to including banks with different organization structures, such as mutuals and cooperatives. However, mutuals and cooperatives are not distributed evenly across maturity gap cohorts, and for this reason they are excluded from the representative results of Table 3.3.

the first row are all statistically different from their "matched" counterparts. Looking at Panel B, a similar pattern exists for the smallest bank group, as expected. All of these results are robust to the inclusion of other controls, such as the change in large time deposits and alternate specifications of the maturity gap regression.

Two important questions remain. The first is whether higher maturity gaps might correlate with other bank-level characteristics that would lead one to expect a greater sensitivity to monetary policy. Though I control for several characteristics known to be associated with sensitivity to monetary policy, it is worth noting that high-maturity-gap banks are both larger and more liquid. It has been shown that smaller banks exhibit a stronger credit channel.[40] Furthermore, as demonstrated in Kashyap and Stein (2000), banks with greater liquidity exhibit a lower sensitivity to monetary policy actions owing to a reduced BLC. Therefore, it appears that the maturity gap cohorts tend to be associated with bank-level characteristics that would bias *against* the detection of a capital channel. I should also note that the results reported here are not materially altered if regressions include thrifts that file Call Reports. However, many state chartered savings banks have very high maturity gaps and are over-represented in the top maturity gap decile when these institutions are included. Finally, different maturity gap cohorts do not give rise to geographic distributional anomalies – another potential concern.

[40] See, for example, Kashyap and Stein (2000), Kishan and Opiela (2000, 2006), and Kandrac (2011) for examples.

**Table 3.3.** Baseline estimation of equation (3.2). Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. Other coefficients described in equation (3.2) are suppressed.

| Panel A (All Bank Sizes) | | | | | | |
|---|---|---|---|---|---|---|
| | Maturity gap percentile | | | | | |
| | < 10th | < 25th | < 50th | > 50th | > 75th | > 90th |
| $\Delta MP_t$ | **-0.128** | **-0.133** | **-0.129** | **-0.184** | **-0.171** | **-0.246** |
| | *0.008* | *0.000* | *0.000* | *0.000* | *0.000* | *0.002* |
| $C_{t-1}$ | 0.672 | **1.438** | **1.491** | -0.369 | -0.466 | -0.844 |
| | *0.308* | *0.001* | *0.001* | *0.250* | *0.260* | *0.137* |
| $C_{t-1} \Delta MP_t$ | 2.522 | **2.501** | **2.440** | 0.932 | -0.533 | -1.311 |
| | *0.216* | *0.055* | *0.011* | *0.446* | *0.671* | *0.460* |

| Panel B (Bank size < 90th percentile) | | | | | | |
|---|---|---|---|---|---|---|
| | Maturity gap percentile | | | | | |
| | < 10th | < 25th | < 50th | > 50th | > 75th | > 90th |
| $\Delta MP_t$ | **-0.125** | **-0.138** | **-0.125** | **-0.196** | **-0.192** | **-0.206** |
| | *0.017* | *0.000* | *0.000* | *0.000* | *0.000* | *0.022* |
| $C_{t-1}$ | -0.108 | 0.647 | **1.304** | 0.254 | 0.018 | 0.004 |
| | *0.895* | *0.218* | *0.001* | *0.501* | *0.960* | *0.997* |
| $C_{t-1} \Delta MP_t$ | 3.195 | **2.991** | **2.672** | **2.044** | **2.044** | -0.125 |
| | *0.149* | *0.044* | *0.012* | *0.044* | *0.062* | *0.942* |

| Panel C (Bank size 90th - 98th percentile) | | | | | | |
|---|---|---|---|---|---|---|
| | Maturity gap percentile | | | | | |
| | < 10th | < 25th | < 50th | > 50th | > 75th | > 90th |
| $\Delta MP_t$ | -0.093 | -0.035 | 0.005 | -0.047 | -0.183 | 0.227 |
| | *0.330* | *0.631* | *0.946* | *0.584* | *0.164* | *0.804* |
| $C_{t-1}$ | 2.139 | 1.324 | 1.273 | -0.816 | -1.032 | 1.479 |
| | *0.162* | *0.305* | *0.167* | *0.468* | *0.494* | *0.847* |
| $C_{t-1} \Delta MP_t$ | **-5.439** | 3.203 | 0.960 | -6.838 | -7.326 | -6.978 |
| | *0.016* | *0.363* | *0.796* | *0.103* | *0.188* | *0.909* |

**Table 3.3.** (continued)

| Panel D (Bank size > 98th percentile) | | | | | | |
|---|---|---|---|---|---|---|
| | Maturity gap percentile | | | | | |
| | < 10th | < 25th | < 50th | > 50th | > 75th | > 90th |
| $\Delta MP_t$ | 0.562 | 0.355 | 0.147 | -0.199 | **-0.417** | 0.211 |
| | *0.647* | *0.345* | *0.460* | *0.287* | *0.034* | *0.883* |
| $C_{t-1}$ | -0.316 | **-2.641** | -1.746 | 0.564 | 0.062 | 1.427 |
| | *0.976* | *0.005* | *0.131* | *0.659* | *0.968* | *0.980* |
| $C_{t-1} \Delta MP_t$ | -5.653 | -4.465 | -3.964 | -4.720 | **-12.031** | 4.734 |
| | *0.848* | *0.332* | *0.356* | *0.492* | *0.016* | *0.885* |

The second important question concerns the economic importance of the high-maturity-gap banks relative to their low-maturity-gap counterparts. Although I find strong evidence in favor of the capital channel, the quantitative significance is less certain. While it might be preferable to evaluate the strength of the capital channel by estimating a fully specified structural model (that also includes the interest rate and credit channels) and then simulating the impact of monetary policy, no such model exists. However, using the estimates presented in this paper may be instructive. Considering the smallest ninety percent of banks, coefficient estimates from Table 3.3 imply that just a one standard deviation increase in the monetary policy indicator would cause banks with above-median maturity gaps to reduce their stock of C&I lending by about 3%. This reaction is 57% stronger than the low-maturity-gap banks.

Finally, comparing the results from Panel B with those in Panels C and D provides further evidence that the bank capital channel of monetary policy works primarily through small lenders. The largest ten percent of banks do not appear to respond to changes in monetary policy given the controls in $\Phi$, many of which typically have a statistically significant influence on lending behavior.

## 4. Conclusions

The "capital channel" of monetary policy describes yet another means by which monetary policy can impact credit supply and, thus, the real economy. This channel recognizes that tighter policy leads to deterioration in banks' current and future capital positions. In the presence of regulatory capital requirements, the capital channel predicts that banks respond to capital deterioration by decreasing new loan supply. Though the capital channel explains how financial frictions impact lending, it differs from the bank lending channel in that there is no explicit role for reserves.

This paper presents two empirical tests consistent with a capital channel working through the smallest ninety percent of banks. First, loan growth of banks with higher levels of capital adequacy responds less dramatically to changes in the stance of monetary policy after controlling for indicators of the bank lending channel. Second, those banks with current and future capital positions that are most sensitive to changes in interest rates tend to contract lending more in response to a monetary tightening.

Besides documenting a relatively unstudied transmission mechanism of monetary policy, the results of this paper have important implications for recent financial reform proposals - many of which have been taken up by the Basel Committee on Banking Supervision. First, the Financial Accounting Standards Board issued an update to FAS #157 in 2009 that somewhat eases mark-to-market rules for banks. The decreased use of mark-to-market accounting rules - which require banks to report certain assets and liabilities at a fair market value - would soften blows to bank capital due to interest rate risk. This would likely mitigate the capital channel somewhat. However, banks' repricing risk would still be present and a change in the stance of monetary policy could still lead to a change in net interest margin, impacting future realizations of capital adequacy. Essentially, dropping mark-to-market rules eases capital constraints since it decreases the chances that a bank will find itself in technical violation of capital adequacy requirements. At the same time, the decreased transparency associated with such a change may increase the lemons premium creditors and investors attach to external funds. Banks could then find it more difficult to raise non-reservable liabilities and equity, strengthening the bank lending channel as well as the capital channel.

Second, there has been increased interest in contingent capital requirements for banks. Contingent capital is in effect a convertible bond that converts into equity if capital ratios fall below a certain level. The effect of such a requirement would most likely weaken the capital channel. The contingent capital securities act as built-in shock absorbers to bank capital positions, decreasing the likelihood of capital adequacy violations and the associated penalties. If monetary policy eases, the increased cost associated with acquiring contingent capital will depress retained earnings, limiting the growth of lending as capital expands at a slower rate. However, banks may face a strong incentive to avoid triggering such a conversion as it may incite a creditor panic. In this way, strong self-imposed capital requirements could mean that contingent capital requirements would have a negligible impact on the capital channel.

Third, there has been a renewed interest in countercyclical capital requirements, ultimately resulting in their inclusion in Basel III. Under a regulatory regime with countercyclical capital requirements, mandatory capital-to-asset ratios increase during expansions and decrease during recessions. The goal of such a regime is to force banks to accumulate capital during cyclical expansions that will make them less likely to face solvency issues during a downturn. As the economy weakens banks experience lower capital-asset ratios as delinquencies and defaults increase and cash flows decrease or become negative. Facing such a situation, banks might contract loan supply to shore up their balance sheets. Given the potential for a feedback loop to weaken the economy further, countercyclical capital ratios attempt to ease the burden on banks by decreasing the capital banks are required to hold during these periods. Leaving aside the difficulties associated with determining when capital ratios should increase or decrease, countercyclical capital requirements would attenuate business cycle peaks and troughs through the mechanism demonstrated in this paper. As the economy expands, loan supply should increase via other channels of monetary policy, but the increasing capital-asset ratio would lead banks to worry about a current or future violation of capital adequacy standards. As a result, loan growth would slow, potentially lowering the rate of growth in the real economy. Alternatively, in response to an economic contraction, banks face lower capital requirements, decreasing the pressure on banks to withdraw loan supply for fear of future regulatory violations.

