# Monetary Policy, Loan Maturity, and Credit Availability*

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The recent financial crisis and economic recovery have renewed interest in how monetary policy affects bank lending. Using loan-level data, we analyze the effect of monetary policy on loan originations. Our results show that tightening monetary policy significantly reduces the supply of commercial loans by shortening loan maturity. A 1-percentage-point increase in the federal funds rate reduces the average maturity of loan supply by 3.3 percent, contributing to an 8.2 percent decline in the steady-state loan supply at a typical bank. This channel of monetary policy affects loan supply similarly at small and large banks. Our results have interesting implications for the effects of monetary policy on bank maturity transformation and credit availability.

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## 1. Introduction

Fears of a credit crunch in the recent financial crisis led many observers to call for central banks to ease monetary policy.[1] Such

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[1]There is evidence that a credit crunch, which has been defined as a "significant leftward shift in the supply curve of loans" (Bernanke and Lown 1991), occurred in the recent crisis (Ivashina and Scharfstein 2010; Puri, Rocholl, and Steffen 2011).

views are partly based on the idea that relaxing monetary policy leads to greater credit availability. Similarly, as the Federal Reserve considers raising rates during a relatively weak recovery, there is concern about a premature restriction of credit supply. This paper explores this premise by examining the impact of monetary policy on the characteristics of banks' loan supply. The key findings show that the influence of monetary policy on the amount of loan supply is observed not in aggregate loan levels, but through changes in loan maturity. A tightening (loosening) of monetary policy reduces (increases) the maturity of bank loan supply, which implies a corresponding change in the maturity transformation being provided by the banking sector. Our results show that monetary policy, through its effect on loan maturity, has an effect on credit availability over time. A 1-percentage-point increase in the federal funds rate—our primary measure of monetary policy tightening—reduces the average maturity of loan supply by 3.3 percent, contributing to an 8.2 percent decrease in the steady-state loan supply at a typical bank.

Previous studies have examined the channels through which monetary policy may affect bank loan supply. If tight monetary policy increases banks' external finance premium, banks may respond by reducing the total amount of credit they are willing to supply (Stein 1998). This bank lending channel suggests a relationship between monetary policy and aggregate loan supply. In addition, monetary contractions can reduce the net worth of banks' borrowers. This increase in the agency costs in lending, referred to as the balance sheet channel, can shift available credit toward higher-net-worth firms (Bernanke, Gertler, and Gilchrist 1996).

More recently, the credit channel literature has focused on the impact of monetary policy on credit allocation (as described in Borio and Zhu 2012). For instance, Jimenez et al. (2012) study loan applications in the credit registry of Spain to identify the effect of bank capital and liquidity on loan acceptance rates. In addition, much of the recent work has brought attention to the "risk-taking channel" of monetary policy by analyzing the allocation effects of risk pricing (e.g., Borio and Zhu 2012; Kishan and Opiela 2012). We build on this literature by examining the impact on credit allocation through loan maturity and loan size. Our paper most directly relates to the model of Diamond and Rajan (2006), a liquidity version of the lending

channel that emphasizes the risk of funding long-term projects with short-term funds.

We use data on commercial loan originations in the United States from the Federal Reserve's Survey of Terms of Business Lending (STBL) to analyze these potential changes in banks' loan supply. Using the STBL, we can examine how banks adjust their commercial lending in response to monetary policy, including how they alter the maturity of loan supply and the size of loan originations. These redistributions in bank lending can have important real effects as they change the availability of credit for different projects and firms. For instance, the availability of longer-term credit for capital investments may be particularly important during an economic recovery.

A key challenge in this literature is the differentiation of changes in loan supply from changes in loan demand. An increase in lending can be supply or demand driven. We identify changes in supply by differentiating between new "spot loan" originations and loans made under a pre-existing commitment. Loan commitments are a form of credit line, giving firms the ability to decide when to borrow.[2] Therefore, changes in commitment lending (in the short run) are primarily due to changes in loan demand. The level of commitment lending should reflect changes in firms' demand for credit, which could change through the traditional interest rate channel by which monetary policy affects firms' cost of borrowing. We identify changes in loan supply by examining spot lending *relative* to commitment lending. Controlling for changes in commitment lending allows us to net out demand effects and focus on changes in banks' willingness to extend new credit.

Our first step is to estimate how the dollar amount of lending is affected by monetary policy. Early empirical studies of the credit channel examine how the stock of loans outstanding responds to monetary policy (e.g., Bernanke and Blinder 1992; Kashyap, Stein and Wilcox 1993). Some results even indicate that loans outstanding—used as a measure of loan supply—increases slightly, contrary to the intuition behind the bank lending channel. However,

[2]Banks have an advantage in hedging liquidity risk (Kashyap, Rajan, and Stein 2002; Gatev and Strahan 2006) and many firms choose to draw down their existing lines of credit when other sources of liquidity become more strained (Ivashina and Scharfstein 2010).

similar to the more recent credit channel literature, we are better able to differentiate supply from demand by examining the flow of lending rather than the stock (e.g., Jimenez et al. 2014). Although we find an increase in lending with monetary tightening, we explore the issue further by analyzing the effect on credit allocation. By examining both the flow and stock of lending, we find evidence that tightening monetary policy decreases banks' loan supply over time.

Our main results hinge on how monetary policy affects loan maturity. The STBL measures the *flow* of lending by a bank, while the bank lending channel makes predictions about the *stock* of loans. In the aggregate data, this difference is not important, since the best proxy for changes in the stock of loans is the flow of loans. However, if a bank reduces the duration of the loans it makes, its stock of loans can decrease fairly quickly even if the flow of loans remains constant or increases. Research focusing on the dollar amount of bank lending can miss this point. We find that during periods of tight (loose) credit, banks reduce (increase) the maturity of their loan supply, consistent with the operation of a bank lending channel.[3]

We then examine the response of overall lending to monetary policy using our data. Our preferred measure of bank lending according to this approach is the *product* of total lending and loan maturity. With this combined measure, we examine how monetary policy affects the "dollar years" of bank loan supply. The results suggest that an increase (reduction) in the real federal funds rate leads to an overall reduction (increase) in loan supply, consistent with an operative bank lending channel.

We also analyze whether the responsiveness of banks' lending to monetary policy is a function of bank size. We find that the distribution of loan supply at both small and large banks is sensitive to monetary policy. This builds on previous empirical findings (e.g., Kashyap and Stein 2000).

Our combined results point to redistributive effects of monetary policy on bank loan supply and the availability of credit. It appears that banks may alter loan supply during periods of tight (loose) monetary policy by shortening (lengthening) loan maturities and

[3]This also indicates a reduction in banks' maturity transformation during periods of tight credit, which ultimately leads to a decline in liquidity creation (Berger and Bouwman 2009).

thereby increasing the liquidity of their loan portfolio. These results support the premise that monetary policy influences the availability and allocation of credit, with changes in loan maturity being the mechanism that implements these changes.

