Unconventional Monetary Policy and Bank Risk Taking

Abstract

We analyze the presence of bank risk taking associated with unconventional monetary policy in the United States between 2008 and 2015 using corporate syndicated loan data at the bank-firm level. We measure monetary policy using the identification-through-heteroskedasticity approach with a VAR model. To identify the risk-taking channel we control for time-varying heterogeneity in credit demand and supply. Our results indicate that accommodating monetary conditions are associated with overall lower loan spreads. However, the spread reduction is lower for riskier firms, suggesting that there is no excessive risk taking in the syndicated loan market during the UMP period.

Keywords: US Banks, Unconventional monetary policy, Risk taking, Syndicated loans

JEL classification: G21, G32, E52

1. Introduction

In response to the banking crisis, the Federal Reserve decreased its policy rate and committed trillions to the implementation of large-scale asset purchases. The use of non-conventional policy tools and the protracted period of monetary easing has raised issues of potential risks to the financial system. In particular, the relationship between monetary policy and bank risk taking has received increased attention. Studies show that low policy rates are associated with increased risk taking in bank loan portfolios and securities holdings (Maddaloni and Peydró, 2011; Borio and Zhu, 2012; Jiménez et al., 2014; Kurtzman et al., 2019). We contribute to the discussion by investigating the effect of *unconventional* monetary policy on bank risk taking in the syndicated loan market in the United States from 2008 to 2015.

The risk-taking channel documents the direct impact of changes in monetary policy on risk tolerance (Borio and Zhu, 2012). Interestingly, two competing mechanisms exist that yield opposite predictions on the relationship between monetary policy accommodation and bank risk taking. First, the search-for-yield mechanism posits that monetary transmission operates through the relationship between low market rates and expected target rates of return (Rajan, 2006). Banks confronted with diminishing revenues as a consequence of lower rates may increase their risk appetite and invest in higher-risk loans and securities (Chodorow-Reich, 2014; Borio and Gambacorta, 2017). Second, lower policy rates and an unusually flat term structure compress banks' net interest margins and erode overall bank profitability (Mamatzakis and Bermpei, 2016; Borio et al., 2017; Molyneux et al., 2019). To safeguard profitability, banks may in turn remain more prudent, i.e. price risk conservatively.

However, exploring the presence of a risk-taking channel of monetary policy in recent years is complicated. The Federal Reserve, constrained by the zero lower bound, implemented three waves of asset purchases and increasingly used forward guidance as a policy tool (McKay et al., 2016; Ferrari et al., 2017). Different types of monetary policy measures have been announced on the same days, and policy actions have been largely anticipated by market participants. Thus, capturing the stance of monetary policy cannot be done by only considering the policy rate or the balance sheet of the central bank. Another challenge relates to the empirical identification of the bank risk-taking channel as such. During periods of expansionary monetary policy, firms' net worth improves and the value of pledgeable assets increases (Bernanke and Gertler, 1995; Mishkin, 1995; Jiménez et al., 2014). As a result, firms' cost of borrowing may decrease regardless of bank risk appetite. Similarly, expansionary monetary policy is likely to reduce bank funding costs, which may in turn improve the banks' ability to grant new loans at lower rates (Bernanke and Gertler, 1995). To examine the presence of a bank risk-taking channel, disentangling confounding changes in loan demand and supply is crucial.

We use a novel measure of monetary policy that captures not only the Federal Reserve's unconventional actions, but also anticipation effects that are relevant for bank risk-taking behavior. We construct a time series of monetary policy shocks using a vector autoregression (VAR) model of financial market variables. As the measure represents the market consensus about the monetary policy stance given prevailing financial conditions, an advantage of our approach is that we avoid the choice of a specific policy instrument. Unlike shadow rates, our measure is not endogenous to US macroeconomic conditions. Further, we identify bank risk taking directly by observing banks' loan pricing decisions in the syndicated loan market. Realized loan spreads should capture the ex-ante, intrinsic risk-taking incentives of the lending bank, as opposed to data on lending surveys or accounting data. Last, we separate confounding firm and bank balance sheet effects from the bank risk-taking channel by controlling for (time-varying) credit demand and supply factors as well as changes in the pool of borrowers. In short, we identify changes in the supply of credit at the bank-firm level and include a combination of different types of fixed effects. We also explore how bank heterogeneity affects risk-taking incentives. Our method allows to identify whether monetary policy easing in recent years has induced banks to take on excessive risks in their syndicated loan books, and whether these risk-taking effects differ across bank business models.

We are unable to find evidence that the bank risk-taking channel was active in the corporate syndicated loan market during the period of unconventional monetary policy in the United States. We find that US banks do transmit expansionary unconventional monetary policy to the real sector by offering lower spreads to corporates. The implication is that the Federal Reserve succeeded in its objective of easing credit conditions in the aggregate. Our estimates suggest that a one unit increase in the stance of monetary policy, corresponding with a 25 basis point decrease in the 10-year US bond yield, reduces corporate loan spreads by 8 basis points, or 3.5%. Yet, we find that the loan spread discount is smaller for riskier firms compared to safer firms when monetary policy is expansionary. It seems that unconventional monetary policy actions by the Federal Reserve have not induced banks to soften their lending standards for risky firms.

Without taking into consideration borrower risk, bank heterogeneity affects the strength of monetary policy transmission. Banks that reduce loans spreads more in response to expansionary monetary policy are less profitable, have a higher-quality existing loan portfolio, and rely more on non-interest income. Banks with an existing loan portfolio that is of high quality may be able to afford receiving lower spreads in response to expansionary monetary policy. Banks' higher reliance on non-interest income may shield them from the negative effect of unconventional monetary policy on net interest margins.

The dynamics of the risk-taking channel are more nuanced. We show that heterogeneous banks price loans differently for varying levels of borrower risk. Less capitalized banks, smaller banks and less profitable banks reduce spreads more aggressively, but only for the safer firms. Thus, weaker banks initially translate expansionary monetary policy into lower spreads than stronger banks. As firm risk rises, weaker banks adjust spreads upwards in an accelerated manner compared to banks with stronger fundamentals. Our results point to prudent lending behavior by US banks in the period 2008-2015.

Our paper contributes to the literature on monetary policy and bank risk taking. Since we focus on the post-2008 period, we specifically analyze the impact of unconventional monetary policy actions on risk-taking behavior. Earlier studies document that low short-term interest rates prior to the financial crisis softened bank lending standards to the extent that they amplified negative economic performance after the financial crisis (Ioannidou et al., 2009; Taylor, 2009; Maddaloni and Peydró, 2011). Moreover, the general application of unconventional monetary policy instruments (or balance sheet expansion) by central banks may have contributed to the build-up of financial imbalances (Borio, 2014; Chen et al., 2016; Lamers et al., 2019). Most studies focus on the period prior to 2008 (Paligorova and Santos, 2017; De Nicolò et al., 2010), while others include a short period of unconventional monetary policy as part of a larger sample period (Delis et al., 2017; Dell'ariccia et al., 2017).

Further, our research contributes to the syndicated loan pricing literature (Carey and Nini, 2007; Schenone, 2010) and especially to the analysis of the effect of monetary policy on bank risk taking (Paligorova and Santos, 2017; Delis et al., 2017).

The paper proceeds as follows. Section 2 presents the syndicated loan sample, the construction of the indicator for the monetary policy stance as well as relevant bank and borrower characteristics. In section 3 we describe the empirical setup to identify the presence of a bank risk-taking channel, and we analyze the empirical results. Section 4 concludes.

2. Data and variable construction

2.1. Corporate syndicated loan sample

Data on corporate loans is obtained from the Loan Pricing Corporation's (henceforth LPC) Dealscan. LPC collects information on loans to companies through attachments on SEC filings, self-reporting by lenders, and the financial press. The database contains comprehensive information on the loan terms (e.g. maturity, collateral, interest rate) as well as the identity and role of the lending bank(s) and the identity of the borrowing firm. Our study focuses on the effects of unconventional monetary policy on bank lending in the United States. Consequently, we retain loans only if they were issued by banks incorporated in the US between 1 October 2008 and 31 December 2015. By construction, sole lender loans have a clearly identified lead bank. However, a large part of the loans in Dealscan (85%) are syndicated loans issued by two or more banks to a single borrower. In these cases, we identify the lead bank for each loan.[1] The lead arranger is typically responsible for the book building process, making it reasonable to assume that the lead bank will exert a large influence on the pricing process. Moreover, lead banks tend to retain the largest share of the syndicated loan among the lending banks in the syndicate.

We use the loan interest spread as a measure of the banks' risk appetite at the time of loan issuance, based on prevailing monetary and financial market conditions. Following Drucker and Puri (2005), we use the all-in-spread drawn defined as the coupon spread over LIBOR on the drawn amount plus the annual fee in basis points. While Dealscan provides details on loan terms, it lacks accounting information about lending banks and corporate borrowers. We obtain quarterly balance sheet and income statement data from the FR Y-9C reports for all lead banks. The identities of the lending banks are aggregated to the parent bank level. Information about the borrowing firms is obtained from Compustat.

Previous studies investigating loan pricing decisions have shown that other non-price terms impact the loan spread (e.g. Schenone (2010)). Loan maturity is the length in months between the facility activation date and the maturity date. Loan size is the loan facility size in millions of real year 2000 dollars. Bharath et al. (2011) show that repeated borrowing from the same lender is associated with significantly lower loan spreads through reduced information asymmetry and monitoring costs. For every loan facility we construct a relationship measure between the lead bank and the borrowing firm to identify whether the loan was granted by a relationship lender.[2]

[1] When the "Lead Arranger Credit" variable in LPC takes on a value of one for a specific bank, we classify it as a lead bank. In addition, we scan the "Lender Role" variable and assign banks with one of the following roles to be lead banks: agent, administrative agent, arranger, lead bank.

[2] We follow the procedure outlined in Bharath et al. (2011) and define the continuous variable REL(Amount) as the dollar amount of loans by bank b to borrower i in the last 5 years, divided by the total dollar amount of loans by borrower i in the last 5 years. The variable thus captures the relationship intensity between a borrowing firm and its lending bank at the time the loan is issued.