Finally, a popular proposal (also scheduled to be included as part of Basel III) is the imposition of a minimum net stable funding (NSF) ratio. Under this requirement, banks face a certain level of *required stable funding* based on the maturity profile of their assets (with longer dated assets requiring more stable funding). Banks' *available stable funding* is similarly calculated based on the profile of their liabilities and capital. Typically, longer dated liabilities represent more "stable" sources of funding, although insured retail deposits are also included. The NSF ratio is then computed by dividing available stable funding by required stable funding. On the margin, a minimum amount of NSF will decrease a bank's maturity gap as the bank accumulates assets that reprice more frequently and/or liabilities that reprice less frequently. Besides the effects on the likelihood of bank failures and financial crises, reducing the liquidity risk of banks in this manner will also mitigate the effects of the capital channel. As this study has shown, banks that engage in a smaller degree of asset transformation have loan portfolios that are less sensitive to changes in monetary policy.

In response to the recent financial crisis, policy makers have proposed numerous regulatory changes. Although many of these changes focus on capital adequacy in some way, the empirical research investigating the macroeconomic effects of this type of prudential regulation is lacking. This paper demonstrates some of the increasingly important links between regulatory and stabilization policy while simultaneously shedding light on a largely unexplored transmission mechanism of monetary policy - the bank capital channel.

## CHAPTER IV

## MODELING THE CAUSES AND MANIFESTATIONS OF BANK STRESS: AN EXAMPLE FROM THE FINANCIAL CRISIS

### 1. Introduction

Following several decades of calm, the savings and loan crisis in the 1980s and 1990s sparked a renewed interest in empirical studies of bank failure. An important line of analysis during this period focused on developing early warning systems (EWSs) that could be used to alert regulators of distressed banks. Though some suggest that a useful EWS model cannot be built using only currently available accounting data (Randall, 1989), the weight of the evidence appears to indicate otherwise. Indeed, regulators spend much effort developing EWSs to flag potentially troubled banks even as more frequent on-site examinations are conducted pursuant to the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991. EWSs not only provide regulators with a low-cost means of monitoring financial institutions at a high frequency, but also yield a more appropriate allocation of scarce resources and examiners. As a result, employing such models most likely serves to reduce the frequency and cost of bank failures.

However, several issues associated with the use of econometric models in financial supervision remain. First, EWSs require well-defined accounting practices and enforcement of penalties assigned to violations. Second, the causes for distress among banks must be similar through time. Third, there should be a consistent regulatory regime in place across time periods. A fourth is that the failure of a bank is not an automatic consequence of legal or economic insolvency. EWS models that use failure as the outcome variable are describing a conscious decision by regulatory authorities to acknowledge and act upon the weakened condition of a bank rather than an objective definition of insolvency. Modeling a regulatory decision rather than economic insolvency is a point recognized by both Demirgüc-Kunt (1989a) and Thomson (1991), though it is largely ignored in the EWS literature. Another consideration – related to the last – is that there has been an increased emphasis on regulating large, systemically important institutions, but most failing banks are small in size. Finally, most bank regulators have routinely used EWSs to monitor bank-level risk for many years. Unfortunately, several banking crises over the past three decades not only demonstrate the difficulty of the task at hand, but also suggest that employing alternative methods alongside traditional EWSs may prove helpful.

This paper rejects such narrow definitions of financial distress – such as failure or acquisition – and attempts to construct a more holistic measure of bank stress, which can then be predicted in a way similar to traditional EWSs. The need for a richer definition of distress is highlighted by Peek and Rosengren (1997), who show that most failed banks in New England during the 1989-1993 banking crisis were well capitalized prior to failure. Similarly, Jones and King (1995) reveal that most troubled banks between 1984 and 1989 would not have been classified as undercapitalized by the FDICIA rules. It is clear that relationships between capital and failure identified up to that point were inadequate for that particular episode. This paper argues that regulators would not only benefit from looking to several indicators of bank distress, but also that predictions of these indicators can prove useful in identifying at-risk banks. Furthermore, regulators may be interested in anticipating bank outcomes beyond failure. For example, deterioration in bank capital and liquidity positions has been shown to negatively impact future loan growth (Kishan & Opiela, 2006). The implication is that higher levels of bank distress may influence the availability of consumer and business credit and could potentially lead to other adverse outcomes, such as increased strain in interbank lending markets and disruption in the financial system more broadly.

Furthermore, the Basel Committee on Banking Supervision (BCBS) identifies market discipline as one of the three pillars of financial regulation outlined in the Basel Accords. In a sense, the market can be viewed as a separate regulator with market outcomes representing "regulatory decisions" akin to the FDIC decisions modeled in the bulk of the EWS literature. It may be of interest, then, to predict market outcomes in a way similar to the traditional approach of predicting regulatory outcomes like failure. By combining these features, this paper provides a methodological contribution to the EWS literature by predicting a latent measure of bank stress using a Multiple Indicator Multiple Cause (MIMIC) model. The aim - as with traditional EWSs - is to help regulators identify troubled financial institutions so that they can take appropriate action to head-off potential failures, prevent a contagious loss of confidence, and limit disruptions in the market for credit.

Though this paper draws heavily from the EWS literature and may be viewed as an early warning model in its own right, it contributes to the literature in several ways. First, this paper focuses on medium to large financial institutions that are most likely to be systemically important. Although empirical models of large bank failure exist (see, for instance, Kolari, Glennon, Shin, & Caputo, 2002) studies of this type are relatively scarce. Additionally, this study takes a broader view of financial distress than previous studies that have tackled a similar issue for large banks. For instance, Pettway (1980) deals with the paucity of large failures by focusing on market outcomes, such as stock prices. Pettway's strategy of appealing to market outcomes is in the spirit of the current study, but again, I take a broader view of bank stress. Second, this paper does not attempt to model a regulatory decision. Using periods encompassing different regulatory regimes and attitudes to form predictions for the future can be problematic.[41] Finally, I provide an examination of the causes of distress during the height of the subprime financial crisis between 2008 and 2009. By comparing the causes of financial disruption during the crisis to earlier studies or taking this model to earlier banking crises, the results of this paper may be useful in determining whether the causes of financial distress are common over time. I should reiterate that although the timeframe chosen to investigate causes of bank stress may be of great interest, the primary goal of this study is to develop a new EWS methodology. Of course, the sample period chosen for this study allows for assessment of the causes of bank-level financial distress during the most recent crisis.

Several robust predictors of bank stress are identified in this study. First, higher Tier 1 capital positions were associated with lower levels of stress realized during the financial crisis, as were higher levels of liquidity. Second, it appears that banks financing their assets with more stable sources of funding exhibited lower levels of stress.

[41] I should note that although regulatory forbearance during the early and middle stages of the S&L crisis presents an issue, the regulatory reform during the S&L crisis in addition to the bank failures during 2007-2011 provide a more reasonable baseline for comparison with expected future regulatory procedures and attitudes.

Additionally, the amount of bad loans realized in the year prior to the crisis significantly increased future realizations of distress, while holding higher levels of residential real estate loans had the opposite effect.

The rest of the paper is organized as follows. Section 2 provides a brief review of relevant literature. Section 3 presents the method employed, Section 4 describes the data, and Section 5 reports the main results. Section 6 concludes.

## 2. Review of the Literature

The literature examining bank failure is extremely deep. Bank failure studies cropped up at an especially rapid pace following the increased failures resulting from the S&L crisis. As such, popular statistical techniques employed to explain bank failure included not just event-history analysis (Lane, Looney, & Wansley, 1986), but also logit regression as well as other hazard and survival models. The dependent variable in these studies is typically an indicator that denotes some form of exit such as closure or inclusion on the FDIC's troubled bank list. Many early studies focused on the inclusion of unique covariates and evaluating their predictive power. Demirgüc-Kunt (1989b) provides a summary of bank-level characteristics that have been shown to robustly predict failure. Subsequent work, such as that of Barr, Seiford, and Siems (1994) and Wheelock and Wilson (2000) focused on including less easily measured predictors such as management quality, while others modeled outcomes related to exit such as the timing of failures (Cole & Gunther, 1995). In light of this extensive literature, the goal of this section is not to present an exhaustive overview, but rather to call attention to several papers that are particularly pertinent to the present study.

For instance, one important development in the literature has been the prediction of outcomes beyond failure. Wheelock and Wilson (2000) examine the causes of both acquisition and failure. For example, low capital-to-asset ratios are associated not just with a higher incidence of failure (as documented in previous studies) but are also met with higher likelihood of acquisition. On the other hand, other traditional EWS regressors such as measures of inefficiency reduce the probability that a bank will be acquired, while increasing the probability of failure.

Another notable subset of articles directly addresses the paucity of EWSs for large banks. Given the lack of failure data, Pettway (1976, 1980) evaluates the sensitivity of large bank stock prices to bank-level attributes like capital that are often used to explain failure. A main result of these studies – summarized in Flannery (1998) – is that market assessments have the ability to provide timely and accurate information to supplement regulators' own information. The ability to leverage information furnished by financial markets is, unfortunately, a luxury afforded only to those studies that focus on large financial institutions. The primary drawback, as mentioned earlier, is that the frequency of large bank failures is so low that implementing traditional EWSs becomes difficult. The use of market information as both a dependent and independent variable is of particular note. Kolari, et. al. (2002), however, use data collected during the 1980s and 1990s to perform direct statistical tests of large bank failure. Included in their sample are fifty banks that held more than $250 million in assets at the time of failure. Using both in- and out-of-sample forecasts, the authors conclude that effective EWSs can be constructed for large banks. Although the $250 million cutoff represents a relatively small bank by U.S. standards, the recent crisis induced an increasing number of failures among banks holding more than $1 billion in assets. As such, another direct EWS approach for large institutions can be constructed with the new data. As consolidation in the banking sector continues, it is increasingly important that regulators have appropriate low-cost screening techniques that can be applied to large institutions.

