Monetary Policy Transmission via Loan Contract Terms in the United States*

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I study monetary transmission via changes in contract terms for C&I loans. I find that nonprice terms tighten and price terms relax following a surprise monetary contraction, consistent with a decrease in loan supply. Adjustments in nonprice terms (maximum line size, covenants, and collateral requirements) are responsible for a statistically significant decrease in GDP of about 0.3 percentage point following a monetary surprise. I also document a lag between the response in bond market credit indicators and the loan contract terms. I interpret this finding as evidence of an important interaction between these two markets.

JEL Codes: E43, E44, E51, E52.

1. Introduction

The study of monetary policy is based on the premise that central banks can influence economic activity. One possible transmission mechanism involves the economy's credit conditions. Adjustments in monetary policy tools lead to changes in credit conditions, which in turn have consequences for aggregate borrowing, consumption, investment, and output. Why do adjustments in the monetary policy tools affect the credit conditions? Which credit conditions are relevant?

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This paper focuses on the second question. I investigate the transmission of monetary policy shocks via changes in price and nonprice contract terms for commercial and industrial (C&I) loans. My motivation is simple; the literature often assumes that changes in credit conditions due to monetary surprises are primarily captured by changes in the risk-free and spread components of interest rates. Although this assumption might be justified when considering bond contracts, it does not obviously follow for loan contracts given that they are intrinsically higher-dimensional objects. For instance, C&I loan contracts often include collateral requirements, covenants, and a maximum line size. Therefore, it is entirely plausible that adjustments in these nonprice terms are relevant for monetary transmission.

One might argue that thinking about transmission via these nonprice terms is unnecessary: after all, most theoretical models conclude that monetary transmission via credit conditions can be thought of "as if" it was captured solely by price-based mechanisms. However, it is important to remember that several of the microfounded theories that result in price-based transmission mechanisms reflect, at their core, adjustments in nonprice credit terms. For example, the idea of monetary policy transmission via spreads over risk-free rates relies on the seminal contributions of Kiyotaki and Moore (1997) and Bernanke, Gertler, and Gilchrist (1999). Both of these papers use collateral requirements as the main modeling device to capture the effect of credit market frictions.[1] Thus, even if we might think of monetary transmission "as if" it was entirely captured by price-based mechanisms, it is important to provide empirical evidence that supports the underlying assumptions of our theoretical models.

Studying transmission via nonprice loan contract terms is challenging; it is much easier to obtain data on interest rates than on nonprice terms. I overcome this issue using data from the Senior Loan Officer Opinion Survey (SLOOS), which contains information about loan demand and adjustments in several different loan

[1] In their introduction, Bernanke, Gertler, and Gilchrist (1999) state that one of the reasons for incorporating credit market effects into their model is the empirical finding (from the household consumption literature) about the importance of credit limits on borrowing.

contract terms. The SLOOS asks a subset of U.S. banks if they have faced stronger than usual loan demand, if they tightened their requirements for approving loan applications, and which specific loan contract terms they adjusted on those loans they were willing to approve.[2] There are three types of contract terms for C&I loans captured by the SLOOS: (i) price terms (cost of credit line and interest rate spread), (ii) *extensive* margin nonprice terms (covenants and collateral requirements), and (iii) *intensive* margin nonprice terms (maximum line size). I validate the SLOOS data using several measures of lending volume from the Survey of Terms of Business Lending (E.2). I show that, after accounting for a common component, the SLOOS price and nonprice terms do indeed reflect adjustments in the margins to which they allude. In particular, the standards and nonprice terms reflect adjustments *other* than changes in interest rates.

My empirical setup is based on quarterly vector autoregressions (VARs) that include the one-year U.S. Treasury yield, real gross domestic product (GDP), the consumer price index, the excess bond premium (as a control for the overall credit conditions), the SLOOS demand for C&I loans, and (one-by-one) the SLOOS C&I loan contract terms. I use the external instrument approach proposed by Gertler and Karadi (2015) to identify monetary policy shocks. This approach allows me to recover the vector $\mathbf{s}^p$ that collects the contemporaneous change in each VAR variable following a monetary policy shock at time t. Given that the identification procedure does not impose any a priori restrictions on the interaction between the different VAR variables, s^p_x captures the contemporaneous monetary policy transmission via variable x. The nature of the VAR implies s^p_x can cause a change in any of the other VAR variables y at any future date $\tau \geq t$. That is, I can compute the transmission of a monetary policy shock to variable y at time τ via variable x. This allows me to document and quantify the

[2]The subset of banks is carefully selected in accordance with the purpose of the survey, which is "to provide qualitative and limited quantitative information on bank credit availability and loan demand, as well as on evolving developments and lending practices in the U.S. loan markets." A complete description of the reporting panel can be found in the Supporting Statement for the Senior Loan Officer Opinion Survey on Bank Lending Practices.

contribution of the price and nonprice contract terms to monetary policy transmission.

My results suggest that a surprise monetary contraction leads to a decrease in loan supply. Following a monetary contraction, the nonprice terms *tighten* while the loan interest rate spreads *relax*. The decrease in loan spreads can be rationalized by noting that loan rates do not adjust as fast as (government) bond market rates. Nonprice terms are responsible for a statistically significant decrease in GDP of about 0.3 percentage point following a monetary surprise. Although the contribution of adjustments in collateral requirements accounts for most of the decrease in GDP, changes in nonprice terms are not individually, but *collectively,* relevant for monetary transmission.

My study also sheds light on the interaction between the loan and bond markets for monetary transmission. I find that the adjustments in loan contract terms happen immediately upon the monetary surprise, while the increase in the excess bond premium happens with a lag. The lagged increase in the excess bond premium suggests that firms turn to the (corporate) bond market to raise funds after they are unable to get funds from banks due to the tightened lending conditions. Note that this interaction between the loan and bond markets is absent in the standard mechanisms à la Kiyotaki and Moore (1997) and à la Bernanke, Gertler, and Gilchrist (1999) commonly used for modeling financial frictions.