The remainder of the paper is organized as follows. Section 2 reviews the literature and section 3 describes the data used in our analysis. Section 4 explains our empirical methodology and section 5 lays out the results as well as robustness tests. Section 6 compares small banks with large banks. Section 7 concludes.

## 2. Literature Review

Monetary policy can affect the real economy both through the demand side (Bernanke and Blinder 1992) and through the supply side. One of the channels of the supply-side effect is known as the credit channel. Financial frictions stemming from information asymmetries may affect the costs for banks to both borrow and lend funds. The relationships between these frictions and short-term interest rates are channels through which monetary policy influences credit availability (Bernanke and Gertler 1995). Our paper contributes to this literature by focusing on changes in loan maturity and loan size.

The credit channel of monetary policy can occur through what is known as the bank lending channel, which operates through banks' liability side. Tight monetary policy drains reserves from the banking system, leaving banks with fewer loanable funds, thereby reducing lending (Bernanke and Blinder 1988). Although this drain in reserves can be partially offset by non-reservable wholesale funds, such as uninsured deposits (Romer and Romer 1990), agency costs between banks and their providers of funds can cause banks to face a greater external finance premium on wholesale funds during periods of tight monetary policy (Stein 1998). This higher cost leads banks to reduce lending. We examine whether the bank lending channel operates through changes in loan maturity.

The credit channel also includes the balance sheet channel, which operates through banks' asset side. In this channel, monetary policy affects agency costs in bank lending, which leads to changes in firms' ability to qualify for credit. Monetary contractions reduce the net worth of borrowers, which increases agency costs, primarily for low-net-worth firms (Bernanke, Gertler, and Gilchrist 1996). When

these agency costs increase, only relatively safer borrowers continue to qualify for credit (Bernanke and Gertler 1989).[4] This implies that changes in monetary policy lead to a reallocation of credit availability across investment projects (Matsuyama 2007). As borrowers become riskier, this could reduce borrowers' ability to qualify for longer-maturity loans.

In addition, recent theoretical literature shows how changes in monetary conditions may alter bank risk. Monetary contractions increase the real value that banks must pay to retain deposits, which increases the real liquidity demands on banks. This causes banks to fund fewer long-term projects (Diamond and Rajan 2006, 2011). The Diamond and Rajan model of banks' maturity transformation predicts that the maturity of loan originations will decline following monetary contractions. Our analysis provides a test of this liquidity version of the lending channel. Related to this, agency problems in banks—especially when capital is low or short-term funding is high—may amplify the reduction in banks' risk taking following monetary contractions (Borio and Zhu 2012).

Early empirical work on identifying the credit channel focuses on the response of aggregate lending to a monetary contraction. Kashyap and Stein (1995, 2000), for instance, find that the loan supply of smaller, less liquid banks is more sensitive to changes in monetary policy, because raising wholesale liabilities is more costly for these banks. Other studies find similarly that the effects of monetary tightening are increasing in the expected costs of raising non-reservable liabilities.[5]

Our paper more directly builds on recent empirical literature that examines the transmission of monetary conditions to credit allocation. Much of this literature focuses on the relationship between monetary policy and bank risk. Den Haan, Summer, and Yamashiro (2007) find that, following a monetary tightening, commercial and industrial (C&I) loans increase while real estate and consumer loans decrease, which the authors interpret as a reallocation into

[4]This channel has also been referred to as the "flight to quality."

[5]Kishan and Opiela (2000) examine the effects of bank capitalization, Jayaratne and Morgan (2000) look at dependence on core deposits, Ashcraft (2006) analyzes banks by holding company status, and Black, Hancock, and Passmore (2007) focus on banks' loan-to-core-deposit ratios.

shorter-term, less risky assets. Similarly, low short-term interest rates soften bank lending standards and increase bank risk taking.[6] Buch, Eickmeier, and Prieto (2014) find evidence for this channel among small banks using aggregate STBL time-series data. Although banks with low risk (low expected default) are less sensitive to monetary policy (Altunbas, Gambacorta, and Marques-Ibanez 2010), there appears to be a risk-taking channel of monetary policy.

Our research examines the effect of monetary policy on loan maturity and loan size as key components of credit allocation. It is possible for monetary policy to affect these loan characteristics through each of the channels described above. For instance, monetary contractions can reduce the maturity of bank loan supply through an increase in banks' external finance premium, a reduction in borrowers' net worth, or a reduction in banks' willingness to take on liquidity risk. If loan size proxies for firm size, then a monetary contraction should cause an increase in loan size, which would be a flight to quality for many of the same reasons.

The results for loan maturity have interesting implications for the literature on corporate loan maturity. Berger et al. (2005) use the STBL data to analyze the effects of risk and asymmetric information on debt maturity. Consistent with the models of Flannery (1986) and Diamond (1991), the authors find among low-risk firms that loan maturity increases with borrower quality and decreases with information asymmetries. Ortiz-Molina and Penas (2008) find similar evidence using the Federal Reserve Survey of Small Business Finance. Through the balance sheet channel, monetary contractions increase borrower risk and agency costs. These findings are consistent with monetary contractions reducing loan maturity.

The empirical methodology focuses on the identification of changes in credit allocation in response to monetary policy. The STBL data does not include borrower characteristics, which is a limiting factor relative to data such as the credit registry in Spain (used by Jimenez et al. 2012).[7] However, we are able to use differences

[6] See Delis and Kouretas (2011); Maddaloni and Peydro (2011, 2012); Altunbas, Gambacorta, and Marques-Ibanez (2014); and Jimenez et al. (2014).

[7] Jimenez et al. (2014) include loan maturity in their analysis but do not directly study the effect of monetary policy on loan maturity.

between commitment and spot lending to measure of changes in loan supply. This approach follows other papers with similar methodologies (Sofianos, Wachtel, and Melnik 1990; Berger and Udell 1992; Morgan 1998). We also focus on loan maturity and loan size, which capture important aspects of credit allocation and credit availability. These are particularly important for understanding the rise and fall in the availability of bank credit with the interest rate cycle in the United States.

## 3. Data and Summary Statistics

The loan data are from the Survey of Terms of Business Lending (STBL), which is a survey conducted by the Board of Governors of the Federal Reserve System. The STBL solicits information from a sample of banks on C&I loans issued during the first full business week of the second month of every quarter.[8] Our sample includes observations from the third quarter of 1982 through the fourth quarter of 2009, a time frame that covers several interest rate cycles. Each quarter, the STBL includes a sample of roughly 340 banks, including both small banks and large banks. While banks move in and out of the STBL panel, the median length of time a domestic bank is surveyed during our sample period is twenty-three quarters.