Berger and Bouwman (*forthcoming*) conduct a study that is similar to the present paper in several ways. First, the authors focus on bank behavior around banking and market crises, including the subprime crisis. Secondly, the authors consider large banks (gross total assets exceeding $3 billion) separately. Finally, Berger and Bouwman consider several bank-level outcomes around crises. In addition to exit, these outcomes include competitive positions, profitability, and stock returns. The results suggest that the effects of capital on bank-level outcomes are generally elevated during banking crises for large banks. However, it is worth highlighting some important differences in the method described below. For example, Berger and Bouwman's focus is primarily on the different role *bank capital* may play in normal times as compared with financial crises. In addition, although the authors consider several bank-level outcomes, they examine each outcome separately whereas the goal here is to combine these outcomes to get a sense of the overall level of financial stress a bank is experiencing.

## 3. Method

Traditional EWSs are typically constructed by regressing a failure indicator on balance sheet characteristics from previous periods. This process generates several limitations that this paper attempts to address. First, the overwhelming majority of bank failures in the United States tend to be concentrated among small banks. As such, traditional EWSs will not necessarily be able to signal trouble looming for larger institutions (which are often not even included in samples). However, the largest banks account for an overwhelming majority of system-wide assets and credit. Moreover, the recent financial crisis demonstrated the importance of monitoring systemically important institutions. This has led to the passage of legislation that grants regulators new powers regarding the oversight and regulation of such firms.

A second drawback associated with traditional EWSs is that financial distress is often identified only by its culminating form of bank failure or resolution. I argue that it may be important to identify those banks that face a high risk of becoming severely distressed even if the result is not failure. Although only a relatively small proportion of banks typically fails during a recession, severe bank-level stress can lead to excessive credit disruptions that can restrain economic recovery or impart an excessive burden on bank-dependent borrowers. Leaving aside the fact that regulators are generally reluctant to let large financial institutions fail, predicting bank stress may be useful if a goal is to prevent or limit spillover into the macroeconomy generated by credit withdrawal, “fire sales” of specialized assets, creditor runs, or sizeable capital crunches. Having a system in place to monitor the likelihood that institutions will experience these types of outcomes could lead to a more robust regulatory regime and a healthier banking system.

A final limitation of traditional EWSs is that they model a regulatory decision rather than a concrete measure of insolvency. A consequence of different regulatory regimes is that they may produce EWSs that are less useful across time periods. For example, the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 includes measures aimed at increasing regulators' options when facing an institution that would have previously been deemed "too big to fail" (TBTF). The new-found vigilance against the TBTF policy means that the behavior of regulators over the last thirty years cannot be used to guide future regulatory action when dealing with large banks.

In light of these drawbacks, the primary goal of this paper is to relate the incidence of a broader measure of bank distress to its causes. Breaking from the traditional EWS methodology, my goal is to identify a latent variable I call "bank stress" that is an amalgamation of several different indicators associated with bank-level financial difficulty. I then generate predictions of bank stress that can be used by regulators in very much the same way that EWSs are used currently.

In order to measure the contribution of many factors to a latent variable (bank stress) that manifests itself in multiple ways, a Multiple Indicator Multiple Cause (MIMIC) model is used. The MIMIC model consists of the following set of equations:

$$y_{i,j} = \beta_j \varphi_i + \upsilon_i \tag{4.1}$$

$$\varphi_i = \delta_k x_{i,k} + \varepsilon_i \tag{4.2}$$

where $y_{i,j}$ is an observation of stress indicator $j$ for bank $i$, $x_{i,k}$ is a potential cause of distress, $k$, for bank $i$, and $\varphi_i$ is a latent variable representing the severity of the distress experienced by bank *i*. $\beta$ and $\delta$ are coefficient vectors, and $\upsilon$ and $\varepsilon$ are well-behaved errors. The first equation links *J* manifestations of bank stress to the unobservable measure of stress severity. These manifestations are described in detail later, but they include capital deterioration, security and loan losses, credit draw downs, government assistance, and the decline in an institution's stock price. The second equation models bank-level stress as a function of *K* causes. Substituting the second equation into the first yields a model that is no longer a function of the latent variable $\varphi_i$. This yields a MIMIC model that is a system of *J* equations with right-hand sides restricted to be proportional to one another. These restrictions constrain the structure to be a one-factor model of the latent variable.

To avoid simultaneity issues and establish a set of predictors that can be identified early enough so as to be helpful to regulators, the data for causes are collected prior to the summer of 2007 while bank stress is measured between 2008 and 2009. This method of delineating cause and effect is common in the EWS literature.

## 4. Data

### *4.1. Indicators*

The primary purpose of employing the method described above is to allow examiners and regulators to take a more holistic view of bank stress. Again, taking a broader look at bank stress – rather than using a simple failure indicator – is the primary difference between the present study and much of the EWS literature. Therefore, the most important empirical task is to identify indicators that are expected to be impacted by the amount of stress a bank is under (i.e. the latent variable). As a first step, I consider several possible manifestations of bank stress summarized in Table 4.1 for the 306 large banks and bank holding companies that existed at the end of the sample. Again, bank stress indicators are measured between 2008Q1 and 2009Q1; a time period that captures the most intense portion of the financial crisis.[42] Unless stated otherwise, the data used in this study are taken from The Reports of Condition and Income (Call Reports), which contain balance sheet and income statement information for the banks and bank holding companies used in this paper.

The first – and perhaps most obvious – indicator of bank stress is the market value of the bank's equity. Signs of severe financial distress would cause investors to bid down the bank's stock price as the bank becomes more likely to fail at worst and experience below-average growth at best. However, if bank capital falls to low levels, stockholders may become risk-loving, and respond well to more risky strategies. This behavior has been well documented – see Park and Peristiani (2007) for a good summary – and implies that shareholders can have interests that are not aligned with those of regulators. During the Savings and Loan crisis, for example, there were many instances of banks engaging in risky behavior as they approached failure. For this reason, it might be preferable to use market outcomes on banks' debt instruments since debt holders have interests that are unequivocally aligned with those of regulators. Although this clear negative response to increases in financial distress and failure probabilities is an attractive feature of using an

[42] Bank mergers that occurred during this time period are handled by aggregating the balance sheet and income statements of the merged banks.

alternate market outcome, compiling a unified measure of bank debt performance is prohibitively difficult for such a large sample. However, Park and Peristiani (2007) found that after the Federal Deposit Insurance Corporation Improvement Act of 1991, shareholders of large financial institutions appear to have interests that are aligned with those of regulators and debt holders (who respond very negatively to increases in financial distress and failure probabilities). A usual limitation of using market outcomes in EWSs is that market data are not available for small institutions which comprise the bulk of financial intermediaries in the United States. However, the focus of this study is on large financial institutions and stock price data can be found for each bank in the sample through the Center for Research in Security Prices (CRSP).

**Table 4.1.** Summary statistics for causes of bank stress. The three rightmost columns report the factor loadings of each indicator on three separate stress factors using confirmatory factor analysis.

| | Indicator (*Change between 2008Q1 and 2009Q1*) | Mean | Std. Dev. | Stress Factors (1) | (2) | (3) |
|---|---|---|---|---|---|---|
| *1.* | *Stock Return*<br>*(2009 stock price / 2008 stock price)* | 54.3% | 28.6% | 10.6 | 7.7 | 7.0 |
| *2.* | *Tier 1 + Tier 2 Capital Loss (v1)*<br>*(% change in capital, adjusted for TARP)** | -0.7% | 2.5% | 2.5 | 3.0 | -- |
| *3.* | *Tier 1 + Tier 2 Capital Loss (v2)*<br>*(As above, excluding 10/28 TARP injections)*** | -0.6% | 2.5% | -- | -- | 3.1 |
| *4.* | *Security Losses*<br>*(Realized security losses as % of total)* | -1.0% | 3.1% | 0.6 | 0.5 | 0.5 |
| *5.* | *Loan Losses*<br>*(% change in loan book)* | 5.5% | 16.6% | 9.8 | 8.1 | 7.6 |
| *6.* | *TARP Injection (v1)*<br>*(-TARP funds received / 2008Q1 Net Asset)** | -1.3% | 1.3% | -- | 0.3 | -- |
| *7.* | *TARP Injection (v2)*<br>*(As above, excluding 10/28 TARP injections)*** | -1.3% | 1.3% | -- | -- | 0.3 |
| | LR Test versus an Independence Model (p-value) | | | 0.000 | 0.000 | 0.000 |

* Including funds received through the Treasury's Targeted Investment Program.

** Excludes the initial TARP funds received by nine large banks on 10/28/08.

The second indicator of the degree of stress experienced by a bank is the size of capital drawdown. This can be measured in many ways, but is measured here as the percentage change in bank capital (Tier 1 plus Tier 2 capital) between 2008Q1 and 2009Q1.[43] Of course, greater declines over the course of the crisis would be associated with a bank that is experiencing a higher level of stress.

Similarly, I look at the extent of losses on securities as another gauge of bank stress. The reasoning here is that securities are often included in measures of bank liquidity and are (in more normal times) viewed as relatively safe assets for a bank. Hence, any bank experiencing losses on its securities needs to worry about a deteriorating liquidity position as well as its accounting profits. Securities losses are measured as the sum of realized losses as a fraction of total pre-crisis securities.