My results are robust to different subsamples, number of lags, and proxies for overall credit conditions. The results actually become quantitatively and statistically more significant when only the precrisis period is considered (i.e., there is a larger effect of nonprice terms on GDP). Decreasing the number of lags from four to two or dropping the loan demand controls helps attenuate overfitting concerns. However, in both cases adjustments in lending standards lose some statistical significance and changes in collateral requirements become relatively more important within the nonprice terms. The former might be a mechanical consequence of just having fewer regressors. The latter suggests that adjustments in collateral requirements are more persistent than adjustments in the other margins and are more strongly associated with changes in loan demand. Including other credit spreads instead of the excess bond premium does alter the response of GDP and other macroeconomic variables to a monetary surprise.[3] However, it doesn't alter the results about the contribution of the nonprice loan terms to the monetary transmission mechanism.

My results provide empirical support for modeling financial frictions à la Kiyotaki and Moore (1997) and à la Bernanke, Gertler, and Gilchrist (1999). Furthermore, they also uncover two avenues that could be useful to resolve the critique that these types of financial frictions, although qualitatively attractive, are quantitatively unimportant. The first one is considering other nonprice margins of adjustments in addition to collateral requirements. The second one is explicitly modeling the interaction between the corporate bond and loan markets.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 presents the data I use for my empirical study and validates the SLOOS data. Section 4 presents the empirical framework. Section 5 discusses the main results of the paper and performs several robustness checks. Section 6 concludes. Online appendixes (available at http://www.ijcb.org) contain details about the methodology and robustness checks.

2. Related Literature

There is an extensive list of empirical studies that focus on the effect of monetary policy on credit conditions. My work is most closely related to those that analyze the impact of monetary policy on banks' lending standards (willingness to give loans). Some recent examples include Maddaloni and Peydró (2011, 2013), Jiménez et al. (2012), and Ciccarelli, Maddaloni, and Peydró (2015). The first two studies analyze the impact of short- and long-term rates on lending standards within the context of securitization, bank supervision, and macroprudential policy. The third one investigates if short-term rates have a different impact on the probability of loans being granted depending on the strength of a bank's balance sheet. The last one isolates the effect of monetary surprises on loan supply

[3]This is not surprising given that there are several other studies that document that the excess bond premium contains relevant additional information not reflected by most other credit indicators. Thus excluding it from the VAR specifications can result in omitted-variables bias.

and tries to identify the underlying factors leading to such changes (i.e., separately identifying the bank lending, balance sheet, and cost of credit channels). Clearly, the goal of all of these studies is to assess the extent to which monetary surprises lead to changes in loan supply and determine which factors might be responsible for such changes. Unlike my study, however, none of them focus on *which* credit conditions (loan contract terms) adjust.

There are several other studies with similar identification strategies. For instance, Kuttner (2001), Faust, Swanson, and Wright (2004), Gürkaynak, Sack, and Swanson (2005), Hamilton (2009), Barakchian and Crowe (2013), and (of course) Gertler and Karadi (2015) all use some variant of a high-frequency identification procedure (and a few of these studies use it within the context of VARs.) However, these papers either focus on introducing a new identification scheme or on applying an existing one to study monetary transmission via *prices* (bond and asset prices, interest rates, term premiums, credit spreads). Additionally, my study expands the scope of the methodology proposed by Gertler and Karadi (2015) by showing that it can be used to quantify the contribution of different variables to monetary transmission.

There are also a few studies that resemble mine in that they use the SLOOS (or similar survey data). For instance, Lown and Morgan (2006) use the SLOOS data to analyze the predictive power of lending standards for U.S. GDP. Bassett et al. (2014) construct a new credit supply indicator using the SLOOS data and then study the effect of credit supply shocks on output, borrowing, bond credit spreads, and monetary policy. The goal of these studies is to validate the SLOOS data and show that it contains useful information about the U.S. credit conditions, rather than to assess the impact and transmission of monetary surprises via credit conditions.

3. Data

3.1 Data Description

I use quarterly macroeconomic and credit data from 1990:Q1 to 2016:Q3. The macroeconomic data include real GDP (Y), the one-year U.S. Treasury yield (1YR), and the consumer price index (P). All three macroeconomic variables are obtained from the Federal

Reserve Economic Database (FRED). Real GDP and the consumer price index are logged.[4]

I use the excess bond premium (EBP) from Gilchrist and Zakrajšek (2012) as a proxy for the overall credit conditions in the economy. Their original EBP monthly series extends only through 2012:M6. Simon Gilchrist has an updated EBP monthly series which extends through 2016:M8.[5] I construct my EBP series by taking the quarterly average of the updated EBP.

I focus only on commercial and industrial loans.[6] The data come from the SLOOS and the Survey of Terms of Business Lending (E.2), which are provided by the Federal Reserve Board (FRB). I use the E.2 release to obtain data on interest rates and different measures of lending volume, mostly for the external validation of the SLOOS variables.

I use the SLOOS variables to proxy for changes in loan demand and changes in price and nonprice terms of loan contracts. The SLOOS data reported at any given quarter pertain to the demand, lending terms, and standards for the *previous* quarter. In other words, one must lag the SLOOS data by one quarter to align it with the other macroeconomic and credit data series. The SLOOS question pertaining to loan demand asks banks if they have seen a change in loan demand after accounting for normal seasonal variation. The SLOOS loan contract data consist of two different types of questions: those that ask about changes in lending "standards" and those that ask about changes in lending "terms." The survey questions related to the "standards" ask if banks tightened their requirements for approving loan applications, while the questions related to the "terms" ask about the specific contract conditions that banks adjusted on those loans they were willing to approve.