To reduce noise in the STBL data's time-series dimension, we apply filters to remove banks that have a limited relevance to our analysis or limited presence in the STBL survey. First, we remove banks that issue almost all their loans under commitment or almost all their loans as spot loans, since these banks are unlikely to respond

[8]Although the survey includes several loan types, we focus strictly on C&I loans in the survey (about 95 percent of the STBL loans are C&I loans). We also eliminate several groups of loans which are not appropriate to our analysis. We exclude all add-on loans, loans booked at a foreign office, loans with maturity greater than ten years, and loans for which the interest rate spread over the Treasury of comparable maturity is less than −1 percent or greater than 10 percent. Some banks report for less than a full week and for less than all branches. For these banks, when we aggregate data by bank, we adjust the data as if they reported for all branches for the full week. Finally, the survey can include Veteran's Day. For a bank that makes loans on a Veteran's Day that total less than 75 percent of its average daily loan volume during the other days of that week, we replace data for Veteran's Day with the average lending on other days that week at that bank.

to changes in monetary policy by changing the mix of spot and commitment loans. Formally, we drop all banks where the average share of commitment loans in total loans is above 99 percent or below 1 percent. Second, we remove foreign banks, since they entered the sample in the middle of our sample period. Third, we remove banks that are in the survey fewer than twenty-five times. These banks have a limited time span in the survey, which reduces the possibility for changes over time. Finally, we remove banks that average less than twenty-five loans per week. With these filters, the final sample includes 230 banks and 3,170,846 loans, with banks in the sample for a median fifty-four quarters.

We include data on macroeconomic conditions from publicly available sources and on bank characteristics from the Consolidated Report of Condition and Income (the"Call Report") associated with the bank making the loan.

Table 1 lists summary statistics for the variables used in our tests. All dollar-amount variables are reported in 2007 U.S. dollars.[9] We discuss the variables used in the regressions in the empirical methodology section below.

The primary loan characteristic we use in our identification strategy is whether a loan is made under commitment. A commitment is either a formal commitment or an informal credit line that provides a borrower with the right to borrow up to a certain amount of credit over a fixed period of time. The important aspect of a commitment is that a bank is committed to making a loan to the firm upon request. Although there is evidence that some firms faced credit line reductions during the crisis (Huang 2010; Ivashina and Scharfstein 2010), only the violation of a material adverse change type covenant typically releases the bank from its commitment.[10] We refer to loans made when there is no prior commitment as spot loans. The average share of commitment loans at a bank in our sample is 76 percent.

Firms use loans for different reasons. Some loans are used more to cover day-to-day operations (working capital) while others are used more to finance discrete, often one-off, projects. It is possible that

[9]We use the CPI net of food and energy prices in 2007:Q4 as the deflator.

[10]Loans generally have material adverse change (MAC) clauses which allow banks to renege on their commitment to lend if the credit quality of the firm deteriorates significantly, but these clauses are rarely exercised in normal times.

## Table 1. Descriptive Statistics

| Variable | Description | Mean | Standard Deviation |
|---|---|---|---|
| | *Loan Characteristics* | | |
| Commitment | Share of loans made under commitment (vs. spot) | 0.76 | 0.30 |
| Fixed Rate | Share of loans with fixed interest rate (vs. floating) | 0.64 | 0.33 |
| Commitment and Fixed Rate | Share of commitment loans with fixed interest rate | 0.67 | 0.34 |
| Spot and Fixed Rate | Share of spot loans with fixed interest rate | 0.60 | 0.36 |
| | *Dependent Variables* | | |
| Total Lending | Log of total loan amount (in thousands of $) | 3.99 | 2.09 |
| Loan Maturity | Log of weighted-average loan maturity (in years) | 0.46 | 0.40 |
| Loan Size | Log of average loan amount (in thousands of $) | 0.48 | 0.60 |
| Total Lending * Loan Maturity | Log of total loan amount multiplied by weighted-average loan maturity | 2.99 | 1.95 |
| | *Macroeconomic Conditions* | | |
| Real Funds Rate | Federal funds rate net of current inflation | 2.12 | 1.98 |
| Baa–Aaa Spread | Baa bond yield – Aaa bond yield | 1.05 | 0.47 |
| Yield-Curve Slope | Ten-year Treasury yield – three-month Treasury yield | 1.79 | 1.19 |
| GDP Growth | Quarterly growth rate in real gross domestic product | 0.74 | 0.66 |
| Unemployment | Percent unemployed | 6.04 | 1.52 |
| SLOOS Net Tightening | Net percentage of banks tightening in SLOOS | 6.97 | 21.31 |
| Pre-SLOOS | Dummy variable: all quarters prior to SLOOS data | 0.27 | 0.44 |
| Crisis Period | Dummy variable: Period of 2007:Q3–2009:Q4 | 0.09 | 0.29 |
| | *Bank Characteristics* | | |
| Large Bank | Share of banks with mean total assets > $10 billion | 0.28 | 0.45 |
| Log (Bank Assets) | Log of total bank assets (in billions of $) | 1.92 | 1.57 |
| Bank Capitalization | Ratio of bank equity to total bank assets | 0.07 | 0.03 |
| Bank-Quarter Observations | 13,589 | | |

**Notes:** The dependent variables are based on the average values for each bank in each quarter of the Survey of Terms of Business Lending (STBL). The macroeconomic data come from various sources (drawn from Fred II at the Federal Reserve Bank of St. Louis) and the bank characteristics come from the Consolidated Report of Condition and Income (the "Call Report"). All values are reported as sample means and standard deviations. The sample covers 1982:Q3–2009:Q4. All dollar values are in 2007 dollars.

commitment loans and spot loans fund different kinds of operations. The STBL does not identify the use of a loan, but it is reasonable to think that floating-rate and shorter-term loans are more likely to be used for working capital while fixed-rate and longer-term loans are used more for discrete projects. As shown in table 1, there is little difference in the share of floating-rate loans across commitment and spot loans: 67 percent of commitment loans are fixed rate and 60 percent of spot loans are fixed rate.[11] However, spot loans have a longer maturity than commitment loans (a difference of 0.42 years). This means that there may be some differences in how spot and commitment loans are used. Our methodology assumes that even if the uses of spot and commitment loans are different, demand for both types of loans changes in the same way with monetary policy. To the extent that this is not true, it affects how our results should be interpreted.

Our primary macroeconomic variable is our measure of monetary policy, which is the real federal funds rate (referred to as the "funds rate"). The credit channel implies loan supply is related to real interest rates, so we adjust the nominal funds rate for expected inflation. We use current inflation as the forecast of the next quarter's inflation. The real federal funds rate is therefore the nominal federal funds rate net of current inflation, where the nominal federal funds rate is the quarterly average of the daily effective federal funds rate and inflation is the quarterly growth rate in the core CPI (that is, the CPI net of food and energy prices). Our results are robust to using business fixed investment (BFI) prices and ex post inflation as alternative measures of expected inflation. The other macroeconomic control variables are described in the methodology.