The fourth manifestation of bank stress I consider is the amount of credit withdrawal, measured as the percentage decline in credit extended. All else equal, banks experiencing more hardship would be expected to cut back more on loans given their risk, higher capital requirement, and adverse impact on bank liquidity. In addition, many policy makers are concerned with the smooth functioning of credit markets given their macroeconomic impact (Bernanke & Blinder, 1992). Note that bank stress can manifest itself directly in lending growth as well as factors that have been shown to impact lending growth like capital (Kishan & Opiela, 2000, 2006) and liquidity (Kashyap & Stein, 2000).

[43] Alternate definitions of the capital ratio were used with little changes to the results reported in the next section. For example, percentage-point changes in the Tier 1 plus Tier 2 capital ratio were used as this may be seen by some as a better measure of capital decline. The main results hold.

The fifth and final indicator of bank stress is the U.S. Treasury capital injections authorized by the Troubled Asset Relief Program (TARP), normalized by pre-crisis bank size. Unlike the previous manifestations of bank stress outlined above, TARP capital injections (or some analogue) are not available outside of the sample period selected for this study. One might expect higher TARP injections to be associated with increased distress for the following reasons. First, there was widespread fear that a stigma would be attached to the receipt of TARP funds similar to the stigma associated with accessing the Federal Reserve's discount window that was present during the early stages of the crisis.[44] In addition, TARP funds were distributed on the condition that companies would lose certain tax benefits, forfeit autonomy over shareholder dividend decisions, and face limitations on executive pay (such as curbs on golden parachutes and compensation clawback provisions). Additionally, the first firms to announce repayments of TARP funds (such as Goldman Sachs) not only cited these onerous conditions as a motivator, but also saw outsized increases in their stock prices upon announcement. In fact, some observers were concerned that lawmakers were taking advantage of TARP to funnel money to weak institutions in their districts. On the other hand, the Treasury's criteria to determine which banks would receive funds might have favored healthier financial institutions that were most likely to survive (and thus limit the Program's losses). For this reason I consider several different formulations of the bank stress indicator, some of which exclude TARP injections. Approximately half of the institutions in the sample did not receive money from TARP.

[44] In fact, the stigma associated with accessing the discount window was a motivating factor behind the creation of the Term Auction Facility, which allowed banks to borrow term funds anonymously from the Federal Reserve.

Table 4.1 also reports the factor loadings of the indicators for several permutations of the latent bank stress variable. All individual *indicators* have been defined such that a lower value is consistent with higher levels of stress. Thus, if the interpretation presented in this section is correct, one would expect the indicators' loadings to possess the same sign. As seen in Table 4.1, all indicators load positively on the latent factor. For the remainder of the paper, I multiply the latent stress factors by negative one to produce measures that increase in bank stress. Unsurprisingly, the measures of bank stress exhibit a high degree of similarity. The correlation between each of the factors is at least 0.92.

### *4.2. Causes*

The predictors (causes) of bank stress should possess a few characteristics to be useful to regulators and policy makers. First, the causes should be comprised of information that is readily available in a timely fashion. Because of this, it is natural to again use data reported in the Call Reports which are available at a quarterly frequency. Secondly, causes should be measured over a period that reasonably predates the measurement of bank stress. This will not only limit simultaneity concerns, but it provides enough lead time to regulators that would be interested in acting on results obtained from EWSs. As such, all explanatory variables (causes) are averages realized between 2006Q1 and 2007Q1.

I take advantage of the deep EWS literature to generate a list of potential causes of bank stress. These variables are summarized in Table 4.2 along with their expected impact on bank stress. Note that although most of the indicators decline with stress, I have adopted the convention that a "+" indicates that as the explanatory variable increases, one would expect bank stress to increase. Again, most of these predictors have been widely used in the EWS literature, and rather than describe each one in detail here I would direct the reader to the literature described in Section 2 for more information.[45]

**Table 4.2.** Summary statistics for typical EWS covariates.

| Cause (*N=306; Average values between 2006Q1 and 2007Q1*) | | | | |
|---|---|---|---|---|
| Variable Name | Definition | Impact | Mean | Std. Dev. |
| *Liquidity* | *Investment Securities / Assets* | - | 19.2% | 11.7% |
| *Tier 1 Capital* | *Tier 1 Capital / Risk Weighted Assets* | - | 11.3% | 3.3% |
| *MBS* | *Mortgage Backed Securities / Net Assets* | + | 13.9% | 9.3% |
| *Bad Loans* | *(Non-accruing + Late Loans) / Net Assets* | + | 0.9% | 0.6% |
| *ROA* | *Net Income / Net Assets* | - | 2.4% | 9.8% |
| *Large CDs* | *Large Denom. Time Deposits / Assets* | + | 15.8% | 8.6% |
| *Demand Deposits* | *Demand Deposits / Assets* | - | 7.3% | 4.4% |
| *Commercial RE* | *Commercial Real Estate Loans/ Assets* | ? | 20.0% | 9.4% |
| *Residential RE* | *Residential Real Estate Loans / Assets* | + | 17.7% | 10.0% |
| *Non-interest Income* | *Non-interest income / Operating Income* | - | 14.6% | 9.6% |
| *Overhead* | *(Fixture + Equipment Costs) / Net Assets* | + | 1.0% | 0.4% |
| *Residential RE Gr.* | *% Change in Residential RE* | + | -0.4% | 2.1% |
| *Broker Dealer* | *1 if Brokered Deposits >1% of Net Assets* | + | 59.8% | 49.1% |
| *Off Balance Sheet* | *Off Balance Sheet Items / Assets* | + | 0.8% | 8.1% |
| *Salary* | *Salary / Net Assets* | + | 3.7% | 1.4% |

## 5. Results

Results for some representative specifications are reported in Table 4.3. Recall that the indicators are constructed such that an increase in a latent factor is associated

[45] In particular, the following studies have used most of the variables that appear in Table 4: Cole and Gunther (1995), Kolari et. al. (2002), and Cole, Cornyn, and Gunther (1995).

with higher levels of stress. As demonstrated by the first row, the pre-crisis Tier 1 capital ratio is generally associated with a lower realization of stress. Although this result is not entirely surprising given the findings in the EWS literature (which routinely find a negative relationship between capital levels and failure probabilities) I should note that the relatively low variation in this ratio made it difficult to predict statistical significance. Secondly, banks entering the crisis with more liquid balance sheets experienced lower levels of stress during the most intense portion of the crisis.

The third predictor of bank stress – mortgage backed security holdings as a proportion of assets – is not typically included in traditional EWSs, and was included simply as a result of an ex-post understanding of the causes of the crisis. Of course, the use of this method as an a-priori bank sorting mechanism would likely exclude this variable. However, it is interesting to note that it has the expected impact on future realizations of stress at the five to ten percent level of confidence (depending on the specification). The fourth line of Table 4.3 shows that those banks entering the height of the financial crisis with a history of high non-accruing and past-due loans fared worse. Separately, the way in which banks fund themselves also appears to predict financial stress. Banks with a large amount of large-denomination time deposits – which tend to be mostly uninsured and less stable – realized higher levels of stress. This could be a result of the difficulty banks had rolling over these types of securities which might lead to realized losses on security sales and slower rates of loan growth. In addition, the proportion of assets funded by stable sources such as demand deposits led to lower adverse adjustments during the crisis. Interestingly, one issue taken up by the BCBS during the formulation of the Basel III accord is whether banks should be required to meet minimum "stable funding" requirements to finance assets. The results reported here provide empirical support for the stabilizing effects of a net stable funding requirement.

**Table 4.3.** Predicting bank stress. Various measures of bank stress are predicted (summaries of each measure in Table 4.1). Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. All regressions include Federal Reserve District dummies.

| | Measure of Bank Stress | | | | | |
|---|---|---|---|---|---|---|
| Cause | (1) | (1) | (2) | (2) | (3) | (3) |
| *Liquidity* | **-0.110** | **-0.089** | **-0.088** | **-0.072** | **-0.082** | **-0.068** |
| | *0.009* | *0.035* | *0.006* | *0.025* | *0.006* | *0.022* |
| *Tier 1 Capital* | **-0.209** | **-0.197** | **-0.147** | **-0.138** | **-0.132** | **-0.124** |
| | *0.027* | *0.034* | *0.042* | *0.052* | *0.046* | *0.058* |
| *MBS* | **0.084** | 0.078 | **0.068** | **0.064** | **0.064** | **0.060** |
| | *0.093* | *0.112* | *0.074* | *0.090* | *0.069* | *0.083* |
| *Bad Loans* | **1.129** | **1.085** | **0.869** | **0.836** | **0.798** | **0.767** |
| | *0.001* | *0.001* | *0.001* | *0.001* | *0.001* | *0.001* |
| *ROA* | -0.041 | -0.034 | -0.029 | -0.024 | -0.026 | -0.021 |
| | *0.229* | *0.310* | *0.266* | *0.355* | *0.272* | *0.363* |
| *Large CDs* | **0.059** | 0.032 | **0.046** | 0.026 | **0.043** | 0.024 |
| | *0.026* | *0.234* | *0.022* | *0.204* | *0.022* | *0.198* |
| *Demand Deposits* | **-0.135** | **-0.118** | **-0.101** | **-0.089** | **-0.092** | **-0.082** |
| | *0.003* | *0.008* | *0.004* | *0.009* | *0.004* | *0.010* |
| *Commercial RE* | **-0.047** | -0.029 | **-0.037** | -0.024 | **-0.034** | -0.022 |
| | *0.085* | *0.290* | *0.075* | *0.255* | *0.073* | *0.248* |
| *Residential RE* | **-0.064** | **-0.057** | **-0.046** | **-0.041** | **-0.041** | **-0.037** |
| | *0.009* | *0.019* | *0.015* | *0.029* | *0.017* | *0.031* |
| *Non-interest Income* | **-0.050** | **-0.053** | **-0.036** | **-0.038** | **-0.033** | **-0.035** |
| | *0.074* | *0.060* | *0.092* | *0.076* | *0.091* | *0.077* |
| *Overhead* | **1.854** | **2.258** | **1.435** | **1.736** | **1.322** | **1.592** |
| | *0.010* | *0.002* | *0.009* | *0.002* | *0.009* | *0.002* |
| *Residential RE Growth* | **0.242** | **0.223** | **0.188** | **0.174** | **0.173** | **0.160** |
| | *0.007* | *0.012* | *0.007* | *0.011* | *0.007* | *0.011* |
| *Broker Dealer* | -- | **0.016** | -- | **0.012** | -- | **0.011** |
| | | *0.000* | | *0.000* | | *0.000* |
| *Off Balance Sheet Size* | -- | 0.014 | -- | 0.010 | -- | 0.008 |
| | | *0.573* | | *0.594* | | *0.631* |
| R-Squared | 0.34 | 0.37 | 0.33 | 0.36 | 0.33 | 0.36 |
| Observations | 306 | | 306 | | 306 | |