[4]The sample period is selected purely for reasons of data availability. The SLOOS credit conditions are available starting in 1990:Q1, the external instruments are available only through 2016:Q4, and the excess bond premium is available only through 2016:Q3. The main results of the paper are robust to using the detrended (HP-filtered) version of these variables.

[5]See https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/updating-the-recession-risk-and-the-excess-bond-premium-20161006.html.

[6]An earlier version of the paper included the households' credit card market in the analysis. However, I decided not to include it in the present version given that I found that adjustments in credit card terms are irrelevant for monetary transmission.

Table 1. SLOOS Data

Commercial and Industrial (C&I) Loans		
Variable Name	**Type**	**Availability Period**
Demand (C&I)	N/A	1991:Q3–2016:Q3
Standards (C&I)	Nonprice	1990:Q1–2016:Q3
Spread (C&I)	Price	1990:Q1–2016:Q3
Cost of Line (C&I)	Price	1990:Q2–2016:Q3
Loan Covenants (C&I)	Nonprice	1990:Q1–2016:Q3
Maximum Line Size (C&I)	Nonprice	1990:Q1–2016:Q3
Collateral Requirement (C&I)	Nonprice	1990:Q1–2016:Q3

Source: SLOOS.

Although the distinction between the two types of questions is conceptually clear, it becomes less evident in practice. For instance, one of the questions related to the "terms" asks banks if they tightened their collateral requirements. One might argue that collateral requirements are part of the "standards" banks use for approving loan applications. Therefore, I include variables that reflect both types of questions.

Table 1 lists the SLOOS variables that are relevant for my study. The demand variable is constructed as the net percent of U.S. domestic banks that reported a stronger loan demand. Each of the loan contract variables is constructed as the net percent of U.S. domestic banks that "tightened" the specified margin (standards, spreads, covenants, collateral requirements, etc.) within a given quarter. As it can be seen from the table, I can distinguish between adjustment in price and nonprice loan contract terms using these variables.[7]

3.2 External Validation of the SLOOS Data

Several studies have established the validity of the SLOOS demand and lending "standards." Lown, Morgan, and Rohatgi (2000) find

[7]There are other SLOOS variables pertaining to C&I lending that I don't use in my study due to their limited sample size. Among those variables are the risk premium (available from 1998:Q3 onwards) and the maximum maturity (available from 2005:Q2 onwards).

Table 2. Contemporaneous Correlation between SLOOS Variables

	Standards	Spread	Cost of Line	Covenants	Line Size	Collateral
Standards	**1.00**	0.90	0.92	0.95	0.92	0.92
Spread	**–0.66**	**1.00**	0.98	0.93	0.93	0.89
Cost of Line	**–0.36**	**0.13**	**1.00**	0.95	0.92	0.92
Covenants	**0.29**	**–0.58**	**–0.50**	**1.00**	0.94	0.96
Line Size	**0.19**	**–0.47**	**–0.43**	**0.19**	**1.00**	0.92
Collateral	**0.24**	**–0.57**	**–0.38**	**0.47**	**0.22**	**1.00**

Source: Author's computation using data from the SLOOS.
Notes: Elements over the main diagonal correspond to the correlation between the raw variables. Elements under the main diagonal correspond to the correlation when the common component is removed.

that the tightening of C&I "standards" is strongly negatively correlated with aggregate commercial loan growth and with various measures of economic activity. Lown and Morgan (2006) find that the C&I "standards" dominate loan rates in explaining variation in business loans and output. Bassett et al. (2014) construct a new credit supply indicator using the lending "standards" for C&I and consumer loans (adjusted for macroeconomic and bank-specific factors) and show that this indicator can substantially explain changes in output. Ciccarelli, Maddaloni, and Peydró (2015) use the SLOOS demand and lending "standards" for C&I loans to identify different channels of monetary policy transmission. However, not much has been said regarding the SLOOS "terms." The purpose of this section is to show that the SLOOS "terms" do indeed convey relevant information about changes in credit conditions.

Table 2 presents the correlation coefficient between different SLOOS variables related to C&I lending. The elements above the main diagonal refer to the correlation between the raw SLOOS variables. The elements below the main diagonal (in bold) correspond to correlation between the transformed SLOOS variables (I discuss such transformation shortly). All C&I lending terms are strongly positively correlated with the lending "standards." In light of the results from the aforementioned literature, this suggests that the SLOOS "terms" are valid indicators of the state of credit conditions for C&I loans.