2.2. Monetary policy stance

Since 2008, central banks have lowered their policy rates but quickly hit the zero lower bound constraint, forcing them to use unconventional monetary policy instruments. In the US, the Federal Reserve announced three waves of asset purchases and used forward guidance to anchor expectations concerning the future path of interest rates and monetary conditions. For this reason, capturing the stance of monetary policy cannot be done by only considering the policy rate or the balance sheet of the central bank. Furthermore, coinciding monetary policy announcements and anticipation effects require that we assess the stance of monetary policy accommodation given prevailing financial conditions.

We estimate a time series of exogenous monetary policy shocks by modeling a set of relevant financial market variables in a structural VAR (SVAR) model at daily frequency as in Wright (2012) and Lamers et al. (2019):

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + R\nu_t \tag{1}$$

where Y_t is an N-dimensional vector of endogenous variables ($t = 1, \ldots, T$), ν_t an N-dimensional vector of orthogonal structural innovations with mean zero and $A_1, \ldots, A_p$ and R are $N \times N$ time-invariant parameter matrices. The reduced-form residuals corresponding to this structural model are given by the relationship $\varepsilon_t = R\nu_t$.

To estimate the SVAR we use a set of variables that capture the pass-through of monetary policy to the financial sector. Following Rogers et al. (2014), we select those variables that are expected to respond most to a monetary policy shock. More specifically, we include the 2-year and 10-year Treasury bill yield, the 5-year forward inflation expectation based on inflation swap rates, the S&P500, and the VIX index. Data are obtained through Thomson Reuters' Datastream. The identification of policy shocks is based on the identification-through-heteroskedasticity strategy first proposed by Rigobon (2004), which assumes that the structural monetary policy shock is more volatile on monetary policy announcement days.[3] The main idea is that there are days on which the volatility of the monetary policy shock is especially high, for example on days when there is a Federal Open Market Committee announcement. Based on the differences in the volatility of the shocks during the two regimes, the structural VAR can uniquely be identified. We only assume that there is some kind of heteroskedastic pattern in the monetary policy shock while all other shocks are homoskedastic:

$$Var\left(\nu_t\right) = \Omega_t = \begin{cases} \Omega^{(0)} = \text{diag}\left(\omega_1, \omega_2, \ldots, \omega_N\right) & \text{if } \textit{no announcement} \\ \Omega^{(1)} = \text{diag}\left(\omega_1^*, \omega_2, \ldots, \omega_N\right) & \text{if } \textit{announcement} \end{cases} \tag{2}$$

It can be shown that, as long as the covariance matrix of the reduced form errors V_t changes on announcement days, these assumptions suffice to uniquely identify the first column of R and the structural monetary policy shock apart from their scale and sign. The model can be estimated following the iterative estimation procedure outlined in Lanne and Lütkepohl (2008).[4] We normalize the monetary policy shock by fixing the response on impact of one of the included variables to a unit monetary policy shock. We define a unit expansionary monetary policy shock as a shock that decreases the 10-year US Treasury bill yield by 25 basis points, in line with Wright (2012) and Rogers et al. (2014). The set of days with monetary policy announcements is determined prior to the estimation of the SVAR model. This identification-through-heteroskedasticity approach is widely used in the literature to identify monetary policy shocks, for example Caporale et al. (2005), Gilchrist and Zakrajšek (2013), Rogers et al. (2014) and Arai (2017). We estimate a VAR of order 2 over a sample period from 1 October 2008 to 31 December 2015 i.e. the period of unconventional mone-

[3]To test this assumption, we perform a likelihood ratio test to check the validity of the heteroskedasticity assumption which confirms the soundness of the identification strategy. A likelihood ratio test for the hypothesis test results in a test statistic of 169.19, so that the null hypothesis of equal variance on both announcement and non-announcement days is strongly rejected by the data. We also perform robustness checks on the inclusion of alternative variables, different choices of the VAR order and different sets of announcement days. All tests show that the results are robust and not driven by the model specification.

[4]For details on the estimation procedure we refer to Lamers et al. (2019).

tary policy by the Federal Reserve. We obtain daily estimates of monetary policy shocks, resulting in 1,892 observations. We use the cumulative monetary policy series on the day prior to the final loan contracting because it captures the monetary policy stance over the period that is relevant for the final pricing of the syndicated loan.

Figure 1 shows the cumulative monetary policy shock.[5] A sequence of positive monetary policy shocks indicates that monetary policy becomes more expansionary and therefore the cumulative series reflects the monetary policy stance with respect to the prevailing economic environment and expectations of financial markets. Accordingly, a drop in the series can reflect a tightening of monetary policy but also the lack of monetary action, or even that there were expansionary announcements that failed to live up to financial market expectations. The figure shows that the shocks are able to capture important monetary policy announcements, as well as the anticipation of some measures. Overall, the QE1 announcement is identified as the largest surprise in terms of market expectations and relative to economic conditions. The daily shocks on the QE2 and QE3 announcement days are smaller, but this is the result of anticipation of the respective programs. The monetary policy stance clearly shows the build-up of accommodating monetary policy around QE1, Operation Twist and QE3, which were highly anticipated programs. The cumulative shock gradually decreases following the taper announcement in May 2013 and the signals of a federal funds rate increase at the end of 2014. Since our cumulative monetary policy stance indicator captures the market assessment about the prevailing monetary and financial conditions, it is likely to influence banks' loan pricing decisions.

2.3. Bank and firm characteristics

We collect quarterly balance sheet and income statement data from the FR Y-9C reports. We select those bank characteristics that can reasonably be assumed to affect loan pricing: capital adequacy, bank size, profitability, the quality of the existing loan portfolio, and

[5] Note that the cumulative shock does not necessarily sum to zero, due to the use of feasible GLS for its estimation.

revenue diversification. Bank capital ratio is the ratio of equity to total assets. We measure bank size by taking the natural logarithm of the bank's total assets expressed in billions of real year 2000 dollars. To measure profitability we use return on assets calculated as income before taxes, extraordinary items and other adjustments divided by total assets. NPL_Loans is non-performing loans divided by gross loans and measures the bank's loan portfolio quality. Diversification is calculated as total non-interest income divided by total revenues.

Borrowing firm characteristics are obtained from Compustat. We merge Dealscan with Compustat using the merger file compiled by Michael Roberts.[6] In the merged data set we apply the following restrictions to our loan sample. We exclude loans issued to other financial services companies (SIC codes 6000 - 6799) and loans for which information on the spread is missing. We include firm characteristics that relate to the creditworthiness of borrowers. The firms' debt position is captured by Leverage, defined as the sum of short-term and long-term debt, scaled by the book value of assets. An alternative firm risk indicator is the volatility of earnings defined as the standard deviation of ROA in the 3 years prior to loan contracting (Vol(ROA)). We also include borrower profitability (ROA) as a control variable.

2.4. Summary statistics

Table 1 presents the descriptive statistics of our sample, which consists of 7,042 loans issued to 2,018 non-financial corporations from October 2008 to December 2015. All variables are winsorized at the 1% and 99% level to mitigate the effects of outliers. Loans in our sample carry an average spread of 228 basis points above LIBOR, with a standard deviation of 133 basis points. These statistics are in line with Bharath et al. (2011), who report a mean loan spread of 217 basis points. The mean (median) loan maturity is approximately 4 years (5 years). Loan sizes are relatively large and positively skewed, with the mean value ($813

[6] For details, please see Chava and Roberts (2008). The merger file contains information until July 2012. For the remaining period (August 2012 to December 2015) we match the borrowers in the Dealscan database with the company names in Compustat using gvkeys.

million) almost twice as large as the median value ($412 million).

Bank characteristics are measured at the bank holding company level. As expected, lending banks in the syndicated loan market tend to be large, with average (median) total assets of $750 ($270) billion and a standard deviation of $870 billion. Over our sample period, the average bank is fairly well capitalized (average equity-to-assets ratio (capital ratio) of 10.67%), relatively diversified (non-interest income is 42% of total revenues), and the average pre-tax ROA is 0.26%.

The firm characteristics are all positively skewed with mean values greater than median values, which is common in corporate samples. Similar to their lenders, borrowers in the syndicated loan market tend to be large (average assets of $9.3 billion). The firms in our sample have short-term and long-term debt amounting to around 30% of total assets (leverage), with a substantial standard deviation of 23%. Return on assets indicates an average profitability of 12.68% and the ROA volatility in the three years prior to loan issuance amounts to 3.02% on average.

3. Empirical identification and results

The association between monetary policy and corporate loan spreads may occur through a number of different channels. For example, lower discount rates as a result of accommodative monetary policy increase firm valuations and raise economic growth prospects. The combination of these outcomes is expected to exert downward pressure on corporate loan spreads. Monetary policy may also have an impact on the overall supply of credit through the bank lending channel. Finally, lower loan spreads may reflect bank incentives to take excessive risk in an environment of loose monetary policy. Hence, we need to establish (1) whether monetary policy easing is associated with lower loan spreads, (2) whether bank heterogeneity matters for corporate loan pricing, (3) whether loan spreads reflect the risk profile of the borrowers and (4) whether risk pricing differs for different types of banks. In this section, we gradually build up our model specification to give an answer to each of these research questions.

We report results for the loan spread regressions using incremental sophistication of the interaction between monetary policy and borrower, loan and bank characteristics. In every stage we include bank-firm fixed effects to investigate the variation in the loan pricing for the same bank-firm pair over different stances of monetary policy. In addition, we disentangle the bank risk-taking effect from endogenous changes in the credit demand or supply by using double and triple interaction terms as well as including different types of fixed effects. The identification isolates the heterogeneous response of banks to monetary policy that can only be the result of bank decisions, which allows the identification of a risk-taking channel.