Another interesting result is the negative coefficient on residential real estate loans as a percentage of assets. With a basic understanding of the causes of the recent financial crisis, one might ostensibly find this result surprising. However, it is consistent with economic theory that those banks holding more real estate loans would have a larger incentive to ensure that they are good investments. These banks might have developed more specialized screening and monitoring procedures for these types of loans. Alternatively, those banks packaging and reselling the bulk of their real estate loans, or acquiring real estate exposure in the form of mortgage backed securities held for trading purposes may either be less assiduous monitors of credit risk or find it more difficult to monitor the total risk assumed. On the other hand, the growth rate of residential loans between 2006 and 2007 is positively associated with future realizations of stress. This result is as expected since it captures a period during which the housing market began to decline. Additionally, this variable may be capturing the future misfortunes experienced by banks that were getting swept up in the real estate bubble by lowering credit standards.

Those banks that have more diversified sources of income, as represented by the “non-interest income” covariate, realized lower levels of distress during the crisis. This “diversification” interpretation is consistent with the motivation behind much of the financial deregulation in the decades prior to the crisis. On the expense side, the financial difficulty faced by a bank in the crisis is positively related to the proportion of overhead costs. In the EWS literature, this covariate commonly serves as a proxy for managerial quality. Thus, the implication is that poorly managed banks are more susceptible to financial downturns. This finding supports the regulatory practice of evaluating management quality alongside more objective measures of capital adequacy and liquidity.[46] Finally, those bank holding companies with a substantial broker-dealer business tended to do worse during the crisis as well. Of course, I should reiterate that EWSs largely lack strong theoretical underpinnings since the primary goal is to simply identify robust predictors of bank distress. Thus, lending interpretation to the results as I have done here is conjectural and these statements warrant more careful study.

Having demonstrated several robust predictors of bank stress during the financial crisis, I now turn to the question of whether the model did an adequate job of identifying high- and low-stress banks. One strategy to evaluate the success of highlighting high-stress banks involves the use of regulatory information. For example, one could compare the sample of banks used in this study with the FDIC's "troubled bank" list. Observing a higher incidence of troubled banks among the highly stressed banks would affirm the method outlined in this paper. However, the troubled bank list is not published for fear that it would lead to a run on institutions added to the list. A second strategy might involve looking at the time the banks took to pay back the TARP funds. While this exercise may be instructive, there are selection issues (low-stress banks by definition have less TARP funds to pay back) and banks may be motivated to hold their TARP injection for reasons unrelated to balance sheet health (to finance a merger, for instance).

In future work, it would be useful to evaluate the extent to which bank stress has explanatory power in a traditional EWS. Although including market outcomes in the measure of bank-level stress may prove impossible, one would expect highly stressed

[46] I should also note that (while not reported in Table 3) those banks with higher salaries as a share of total expenses did not fare any better (or worse) during the crisis in terms of stress levels.

banks to be at greater risk of failure in future periods. Observing this result would lend confidence to the interpretation and significance of the bank stress variable.

It is also possible to evaluate anecdotal evidence when assessing the reliability of the stress indicator. This method is of course fraught with potential problems and should be met with some degree of skepticism. However, some of the most publicized outcomes accord with the results achieved in this paper. For instance, J.P. Morgan Chase is among the low-stress banks, while Citigroup and Bank of America appear in the ranks of the high-stress banks.

To evaluate whether I have accurately separated high- and low-stress banks more formally, I take advantage of the emergency lending programs initiated by the Federal Reserve during the recession. Although some programs were aimed at inducing banks to participate in troubled credit markets by underwriting profits, others were created to provide financial institutions with desperately needed liquidity. One important feature of these programs was the anonymity they provided the borrowers. This anonymity was required to encourage troubled banks to freely participate in these programs without facing the stigma associated with short-term borrowing from either the interbank market or the Federal Reserve's discount window. The information on banks accessing these programs was ultimately made public, however, at the urging of Congress. Table 4.4 summarizes bank participation in both the Term Auction Facility (TAF) and the Primary Dealer Credit Facility (PDCF). Both of these lending programs were introduced relatively early, and one would generally expect the most financially distressed banks to make greater use of these programs. Indeed, this is the pattern that appears. Not only were highly stressed banks more likely to participate in these programs, but (conditional on participation) they also drew more heavily on the TAF and PDCF.

Finally, I should note that this paper does not (yet) attempt to identify a threshold level of bank stress that would be considered worrisome. However, as with traditional EWSs, the technique presented here can be used as a sorting mechanism to prioritize on-site exams. Therefore, it is most important that the method provides an ordinal ranking of potentially at-risk banks.

**Table 4.4.** Bank participation in Federal Reserve emergency liquidity facilities. The "Most Stressed Decile" contains 31 banks with the highest values of stress factor (3). The "Least Stressed Decile" contains 31 banks with the lowest stress factor (3) scores. The final column - Count - refers to the number of banks in each decile that received TAF of PDCF funds during the measurement period.

| | (TAF + PDCF Funds Received) / Total Assets | | |
|---|---|---|---|
| Stress Factor (3) | Mean* | Median* | Count |
| *Most Stressed Decile* | 9.5% | 12.8% | 11 |
| *Least Stressed Decile* | 2.7% | 3.7% | 5 |

* Conditional on receiving funds.

## 6. Conclusions

The primary contribution of this paper is to provide a method for measuring bank distress that does not merely model the way in which regulators have closed banks in the past. Ultimately, this has the potential to lower the frequency and costs of future disruptions in the financial sector. In addition, regulators are charged with developing a risk-matrix that can be used as a basis for initiating on-site examinations, assessing deposit insurance premiums, or levying fees to cover the costs of future bailouts. Looking at a composite measure of "bank stress" can be useful in such endeavors. Furthermore, this methodology has the potential to signal episodes of heightened bank stress even if that does not lead to a high rate of failures.

Second, this paper helps clarify factors that increased the likelihood of financial distress during the subprime crisis. As a result, it appears that an early warning system would have been useful in mitigating the severity of the crisis. From a regulatory standpoint, it is interesting to note that banks would have better prepared to face the crisis with higher Tier 1 capital ratios (as has since been mandated by Basel III). Additionally, the recently legislated requirement (in the Dodd-Frank) that mandates banks retain a portion of their originated residential loans is seemingly supported by these results. Finally, it appears that (at a minimum) close monitoring of healthy banks' non-performing loan rate may be worthwhile.

Preventing financial crises may prove increasingly difficult as regulators face larger institutions, greater bank connectivity, and rapid financial innovation. Even in the absence of these developments, many observers suggest that financial crises are inevitable and it is unlikely that regulators can successfully prevent future panics. At a minimum, however, informed regulators can help reduce the frequency and cost of such crises as we learn from mistakes and experience. Developing a more robust early warning system for large financial institutions as attempted by this paper can serve as a useful tool for regulators in the effort to achieve a more stable and resilient banking system.

# CHAPTER V

# CONCLUSION

The preceding chapters have demonstrated the usefulness of analyzing bank balance sheets to better understand important phenomena.  In the case of Chapter II, I show that the so-called "balance sheet channel" can have uneven impacts on large and small borrowers.  This study uses a unique strategy to identify the balance sheet channel, and provides evidence that the effect is in fact driven by the borrower (rather than lender) profile.  Furthermore, this study focuses on ascertaining evidence of a financial mechanism through which the balance sheet channel works.  In many previous studies, evidence further downstream – such as spending and investment decisions – is used to demonstrate the existence of the channel while a financial mechanism is assumed.

Separately, Chapter III illustrates that a complete understanding of how monetary policy works requires an evaluation of the financial condition of banks.  Specifically, I show that the strength of monetary policy actions can depend on the capital adequacy of the banking sector.  Besides contributing to a scarce empirical literature, this finding is important for policy makers.  Properly assessing the stance of monetary policy at a given point in time is essential, and Chapter III demonstrates that bank-level capital concerns can influence the availability of credit.  Furthermore, it is critical to understand the lag-times and ultimate strength associated with policy changes.  This chapter finds that the quantity and distribution of capital across the banking sector can inform these issues.

Finally, Chapter IV proposes a methodological contribution to an existing literature that attempts to identify banks at risk of failure. I argue that it is useful for policymakers and regulators to predict not just failure, but also the degree of financial stress a bank will experience in the future. Periods of severe financial stress – particularly at large financial institutions – can lead to many of the same adverse effects of bank failure. I apply this method to produce a set of bank-level characteristics associated with greater difficulty during the height of the subprime financial crisis. Understanding the factors that signal a weakening bank can potentially lead to a more resilient financial system that is then less likely to export disruptions to the real economy.