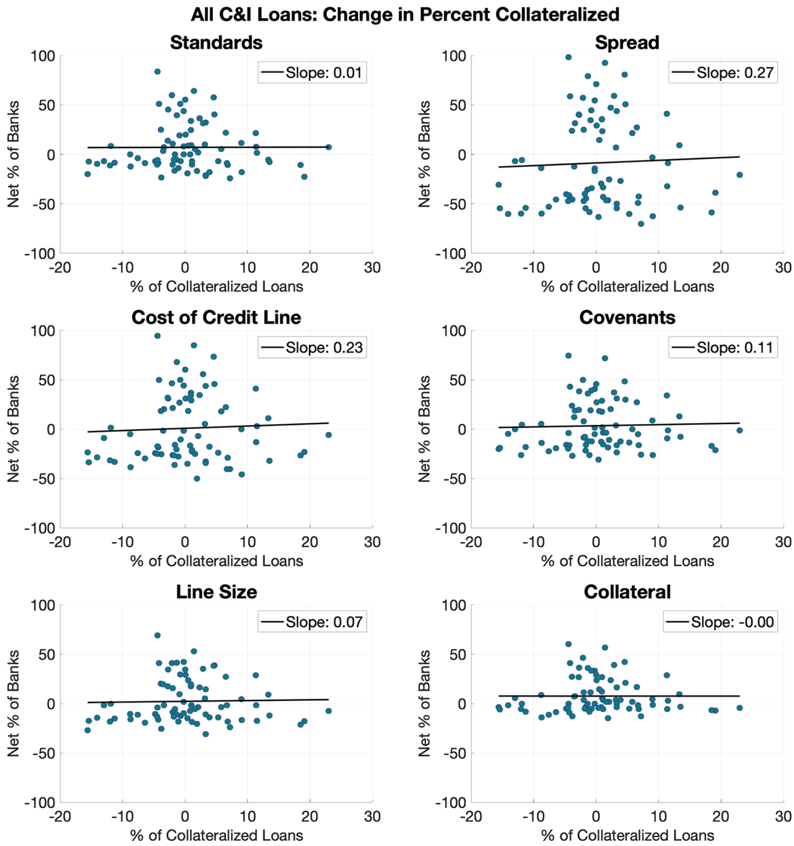
The C&I lending "terms" are also strongly correlated with each other, evidence of an underlying common factor(s). This is not surprising considering that different banks might adjust different contract terms (some may raise rates, some may increase collateral requirements, some may decrease the maximum line size). It is also possible that the same bank might choose to adjust rates for some subset of contracts, covenants for another, collateral requirements for another, etc. Therefore, it is important to account for the common factor(s) in order to isolate the effect of changes in each different loan "term." I remove the common factor using the principal component decomposition of the "terms" and lending "standards." Given this decomposition, I regress each of the "terms" and "standards" on the corresponding main principal component and use the residual as my transformed SLOOS variable. As I show next, this transformation effectively isolates adjustments in the corresponding loan contract "term."

The magnitude of the correlations between the transformed C&I variables (bold elements below the main diagonal in table 2) becomes much smaller, a consequence of removing the common factor(s). This correlation also offers some insights about the relationship between the price and nonprice loan terms. All of the price terms (spread and cost of line) and nonprice terms (covenants, line size, and collateral) are positively correlated within each category but negatively correlated across categories. The correlation between price and nonprice terms becomes positive when the nonprice terms lead the price terms by about four quarters. This is consistent with basic economic theory; after a change in nonprice terms (shift in loan supply) price terms (slowly) adjust to reach the new equilibrium. Finally, the transformed "standards" are positively correlated with the nonprice terms and negatively correlated with the price terms. In other words, the "standards" reflect mainly nonprice factors.[8]

Within the nonprice terms, the correlation between covenants and collateral requirements is much stronger than either of their

[8]That "standards" reflect nonprice terms is not only intuitive but also consistent with previous studies. For instance, Lown and Morgan (2006, p. 1577) explicitly state that they use lending "standards" as a proxy for the full vector of nonprice lending terms.

Figure 1. Relationship between Different C&I Credit Variables and the Percent (value) of C&I Loans Secured by Collateral.



Source: SLOOS and E.2.
Note: The slope of the best fit line is included for each case.

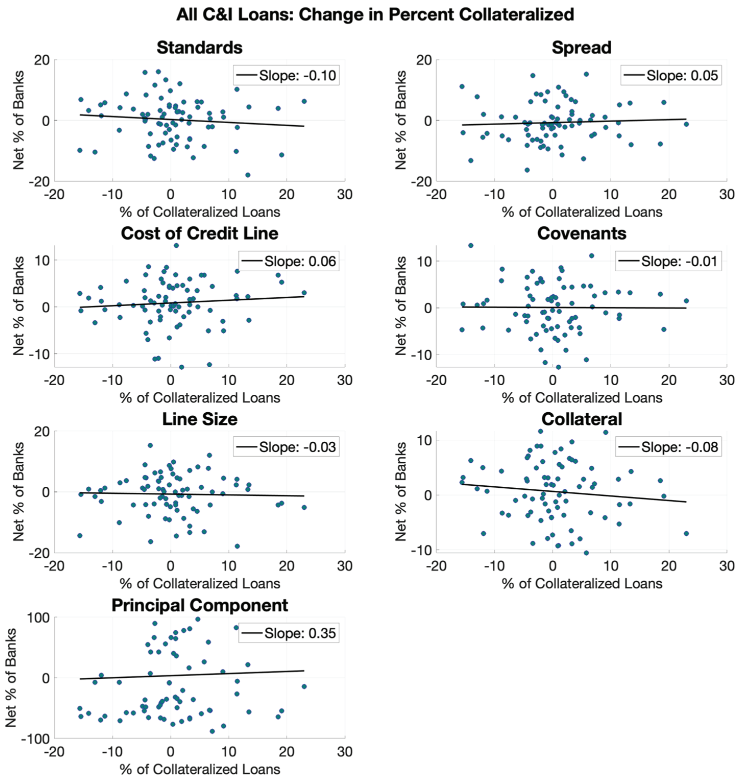
correlations with the maximum line size. Again, this is not surprising given that covenants and collateral requirements both capture the willingness of banks to approve additional loans (*extensive margin*). On the other hand, the maximum line size mostly reflects credit conditions within the existing loans (*intensive margin*).

Figure 1 presents scatter plots that illustrate the relationship between the raw SLOOS C&I variables and the change in percent (value) of C&I loans secured by collateral from the E.2. The best fit line and its corresponding slope are included in each graph. All price and nonprice terms are positively correlated with the change in the percent of loans secured by collateral, but the correlation is largest for the price terms (spread and cost of line). At first it might seem counterintuitive that a tightening in credit conditions leads to an increase in the percent of loans secured by collateral. However, economic theory suggests that a tightening in credit conditions would lead to a decrease in both total loans *and* collateralized loans. A larger decrease in total loans would explain the positive correlation. For the terms that more directly affect collateralized loans rather than noncollateralized loans (such as a tightening in collateral requirements or covenants), one would expect to see a smaller positive correlation, which is indeed the case.