The STBL identifies the bank originating each loan, which allows us to match the STBL data to the quarterly Call Report data for each lender. We focus on total bank assets as the primary bank characteristic in our empirical specification. Using these data, we can consider whether bank size is related to the relative importance of the bank lending channel. It is also possible that the prevalence of commitment loans could depend on the size of the bank making the loan, so we include the natural log of a bank's total assets as a

[11] Percentages are based on dollar amount.

control. Lastly, the STBL match with bank identities allows us to use a bank-specific fixed-effects specification.

## 4. Empirical Methodology: Identifying Changes in Loan Supply

The theory of the credit channel provides predictions about the changes in loan supply in response to monetary policy. In our methodology, commitment lending serves as a baseline for measuring changes in the demand for spot loans, with changes in spot lending relative to commitment lending helping to identify changes in bank loan supply following changes in monetary policy.

Loan commitments limit the ability of banks to control the amount of lending in a given period, so a firm with an existing line of credit can borrow against this line whenever it has a demand for credit.[12] This gives the firm, rather than the bank, control over the amount of commitment lending. Although some commitment loans are drawn shortly after commitment contracts are signed, our data indicate that most drawdowns occur months after the signing of a commitment.[13] Thus, we assume that a bank has limited influence over the amount of commitment lending it does in the short run.[14] Based on this, changes in commitment lending can be used as a measure of changes in demand for loans under commitment.

There is evidence that the effects of monetary policy on commitment lending over a short period of time reflect changes in loan demand, not loan supply. Beginning in the second quarter of 2003, the STBL data include the date on which the commitment contract underlying a loan was signed. To test for a relationship between commitment signing and the funds rate, we regress the log of the average

[12]As noted above, commitments typically allow firms to borrow on demand, with credit line reductions during the recent financial crisis being an exception.

[13]Starting in the second quarter of 2003, we have data on the date a commitment was signed if a loan is made under commitment. These data show that only 25 percent of commitment borrowings are from commitment agreements that were signed in the three months prior to the drawdown, with 57 percent over six months old and 31 percent over one year old.

[14]This assumption becomes weaker over longer periods of time. However, if banks reduce new commitments over time, it will reduce the difference between spot and commitment loans, reducing the power of our tests.

time since commitments were signed for each bank in each quarter on the real funds rate and a time trend. The coefficient on time-since-signed is insignificant (results not shown). This suggests that the *signing* of commitments—the main ways banks can increase the supply of loans drawn under commitment—is not strongly responsive to changes in the real funds rate, because there is not a greater *amount* of commitment lending as rates are rising (rising rates should lead borrowers to seek more new commitment contracts). However, to the extent that changes in commitment lending reflect changes in loan supply, our methodology will under-estimate changes in supply and over-estimate changes in demand.

The difference in the adjustability of loan supply for spot loans and commitment loans allows us to use commitment lending as a baseline against which to measure changes in the supply of loans.[15] We assume that the demand for spot loans responds similarly to monetary policy as the demand for commitment loans, which implies that changes of the same direction and magnitude in spot lending and commitment lending should reflect changes in demand. If spot lending decreases relative to commitment lending, we interpret this as a reduction in the supply of loans. On the other hand, an increase in spot lending relative to commitment lending is interpreted as an increase in the supply of loans.

### *4.1 Baseline Specification*

We aggregate the loan-level data to bank-quarter observations to measure the characteristics of spot and commitment loans made by a bank in a quarter. Our baseline model is

$$\begin{aligned} Y_{i,t} = {} & \alpha_i + \Sigma_{j=0}^{4}\beta_{1,j}(\textit{Monetary Policy})_{t-j} + \Sigma_{j=0}^{4}\beta_{2,j}(\textit{Baa} - \textit{Aaa Spread})_{t-j} \\ & + \Sigma_{j=0}^{4}\beta_{3,j}(\textit{Yield Curve Slope})_{t-j} + \Sigma_{j=0}^{4}\beta_{4,j}(\textit{GDP Growth})_{t-j} \\ & + \Sigma_{j=0}^{4}\beta_{5,j}(\textit{Unemployment})_{t-j} + \beta_6(\textit{SLOOS Net Tightening})_t \\ & + \beta_7(\textit{Pre-SLOOS})_t + \beta_8(\textit{Crisis Period})_t + \beta_9(\textit{Bank Assets})_{i,t} \\ & + \beta_{10}(\textit{Bank Capitalization})_{i,t} + \beta_{11}(\textit{Time Trend})_t + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

[15] One possible issue is the bank capital constraint. A bank which has large drawdowns on its commitments might reduce its spot lending in an effort to limit the change in total lending. However, commitment lending and spot lending are positively correlated at the bank level, indicating that the two are not first-order substitutes.

where the dependent variable, $Y_{it}$, measures characteristics of bank lending. Our first dependent variable is *total lending*, which is the total dollar amount of either spot or commitment lending for a bank in a quarter.[16] We then analyze *loan maturity* and *loan size* as dependent variables to analyze distributional changes in loan supply in response to changes in monetary policy. Loan maturity is the average maturity of a bank's loans in a quarter, weighted by dollar amount, and loan size is the average dollar amount of a bank's loans in a quarter.[17] Our final dependent variable is the *product* of total lending and loan maturity. Each of these four dependent variables is measured in logs.[18] Lastly, as shown in equation (1), the macro variables include the contemporaneous value and four lags.[19] For these variables, the results are reported as the sum of the coefficients (e.g., Funds Rate (Sum)).

In our baseline specification, we use the real federal funds rate to measure monetary policy, with a higher rate indicating a policy tightening (Bernanke and Blinder 1992). Negative coefficients on the funds rate indicate that lending decreases with the tightness of monetary policy. Based on the assumptions stated above, a change in commitment lending will reflect a change in loan demand and we can measure loan supply changes by examining the difference between the coefficients on the funds rate variable in a regression with spot loans as the dependent variable and one with commitment loans as the dependent variable.[20]

To address concerns about the endogeneity of the federal funds rate, we have also estimated our model using Taylor residuals as the measure of monetary policy (Taylor 1993). By controlling for the predicted value of the federal funds rate based on economic

[16]The term "total lending" refers to each bank's total C&I lending in the STBL data.

[17]Individual loan maturity is capped at thirty years.

[18]We add one to all dependent variables prior to the log transformation.

[19]Havranek and Rusnak (2013) document the transmission lags of monetary policy. Our results are qualitatively the same when we exclude the contemporaneous values of all macro variables including the funds rate or when we use fewer lags.

[20]We also examined the probability of a loan being made under commitment. The results using this alternative specification, which included additional loan-level controls, produced similar results regarding changes in loan supply in response to monetary policy (see Black and Rosen 2009).

conditions, the Taylor residuals measure the "discretionary" component of monetary tightness or looseness relative to a basic policy rule. This measure of monetary policy has been used in other studies of the credit channel, including Maddaloni and Peydro (2011). In our analysis, the results based on Taylor residuals (shown in the robustness section) are qualitatively similar to the results based on the funds rate itself.