The importance of banks to developed economies can be immense. For many individuals and businesses banks or thrifts may be the only source of credit. As such, banks supply the financing necessary for a tremendous amount of investment and consumption that contributes to a higher growth rate and quality of life. Among other things, workers use these loans to acquire desired human capital and improve their standard of living, while businesses depend on credit to make payrolls, carry inventory, fund research projects, and launch new products. Thus, it is not appropriate to draw a stark dichotomy between the financial and real sectors of the economy. In fact, with appropriate regulation and policy, the relationship between these sectors can be incredibly positive and symbiotic. It is the aim of this dissertation to help cultivate this positive relationship by adding to the understanding of the factors that can generate disruptions in the supply of intermediated credit.

## APPENDIX A

## ROBUSTNESS CONSIDERATIONS

Table A.1 presents results of robustness checks. Only the coefficient on the FFR is reported for parsimony. Although results by group are not reported, patterns are very similar to those in Table 2.2. A short description of each panel follows:

*Panel A* considers loans to small firms to be those loans less than $250,000.

*Panel B* uses state-specific measures of real activity. The coincident economic activity index for each state and a state-specific unemployment rate were used.

*Panel C* replaces the FFR with the negative of the Bernanke-Mihov (1998) Index (so that an increase indicates a monetary tightening).

*Panel D* replaces a time trend with time fixed effects.

*Panel E* assumes the Baa-Aaa spread is endogenous.

*Panel F* assumes exogenous bank liquidity.

*Panel G* constructs an alternate measure of inflation expectations for construction of the real FFR.

*Panel H* includes the spread between 10 year and 3 month United States Treasury Securities.

*Panel I* excludes the net interest margin from the vector of covariates.

**Table A.1.** Robustness checks for results reported in Table 2.2. Only the coefficient on the measure of monetary policy is reported. Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text.

| Panel A - Loans to Small Firms <= $250,000 | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.266** | **-0.219** |
| | *0.000* | *0.000* |

| Panel B - State-specific Measures of Real Activity | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.192** | **-0.211** |
| | *0.005* | *0.001* |

| Panel C - Negative of Bernanke-Mihov (1998) Index | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Bernanke-Mihov | **-3.015** | **-3.640** |
| | *0.002* | *0.000* |

| Panel D - Allowing for Time Fixed Effects | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.757** | **-0.660** |
| | *0.000* | *0.000* |

| Panel E - Endogenous Baa-Aaa Spread | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.222** | **-0.215** |
| | *0.000* | *0.000* |

| Panel F - Assuming Exogenous Bank Liquidity | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.537** | **-0.406** |
| | *0.005* | *0.018* |

**Table A.1.** (continued)

| Panel G - Using the ex-ante Real Rate (Mishkin,1981 method) | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.064** | **-0.064** |
| | *0.059* | *0.043* |

| Panel H - Inclusion of Yield Curve Measure | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.346** | **-0.287** |
| | *0.000* | *0.002* |

| Panel I - Excluding the Net Interest Margin Regressor | | |
|---|---|---|
| Coefficient | C&I Loans to Small Firms | C&I + CRE Loans to Small Firms |
| Fed Funds Rate | **-0.229** | **-0.237** |
| | *0.001* | *0.000* |

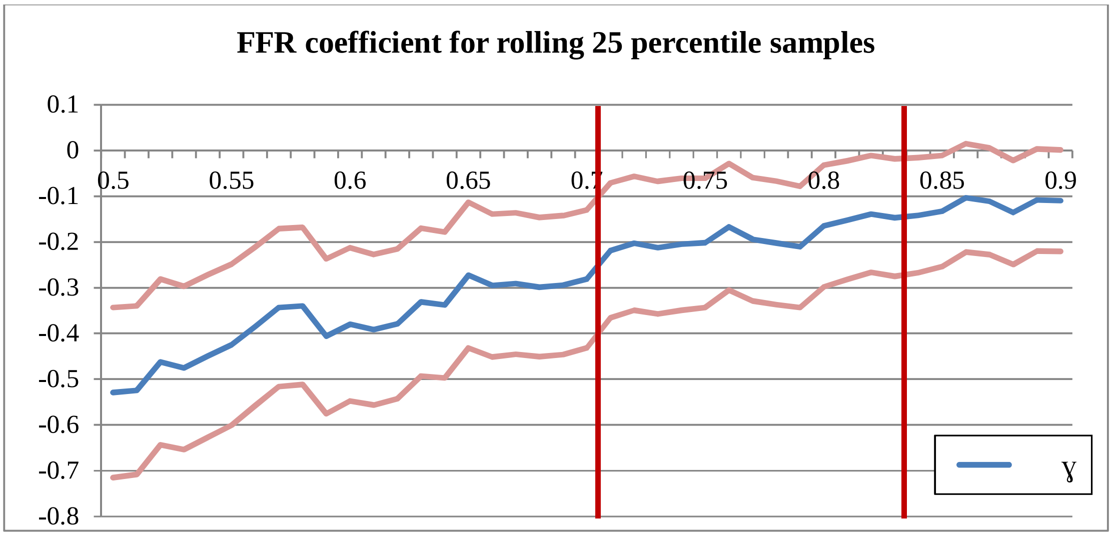
## APPENDIX B

## EXAMINING BANK SIZE CLASSIFICATIONS

In the main text of the paper, size classes were chosen for comparison with existing credit channel literature. However, it is possible to search for size class thresholds around which the value of $\gamma$ (from equation 2.6) achieves significantly different values. The method employed is similar to that described in Hansen (1999). However, the method outlined by the Hansen threshold model does not accommodate dynamic panels since standard transformations used to eliminate fixed effects will still lead to correlation between the error term and the endogenous variables. Extending this model, Kremer, Bick, and Nautz (2009) (henceforth KBN) use forward orthogonal deviations to eliminate fixed effects. The authors show that this transformation produces uncorrelated error terms. I should note that in this particular case, employing the KBN method presents several limitations. The most significant one is that it becomes necessary to assign a single size class to each bank over its lifetime.

Figure B.1 plots the estimate of the FFR coefficient (with confidence intervals) for a rolling size class "window" as indicated. Vertical lines are included at thresholds identified by using the KBN threshold model. As indicated, it appears that there is a "very small" size class of banks that exhibit a balance sheet channel that is stronger than the "small" banks between the $71^{st}$ and $83^{rd}$ percentiles. Applying these coefficient estimates to the full sample, the impact on small firm credit reported in the main text is slightly reduced when taking into account these compositional differences.

**Figure B.1.** Coefficient on FFR from estimations of rolling size-class windows up to the ninetieth percentile. The values on the horizontal axis represent size percentiles. Vertical lines are positioned at KBN-style threshold estimates.



## APPENDIX C

## ASYMMETRY ACROSS THE BUSINESS CYCLE

Does the balance sheet channel exhibit asymmetry across the business cycle? The answer to this question would be useful to policymakers concerned with the fortunes of small businesses during recessions. Though a longer time series would be ideal to test such an asymmetry, strategies to investigate this issue are at hand. The first - and simplest - method is to include a dummy variable indicating a recession in the subset of covariates and interacting that with the measure of monetary policy. In the sample period covered, this amounts to a dummy taking the value of one in 2001 and 2008 only. Unfortunately, this method of detecting business cycle asymmetries yields insignificant results, or *positive* effects of monetary tightening on the SBL ratio. However, the identification strategy described in the paper is not ideal for testing asymmetries over the business cycle in this manner. The reason is that the SBL likely receives upward pressure from factors influencing loan demand similar to those described in Section 3. To the extent that GDP and unemployment regressors only imperfectly control for the business cycle (a plausible assumption since I use forecasted values and there are timing issues introduced by the annual measurement) the recession dummy may be picking up noise generated by the increased loan demand of small firms relative to large firms during recessions.[47]

As a second test, I include an interaction term in the baseline regressions that is equal to averages of (actual) GDP growth multiplied by the monetary policy indicator. A

[47] Further clouding the issue of whether this "recession dummy" method is preferred for the purpose at hand is the fact that the 2008 "financial crisis" dummy included in the baseline regressions is almost always negative and significant.

"stronger" balance sheet channel in recessions would imply a positive coefficient on the interaction term. That is, as GDP growth falls, the sensitivity of the SBL ratio to monetary actions is intensified. When this interaction term is included in regressions with the measure of monetary policy, its coefficient is negative for small banks, but significant only at the twelve percent level of confidence for SBL1 (C&I loans only).[48] The implication of this result is that the balance sheet channel is weakened during recessions. However, several caveats remain. First, although the magnitude of the coefficient on the interaction term for SBL2 seems large, considering the "total" effect of a change in GDP wipes out any economic significance. Moving from the highest to lowest GDP reading in the sample alters the sensitivity of the SBL ratio to FFR by less than ten percent. Second, this interaction term itself is not robust to the considerations outlined in Appendix A. This characteristic remains even when the 2008 dummy is removed. Finally - and most importantly - interacting alternate measures of monetary policy with GDP growth causes any previous statistical significance of this term to completely evaporate. The results of this exercise are reported in Table C.1 in the first line of panels A and B.

Alternatively, I consider interacting the FFR with a dummy for both "slow growth" regimes and “rapid growth" regimes. Slow growth years occur when measures of GDP growth are below median, whereas rapid growth years are those in which measures of GDP growth are above median. These results are reported in the bottom of each panel of Table C.1. This method provides additional support for the notion that the

[48] The average GDP growth over the prior two quarters was used to better capture business cycle volatility. Since the recessions in the sample were all relatively short, four quarter averages smooth the recessions and reduce the volatility of this measure.

balance sheet channel is weaker during low-growth (though not necessarily recessionary) periods. The results are highly significant for small banks when using either SBL1 or SBL2 as the dependent variable.