However, collateral requirements should affect *only* collateralized loans; a tightening in collateral requirements should lead to a *decrease* in the percent of collateralized loans. That is, the correlation should be negative. Why is it not? Because the SLOOS variables (including the tightening of collateral requirements) are all contaminated by the common factor. Figure 2 is the equivalent of figure 1 but for the transformed SLOOS variables. A tightening in collateral requirements is indeed associated with a decrease in collateralized loans after accounting for the common factor. Importantly, the correlation is still positive for the price terms (spread and cost of line) given that these terms affect collateralized and noncollateralized loans. The results also reaffirm that the nonprice factors are strongly related to one another; tightening in the line size, covenant requirements, or lending standards are all associated with a decrease in collateralized loans. Finally, I have also included the common component in figure 2 to show that it is positively correlated with changes in collateralized loans. Again, this suggests the common component does indeed capture factors that affect all loans (I will argue shortly that it mostly captures changes in interest rates).

Table 3 summarizes the normalized covariance (i.e., slope of the best fit line) between different lending measures from the E.2 and the raw (panel A) and transformed (panel B) SLOOS variables for C&I loans. The raw SLOOS variables are all positively correlated with changes in interest rates and negatively correlated with changes in lending volume. Again, this observation reaffirms that the SLOOS

Figure 2. Relationship between Different C&I Variables (with the common component removed) and the Percent (value) of C&I Loans Secured by Collateral



Source: SLOOS and E.2.
Note: The slope of the best fit line is included for each case.

"terms" do capture changes in credit conditions.[9] Note that the spread and cost of line terms have the highest correlation with the interest rate, which is another reason why I refer to them as the price terms.

[9]The SLOOS variables are also negatively correlated with average measures from the E.2 (such as the average loan size and average maturity). However, the magnitude of the correlation is about an order of magnitude smaller than for the variables presented here. The reason for such small correlation is that averages reflect a ratio of intensive to extensive margins, and both are affected by changes of credit standards.

Table 3. Covariance between Lending Measures and SLOOS Variables

	A. Raw SLOOS						
Change In:	**Standards**	**Spread**	**Cost of Line**	**Covenants**	**Line Size**	**Collateral**	
Interest Rate	23.23	42.04	32.87	25.98	22.66	17.23	
Percent Collateralized	0.01	0.27	0.23	0.11	0.07	0.00	
Total Value ($ Billions)	−0.20	−0.39	−0.32	−0.25	−0.26	−0.16	
	B. Transformed SLOOS						
Change In:	**Standards**	**Spread**	**Cost of Line**	**Covenants**	**Line Size**	**Collateral**	**Common**
Interest Rate	1.49	−2.02	−1.51	2.08	2.17	0.79	70.08
Percent Collateralized	−0.10	0.05	0.06	−0.01	−0.03	−0.08	0.35
Total Value ($ Billions)	0.01	0.03	0.01	−0.02	−0.07	0.00	−0.67

Notes: The values presented in the table correspond to the normalized covariance: $cov(x, y)/var(x)$. y (columns) refer to the data series from the Senior Loan Officer Opinion Survey (SLOOS). x (rows) refer to the data series from the Survey of Terms Business Lending (E.2).

The correlation of the SLOOS variables with changes in the interest rates becomes much smaller once the common component is removed. In other words, the common component reflects most of the overall lending conditions captured by C&I lending rates. Interestingly, the correlation for the price terms becomes *negative,* while it remains positive for the nonprice terms. Although this might seem counterintuitive, it is actually consistent with standard economic theory. The results suggest that a tightening in the economy's credit conditions is manifested in the loan market by an increase in the lending rate accompanied by a tightening in the nonprice terms (standards, covenants, line size, and collateral). However, (aggregate) loan rates might not adjust as fast as government bond rates (think, for instance, of fixed-rate loan contracts), which implies a decrease in the C&I loan spread (and other price terms).

One might be concerned about the positive correlation between the nonprice terms and the changes in interest rate. After all, the goal of the transformation is to ensure that the SLOOS variables isolate changes in the different margins of adjustments *not captured* by changes in interest rates (hence the nonprice tag). Nonetheless, one must keep in mind that all of the transformed nonprice variables are negatively correlated with changes in the percent of collateralized loans. If the transformed nonprice terms were mainly driven by changes in the interest rate, this correlation would be positive (as discussed earlier). In fact, the correlation between the *actual* changes in the interest rate and the percent of collateralized loans is about 0.12. That is, the transformed standards and nonprice terms do indeed reflect margins of adjustments *other* than changes in interest rates (i.e., changes in the maximum line size, covenants, and collateral requirements).

The correlation of the SLOOS variables with the change in total C&I lending also becomes an order of magnitude smaller for all variables. However, it remains negative only for the three nonprice margins of adjustment (maximum line size, covenants, and collateral requirements). Furthermore, this negative correlation is significantly larger (in magnitude) for the maximum line size. By definition, the change in total value of loans is *conditional* on only the approved loans. Therefore, one would expect the intensive margins of adjustments (such as tightening of the line size) to matter the most.

The results show that this is indeed the case. Note also that correlation between total lending volume and the common component is also negative (and is the largest in magnitude), which provides further evidence that this term does indeed capture overall changes in the lending rate.

The previous discussion shows that, after accounting for a common component, the different SLOOS "terms" do indeed reflect adjustments in the margin to which they allude. The common component reflects mostly changes in the lending rate (overall credit conditions). The lending "standards" capture adjustments in the nonprice terms, which are also individually captured by the maximum line size, covenants, and collateral requirements. Finally, the spread and the cost of line variables (the price terms) account for changes in the loan interest rate relative to other (i.e., bond) rates.