To control for other macroeconomic factors that can influence loan supply and demand, we include the Baa–Aaa spread, the yield-curve slope, GDP growth, unemployment, and a time trend in our baseline model. Because we are using a lag structure, quarterly averages are constructed from the weekly Baa–Aaa spread, the daily yield-curve slope, and the monthly unemployment rate. The Baa–Aaa spread controls for the overall level of risk in the economy. To the extent that loan commitments provide insurance against widening interest rate risk spreads on loans, we expect that commitment lending might increase when the risk spread is larger. The yield-curve slope controls for expectations of the future path of the funds rate, which partially addresses the potential for debt market timing. Overall economic conditions for loan demand are captured through GDP growth and the unemployment rate. The time trend picks up the systemic change in the shares of commitment and spot lending during our sample period.

Our analysis includes two additional controls to highlight aspects of the economy that might influence lending patterns. The recent financial crisis affected banks in many ways, including their lending practices. We examine whether this changed the proportion of commitment lending by including a crisis dummy that is one for the period from the third quarter of 2007 through the fourth quarter of 2009, inclusive. It is also possible that changes by banks in the terms and conditions (including covenants) of the loans they issue can change the incentives for a firm to choose a spot loan versus a commitment loan. We do not have information on additional loan characteristics, but we use the average value in a quarter for the net percentage of banks that report tightening the terms and conditions on commercial and industrial loans from the Federal Reserve's Senior Loan Officer Opinion Survey (SLOOS) as a control.[21] Since

[21] We use the value for "large and middle market firms" in the survey.

this question has been asked on the SLOOS only since 1990, we include a pre-SLOOS dummy for the dates before 1990.

It is possible that the coefficients on the federal funds rate might be sensitive to the combination of macroeconomic factors included in the regression. To test the robustness of our results to this concern, we varied the combination of macroeconomic factors (results not shown). In particular, we tried isolating the effects of the financial macroeconomic variables (Baa–Aaa spread and yield-curve slope), the real macroeconomic variables (GDP growth and unemployment), and the bank macroeconomic variables (SLOOS net tightening and pre-SLOOS). Our results are generally robust to alternative combinations of these variables.

We include bank size and capitalization as important bank characteristics. Bank size (the log of bank assets) is an essential control because C&I lending technologies and opportunities differ with bank size (Berger and Black 2011), making it possible for bank size to be correlated with the shares of a bank's total assets used for commitment and spot lending. The strength of a bank may affect the types of loans it makes, so we include the capital-to-asset ratio of the bank as a control (Kishan and Opiela 2000). We also include bank fixed effects to control for systematic differences in lending across banks; therefore, the other variables explain changes within a given bank over time.

### *4.2 The Response of Loan Supply to Changes in Monetary Policy*

We use our four dependent variables to examine the potential responses of loan supply to monetary policy. The first step is to examine the effect of monetary policy of total lending. However, this is only a first step because total lending measures the flow of loans, while loan supply is the stock of lending. To get a picture of the stock of lending, we need to examine how loan maturity changes with monetary policy. A reduction in the stock of loans during periods of tight monetary policy, implied by the bank lending channel, can occur indirectly via a reduction in the average maturity of bank loan supply. A bank that reduces the maturity of loans it originates while keeping the amount of originations constant will gradually reduce the size of its loan portfolio over time.

In addition, we can use our framework to test whether the balance sheet channel is operative. If it is, banks will reallocate loan supply toward higher-net-worth firms during periods of tight monetary policy. The theory predicts that a reduction in firms' net worth due to a monetary contraction causes the risk of smaller firms to increase more than larger firms, causing banks to shift their loan supply toward larger firms. The STBL does not have borrower information, so we use loan size as a proxy for firm size in our test.

To determine the overall effect of monetary policy on loan supply, we combine the effects on the amount of total lending and loan maturity. To do this, we use the *product* of total lending and loan maturity. As noted above, our data measure *flow* effects but we want the effect on the *stock* of loans. Using the product of total lending and loan maturity allows us to connect flows and stocks. As an example, assume a bank that goes from supplying a \$1,000, five-year loan every quarter to supplying two \$1,000, three-month loans during a quarter. Total lending—the supply flow—increases from \$1,000 per quarter to \$2,000 per quarter, but the steady-state quantity of loans outstanding for the bank decreases from \$20,000 (\$1,000 $\times$ 5 years $\times$ 4 quarters) to \$2,000 (\$2,000 $\times$ 1 quarter). As the example indicates, changes in total lending multiplied by loan maturity gives the steady-state stock of loans outstanding. We use this measure as our proxy for the loan stock.

## 5. Results: The Effect of Monetary Policy on Lending

Tables 2 and 3 present the results for the baseline model using the full sample of loans.[22] In these tables, we examine how each bank's quarterly commitment and spot lending is affected by monetary policy. Table 2 contains the regression results for each of our dependent variables: total lending, loan maturity, loan size, and the product of total lending and maturity (each in logs). The odd-numbered columns show the results for commitment loans, and the even-numbered columns show the results for spot loans. Table 3

[22] All the reported standard errors in the regressions are robust and are corrected for bank-level clustering. Note that the sample sizes are different because not all banks make both commitment loans and spot loans in every quarter.