**Table C.1.** Business cycle asymmetry investigations. Only the coefficient on the measure of monetary policy is reported. Robust p-values are reported beneath the corresponding coefficient in italics. Coefficients that are significant at least at the 10% level are in bold text. In the top portion of each panel is the coefficient of the monetary policy measure interacted with trailing GDP growth. The bottom rows of each panel report coefficients on FFR for below-median GDP growth years ("Slow Growth") and above-median years ("Rapid Growth").

| Panel A - Dependent Variable: SBL1 (Share of C&I Loans to Small Firms) | | | | |
|---|---|---|---|---|
| Coefficient | < 90th percentile | 90th - 98th percentile | > 98th percentile | All Banks |
| *Interaction with GDP Growth* | | | | |
| FFR*(GDP growth) | -0.024 | -0.013 | 0.027 | -0.021 |
| | *0.126* | *0.300* | *0.391* | *0.148* |
| *Dummies for Slow-Growth Regimes vs. Rapid-Growth Regimes* | | | | |
| $FFR_{Slow\ Growth}$ | **-0.257** | **0.085** | -0.127 | **-0.203** |
| | *0.002* | *0.060* | *0.617* | *0.007* |
| $FFR_{Rapid\ Growth}$ | **-0.307** | **0.069** | -0.114 | **-0.241** |
| | *0.000* | *0.085* | *0.612* | *0.000* |

| Panel B - Dependent Variable: SBL2 (Share of C&I and CRE Loans to Small Firms) | | | | |
|---|---|---|---|---|
| Coefficient | < 90th percentile | 90th - 98th percentile | > 98th percentile | All Banks |
| *Interaction with GDP Growth* | | | | |
| FFR*(GDP growth) | **-0.034** | -0.003 | 0.033 | **-0.030** |
| | *0.027* | *0.652* | *0.330* | *0.029* |
| *Dummies for Slow-Growth Regimes vs. Rapid-Growth Regimes* | | | | |
| $FFR_{Slow\ Growth}$ | **-0.233** | -0.018 | -0.171 | **-0.189** |
| | *0.002* | *0.590* | *0.339* | *0.006* |
| $FFR_{Rapid\ Growth}$ | **-0.316** | -0.016 | -0.143 | **-0.260** |
| | *0.000* | *0.596* | *0.366* | *0.000* |

In summary, the data appear to indicate that the balance sheet channel is weaker during recessionary periods. However, the tests reported here indicate that this interpretation is inconclusive, and there may be no significant asymmetry present. Primarily for this reason, the consideration of this matter is excluded from the main text of the paper.

# APPENDIX D

## MATURITY GAP REGRESSIONS

In order to generate maturity gaps for each bank across all time periods, a prediction approach must be used. Taking advantage of the maturity information contained in the notes and memoranda from the Call Reports beginning in 2006, I form actual bank-level maturity gaps. Next, I regress these observed maturity gaps on broad balance sheet characteristics to form "prediction equations" that can be used to generate maturity gaps for banks in each time period. The regression summarized in Table D.1 was used to create the bank-level maturity gaps for Table 3.3. Though results are reported for 2006Q4 only, I should note that the coefficient estimates are very stable throughout the period over which maturity gap regressions can be run. Finally, many additional specifications (often with more covariates) were used. These additional maturity gap regressions produced an adjusted $R^2$ of between 0.31 and 0.38, and all yield similar results to those presented in the paper.

**Table D.1.** Maturity gap regression for 2006Q4. The following equation contains estimates from a simple OLS regression of constructed (actual) maturity gap on balance sheet characteristics. Size is measured as the natural log of total assets, and Mutual, Cooperative, and Org. Type: Other are dummy values that take a value of one based on a financial institution's organization structure. These coefficients are used to predict bank-level maturity gaps for the entire sample.

| Maturity gap regression | |
|---|---|
| | Dependent Variable: Maturity Gap (2006:4) |
| *Securities/Assets* | **5.517** |
| | *0.000* |
| *Transaction Accts.* | **-2.281** |
| | *0.000* |
| *Non-Transaction Accts.* | **-0.973** |
| | *0.000* |
| *Personal/Assets* | **2.307** |
| | *0.000* |
| *RE Loans/Assets* | **2.621** |
| | *0.001* |
| *Size* | **0.159** |
| | *0.000* |
| *Mutual* | **3.293** |
| | *0.000* |
| *Cooperative* | **2.791** |
| | *0.001* |
| *Org. Type: Other* | **-2.566** |
| | *0.001* |
| *Observations* | 8,030 |
| *Adjusted* $R^2$ | 0.31 |

## REFERENCES CITED


Ang, J. S. (1991). Small Business Uniqueness and the Theory of Financial Management. *Journal of Small Business Finance, 1*, 1-13.

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, *58*(2), 277-297.

Ashcraft, A. (2006). New Evidence on the Lending Channel. *Journal of Money, Credit, and Banking, 38*(3), 751-775.

Ashcraft, A. (2008). Are Bank Holding Companies a Source of Strength to Their Banking Subsidiaries? *Journal of Money, Credit, and Banking, 40*(2-3), 273-294.

Asquith, P., & Mullins, D. W. (1986). Equity Issues and Offering Dilution. *Journal of Financial Economics, 15*(1-2), 61-89.

Bach, G. L., & Huizenga, C. J. (1960). Differential Effects of Tight Money. *American Economic Review, 50*, 53-80.

Baer, H. L., & McElravey, J. N. (1993). Capital Shocks and Bank Growth - 1973 to 1991. *Economic Perspectives, 17*(4), 1-21.

Barr, R. S., Seiford, L. M., & Siems, T. F. (Producer). (1994). Forecasting Bank Failure: A Non-Parametric Frontier Estimation Approach. *Discussion Papers (REL - Recherches Economiques de Louvain)*.

Berger, A., Kashyap, A., & Scalise, J. (1995). The Transformation of the U.S. Banking Industry: What a Long, Strange Trip It's Been. *Brookings Papers on Economic Activity*(2), 55-201.

Berger, A. N., & Bouwman, C. H. S. (Forthcoming). Bank Capital, Survival, and Performance Around Financial Crises. *Review of Financial Studies*.

Berger, A. N., & Udell, G. F. (1994). Did Risk-Based Capital Allocate Bank Credit and Cause a "Credit Crunch" in the United States? *Journal of Money, Credit and Banking, 26*(3), 585-628.

Bernanke, B., & Blinder, A. (1988). Credit, Money, and Aggregate Demand. *American Economic Review, 78*, 435-439.

Bernanke, B., & Blinder, A. (1992). The Federal Funds Rate and the Channels of Monetary Transmission. *American Economic Review 82*, 901-921.

Bernanke, B., & Gertler, M. (1989). Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review, 79*, 14-31.

Bernanke, B. S., & Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *The Journal of Economic Perspectives, 9*(4), 27-48.

Bernanke, B., Gertler, M., & Gilchrist, S. (1996). The Financial Accelerator and the Flight to Quality. *The Review of Economics and Statistics, 78*, 1-15.

Bernanke, B., & Mihov, I. (1998). Measuring Monetary Policy. *Quarterly Journal of Economics, 113*, 869-902.

Bernanke, B. S., & Blinder, A. S. (1988). Credit, Money, and Aggregate Demand. *The American Economic Review, 78*(2), 435-439.

Bernanke, B. S., & Lown, C. S. (1991). The Credit Crunch. *Brookings Papers on Economic Activity, 1991*(2), 205-239.

Bernanke, B. S., & Mihov, I. (1998). Measuring Monetary Policy. *The Quarterly Journal of Economics, 113*(3), 869-902.

Black, L., & Rosen, R. (2007). *How the Credit Channel Works: Differentiating the Bank Lending Channel and the Balance Sheet Channel*. Working Paper Series: Seventh Federal Reserve District. Federal Reserve Bank of Chicago. Chicago, IL.

Blundell, R., & Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics, 87*, 115-143.

Blundell, R., Bond, S., & Windmeijer, F. (2000). Estimation in Dynamic Panel Data Models: Improving on the Performance of the Standard GMM Estimator. In B. Baltagi (Ed.), *Nonstationary Panels, Cointegrating Panels and Dynamic Panels* (pp. 53-92). New York: Elsevier.

Choi, I. (2001). Unit Root Tests for Panel Data. *Journal of International Money and Finance, 20*, 249-272.

Christiano, L., Eichenbaum, M., & Evans, C. (2000). Monetary Policy Shocks: What Have We Learned and to What End?". *Handbook of Macroeconomics*.

Cole, R. A., Cornyn, B. G., & Gunther, J. W. (1995). FIMS: A New Monitoring System for Banking Organizations. *Federal Reserve Bulletin, 81*, 1-15.

Cole, R. A., & Gunther, J. W. (1995). Separating the Likelihood and Timing of Bank Failure. *Journal of Banking & Finance, 19*, 1073-1089.

Dahl, D., & Shrieves, R. E. (1995). Regulation, Recession, and Bank Lending Behavior: The 1990 Credit Crunch. *Journal of Financial Services Research, 9*(1), 5-30.

Demirguc-Kunt, A. (1989a). *Modeling Large Commercial Bank Failures: A Simultaneous-Equation Analysis*. Federal Reserve Bank of Cleveland Working Paper #8905.

Demirguc-Kunt, A. (1989b). Deposit-Institution Failures: A Review of Empirical Literature. *Federal Reserve Bank of Cleveland, Economic Review, 1989*(4), 2-18.

Estrella, A., Park, S., & Peristiani, S. (2000). Capital Ratios as Predictors of Bank Failure. *Economic Policy Review, 6*, 33-52.