3.1. How does the monetary policy stance affect loan spreads?

In a first set of specifications, we establish the association between corporate loan spreads and the stance of monetary policy, controlling for bank, borrower and loan features. We estimate a multivariate regression of the following form:

$$Spread_{f,b,t} = \alpha_0 + \beta_0 MP\ Stance_{t-1} + \sum_{k=1}^{K} \lambda_k Bank_{k,b,t} + \sum_{l=1}^{L} \psi_l Firm_{l,f,t} + \sum_{m=1}^{M} \omega_m Loan_{m,f,b,t} + \varepsilon_{f,b,t} \tag{3}$$

where $Spread_{f,b,t}$ is the natural logarithm of the all-in-spread drawn (AISD) for firm f with bank b at time t, defined as the coupon spread over LIBOR on the drawn loan amount.[7] The loan spread thus captures the bank's assessment of the borrower's risk profile at the time the loan is contracted. $MP\ Stance_{t-1}$ is the monetary policy stance given the prevailing financial market conditions on the day prior to loan issuance and is captured by the cumulative monetary policy shock identified with a daily financial VAR. The variable is identified such that higher values reflect an expansionary stance of monetary policy, and vice versa. A

[7] As a robustness check, we use the total cost of borrowing measure which includes the fee structure as in Berg et al. (2016) as the dependent variable. Our estimation results using this measure (unreported for brevity) remain unchanged. We are grateful to the authors for sharing their data and programs.

negative (positive) coefficient β_0 indicates that banks decrease (increase) the loan spread when monetary policy conditions are perceived to be expansionary, on average, for all firms. Since accommodative monetary policy is intended to lower loan rates, we expect a negative association between the loan spread and the MP Stance variable. $Bank_{k,b,t}$, $Firm_{l,f,t}$ and $Loan_{m,f,b,t}$ are vectors with time-varying bank, firm, and loan-level characteristics. Table 2 shows estimation results for equation 3.

The coefficient on MP Stance indicates that, faced with expansionary monetary policy, banks reduce loan spreads to borrowers. Since the dependent variable is expressed as a natural logarithm, we can economically interpret the coefficient on the MP Stance variable as follows. In column (1), a one unit increase in the MP Stance variable, corresponding with a 25 basis point decrease in the 10-year US bond yield, is associated with a 3.50% decrease in the corporate loan spread. Our finding is consistent with the interpretation that stimulating monetary conditions reduces risk considerations through higher expected economic growth and lower discount rates, which make investment projects more valuable. The firm balance sheet mechanism also predicts a negative relationship because low interest rates boost firms' collateral values and raise profits (Bernanke and Gertler, 1995; Jiménez et al., 2014; Lee et al., 2017). Higher economic growth is in principle also associated with fewer non-performing loans in banks' loan portfolios, providing an additional impetus to lend at lower spreads. However, finding a negative effect of monetary policy conditions on credit spreads is also consistent with banks taking excessive risk by underpricing credit risk, hence this channel needs further elaboration.

Since the cost of corporate borrowing is likely to depend on various lender, borrower, and loan-specific characteristics, we include a wide array of control variables and incrementally add dummy variables for loan type, bank, firm, and bank-firm relationships. In column (1), we estimate our model only with control variables and without fixed effects. Next, we include loan type fixed effects in column (2) to account for loan type heterogeneity. We add bank fixed effects in column (3) to control for time-invariant heterogeneity between banks and which may influence loan spreads; the identification is then performed using only the time or within-bank dimension. Firm fixed effects, included in column (4), allow us to compare loan pricing by different banks to one specific firm over time. Finally, the inclusion of bank-firm fixed effects in column (6) accounts for time-invariant heterogeneity between pairs of banks and firms that may still affect loan spreads. Even after the inclusion of the fixed effects at bank, firm or bank-firm level, the coefficient on the MP stance remains negative and significant, although the magnitude is somewhat lower.

The coefficients on our control variables are in line with expectations. Riskier firms, measured by higher values of both Firm Leverage and Firm Vol(ROA), pay higher spreads at the time of loan origination, which is consistent with risk-based loan pricing by banks. Similarly, banks price in the higher probability of loan repayment when firms are profitable, as evidenced by the significantly negative coefficient on the borrowers' Return on Assets (Firm ROA). Finally, banks with higher capital ratios and larger banks tend to offer loans with lower credit spreads. Hubbard et al. (2002), using a sample of loans by US banks, show that low-capital banks are more risk averse than high-capital banks. The finding is also consistent with Gambacorta et al. (2014), who report that well-capitalized banks supply more and less expensive loans to corporate borrowers compared to their poorly capitalized peers. Similarly, larger banks tend to be better diversified and will likely have access to a lower cost of funds and are thus able to offer lower spreads (Santos, 2011). The results in table 2 further confirm a series of previously identified regularities in loan pricing: larger loans (Loan Size), loans with shorter maturities (Loan Maturity), and relationship loans (REL(Amount)) carry lower spreads.

Monetary policy has an additional contemporaneous effect on the determination of the loan spread at the time of origination. We next investigate whether this monetary policy transmission is contingent on specific bank and firm characteristics.

3.2. Bank heterogeneity and the transmission of monetary policy

In a second set of specifications, we investigate whether loan pricing is supply driven following monetary policy changes. While an accommodative stance of monetary policy at the time of loan origination has a significant effect on the loan spread, the distributional effect of monetary policy may depend on bank characteristics (Altunbas et al., 2009; Gambacorta, 2011). We explore the following five bank characteristics: bank capital, size, quality of existing loan portfolio, reliance on non-interest income, and profitability.

Banks with higher levels of bank capital (*Bank Capital Ratio*) have a lower cost of funding, which allows these banks to provide credit to the real sector at a lower cost. (Kishan and Opiela, 2000; Jiménez et al., 2012; Gambacorta and Shin, 2018). Confronted with an identical monetary policy stance, we expect that banks with higher capital buffers offer lower credit spreads compared to banks with lower levels of capitalization. Similarly, large banks (*Bank Size*) benefit from an implicit too-big-to-fail protection and rely more on interbank funding, lowering their funding costs (Demsetz and Strahan, 1997; Kaufman, 2014). We expect larger banks to pass on expansionary monetary policy to the real sector at a faster pace compared to smaller banks. The ratio of non-performing loans to total loans (*NPL_Loans*) is an indicator of the quality of the existing bank loan portfolio. A larger ratio signals that a larger part of the loan portfolio is experiencing problems of repayment. We expect banks with lower existing loan quality to become more prudent and charge higher spreads on new loans. We include the ratio of non-interest income to total revenues (*Bank Diversification*), which captures the relative reliance on non-interest income. Unconventional monetary policy reduces long term interest rates which in turn decreases the difference between long term (lending) interest rates and short term (deposit) interest rates. Put differently, the Federal Reserve's actions have put pressure on banks' interest margins (Mamatzakis and Bermpei, 2016). Banks that rely to a larger extent on non-interest income are thus less affected. We hypothesize that, in response to expansionary monetary policy, banks with higher levels of diversification reduce loan spreads more aggressively compared to banks with lower levels of diversification. Finally, we include bank profitability (*Bank Return on Assets (ROA)*) to test two conflicting hypotheses. Profitable banks have more scope to reduce loan spreads compared to less profitable banks when rates are low. However, profitable banks may want to maintain their high profitability over time. In a low-interest rate environment, that entails increasing loan spreads.

Our empirical setup allows us to provide insights into which types of banks tend to transmit expansionary monetary policy to corporate loan spreads. We include bank-specific characteristics in interaction with the monetary policy stance, and estimate the following equation:

$$\begin{aligned} Spread_{f,b,t} = \alpha_0 + (\beta_0 + \sum_{k=1}^{K} \beta_k Bank_{k,b,t}) \times MP\ Stance_{t-1} + \\ \sum_{k=1}^{K} \gamma_k Bank_{k,b,t} + \sum_{l=1}^{L} \gamma_l Firm_{l,f,t} + \sum_{m=1}^{M} \gamma_m Loan_{m,f,b,t} + \varepsilon_{f,b,t} \end{aligned} \quad (4)$$

where *Bank* denotes the different bank-specific variables. The coefficient of interest is the interaction term between $MP\ Stance_{t-1}$ and $Bank_{k,b,t}$, which captures the heterogeneous response by banks to an expansionary monetary policy stance. We add bank and firm fixed effects and vectors of time-varying control variables with firm and loan-level characteristics. Table 3 shows results for equation 4.[8]

Columns (1) and (2) in table 3 allow us to assess the heterogeneous loan pricing reactions of different types of banks in an environment of perceived monetary accommodation. The interaction term between bank capital ratio and MP Stance is positive, indicating that even

[8] Columns (1) and (2) show coefficient estimates for bank variables and their interaction with MP Stance, the only difference being the addition of bank-firm fixed effects. In columns (3) and (4) we show results for the inclusion of loan characteristics (loan size, loan maturity and the relationship intensity) and in columns (5) and (6) those with firm characteristics. Columns (7) and (8) combine all variables to assess the relative importance of the effects. In this table, we only present the interaction terms of the relevant variables with the monetary policy stance. The standalone variables are also included in the estimation, but unreported for brevity.

banks with robust capital buffers apply higher credit spreads to the average borrower relative to less capitalized banks. Larger banks reduce loan risk premia more than smaller banks in times of expansionary monetary policy, as evidenced by the negative sign on the interaction term between bank size and MP Stance. The most likely explanation for this effect is that large banks tend to be more reliant on wholesale funding than small banks, so that monetary policy accommodation directly reduces their cost of funding, which allows them to lower spreads in the pursuit of remaining competitive in the syndicated loan market. The interaction of MP Stance with NPL_Loans is positive and significant, indicating that banks with safer ex-ante loan portfolios decrease loan spreads more relative to banks with riskier loan portfolios when confronted with monetary accommodation. The finding that banks with higher expected losses in their existing loan portfolios tend to avoid passing on any perceived monetary policy easing is not compatible with the notion of excessive risk taking. On the contrary, our findings point at prudent lending behavior. Similarly, the interaction of the MP Stance with bank pre-tax ROA is significantly positive. Hence, those banks that could afford to take additional risk, e.g. to increase their market share, refrain from doing so. Apparently, solid lending margins have supported higher profitability and those banks do not elect to put their high ROA at risk, again suggesting prudent lending behavior. Finally, the interaction between bank diversification (a higher share of non-interest income) and the MP Stance is negative and always significant, signaling that diversified banks reduce loan spreads more when monetary policy is accommodative. One interpretation of this result is that banks with greater reliance on non-interest income are simply associated with higher risk profiles (Stiroh, 2004). A more benign interpretation is that more diversified banks can afford to reduce loan spreads when monetary policy is accommodative, as opposed to banks which are highly dependent on interest income.

When the bank interaction effects are combined with interaction effects for loan characteristics and firm characteristics in columns (7) and (8), we continue to find most previously documented bank effects. We present the results in column (8) graphically in figure 2.[9] Lower spreads in an environment of perceived monetary policy accommodation are associated with large banks and banks exhibiting a greater degree of revenue diversification. Banks with a high ROA and those with more non-performing loans tend to forgo passing on more favorable monetary conditions, even when they have high capital buffers.