**Table 2. The Effect of Monetary Policy on Bank Loan Supply: Regression Estimates**

| | Total Lending | | Loan Maturity | | Loan Size | | Total Lending * Loan Maturity | |
|---|---|---|---|---|---|---|---|---|
| | (1) Commit | (2) Spot | (3) Commit | (4) Spot | (5) Commit | (6) Spot | (7) Commit | (8) Spot |
| Real Funds Rate (Sum) | −0.053* | 0.052 | 0.031*** | −0.002 | 0.002 | 0.026** | 0.124*** | 0.042 |
| | (0.029) | (0.034) | (0.006) | (0.010) | (0.010) | (0.013) | (0.031) | (0.027) |
| Baa–Aaa Spread (Sum) | 0.105 | −0.192 | 0.118*** | 0.043 | 0.075* | −0.140** | 0.606*** | 0.099 |
| | (0.128) | (0.180) | (0.035) | (0.062) | (0.044) | (0.066) | (0.166) | (0.151) |
| Yield Curve Slope (Sum) | −0.067* | 0.049 | 0.016 | −0.009 | 0.001 | 0.035** | 0.003 | 0.016 |
| | (0.038) | (0.047) | (0.010) | (0.018) | (0.012) | (0.018) | (0.043) | (0.046) |
| GDP Growth (Sum) | 0.201*** | −0.009 | 0.059*** | 0.046 | −0.025 | −0.032 | 0.445*** | 0.136 |
| | (0.068) | (0.086) | (0.019) | (0.036) | (0.024) | (0.033) | (0.087) | (0.087) |
| Unemployment (Sum) | −0.156*** | 0.026 | 0.000 | −0.022 | −0.014 | 0.007 | −0.099** | −0.055 |
| | (0.034) | (0.045) | (0.009) | (0.219) | (0.012) | (0.018) | (0.040) | (0.043) |
| SLOOS Net Tightening | −0.004*** | −0.002 | −0.001 | −0.001* | −0.001*** | −0.000 | −0.006*** | −0.004** |
| | (0.001) | (0.002) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Pre-SLOOS | −0.224*** | 0.029 | −0.005 | 0.050 | −0.006 | −0.046 | −0.173* | 0.126 |
| | (0.082) | (0.124) | (0.022) | (0.041) | (0.028) | (0.038) | (0.096) | (0.105) |
| Crisis Period | 0.063 | 0.048 | −0.136*** | −0.020 | 0.034 | 0.066 | −0.517*** | −0.120 |
| | (0.152) | (0.209) | (0.037) | (0.067) | (0.042) | (0.065) | (0.193) | (0.193) |
| Log(Bank Assets) | 0.785*** | 0.973*** | 0.034 | −0.005 | −0.015 | 0.175*** | 0.962*** | 0.748*** |
| | (0.098) | (0.164) | (0.024) | (0.038) | (0.038) | (0.056) | (0.106) | (0.112) |
| Bank Capitalization | 1.965 | −1.050 | 0.241 | −0.122 | −0.396 | −0.475 | 3.264 | 0.833 |
| | (2.095) | (3.040) | (0.525) | (0.825) | (0.742) | (1.245) | (2.733) | (1.781) |
| Time Trend | −0.010** | −0.028*** | 0.007*** | 0.003 | −0.001 | −0.004** | 0.015*** | −0.011** |
| | (0.005) | (0.006) | (0.001) | (0.002) | (0.001) | (0.002) | (0.005) | (0.005) |
| Observations | 12,821 | 11,499 | 12,821 | 11,499 | 12,821 | 11,499 | 12,821 | 11,499 |
| Adj. R-squared | 0.793 | 0.598 | 0.398 | 0.322 | 0.629 | 0.518 | 0.681 | 0.423 |

**Notes:** This table reports regression estimates for equation (1), with each column showing the results for a different dependent variable. All dependent variables are in logs. "Commit" refers to commitment loans and "Spot" refers to spot loans. "Sum" indicates the sum of the contemporary and lagged coefficients. The robust standard errors clustered by bank are shown in parentheses with *, **, and *** indicating significance at 10 percent, 5 percent, and 1 percent, respectively.

**Table 3. Effect of Monetary Policy on Bank Loan Supply: Difference in Coefficients on the Real Funds Rate**

| Regression | Spot Coefficient − Commit Coefficient |
|---|---|
| Total Lending | 0.105** |
| | (0.045) |
| Loan Maturity | −0.033*** |
| | (0.012) |
| Loan Size | 0.023 |
| | (0.016) |
| Total Lending * Loan Maturity | −0.082** |
| | (0.041) |

**Notes:** Tests are based on coefficients in table 2. We report the difference between the coefficients on the real funds rate in the spot loan regressions and the coefficients in the commitment loan regressions. The standard error of a test for whether that value is significantly different from zero is shown in parentheses. *, **, and *** indicate significance at 10 percent, 5 percent, and 1 percent, respectively.

shows the difference in the coefficients on monetary policy across commitment and spot loans for each dependent variable.

### *5.1 Baseline Results*

The regression results for total lending are shown in the first two columns of table 2. When commitment lending is the dependent variable, the sum of the funds rate coefficients, our measure of monetary policy, equals –0.053, which is significantly different from zero at the 10 percent level. This indicates that loan demand decreases somewhat in response to tighter monetary policy, which is consistent with the interest rate channel. The effect of monetary policy on spot lending is less clear. When spot lending is the dependent variable, as reported in column 2, the sum of coefficients on the funds rate variable, 0.052, is not significantly different from zero. To identify the effect on loan supply, we discuss the difference in these coefficients in table 3.

The other coefficients in the first two columns, when significant, are consistent with expectations. The real economy

variables—GDP growth and unemployment—show that commitment lending increases when economic growth is high and unemployment is low. Commitment lending also tends to be lower with a steeper yield curve and the increased tightening of bank underwriting standards. Not surprisingly, the evidence is consistent with larger banks originating more total loans. The coefficients on the time trend show that the amount of spot lending is decreasing relative to commitment lending over time.

The results in columns 3–6 in table 2 suggest that monetary policy affects the average maturity of loans and average loan size. The coefficients reported for the loan maturity regressions are consistent with tighter monetary policy leading firms to draw longer-maturity commitment loans (the sum of the funds rate coefficients in column 3 is 0.031) but to take weakly shorter-maturity spot loans (the funds rate coefficient sum is –0.002 in column 4). When loan size is the dependent variable, the coefficients on the federal funds rate for spot loans indicate that tighter monetary policy leads to larger spot loans. If loan size serves as a reasonable proxy for firm size, monetary policy may have some effect on the allocation of credit across firms of different sizes.

To estimate the net effect of a change in monetary policy on loan supply, we use the product of total lending and loan maturity as the dependent variable. We discuss this further below, but for now, columns 7 and 8 show the results of the baseline model using this as the dependent variable. Tighter monetary policy increases commitment lending but has no effect on spot lending.

### *5.2 Banks' Spot Lending Relative to Commitment Lending*

Although the above results are of interest, our analysis is focused primarily on the differences between the spot and commitment loan regressions. Following our identification strategy, we use these differences to estimate of the effect of monetary policy on bank loan supply. For a given variable, the coefficients from the spot loan regression minus the coefficients on the commitment loan regression is our estimate of the marginal effect on supply of a change in that variable. The marginal supply effects are shown in table 3, for each of the four dependent variables.

We find that the banks increase total lending when monetary policy tightens. The difference between the spot and commitment coefficients on the federal funds variables in the regressions in columns 1 and 2 in table 2, reported in the first row in table 3, is 0.105, which is significantly different from zero at the 5 percent level. This implies, perhaps surprisingly, that the flow of lending banks that are willing to supply increases when monetary policy tightens (consistent with the findings of den Haan, Summer, and Yamashiro 2007, for C&I lending). But, if tighter monetary policy reduces the maturity of loans banks supply, then an increase in the *flow* of lending may not lead to an increase in the *stock* of loans outstanding.

Our results indicate that, indeed, loan maturity decreases significantly when monetary policy tightens. Specifically, the difference between the spot and commitment coefficients in the loan maturity regressions is –0.033, which is statistically significant at the 1 percent level. This can be thought of as an inward shift in the loan supply curve along the dimension of maturity rather than quantity, which is consistent with a bank lending channel. This finding is consistent with the liquidity version of the lending channel in Diamond and Rajan (2006). The result is also economically significant—a 1-percentage-point increase in the federal funds rate reduces the average maturity of loan supply by 3.3 percent.