Fazzari, S., Hubbard, G., & Peterson, B. (1988). Financing Constraints and Corporate Investment. *Brookings Papers on Economic Activity, 1*, 141-195.

Flannery, M. J. (1998). Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence. *Journal of Money, Credit and Banking, 30*(3), 273-305.

Friedman, B. (1991). Comment on "The Credit Crunch" by Ben S. Bernanke and Cara S. Lown. *Brookings Papers on Economic Activity, 2*, 240-247.

Furlong, F. T. (1992). Capital Regulation and Bank Lending. *Economic Review, 3*, 23-33.

Galbraith, J. K. (1957). Market Structure and Stabilization Policy. *Review of Economics and Statistics, 39*, 124-133.

Gambacorta, L., & Mistrulli, P. E. (2004). Does Bank Capital Affect Lending Behavior? *Journal of Financial Intermediation, 13*(4), 436-457.

Gertler, M., & Gilchrist, S. (1994). Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms. *The Quarterly Journal of Economics, 109*, 309-340.

Gertler, M., & Gilchrist, S. (1996). The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence. In M. Blejer, Z. Eckstein, Z. Hercowitz & L. Leiderman (Eds.), *Financial Factors in Economic Stabilization and Growth* (pp. 11-35): Cambridge University Press.

Gilchrist, S. (1990, December). *An Empirical Analysis of Corporate Investment and Financing Hierarchies Using Firm Level Panel Data*. Board of Governors of the Federal Reserve System. Mimeograph.

Hancock, D., & Wilcox, J. A. (1998). The "Credit Crunch" and the Availability of Credit to Small Businesses. *Journal of Banking & Finance, 22,* 983-1014.

Hansen, B. E. (1999). Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference. *Journal of Econometrics, 93*(2), 345-368.

Houston, J., James, C., & Marcus, D. (1997). Capital Market Frictions and the Role of Internal Capital Markets in Banking. *Journal of Financial Economics, 46*, 135-164.

Hubbard, G. (2000, May). *Capital-Market Imperfections, Investment, and the Monetary Transmission Mechanism*. Columbia University. Mimeograph.

Hubbard, R. G., Kuttner, K. N., & Palia, D. N. (2002). Are There Bank Effects in Borrowers' Costs of Funds? Evidence from a Matched Sample of Borrowers and Banks. *The Journal of Business, 75*(4), 559-581.

Hyytinen, A., & Pajarinen, M. (2008). Opacity of Young Businesses: Evidence from Rating Disagreements. *Journal of Banking & Finance, 32*(7), 1234-1241.

Im, K., Pesaran, M., Shin, Y. (2003). Testing for Unit Roots in Heterogeneous panels. *Journal of Econometrics, 115*, 53-74.

Jones, D. S., & King, K. K. (1995). The Implementation of Prompt Corrective Action: An Assessment. *Journal of Banking & Finance, 19*(3-4), 491-510.

Kashyap, A., Lamont, O., & Stein, J. (1994). Credit Conditions and the Cyclical Behavior of Inventories. *Quarterly Journal of Economics, 109*, 565-592.

Kashyap, A., & Stein, J. (1994). Monetary Policy and Bank Lending. In G. Mankiw (Ed.), *NBER Studies in Business Cycles* (Vol. 29, pp. 221-256): National Bureau of Economic Research, University of Chicago Press.

Kashyap, A., & Stein, J. (2000). What Do a Million Observations on Banks Say about the Transmission of Monetary Policy? *American Economic Review, 90*, 407-428.

Kashyap, A., Stein, J., & Wilcox, D. (1993). Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance. *American Economic Review, 83*, 78-98.

Kashyap, A., Stein, J., & Wilcox, D. (1996). Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance: Reply. *American Economic Review, 86*, 310-314.

Kashyap, A. K., & Stein, J. C. (1995). *The Impact of Monetary Policy on Bank Balance Sheets.* Paper presented at the Carnegie-Rochester Conference Series on Public Policy.

Kashyap, A. K., & Stein, J. C. (2000). What Do a Million Observations on Banks Say about the Transmission of Monetary Policy? *The American Economic Review, 90*(3), 407-428.

Kishan, R. P., & Opiela, T. P. (2000). Bank Size, Bank Capital, and the Bank Lending Channel. *Journal of Money, Credit and Banking, 32*(1), 121-141.

Kishan, R. P. K., & Opiela, T. P. (2006). Bank Capital and Loan Asymmetry in the Transmission of Monetary Policy. *Journal of Banking & Finance, 30*(1), 259-285.

Kiyotaki, N., & Moore, J. (1997). Credit Cycles. *Journal of Political Economy, 105*, 211-248.

Kolari, J., Glennon, D., Shin, H., & Caputo, M. (2002). Predicting large US commercial bank failures. *Journal of Economics and Business, 54*(4), 361-387.

Kremer, S., Bick, A., & Nautz, D. (2009). Inflation and Growth: New Evidence From a Dynamic Panel Threshold Analysis. In S. D. Papers (Ed.).

Lane, W. R., Looney, S. W., & Wansley, J. W. (1986). An Application of the Cox Proportional Hazards Model to Bank Failure. *Journal of Banking & Finance, 10*(4), 511-531.

Lang, W., & Nakamura, L. (1995). 'Flight to Quality' in Banking and Economic Activity. *Journal of Monetary Economics, 36*, 145-164.

Milne, A. (1991). *Financial Effects on Inventory Investment*. Manuscript. London Business School. Mimeograph.

Mishkin, F. (1981). The Real Interest Rate: An Empirical Investigation. *Carnegie-Rochester Conference Series on Public Policy*(15), 151-200.

Mishkin, F. (2007). *The Economics of Money, Banking, and Financial Markets* (8th ed.). Boston, MA: Pearson Addison-Wesley.

Mishkin, F. *Small Business Lending*, Committee on Small Business and Entrepreneurship, U.S. Senate (2008).

Morgan, D. (1992). Are Bank Loans a Force in Monetary Policy? *Federal Reserve of Kansas City Economic Review, 2*, 31-41.

Morgan, D. (1998). The Credit Effects of Monetary Policy: Evidence Using Loan Commitments. *Journal of Money, Credit, and Banking, 30*, 102-118.

Oliner, S. D., & Rudebusch, G. D. (1995). Is There a Bank Lending Channel for Monetary Policy? *Federal Reserve Bank of San Francisco Economic Review*(2), 3-20.

Oliner, S. D., & Rudebusch, G. D. (1996). Is There a Broad Credit Channel for Monetary Policy? *Federal Reserve Bank of San Francisco Economic Review*(1), 3-13.

Park, S., & Peristiani, S. (2007). Are Bank Shareholders Enemies of Regulators or a Potential Source of Market Discipline? *Journal of Banking & Finance, 31*, 2493-2515.

Peek, J., & Rosengren, E. (1995). The Capital Crunch: Neither a Borrower nor a Lender Be. *Journal of Money, Credit and Banking, 27*(3), 625-638.

Peek, J., & Rosengren, E. (1997). How Well Capitalized are Well-Capitalized Banks? *New England Economic Review*(Sep), 41-50.

Peek, J., & Rosengren, E. S. (1998). Bank Consolidation and Small Business Lending: It's Not Just Banks Size That Matters. *Journal of Banking & Finance, 22*(6), 799-819.

Peterson, P. P., & Wall, L. D. (1996). Banks' Responses to Binding Regulatory Capital Requirements. *Economic Review*.

Pettway, R. H. (1976). Market Test of Capital Adequacy of Large Commercial Banks. *The Journal of Finance, 31*(3), 865-875.

Pettway, R. H. (1980). Potential Insolvency, Market Efficiency, and Bank Regulation of Large Commercial Banks. *Journal of Financial and Quantitative Analysis, 15*(1), 219-236.

Philip E. Strahan, J. P. W. (1998). Small Business Lending and the Changing Structure of the Banking Industry. *Journal of Banking & Finance, 22*(6), 821-845.

Randall, R. E. (1989). Can the Market Evaluate Asset Quality Exposure in Banks? *New England Economic Review*(Jul), 3-24.

Stein, J. C. (1998). An Adverse-Selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy. *The RAND Journal of Economics, 29*(3), 466-486.

Stein, J. C. (2002). Information Production and Capital Allocation: Decentralized Versus Hierarchical Firms. *Journal of Finance, 57*, 1891-1921.

Syron, R. F. (1991). Are We Experiencing a Credit Crunch? *New England Economic Review*(Jul/Aug), 3-10.

Thakor, A. V. (1996). Capital Requirements, Monetary Policy, and Aggregate Bank Lending: Theory and Empirical Evidence. *The Journal of Finance, 51*(1), 279-324.

Thomson, J. B. (1991). Predicting Bank Failures in the 1980s. *Federal Reserve Bank of Cleveland, Economic Review, 1991*(1), 9-20.

Van den Heuvel, S. J. (2002a). Does Bank Capital Matter for Monetary Transmission? *Economic Policy Review, 5*, 259-265.

Van den Heuvel, S. J. (2002b). *Banking Conditions and the Effects of Monetary Policy: Evidence from U.S. States*. University of Pennsylvania.

Van den Heuvel, S. J. (2007). *Do Monetary Policy Effects on Bank Lending Depend on Bank Capitalization?* University of Pennsylvania.

Van den Heuvel, S. J. (2009). *The Bank Capital Channel of Monetary Policy*. Board of Governors of the Federal Reserve System.

Walsh, C. (2003). *Monetary Theory and Policy* (2 ed.). Cambridge, MA: MIT Press.

Wheelock, D. C., & Wilson, P. W. (2000). Why do Banks Disappear? The Determinants of U.S. Bank Failures and Acquisitions. *The Review of Economics and Statistics, 82*(1), 127-138.