3.3. Does unconventional monetary policy provoke excessive risk taking?

In a third set of specifications, we identify the risk-taking channel by including the variable *Firm Risk* in interaction with the stance of monetary policy:

$$
\begin{aligned}
Spread_{f,b,t} = \alpha_0 + (\beta_0 + \beta_1 Firm\ Risk_{f,t}) \times MP\ Stance_{t-1} + \\
\sum_{k=1}^{K} \lambda_k Bank_{k,b,t} + \sum_{l=1}^{L} \psi_l Firm_{l,f,t} + \sum_{m=1}^{M} \omega_m Loan_{m,f,b,t} + \varepsilon_{f,b,t} \quad (5)
\end{aligned}
$$

where $Firm\ Risk_{f,t}$ captures the borrowers' credit risk, proxied by two firm-specific variables: *Firm Leverage* and *Firm Vol(ROA)*. *Firm Leverage* is the sum of the borrowers' short-term and long-term debt divided by total assets. *Firm Vol(ROA)* is the volatility of return on assets in the three years preceding the loan issuance. A higher value for *Firm Risk* thus represents lower borrowing firm creditworthiness.[10] A negative coefficient estimate for the interaction term *MP Stance* × *Firm Risk* would suggest that lenders apply a larger loan spread reduction for riskier firms compared to less risky firms in times of monetary easing, indicating the presence of a risk-taking channel. If we find a positive coefficient on the

[9] The marginal effects are based on the coefficients estimated using equation 4 and are calculated as:

$$\frac{\partial Spread_{f,b,t}}{\partial MP\ Stance_{t-1}} = \hat{\beta}_0 + \sum_{k=1}^{K} \hat{\beta}_k Bank_{k,b,t}$$

[10] In addition, we define a third firm risk variable *Low IC*, which is a dummy variable equal to one if the firm's interest coverage ratio is below the median of the yearly sample distribution, and zero otherwise. Estimation results using this firm risk variable are available upon request.

interaction term, there is no evidence for a risk-taking channel.

The main challenge is to disentangle the risk-taking channel from other channels, such as bank lending and firm borrowing channels which could impact the loan pricing following monetary policy events. Several studies (for example Khwaja and Mian, 2008 and Jiménez et al., 2012) point out that databases at the bank-firm level, such as credit registers, can be useful to address this identification challenge. First, to account for time-varying supply side effects we add specifications that include bank-year fixed effects. Second, to control for time-varying changes in credit demand we could opt to include firm-time fixed effects as in Khwaja and Mian (2008). However, we lack information on firms that borrow from more than one lead bank on the same day, or even in the same year. As a result, the coefficient estimates would be based on a limited sample of firms that borrow from different banks at the same point in time.[11]

To address this concern we follow the approach of Degryse et al. (2019) and cluster firms that can be assumed to face very similar credit demand conditions. Degryse et al. (2019) cluster firms based on their industry, location and size (ILS) which allows them to use the information of almost all firms. The key in the identification is to verify that clusters include firms with equivalent credit demand, and that each of the clusters borrow from more than one bank in the same time period. The identification involves a trade-off. The narrower the cluster, the more specific the credit demand will be. However, narrower clusters also imply that more observations are lost, since more firms within a cluster lend from the same bank. To decide on the optimal cluster level, we group firms based on different types of characteristics.[12] We decide to cluster firms based on their industry, location and size, in

[11]For example, the inclusion of firm-year fixed effects reduces the sample to 56% of the original sample. If we further eliminate firms that borrow from the same bank within the year, the sample further reduces to around 5% of the original sample, causing the method to be ineffective in our case.

[12]We experiment with different clustering methods based on the industry, size, location, leverage, and risk profile of the firms. We then inspect the amount of clusters and how many of these clusters lend to another bank in the same year. Based on the proposed industry-location-size clustering we retain 91% of the observations in the sample. The experiment shows that the coefficients are robust to different levels of firm clustering. We therefore choose the specification where we retain most of the observations in the sample. Results of this robustness check are available upon request.

line with Degryse et al. (2019). The industry clusters are based on the first two digits of the firms' Standard Industrial Classification (SIC) codes, location clusters are based on the country of the firm, and the size clusters are based on the median of total assets of the firms. Based on this clustering we create industry-location-size-year fixed effects that filter out time-varying changes in credit demand.

Table 4 shows results for the individual firm risk variables with alternating fixed effects. In columns (1), (3) and (5) we include loan type, bank and firm fixed effects. In columns (2), (4) and (6) we acknowledge that credit supply and demand factors may be time-varying and add bank-year, industry-location-size-year and bank-firm fixed effects to the model. The coefficient on the MP Stance measure is negative and significant in most specifications, suggesting that banks charge lower loan spreads when monetary policy is perceived to be accommodative. Our measures of firm risk are positively associated with loan spreads, i.e. banks require additional compensation for taking more credit risk. The specifications in columns (1) and (3) show that the interaction terms between both Firm Leverage and Firm Vol(ROA) and the MP Stance are positive but only significant for Firm Vol(ROA). Firm leverage remains relatively constant over time, such that the effect is subdued by the addition of firm fixed effects. The loan spread reduction following expansionary monetary policy is thus smaller for riskier firms compared to safer firms. In columns (2) and (4) of table 4 we again find a positive coefficient on the interaction term between the MP stance and firm leverage, however again insignificant. The coefficient on the interaction between MP stance and Firm Vol(ROA) remains positive and significant indicating that firms with more volatile earnings are charged higher loan spreads, even when monetary policy is perceived by the financial markets as accommodative. These results are not consistent with banks taking excessive credit risk or underpricing risk when monetary conditions are benign.

We present the net effect of the monetary policy stance on loan spreads graphically in figure 3.[13] The left panel uses firm leverage and the middle panel shows the result for

[13]The net effect is the sum of the standalone and the interaction effects. We calculate the first derivative

ROA volatility. Both graphs indicate that accommodative monetary policy conditions are associated with lower credit spreads, but as firm risk increases (in our sample, firm leverage ranges from 10% to 60% and Vol(ROA) is situated between 1% and 6%), the spread reduction diminishes, implying that riskier firms obtain relatively less beneficial loan spreads.

A third firm-specific characteristic we include in columns (5) and (6) of table 4 is the intensity of the bank-borrower relationship. Evidence has shown that relationship lenders tend to support their borrowers in bad times (Sette and Gobbi, 2015). REL(Amount) captures the degree of relationship lending between lender and borrower pairs. By interacting the relationship indicator with our measure of monetary policy, we assess whether relationship lenders favor channeling more accommodating lending conditions to their relationship borrowers compared to non-relationship borrowers. Relationship borrowers seem to obtain loans at lower cost. However, the interaction term with MP Stance is insignificant, suggesting no additional benefit of maintaining a lending relationship when monetary policy is expansionary. The right panel of figure 3 shows the net effect.

The conclusion of our analysis so far is that we are unable to find support for the risk-taking channel of monetary policy. Banks do pass on more benign monetary conditions to their borrowers in terms of lower spreads, but the loan spread reduction is smaller for riskier borrowers, consistent with sound loan risk pricing.

3.4. How does the risk-taking channel differ across bank business models?

In this section, we examine whether bank heterogeneity plays a role for risk-taking behavior. From a policy and financial stability view, this issue is particularly relevant as it allows the identification of those banks more likely to engage in risk-taking. We include triple interaction terms between the stance of monetary policy, relevant bank characteristics, and

of the loan spread with respect to the MP Stance for the two measures of firm risk based on equation 5:

$$\frac{\partial Spread_{f,b,t}}{\partial MP\ Stance_{t-1}} = \hat{\beta}_0 + \hat{\beta}_1 Firm\ risk_{f,t}$$

firm risk characteristics. After controlling for changes in credit demand, the heterogeneous response of banks to the monetary policy stance can only be the result of bank decisions. The residual effect represents bank risk taking. We estimate the following loan spread regression:

$$\begin{aligned} Spread_{f,b,t} = \alpha_0 + \Bigg(\beta_0 + \beta_1 Firm\ Risk_{f,t} + \sum_{k=1}^{K} \lambda_k Bank_{k,b,t} \\ + \sum_{k=1}^{K} \psi_k (Bank_{k,b,t} \times Firm\ Risk_{f,t})\Bigg) \times MP\ stance_{t-1} + \\ \sum_{k=1}^{K} \gamma_k Bank_{k,b,t} + \sum_{l=1}^{L} \kappa_l Firm_{l,f,t} + \sum_{m=1}^{M} \omega_m Loan_{m,f,b,t} + \varepsilon_{f,b,t} \end{aligned} \tag{6}$$

where all variables are defined as before. The coefficient of interest is ψ_k, which captures the loan spread differential among heterogeneous lending banks, controlling for the risk profile of the borrower. If banks take excessive risk in times of monetary policy accommodation, the coefficient ψ_k should be negative, reflecting that a bank offers a larger spread discount to a riskier borrower relative to a less risky borrower. We filter out time-varying credit demand factors by including industry-location-size-year fixed effects. Table 5 presents the results. In columns (1) - (6) we incrementally add bank features.

Since the MP Stance is interacted with firm risk and with various bank characteristics, the net effect of the monetary policy stance on the loan spread is the combination of these effects. We represent the marginal effect graphically in figures 4 and 5.[14] To construct the marginal effects graphs, we calculate the effect for varying levels of each of the bank characteristics, while plugging in the mean value for all other bank variables. Hence, the top left graph shows the marginal effect of MP Stance on the loan spread (depicted on the Y-axis)

[14]The first derivative of the loan spread with respect to MP Stance is calculated based on equation 6 and can be expressed as:

$$\frac{\partial Spread_{f,b,t}}{\partial MP\ Stance_{t-1}} = \hat{\beta}_0 + \hat{\beta}_1 Firm\ Risk_{f,t} + \sum_{k=1}^{K} \hat{\lambda}_k Bank_{k,b,t} + \sum_{k=1}^{K} \hat{\psi}_k (Bank_{k,b,t} \times Firm\ Risk_{f,t})$$

for the range of the firm risk variable observed in our sample (depicted on the X-axis) and for low/high values of the bank variable, in this case the banks' capital ratio. We perform this procedure for the two firm risk indicators: firm leverage (figure 4, X-axis ranging from 10% to 60%), and volatility of ROA (figure 5, X-axis ranging from 0% to 6%).