The increase in total lending is not because banks are more willing to make larger loans. We do not find a significant difference in the real funds rate coefficients for spot and commitment lending for the loan size regression. If loan size serves as a reasonable proxy for firm size, this implies that there is not a significant redistribution of loan supply across small and large firms. Based on this proxy, the loan size results would suggest that the balance sheet channel is relatively weak.

The results with total lending times loan maturity as the dependent variable are reported in columns 7 and 8 in table 2 and the final row in table 3. Focusing on the final row in table 3, we find that the monetary policy coefficients are significantly smaller in the spot loan regression than in the commitment loan regression, with a difference of –0.082. The difference in coefficients on the funds rate variables can be interpreted as the percent change in bank loan supply with a 1-percentage-point change in the (steady-state) funds rate. So, a 1-percentage-point increase in the funds rate would decrease bank

loan supply by 8.2 percent. Thus, changes in monetary policy have economically significant effects on loan supply.

This last set of results (the product of total lending and loan maturity) is particularly important, because it gives the most complete picture of the effect of monetary policy on bank loan supply. Unlike total lending, which only captures the dollar amount of bank lending, this measure captures the amount and *duration* of lending. The negative difference in coefficient suggests that loan supply at a typical bank contracts with monetary tightening even if the flow of new loans does not shrink. The key factor appears to be the change in loan maturity since banks react to tightening by reducing loan maturity. We believe these results highlight an effect of monetary policy on bank loan supply that is not directly observable in total lending. Our evidence for a bank lending channel in C&I lending extends beyond prior work by providing evidence on how monetary policy affects the allocation of loan supply *within* C&I lending.

### *5.3 Robustness*

In this subsection, we address two possible concerns about the robustness of our results. Our baseline results could be affected by debt market timing and the potential endogeneity of the federal funds rate. Based on additional analysis of the data, we find that our results are robust.

One potential limitation to our approach would be changes in firms' demand for fixed- versus floating-rate debt, known as debt market timing. Firms' relative demand for fixed-rate debt has been shown to move with the term structure of interest rates and with bond risk premia (Baker, Greenwood, and Wurgler 2003; Vickery 2008). To see whether it matters if the interest rate on a loan is fixed, we split our sample into fixed- and floating-rate loans and analyze spot lending relative to commitment lending within each subsample. The results are shown in table 4. We find that the supply of fixed-rate loans is sensitive to monetary policy but the supply of floating-rate loans does not change much, either in a statistical or economic sense, when monetary policy changes. In particular, when monetary policy tightens, fixed-rate loan maturity shortens and there is a shift in the flow of lending from fixed-rate loans to floating-rate loans.

**Table 4. Effect of Monetary Policy on Bank Loan Supply, by Type of Loan**

| | Fixed Rate | Floating Rate |
|---|---|---|
| **Regression** | **Spot Coefficient − Commit Coefficient** | **Spot Coefficient − Commit Coefficient** |
| Total Lending | 0.083** | 0.079 |
| | (0.038) | (0.051) |
| Loan Maturity | −0.075** | −0.019 |
| | (0.030) | (0.013) |
| Loan Size | 0.002 | 0.062*** |
| | (0.011) | (0.022) |
| Total Lending * Loan Maturity | −0.128*** | 0.009 |
| | (0.036) | (0.039) |

**Notes:** This table reports results based on regression estimates for equation (1) where the sample is split into fixed-rate and floating-rate loans. The regressions include the same variables as in table 2. We report the difference between the coefficients on the real funds rate in the spot loan regressions and the coefficients in the commitment loan regressions. The standard error of a test for whether that value is significantly different from zero is shown in parentheses. *, **, and *** indicate significance at 10 percent, 5 percent, and 1 percent, respectively.

This may occur because when monetary policy tightens, firms are more likely to put off large, discrete projects (presumably financed with fixed-rate loans) than they are to significantly reduce working capital (often financed with floating-rate loans). Since roughly two-thirds of lending in our sample is fixed rate (table 1), the changes are consistent with the significant effect on supply we report in the full-sample results in tables 2 and 3.

We use the real federal funds rate as our baseline measure of U.S. monetary policy because it directly indicates the decisions of the Federal Open Market Committee (FOMC) during our sample period. However, as shown by the Taylor rule, monetary policymakers respond to economic conditions, potentially making the target funds rate an endogenous variable (Taylor 1993). The Taylor rule is a policy rule for modeling the relationship of the funds rate to the inflation and output gaps. To address the endogeneity concern, we have also run our regressions using the Taylor residuals as our

**Table 5. Effect of Monetary Policy on Bank Loan Supply Using Taylor Residuals**

| Regression | Spot Coefficient − Commit Coefficient |
|---|---|
| Total Lending | 0.076 |
| | (0.053) |
| Loan Maturity | −0.076** |
| | (0.035) |
| Loan Size | −0.031 |
| | (0.020) |
| Total Lending * Loan Maturity | −0.119** |
| | (0.053) |

**Notes:** This table reports results based on regression estimates for equation (1) where Taylor residuals are used as the measure of monetary policy. The regressions include the same variables as in table 2. We report the difference between the coefficients on the real funds rate in the spot loan regressions and the coefficients in the commitment loan regressions. The standard error of a test for whether that value is significantly different from zero is shown in parentheses. *, **, and *** indicate significance at 10 percent, 5 percent, and 1 percent, respectively.

measure of monetary policy.[23] This is an alternative approach to Jimenez et al. (2012), who use monetary policy determined outside the country. See Maddaloni and Peydro (2011) for a similar approach.

Table 5 shows the results for the difference in coefficients on Taylor residuals for spot loans and commitment loans. The Taylor residuals provide exogenous variation in the stance of monetary policy by measuring the difference between the actual federal funds rate and the funds rate predicted by the Taylor rule. In other words, a positive residual indicates that the funds rate is higher than the Taylor rule would predict. We find that the results are qualitatively similar to our baseline results.

[23]Our Taylor residual regressions are only run through 2008:Q3, which is when the nominal federal funds rate reached zero. A simple Taylor rule does not account for the zero lower bound. Results for the Taylor-rule regressions run for our entire sample period are qualitatively similar in magnitude to those reported but with weaker statistical significance.

## 6. Differences in the Strength of the Credit Channel across Banks

The credit channel literature has focused on bank size as an important factor in determining the sensitivity of loan supply to monetary policy. However, despite the number of empirical articles comparing lending sensitivities across bank sizes, the theoretical prediction for a small-versus-large bank comparison is not well established. Small banks likely face greater information frictions on the liability side of their balance sheet, while large banks likely face greater information frictions on the asset side of their balance sheet. On the liability side, Stein (1998) shows that uninsured forms of bank finance are subject to adverse selection. Therefore, smaller banks, which tend to be less transparent than large banks, may face greater costs of raising external funds during periods of tight monetary policy. This implies that small-bank loan supply should be more sensitive to changes in monetary policy. On the asset side, Stiglitz and Weiss (1981) show that agency problems in lending increase with the interest rate charged to borrowers, which implies that agency problems are greater during periods of tight monetary policy. Stein (2002) shows that large banks are not as effective as small banks at overcoming agency problems in lending. This could mean that large-bank loan supply is also sensitive to changes in monetary policy.