4. Methodology

4.1 Econometric Framework

I use VARs that include the one-year U.S. Treasury yield, real GDP, and the consumer price index as the three macroeconomic variables, the excess bond premium as an indicator of overall credit conditions, the SLOOS loan demand, and (one-by-one) the SLOOS loan contract terms. Each VAR includes four lags.[10]

I use the external instrument methodology proposed by Gertler and Karadi (2015) to identify the monetary policy shock. I use this identification procedure for three reasons. First, it allows me to include credit variables in the VAR specification without imposing a priori restrictions on the interaction between them and the monetary policy indicator.[11] Second, depending on the choice of policy

[10]To alleviate overfitting concerns, I do robustness checks removing the SLOOS demand control and including only two lags instead of four (see section 5.2).

[11]For instance, the identification scheme of Christiano, Eichenbaum, and Evans (1996) assumes that the federal funds rate responds to all the variables in the VAR within a period but not vice versa. For aggregate macroeconomic variables, such as prices or real output measures, this assumption might be justified if the frequency of the data is not too low (monthly or quarterly). For financial and credit variables, such an assumption is less likely to hold (even for monthly or quarterly data).

indicator and external instrument, the identified policy surprise can be informative not only about the current policy stance but also about the expected future policy stance. This is precisely why I use the one-year rate as the monetary policy indicator rather than the federal funds rate. The use of the one-year rate as the policy indicator does not imply that the Federal Reserve conducts policy by directly manipulating this rate. As the general consensus dictates, I presume that the Federal Reserve conducts policy by setting a target federal funds rate (i.e., the policy instrument). However, any movements in the federal funds rate affect the one-year rate per the standard term structure argument. In this sense, the one-year rate is an indicator of the monetary policy stance. The advantage of using this mid-term rate is that it captures movements in the expected future path of the policy instrument in addition to current movements.[12] Finally, this identification approach allows me to quantify the contribution of different channels to the monetary policy transmission mechanism.

I use the surprise in the three-month-ahead (FF_3) federal funds futures as my external instrument for the identification procedure. There are two advantages of using the surprise in the three months ahead over the surprise in current-month federal funds futures (FF_0). First, FF_3 reflects expectations of short rate movements further into the future.[13] Second, the original FF_0 and FF_3 monthly series from Gertler and Karadi (2015) extend only through 2012:M6. Jarociński and Karaki (2020) have an updated version that extends through 2016:12, but they provide it only for FF_3. Thus I construct my FF_3 series by taking the quarterly average of the updated monthly FF_3 series.

[12]Using the one-year rate as the policy indicator does also alleviate some of the concerns about the zero lower bound. Refer to Gertler and Karadi (2015) for a detailed discussion of this and other benefits of using mid-term rates as policy indicators over the federal funds rate. Kuttner (2001), Bernanke, Reinhart, and Sack (2004), and Swanson and Williams (2014) provide evidence that mid-term rates instrumented by surprises in futures contracts better capture the persistent effect of monetary policy news.

[13]For a more detailed discussion about the validity of futures rates surprises as external instruments for monetary policy shocks, refer to Kuttner (2001), Piazzesi and Swanson (2008), Hamilton (2009), Gertler and Karadi (2015), and Ramey (2016).

4.2 Monetary Policy Transmission

Let $\mathbf{Z}_t$ denote the vector of variables included in the VAR, ϵ_t the vector of fundamental shocks, and $\epsilon_t^p \in \epsilon_t$ the fundamental monetary policy shock. The vector of reduced-form shocks can then be expressed as $\mathbf{u}_t = \mathbf{s}^p \epsilon_t^p + \tilde{\mathbf{S}} \epsilon_t$, where $\mathbf{s}^p$ captures the impact of the monetary policy shock in each of the reduced-form errors. The advantage of the external instrument high-frequency indicators (HFI) procedure is that it allows one to identify the vector $\mathbf{s}^p$.[14]

Once $\mathbf{s}^p$ is identified and the reduced-form VAR is estimated, one can easily assess and quantify the contribution of different variables to the transmission of monetary policy shocks. For any horizon $t \geq \tau$, a given sequence of monetary policy shocks $\left\{\epsilon_j^p\right\}_{j=\tau}^t$ leads to changes in $\mathbf{Z}_t$ that are the result of the propagation of $\mathbf{s}^p$. In other words,

$$\mathbf{Z}_t = \mathbf{B}(L)\, \mathbf{Z}_{t-1} + \mathbf{s}^p \epsilon_t^p, \quad t \geq \tau \text{ and } \mathbf{Z}_{\tau-1} \text{ given,} \tag{1}$$

where all nonmonetary fundamental shocks have been set to zero. For $t = \tau$ and conditional on the system being unperturbed (i.e., $\mathbf{Z}_{\tau-1} = 0$), a monetary policy shock of one standard deviation implies that $\mathbf{Z}_\tau = \mathbf{s}^p$. In other words, $s_j^p \in \mathbf{s}^p$ is an indicator of the *contemporaneous transmission* of the monetary policy shock via variable $z_j \in \mathbf{Z}$.