To interpret the empirical results relevant for the risk-taking hypothesis, we consider table 5 and figures 4 and 5 simultaneously. Two general observations merit attention. First, the third row of table 5 indicates that, controlling for all other interactions, the interaction of MP Stance and firm risk is always positive, and in the case of firm Vol(ROA) in columns (4) and (6) even significantly so. This confirms the findings in table 4 that an accommodative monetary policy environment is not associated with lower loan spreads for riskier firms. Second, the graphs in figures 4 and 5 show that almost all point estimates of the effect of MP Stance on the loan spread are negative. This corroborates the findings in previous tables and confirms that an accommodative monetary policy stance of the Federal Reserve is associated with banks overall applying lower credit spreads. Hence, unconventional monetary policy has eased credit conditions.

Turning to the triple interactions, we have to consider the coefficient on the MP-bank-firm interaction term in table 5, but also the marginal effect as depicted in figures 4 and 5. To illustrate the interpretation nexus, consider the findings for the interaction between MP Stance, bank capital and firm risk (leverage and ROA volatility in figures 4 and 5, respectively). The marginal effects in the top left panels of figures 4 and 5 show that the loan spread reduction becomes smaller for firms with higher credit risk. In addition, when firm risk increases, banks characterized by relatively low capital ratios charge higher spreads compared to their highly capitalized counterparts (or more precisely, the negative impact of monetary policy easing on loan spreads decreases and even disappears for high-leverage firms), hence the low-cap banks behave prudently. For relatively high levels of firm risk (i.e. ROA volatility exceeding 5% or leverage ratios exceeding 40%), high-cap banks lower their spreads more than low-cap banks. While this finding can be interpreted as risk taking, banks with relatively high capital ratios have sufficient equity buffers to take the increased credit risk. Hence, in the case where unconventional monetary policy may promote risk taking, this is done by banks who can bear the risk.

Highly similar observations hold for the other bank variables we consider. The marginal effect of the loan spread for small versus large banks in figures 4 and 5 (top middle panels) shows that small banks lower their spreads more than large banks for low-risk firms. Yet, when firm risk increases, small banks adjust their loan pricing upward more swiftly than large banks. Moreover, small banks react much more strongly to weaker firm creditworthiness when this is measured by the leverage ratio and even increase credit spreads for the riskiest firms. Hence, if there is evidence that high-risk firms obtain syndicated loans at reduced spreads, then this is only the case when they deal with large banks, who typically benefit from their access to lower-cost funding sources. On the bank profit side, the results for revenue diversification are pronounced (bottom left panels in figures 4 and 5). Only banks characterized by a high degree of income diversification engage in loan spread accommodation, but when firm risk increases they accommodate less. Low-diversification banks only apply reduced spreads for the least risky firms. The reason is that these banks rely on interest income (mainly from loans) so that they cannot compensate lower loan revenues by tapping into other sources of revenue. Finally, the bottom right panels indicate that low-ROA banks decrease the loan spreads more compared to more profitable banks, which may be due to competitive pressure or may even signal reverse causation in the sense that banks charging lower spreads will be less profitable. However, also in this case we observe that higher firm risk is associated with a decrease in loan spread reduction.

Taken together, the findings in table 5 and figures 4 and 5 paint a consistent picture. Looser monetary conditions as a result of unconventional policy are transmitted into lower credit spreads for syndicated loans. However, even the more risky banks have not lowered credit spreads for loans to more risky firms. On the contrary, when firm risk increases, banks with low capital ratios, less profitable banks and smaller banks moderate their accommodative lending standards, which is an indication of prudent lending behavior. Hence, the hypothesis of excessive risk taking by banks caused by very accommodative unconventional monetary policy conditions receives no general support.

4. Conclusion

Central banks in recent years have resorted to extensive monetary policy easing, as well as the deployment of unconventional policy. Their actions have spurred the debate on the implications of extended expansionary monetary policy for bank risk taking. Previous studies have used the evolution of monetary policy rates to investigate the impact of monetary policy on financial markets, securitization, and bank risk taking. However, relying on policy rates may prove inadequate to evaluate the impact of monetary policy in a period where central bank actions are unconventional and when policy rates reach the zero lower bound. We contribute to the existing literature by developing a monetary policy shock variable from a structural VAR using relevant financial market variables. In doing so, we do not only capture actual monetary policy shocks, but also incorporate anticipation by financial market participants. The SVAR provides an exogenous measure of the monetary policy stance while avoiding the choice of a specific policy instrument. We use data on corporate loans issued by US banks from 2008 through 2015 and assess the impact of monetary policy on loan spreads.

From a methodological point of view, we contribute to existing methods by including interaction terms and a wide range of fixed effects to properly disentangle credit supply and demand effects in an incremental way. Monetary policy accommodation is intended to stimulate economic growth and these more benign conditions may induce banks to lower their loans spreads. Alternatively, loose monetary conditions may incentivize banks to increase their risk appetite by granting loans with lower spreads to riskier firms. To mitigate the confounding effects of these alternative channels, we also include triple interaction terms between bank, firm risk, and monetary policy variables. In doing so, we control for banks' cross-sectional heterogeneity in supplying credit to riskier firms.

Our results demonstrate that, faced with an expansionary stance of monetary policy at the time of the loan issuance, banks reduce the credit spreads of syndicated loans to corporate borrowers in the 2008-2015 unconventional monetary policy period in the US. Hence, the unconventional monetary policy easing by the Federal Reserve is transmitted to more accommodative loan conditions. When we focus on the creditworthiness of the borrowers, we find no evidence in support of the bank risk-taking channel in this segment of the corporate loan market. Although banks apply lower spreads, the credit spread reduction is found to be lower for riskier borrowers, consistent with prudent lending behavior.

From the bank perspective, we show that the loan spread reduction is most pronounced for small banks, banks with low capital buffers, high existing loan quality, and banks with higher levels of diversification. However, when controlling for borrower risk we find that banks with low capital ratios, less profitable banks and smaller banks more aggressively reduce the corporate loan spreads following an expansionary monetary policy shock, but only for the safest firms. Hence, our findings indicate that the unconventional monetary policy actions of the Federal Reserve are not associated with excessive risk taking by banks in the syndicated loan market, contrary to pre-2008 evidence.

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Tables

Table 1: Descriptive statistics.

Variable	Obs.	Mean	St.Dev.	25th	Median	75th
MP Stance	1,655	-0.17	2.58	-2.86	0.96	2.03
			Loan characteristics			
Loan spread (bps)	7,042	228.02	132.63	137.50	200.00	275.00
Loan Maturity (months)	7,042	52.21	16.71	46.00	60.00	60.00
Loan Size (mln USD)	7,042	812.84	1,106.20	163.28	412.43	999.97
REL(Amount)	7,042	0.60	0.45	0.00	0.88	1.00
Number of Lenders	7,042	9.04	7.29	4.00	7.00	12.00
			Bank characteristics			
Total Assets (bln USD)	351	750.00	870.00	93.00	270.00	1,800.00
Capital Ratio (%)	351	10.67	1.52	9.59	10.86	11.72
Return on Assets (%)	351	0.26	0.26	0.20	0.32	0.42
NPL_Loans	351	4.19	2.21	2.46	3.99	5.76
Diversification	351	41.64	14.00	37.57	43.56	48.03
			Firm characteristics			
Assets (mln USD)	4,676	9,265.44	33,896.40	786.52	2,275.52	7,032.30
Leverage (%)	4,676	29.96	23.14	14.95	27.41	40.36
Return on Assets (%)	4,676	12.68	9.06	8.52	11.94	16.41
Vol(ROA)	4,676	3.02	4.39	0.91	1.82	3.44

Notes: MP Stance is the cumulative monetary policy shock estimated using a structural VAR of financial market variables, as described in section 2.2. Loan spread is the all-in-spread drawn (AISD), which equals the coupon spread over LIBOR on the drawn amount plus the annual fee in basis points. Loan Maturity is the length in months between facility activation date and maturity date. Loan Size is the loan facility size in millions of real year 2000 dollars. REL(Amount) is the ratio of the dollar value of facilities with the current lead bank in the last five years, divided by the total dollar value of facilities borrowed by the firm in the last five years. Number of Lenders is the total number of lenders in the facility lending pool. Bank characteristics are defined as follows. Total Assets is the bank's Total Assets expressed in billions of real year 2000 dollars. Capital Ratio is the ratio of equity to total assets. Bank Return on Assets is income before taxes and extraordinary items and other adjustments, divided by total assets. NPL_Loans is non-performing loans divided by gross loans. Diversification is total non-interest income divided by total income. Firm characteristics are defined as follows. Assets is the book value of assets in millions of real year 2000 dollars of the firm as reported in Compustat. Leverage is the sum of short-term and long-term debt, scaled by the book value of assets. Firm Return on Assets is EBITDA divided by the book value of assets. Vol(ROA) is the standard deviation of Return on Assets in the three years prior to the start date of the loan.

Table 2: Effect of monetary policy stance on corporate loan spreads.