The difference in the transmission of monetary policy through large and small banks could reflect differences in large- and small-bank characteristics. For instance, bank capital and deposit funding could play a key role in the credit channel (Diamond and Rajan 2006, 2011), as shown empirically in papers such as Kishan and Opiela (2000) and Black, Hancock, and Passmore (2007). Kashyap and Stein (2000) analyze the effect of balance sheet liquidity, building on earlier work that analyzes the sensitivity of bank lending to monetary policy for different bank sizes under the hypothesis that large banks face lower costs of external financing (Kashyap and Stein 1995). We focus on bank size as a basic proxy for other forms of bank heterogeneity.

To test whether a bank's size affects the way it reacts to monetary policy changes, we split our sample between large and small banks. "Small" banks have average total assets over the sample period of less than or equal to $10 billion, while all other banks are considered

**Table 6. Effect of Monetary Policy on Bank Loan Supply, by Bank Size: Regression Estimates**

| | Commitment Loans | Spot Loans |
|---|---|---|
| | Funds Rate Coefficient | Funds Rate Coefficient |
| *Small Banks* | | |
| Total Lending | 0.001 | 0.013 |
| Loan Maturity | 0.037*** | 0.011 |
| Loan Size | 0.016 | 0.012 |
| Total Lending * Loan Maturity | 0.117*** | 0.029 |
| *Large Banks* | | |
| Total Lending | −0.133*** | 0.078 |
| Loan Maturity | 0.026*** | −0.015 |
| Loan Size | −0.015 | 0.036 |
| Total Lending * Loan Maturity | 0.136** | 0.046 |

**Notes:** This table reports the coefficients on the real federal funds rate for equation (1) split by bank size. "Small" banks have average total assets over the sample period of less than or equal to $10 billion, while all other banks are considered "large" banks. The dependent variables listed in the first column are in logs. "Spot" refers to spot loans and "Commit" refers to commitment loans. "Funds Rate Coefficient" refers to the coefficients labeled as Real Funds Rate (Sum) in table 2, with *, **, and *** indicating significance at 10 percent, 5 percent, and 1 percent, respectively. The small-bank regressions have between 5,169 and 7,115 observations, while the large-bank regressions have between 4,756 and 5,706 observations.

"large" banks.[24] We use a more restrictive definition of large banks than is common. The $10 billion threshold allows us to ensure that the large banks in our sample have the low-cost access to financing present in the arguments of Kashyap and Stein (1995) and Stein (1998). In our full sample, there are 143 small banks and 87 large banks.

Tables 6 and 7 present results of the baseline regressions with the sample split into small and large banks. To simplify the presentation, in table 6, we give the coefficients for the federal funds rate variable

[24] A bank is either small or large for the entire sample. Asset size is based on real assets in 2007 dollars.

**Table 7. Effect of Monetary Policy on Bank Loan Supply, by Bank Size: Difference in Coefficients on the Real Funds Rate**

| | Small Banks | Large Banks |
|---|---|---|
| **Regression** | **Spot Coefficient − Commit Coefficient** | **Spot Coefficient − Commit Coefficient** |
| Total Lending | 0.012 | 0.211** |
| | (0.042) | (0.084) |
| Loan Maturity | −0.027 | −0.041** |
| | (0.018) | (0.016) |
| Loan Size | −0.004 | 0.051* |
| | (0.014) | (0.031) |
| Total Lending * Loan Maturity | −0.088** | −0.090 |
| | (0.041) | (0.077) |

**Notes:** Tests are based on coefficients in table 6. We report the difference between the coefficients on the real funds rate in the spot loan regressions and the coefficients in the commitment loan regressions, and the standard error of a test for whether that value is significantly different from zero. This is done separately for small and large banks.

only, but the underlying regressions include all the controls used in the prior regressions. These results are provided primarily for reference, because our methodology focuses on the differences between spot and commitment lending. Table 7 reports the results of tests on the difference between the spot and commitment coefficients on the real federal funds rate for each of the dependent variables.

For both small and large banks, the pattern is qualitatively similar to the full-sample results. As can be seen in table 7, there is an increase in lending and a shortening in the average maturity of banks' loan supply when monetary policy tightens, although the differences are only significant for large banks. Our overall result, the product of total lending and loan maturity, shows a decline in the availability of credit with a tightening of monetary policy, but this time the result is only significant for small banks (but the magnitudes are virtually the same for large banks as for small banks).

Our results for small banks are generally consistent with previous findings indicating that small banks are sensitive to the

credit channel (Kashyap and Stein 1995, 2000; Zaheer, Ongena, and van Wijnbergen 2013). To compare our results more directly with Kashyap and Stein (2000), we also interacted the federal funds rate with each bank's ratio of liquid assets to total assets. We find that the interaction does not have a significant effect on our measure of overall loan supply for either small or large banks.

Our results for large banks illustrate the importance of considering effects on loan maturity. The large-bank results based on total lending suggest that large banks increase their loan supply when monetary policy is tightened; however, this hides the reduction in the maturity of loans supplied. Our analysis shows that results based on total lending can hide significant shifts in credit allocation over the monetary policy cycle.

## 7. Conclusion

We find that changes in monetary policy have an effect on bank loan supply and the distribution of banks' loan supply. A contribution of the paper is the identification of a *redistribution* in loan supply across loans of different maturities. In response to a monetary tightening, banks reduce the average maturity of their loan supply, which effectively reduces loan supply over time. This is consistent with the liquidity theory of Diamond and Rajan (2006), who predict that long-term lending is sensitive to monetary policy due to banks' short-term funding. A 1-percentage-point increase in the federal funds rate—our primary measure of monetary policy tightening—reduces the average maturity of loan supply by 3.3 percent, contributing to an 8.2 percent decline in the steady-state loan supply at a typical bank. Therefore, our paper shows that loan maturity is an important transmission mechanism of monetary policy through the bank lending channel.

In addition, we find evidence that the distribution of loan supply at both small and large banks is sensitive to monetary policy. In particular, we show that the channel is not limited to small banks. This suggests that these effects will continue to play an important role even with the ongoing consolidation of the banking system.

In the context of the recent financial crisis, our results show that monetary loosening can have a mitigating effect on a "credit crunch." We find that lowering the federal funds rate increases the average

maturity at which credit is made available. This can improve the availability of financing for projects at longer maturities, which can have a large impact on the real activity of firms.

The results also suggest that monetary tightening can have a dampening effect on bank loan supply. Banks appear to reduce the amount of maturity transformation through the banking sector when the federal funds rate increases. This implies that future rate increases during an economic recovery should be undertaken with an acknowledgment of the potential reduction in credit availability over time, especially at longer maturities.

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