For $t > \tau$, the *transmission* of monetary policy shocks via variable $z_j \in \mathbf{Z}$ depends on both $s_j^p \in \mathbf{s}^p$ and the reduced-form VAR coefficients $\mathbf{B}(L)$. Equation (1) can be used to obtain the impulse response functions (IRFs) after a one-time monetary policy shock at date τ (i.e., $\epsilon_\tau^p = 1$ and $\epsilon_t^p = 0, \ \forall t > \tau$). The importance of variable $z_j \in \mathbf{Z}$ for the transmission of monetary policy shocks can then be evaluated by comparing two sets of IRFs. The first set is just obtained using the estimated coefficients $\mathbf{B}(L)$ and the contemporaneous transmission vector $\mathbf{s}^p$. The second set is obtained by counterfactually setting $s_j^p = 0$ while keeping the VAR coefficients $\mathbf{B}(L)$ and all other elements of the vector $\mathbf{s}^p$ at their estimated values. If variable $z_j \in \mathbf{Z}$ (for instance, one of the SLOOS lending terms)

[14] For details on the identification procedure, refer to online appendix A.

is relevant for monetary policy transmission, then the IRFs corresponding to the counterfactual experiment should be significantly different than their counterparts.[15]

Another way to evaluate the contribution of variable $z_j \in \mathbf{Z}$ to the transmission of monetary policy shocks is via the forecast error variance decomposition. For $q \in \{0, 1, 2, \ldots\}$, let $\mathbf{\Psi}_q$ denote the matrix of coefficients corresponding to the moving-average representation of the reduced-form VAR.[16] As usual, $\psi_q^{i,j}$ refers to the $\left(i^{\text{th}}, j^{\text{th}}\right)$ element of $\mathbf{\Psi}_q$. For any horizon $h = \tau - t$ define

$$\phi_{i,j}(h) \equiv \sum_{q=0}^{h-1} \left(\psi_q^{i,j} s_j^p\right)^2, \tag{2}$$

which measures the forecast error variance of variable $z_i \in \mathbf{Z}$ at horizon h due to changes (caused by contemporaneous monetary policy shocks) in variable $z_j \in \mathbf{Z}$.[17] In other words, it measures the transmission of monetary policy shocks to variable z_i via variable z_j at horizon h. Note that $\phi_i(h) \equiv \sum_{z_j \in \mathbf{Z}} \phi_{i,j}(h)$ then measures the total variation in z_i due to monetary policy shocks. Suppose z_i is real GDP and z_j is one of the SLOOS lending terms. The ratio $\phi_{i,j}(h) / \phi_i(h)$ provides an idea of the contribution of changes in the SLOOS lending terms to the transmission of monetary policy to real GDP.

Finally, a third way to assess the contribution of variable $z_j \in \mathbf{Z}$ to the transmission of monetary policy shocks is using historical decomposition. The finite approximation of the moving-average representation of equation (1) can be written as

$$\tilde{\mathbf{Z}}_t = \sum_{q=0}^{t-1} \mathbf{\Psi}_q \, \gamma \, \mathrm{IV}_{t-q}, \tag{3}$$

where IV_t is the external instrument used for the identification of the monetary policy shock. The vector of coefficients γ is estimated as a byproduct of the two-stage least square implementation of the

[15] Instead of just shutting off the *contemporaneous* transmission via variable $z_t^j \in \mathbf{Z}_t$ (i.e., $s_j^p = 0$), one could also shut off the transmission via z_t^j for all periods (i.e., $z_t^j = 0, \;\forall t \geq \tau$).

[16] Note that one can easily obtain $\mathbf{\Psi}_q$ for $q \in \{0, 1, 2, \ldots\}$ given the estimated coefficients of the reduced-form VAR.

[17] The derivation of equation (2) is presented in online appendix B.

identification procedure.[18] Intuitively, if IV_t is a valid external instrument for the monetary policy shock (i.e., relevant and exogenous), then equation (3) follows given that $\mathbf{s}^p \epsilon_t^p \propto \gamma \text{IV}_t$ and $\tilde{\mathbf{S}} \epsilon_t \perp \gamma \text{IV}_t$. The contribution of variable z_j to the transmission of monetary policy shocks can then be isolated by setting (counterfactually) $\gamma_k = 0$, $\forall \gamma_k \in \gamma$, $k \neq j$ in equation (3). Denote this counterfactual by $\tilde{\mathbf{Z}}_{c_j,t}$. Suppose $z_i \in \mathbf{Z}$ is real GDP. Then $\tilde{z}^i_{c_j,t} \in \tilde{\mathbf{Z}}_{c_j,t}$ refers to the element corresponding to real GDP in the finite approximation counterfactual. For each period t, the ratio $|\tilde{z}^i_{c_j,t}| / \sum_{z_j \in \mathbf{Z}} |\tilde{z}^i_{c_j,t}|$ captures the contribution of changes in variable $z_j \in \mathbf{Z}$ to the historical fluctuations in real GDP caused by monetary policy shocks.

5. Results

This section presents and validates the main results of the paper: a surprise monetary contraction leads to a decrease in loan supply, there is an important interaction between the loan and bond markets for monetary transmission, and adjustments in the nonprice loan terms (such as maximum line size, covenants, and collateral requirements) are relevant for monetary policy transmission.[19]