	(1) Loan Spread	(2) Loan Spread	(3) Loan Spread	(4) Loan Spread	(5) Loan Spread	(6) Loan Spread
MP Stance	-0.035***	-0.038***	-0.026***	-0.027***	-0.022***	-0.022***
	(-14.90)	(-17.21)	(-9.26)	(-11.60)	(-8.79)	(-8.59)
Loan Maturity	0.067***	0.022	0.026	-0.058***	-0.052***	-0.061***
	(3.84)	(1.20)	(1.43)	(-3.77)	(-3.40)	(-3.66)
Loan Size	-0.105***	-0.094***	-0.089***	-0.005	-0.005	-0.007
	(-21.50)	(-19.69)	(-18.19)	(-0.74)	(-0.78)	(-1.09)
REL(Amount)	-0.075***	-0.060***	-0.059***	-0.041***	-0.040***	-0.053***
	(-5.86)	(-4.98)	(-4.83)	(-3.00)	(-2.94)	(-3.20)
Firm Vol(ROA)	0.008***	0.009***	0.009***	-0.001	-0.001	-0.001
	(5.06)	(5.66)	(5.47)	(-0.44)	(-0.59)	(-0.34)
Firm Leverage	0.007***	0.006***	0.006***	0.002***	0.002***	0.002***
	(23.10)	(21.44)	(21.31)	(4.11)	(4.17)	(3.28)
Firm ROA	-0.009***	-0.009***	-0.009***	-0.003***	-0.003***	-0.004***
	(-9.24)	(-9.98)	(-9.78)	(-2.65)	(-2.74)	(-2.99)
Bank Capital Ratio	-0.022***	-0.018***	-0.078***	-0.042***	-0.056***	-0.048***
	(-4.63)	(-3.85)	(-7.65)	(-5.54)	(-5.93)	(-4.81)
Bank Size	-0.012*	-0.016**	-0.127**	-0.070***	-0.227***	-0.205***
	(-1.78)	(-2.35)	(-2.47)	(-3.81)	(-3.47)	(-3.06)
Cons.	6.055***	6.229***	9.132***	7.451***	10.901***	10.433***
	(34.48)	(36.01)	(8.29)	(17.66)	(7.76)	(7.26)
Loan Type FE	-	Yes	Yes	Yes	Yes	Yes
Bank FE	-	-	Yes	-	Yes	Yes
Firm FE	-	-	-	Yes	Yes	Yes
Bank-Firm FE	-	-	-	-	-	Yes
R^2	0.25	0.33	0.34	0.79	0.79	0.82
N	7,042	7,042	7,037	6,569	6,566	6,249

Notes: This table reports coefficient estimates from OLS regressions relating the monetary policy stance to corporate loan spreads. The dependent variable is Loan Spread, defined as the natural logarithm of the all-in-spread drawn on the loan. The all-in-spread drawn is defined as the coupon spread over LIBOR on the drawn amount plus the annual fee in basis points. MP Stance is the cumulative monetary policy shock estimated using a structural VAR of financial market variables, as described in section 2.2. Loan Maturity is the natural logarithm of loan maturity in months, Loan Size is the natural logarithm of the loan size in real year 2000 dollars, and REL(Amount) is the ratio of the dollar value of facilities with the current lead bank in the last five years, divided by the total dollar value of facilities borrowed by the firm in the last five years. Firm Vol(ROA) is the standard deviation of Firm Return on Assets over the past three years. Firm Leverage is the sum of short-term and long-term debt, divided by assets. Firm ROA is EBITDA divided by assets. Bank Capital Ratio is equity divided by assets, and Bank Size is the natural logarithm of bank assets expressed in billions of real year 2000 dollars. The table reports coefficients and t-statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors.

Table 3: Effect of bank heterogeneity, loan, and firm characteristics on the monetary policy transmission channel.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP Stance	0.056 (0.74)	0.104 (1.30)	-0.066*** (-3.03)	-0.043* (-1.85)	-0.028*** (-5.37)	-0.026*** (-5.07)	0.036 (0.46)	0.102 (1.23)
MP Stance x Bank Capital Ratio	0.001 (0.78)	0.001 (0.64)					0.001 (0.80)	0.001 (0.73)
MP Stance x Bank Size	-0.004 (-1.09)	-0.006* (-1.70)					-0.003 (-0.95)	-0.006 (-1.54)
MP Stance x NPL_Loans	0.008*** (5.72)	0.009*** (6.15)					0.008*** (5.56)	0.009*** (6.04)
MP Stance x Bank Diversification	-0.002*** (-5.73)	-0.002*** (-5.89)					-0.002*** (-5.73)	-0.002*** (-5.89)
MP Stance x Bank ROA	0.062*** (5.13)	0.055*** (4.50)					0.059*** (4.84)	0.053*** (4.28)
MP Stance x Loan Size			0.003** (2.01)	0.001 (0.50)			0.002 (1.31)	0.001 (0.36)
MP Stance x Loan Maturity			0.007 (1.36)	0.004 (0.78)			-0.001 (-0.16)	-0.004 (-0.77)
MP Stance x REL(Amount)			-0.004 (-0.85)	-0.002 (-0.42)			-0.005 (-1.02)	-0.003 (-0.55)
MP Stance x Firm Leverage					-0.00002 (-0.31)	-0.00003 (-0.38)	0.00003 (0.33)	0.00004 (0.55)
MP Stance x Firm Vol(ROA)					0.002*** (4.52)	0.002*** (4.74)	0.002*** (4.18)	0.002*** (4.18)
MP Stance x Firm ROA					-0.00001 (-0.06)	-0.0001 (-0.62)	0.0002 (0.71)	0.00000 (0.02)
Cons.	13.494*** (7.64)	12.351*** (6.80)	10.720*** (7.68)	10.339*** (7.26)	10.815*** (7.71)	10.412*** (7.28)	13.421*** (7.59)	12.406*** (6.80)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Loan controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Loan Type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank-Firm FE	-	Yes	-	Yes	-	Yes	-	Yes
R^2	0.80	0.82	0.79	0.82	0.79	0.82	0.80	0.83
N	6,566	6,249	6,566	6,249	6,566	6,249	6,566	6,249

Notes: This table reports coefficient estimates from OLS regressions relating the monetary policy stance in interaction with bank, loan, and firm characteristics to corporate loan spreads. The dependent variable is Loan Spread, defined as the natural logarithm of the all-in-spread drawn on the loan. The all-in-spread drawn is defined as the coupon spread over LIBOR on the drawn amount plus the annual fee in basis points. MP Stance is the cumulative monetary policy shock estimated using a structural VAR of financial market variables, as described in section 2.2. Bank Capital Ratio is equity divided by assets, and Bank Size is the natural logarithm of bank assets. NPL_Loans is the ratio of non-performing loans to gross loans. Bank Diversification is total non-interest income divided by total income. Bank ROA is income before taxes and extraordinary items and other adjustments, divided by total assets. Loan Size is the natural logarithm of the loan size in real year 2000 dollars. Loan Maturity is the natural logarithm of loan maturity in months. REL(Amount) is the ratio of the dollar value of facilities with the current lead bank in the last five years, divided by the total dollar value of facilities borrowed by the firm in the last five years. Firm Leverage is the sum of short-term and long-term debt, divided by assets. Firm Vol(ROA) is the standard deviation of Firm Return on Assets over the past three years. Firm ROA is EBITDA divided by assets. All specifications include control variables as in table 2, as well as the standalone variables, unreported for brevity. The table reports coefficients and t-statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors.

Table 4: Effect of firm risk and lending relationships on the monetary policy transmission channel.

	(1) Loan Spread	(2) Loan Spread	(3) Loan Spread	(4) Loan Spread	(5) Loan Spread	(6) Loan Spread
MP Stance	-0.039***	-0.017**	-0.044***	-0.017***	-0.036***	-0.010
	(-11.40)	(-2.41)	(-19.32)	(-2.78)	(-9.86)	(-1.45)
Firm Leverage	0.002***	0.001				
	(3.91)	(1.25)				
MP Stance x Firm Leverage	0.00003	0.00001				
	(0.35)	(1.50)				
Firm Vol(ROA)			0.004**	0.004**		
			(2.03)	(2.07)		
MP Stance x Firm Vol(ROA)			0.002***	0.002***		
			(4.37)	(2.80)		
REL(Amount)					-0.049***	-0.003
					(-3.66)	(-0.15)
MP Stance x REL(Amount)					0.00003	-0.003
					(0.01)	(-0.50)
Cons.	5.217***	5.270***	5.280***	5.285***	5.319***	5.297***
	(280.55)	(259.53)	(909.44)	(891.89)	(584.64)	(443.05)
Loan Type FE	Yes	-	Yes	-	Yes	-
Bank FE	Yes	-	Yes	-	Yes	-
Firm FE	Yes	-	Yes	-	Yes	-
Bank-Year FE	-	Yes	-	Yes	-	Yes
Industry-Location-Size-Year FE	-	Yes	-	Yes	-	Yes
Bank-Firm FE	-	Yes	-	Yes	-	Yes
R^2	0.78	0.87	0.78	0.87	0.78	0.87
N	6,566	6,022	6,566	6,022	6,566	6,022

Notes: This table reports coefficient estimates from OLS regressions relating the monetary policy stance in interaction with firm risk variables to corporate loan spreads. The dependent variable is Loan Spread, defined as the natural logarithm of the all-in-spread drawn on the loan. The all-in-spread drawn is defined as the coupon spread over LIBOR on the drawn amount plus the annual fee in basis points. MP Stance is the cumulative monetary policy shock estimated using a structural VAR of financial market variables, as described in section 2.2. Firm Leverage is the sum of short-term and long-term debt, scaled by the book value of assets. Firm Vol(ROA) is the standard deviation of Return on Assets in the three years prior to the start date of the current loan. REL(Amount) is the ratio of the dollar value of facilities with the current lead bank in the last five years, divided by the total dollar value of facilities borrowed by the firm in the last five years. The table reports coefficients and t-statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors.

Table 5: Effect of monetary policy stance on corporate loan spreads - triple interaction terms.

	(1) Firm Leverage	(2) Firm Vol(ROA)	(3) Firm Leverage	(4) Firm Vol(ROA)	(5) Firm Leverage	(6) Firm Vol(ROA)
MP Stance	-0.115	-0.127	-0.160	-0.199*	-0.197	-0.229*
	(-0.73)	(-1.11)	(-0.97)	(-1.65)	(-1.09)	(-1.73)
Firm Risk	0.069***	-0.071	0.060***	-0.169	0.057**	-0.097
	(3.10)	(-0.74)	(2.58)	(-1.62)	(2.37)	(-0.95)
MP Stance x Firm Risk	0.004	0.044	0.007	0.068**	0.007	0.064**
	(0.96)	(1.57)	(1.36)	(2.41)	(1.41)	(2.23)
MP Stance x Bank Capital Ratio x Firm Risk	-0.0001	-0.001**	-0.0002*	-0.001*	-0.0002*	-0.001**
	(-1.64)	(-2.45)	(-1.92)	(-1.86)	(-1.72)	(-2.16)
MP Stance x Bank Size x Firm Risk	-0.0001	-0.001	-0.0002	-0.003**	-0.0003	-0.002*
	(-0.67)	(-1.20)	(-1.01)	(-2.39)	(-1.18)	(-1.86)
MP Stance x Bank ROA x Firm Risk			-0.001	-0.010***	-0.001	-0.010***
			(-1.45)	(-3.02)	(-1.18)	(-2.88)
MP Stance x Bank Diversification x Firm Risk			0.000000	0.00001	0.00001	0.00001
			(0.24)	(1.55)	(0.32)	(1.54)
MP Stance x NPL_Loans x Firm Risk					0.0001	-0.001
					(0.91)	(-1.25)
Cons.	0.405	2.303	1.177	3.024	0.884	1.592
	(0.20)	(1.16)	(0.50)	(1.31)	(0.36)	(0.67)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Location-Size-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.87	0.87	0.87	0.87	0.87	0.87
N	6,048	6,048	6,048	6,048	6,048	6,048

Notes: This table reports coefficient estimates from OLS regressions relating the monetary policy stance to bank characteristics and firm risk variables to corporate loan spreads using triple interaction terms. The dependent variable is Loan Spread, defined as the natural logarithm of the all-in-spread drawn on the loan. MP Stance is the cumulative monetary policy shock estimated using a structural VAR of financial market variables, as described in section 2.2. Firm Risk is either Firm Leverage or Firm Vol(ROA), indicated by each column header. Firm Leverage is the sum of short-term and long-term debt, divided by assets. Firm Vol(ROA) is the standard deviation of Return on Assets in the three years prior to the start date of the current loan. Bank Capital Ratio is equity divided by assets, and Bank Size is the natural logarithm of bank assets. Bank ROA is Return on Assets, defined as income before income taxes and extraordinary items and other adjustments, divided by total assets. Bank Diversification is total non-interest income divided by total income. NPL_Loans is the ratio of non-performing loans to gross loans. All specifications include control variables as in table 2, and double interaction terms as in equation 6, unreported for brevity. The table reports coefficients and t-statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors.

Figures

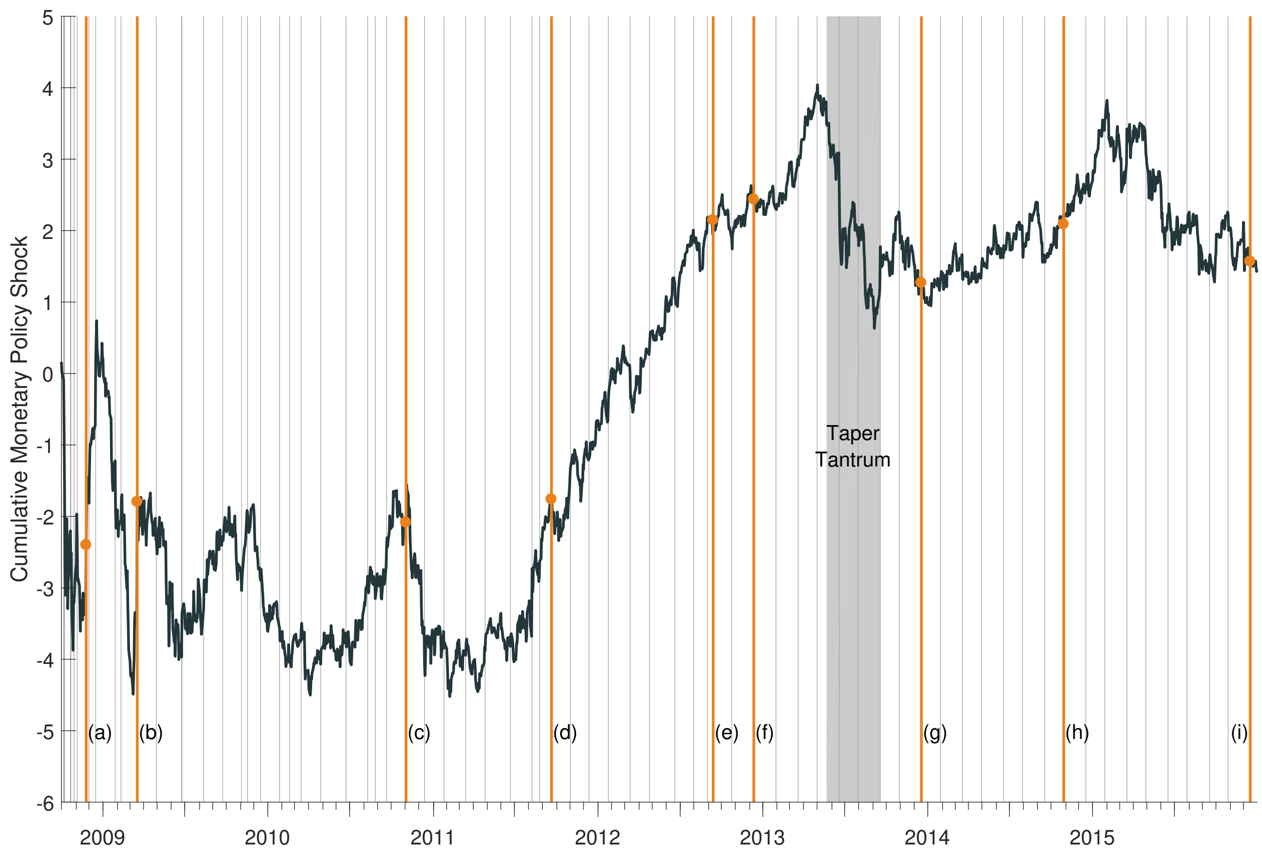

Figure 1: Time series of the cumulative monetary policy shocks for the United States. An increase of the cumulative shock series reflects an expansionary monetary policy announcement. Vertical lines represent the set of announcement dates used in the estimation of the shock. We highlight some of these announcement dates: (a) the Fed creates the Term ABS Loan Facility (TALF) and starts purchasing Agency MBS and debt (QE1); (b) the Fed expands its purchases of Agency MBS and debt and starts buying longer-term Treasury securities; (c) the Fed announces that it will again start buying longer-term Treasury securities (QE2); (d) the Fed announces that it will extend the average maturity of its securities holdings ("Operation Twist"); (e) the Fed decides to start purchasing Agency MBS (QE3); (f) the Fed again starts purchasing additional longer-term Treasury securities after the conclusion of its program to extend the average maturity of its securities holdings; (g) the monthly purchases of Agency MBS and Treasury securities are reduced for the first time; (h) the Agency MBS and Treasury purchase programs are discontinued and the Fed signals that a rate increase is possible in the near future "if incoming information indicates faster progress toward the Committee's employment and inflation objectives than the Committee now expects"; (i) the Fed increases the federal funds rate. The period commonly known as the taper tantrum is indicated by a shaded area.

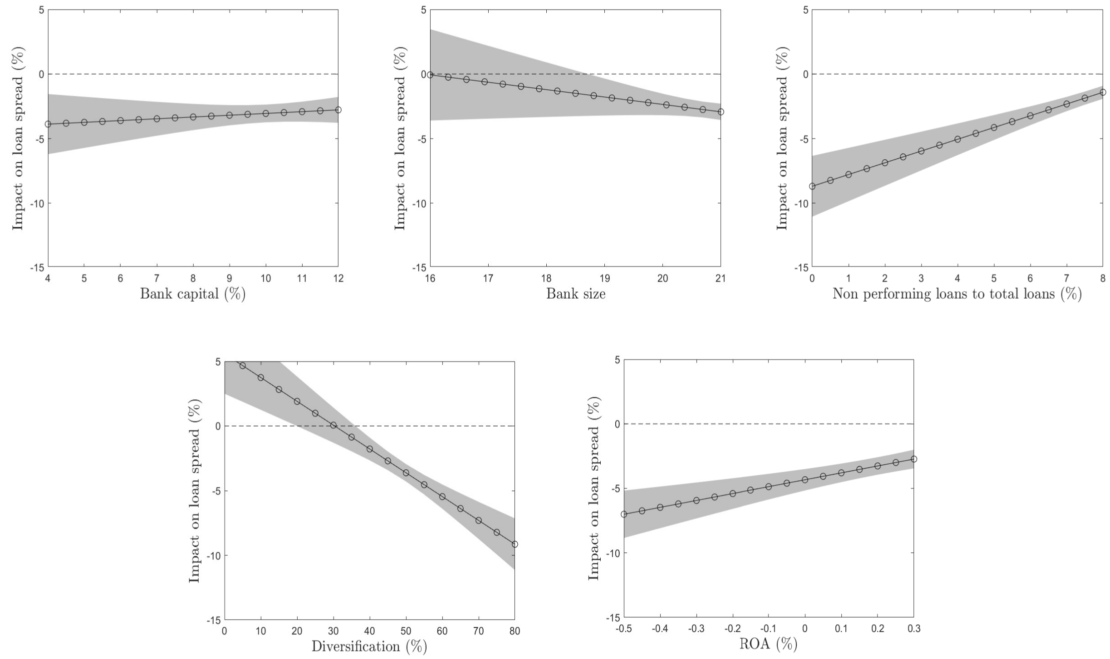

Figure 2: Marginal effects of a unit increase in the monetary policy stance on the all-in-spread drawn (in %) for different bank business model characteristics ranging from low (small) to high (large). The results are based on the coefficients estimated in table 3 (column 8). The shaded area represents the 5% confidence interval.

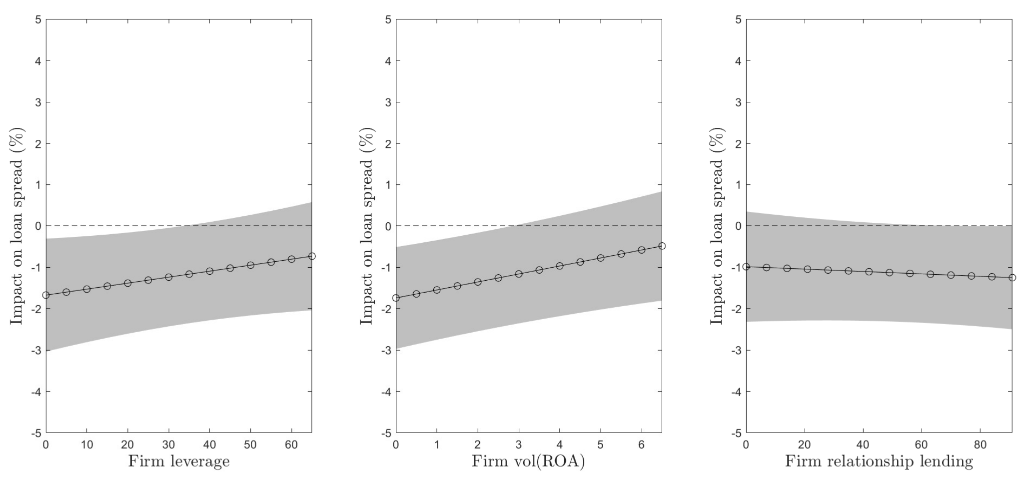

Figure 3: Marginal effects of a unit increase in the monetary policy stance on the all-in-spread drawn (in %) for different levels of firm risk and relationship lending. The results are based on the coefficients estimated in table 4 (columns 2, 4 and 6) where the model includes bank-year fixed effects to controls for time-varying supply factors, industry-location-size-year fixed effects to control for time-varying demand factors and bank-firm fixed effects to control for compositional changes in the pool of borrowers and lenders. The shaded area represents the 5% confidence interval.

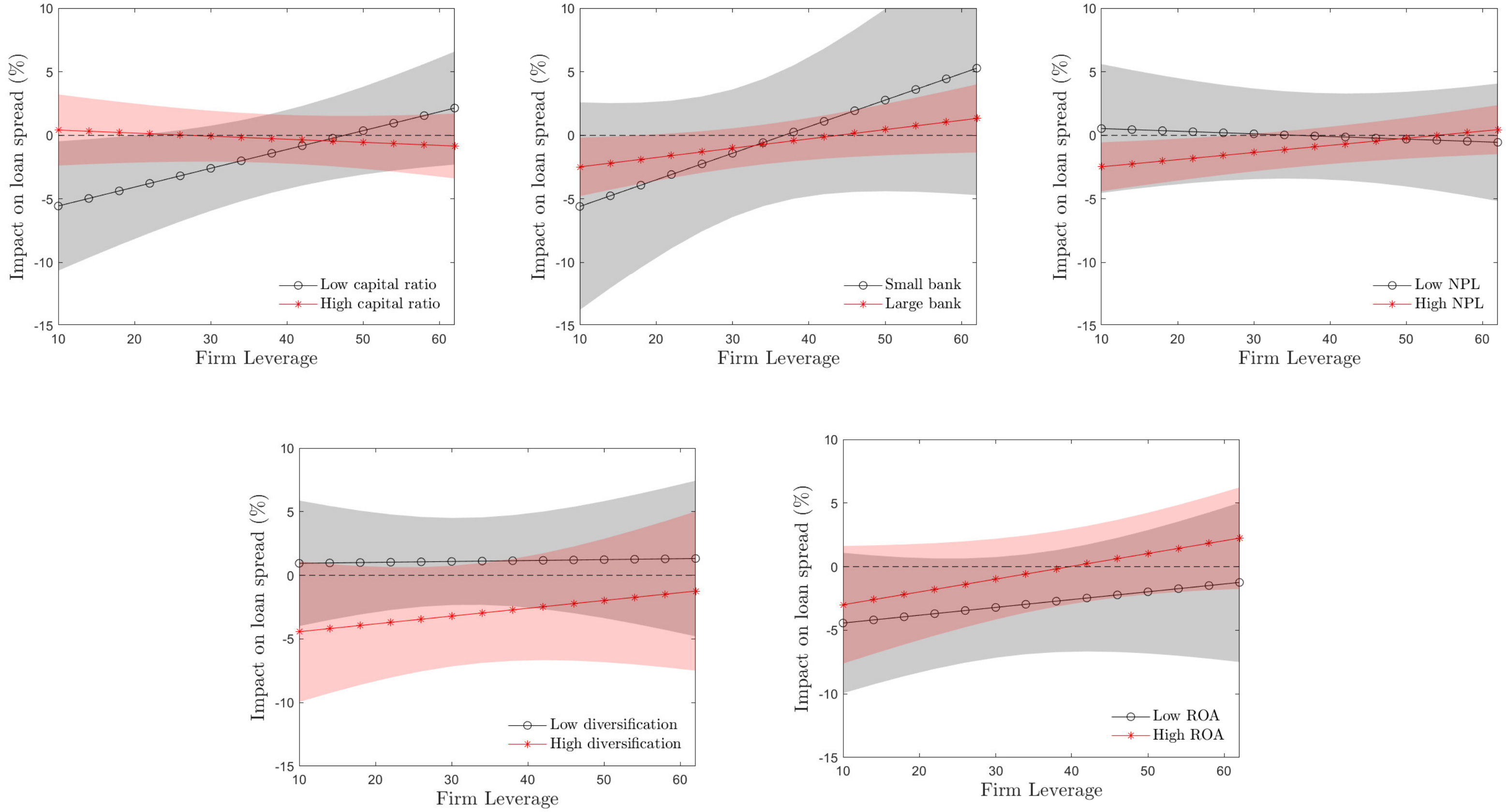

Figure 4: Marginal effects of a unit increase in the monetary policy stance on the all-in-spread drawn (in %) for different firm leverage levels ranging from low (small) to high (large). We do this for banks that have low values (grey) of a specific bank characteristic and banks that have high values (red). A low capital ratio corresponds to a capital ratio of 4%, a high capital ratio is set at 13%. A small bank is a bank with ln(total assets) of 16, a large bank has a ln(total assets) of 20. A low diversification corresponds to 10%, a high diversification level is 90%. A low ROA value corresponds with a value of -0.5%, a high ROA is 0.4%. A low NPL ratio corresponds with a ratio of 0%, a high NPL ratio is 9%. The results are based on the coefficients estimated in Table 5 (column 5).

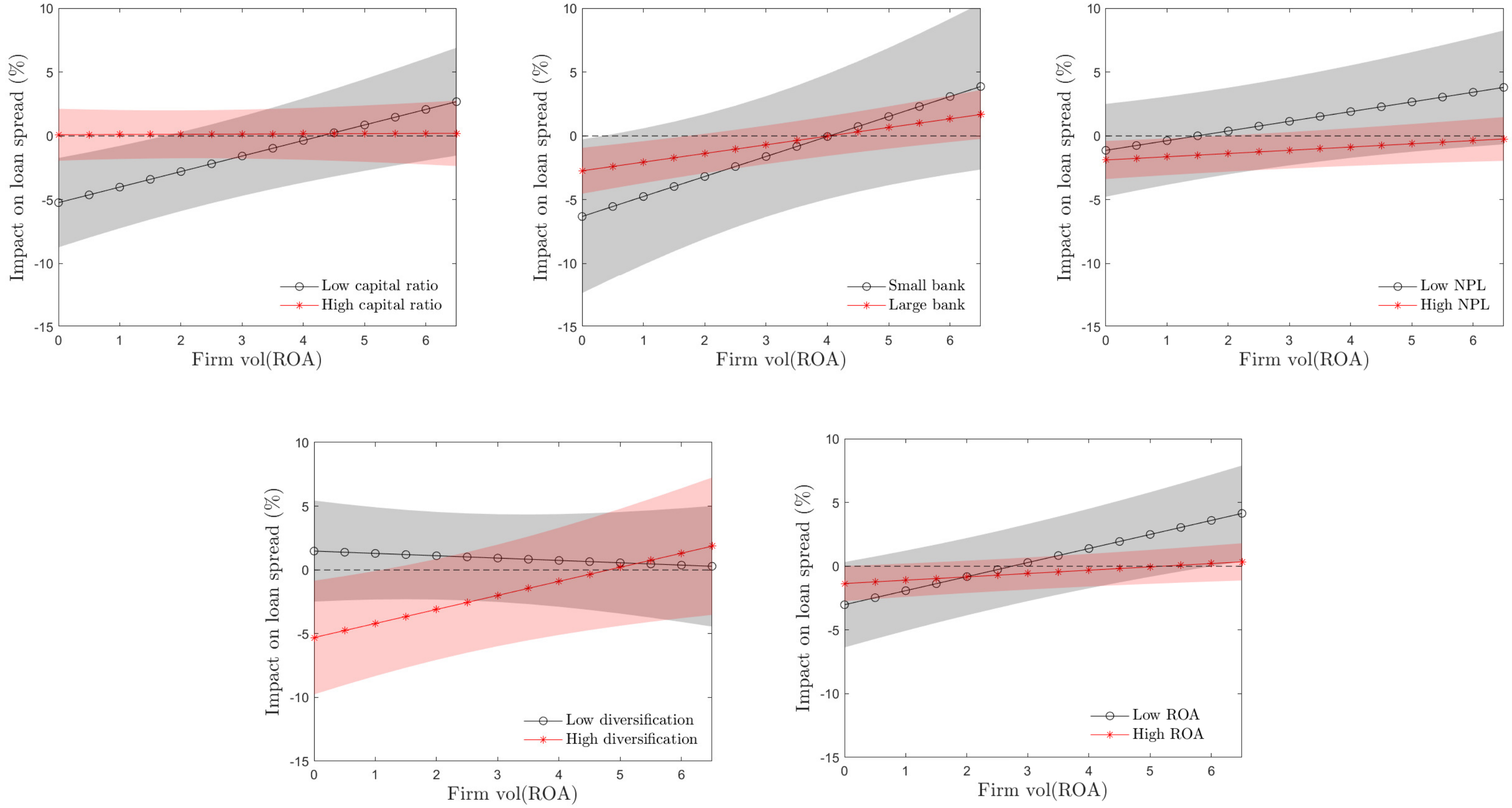

Figure 5: Marginal effects of a unit increase in the monetary policy stance on the all-in-spread drawn (in %) for different firm volatility of ROA levels ranging from low (small) to high (large). We do this for banks that have low values (grey) of a specific bank characteristic and banks that have high values (red). A low capital ratio corresponds to a capital ratio of 4%, a high capital ratio is set at 13%. A small bank is a bank with ln(total assets) of 16, a large bank has a ln(total assets) of 20. A low diversification corresponds to 10%, a high diversification level is 90%. A low ROA value corresponds with a value of -0.5%, a high ROA is 0.4%. A low NPL ratio corresponds with a ratio of 0%, a high NPL ratio is 9%. The results are based on the coefficients estimated in Table 5 (column 6).