5.1 Discussion of Main Results

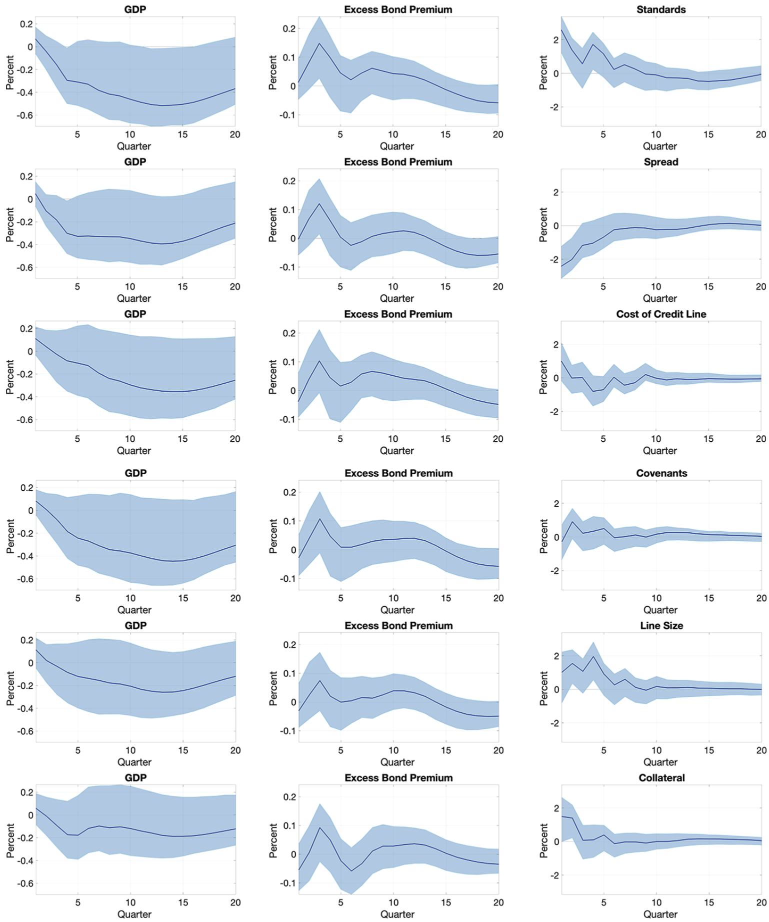
Figure 3 presents the impulse response functions for real GDP (left pane), the excess bond premium (middle pane), and the SLOOS net percent of banks tightening the specified C&I loan contract term (right pane) after a surprise monetary contraction.[20] The responses are robust across the different specifications and are consistent with conventional theory. The one-year rate increases by about 30 basis points upon impact and then reverts back to trend after roughly

[18] The derivation of equation (3) is presented in online appendix C.

[19] I obtain the confidence intervals for all the IRFs presented in this section using a wild bootstrap; see Gonçalves and Kilian (2004). The regression to obtain the SLOOS transformed variables as well as both stages of the identification procedure are included in the bootstrapping procedure, hence effectively addressing the "generated regression" problem.

[20] The IRFs for the one-year government bond rate and the CPI can be found in online appendix D.

Figure 3. Effect of a Surprise Monetary Tightening on Credit Conditions for Corporate Bonds and C&I Loans



Notes: The IRFs correspond to one standard deviation of the monetary policy shock. The shaded area represents the 90 percent confidence interval.

six quarters. This increase is statistically significant across all specifications. The CPI does not experience any statistically significant change.[21] GDP experiences a rather persistent decrease, which is

[21]In some specifications there is slight evidence of the price "puzzle": the contractionary monetary policy shock induces a modest and (marginally) statistically significant increase in the CPI during the first quarter or two.

largest at a horizon of about 12 months, reaching as much as 0.6 percentage point. However, the GDP decrease is (marginally) statistically significant only for the specifications that include the lending standards and the loan spread.

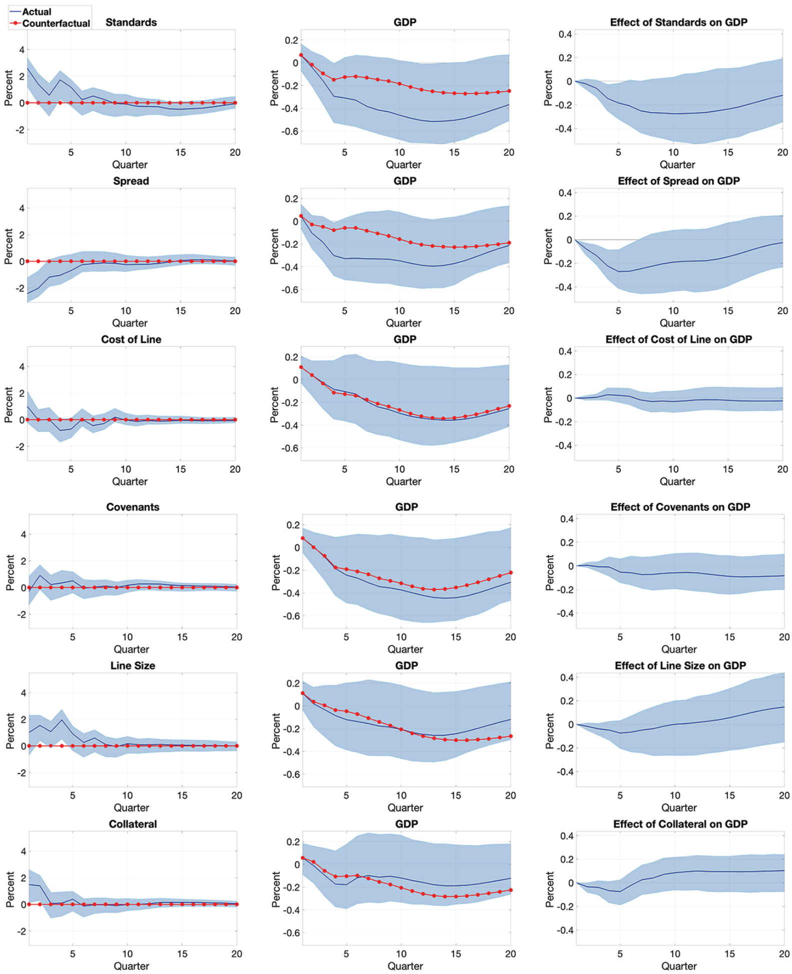
The response of the excess bond premium and the loan terms reflects a change in the credit conditions during the first five quarters after the shock. The excess bond premium and the SLOOS nonprice terms (standards, covenants, line size, and collateral) all tighten (increase). The SLOOS price terms (spread and cost of line) actually *relax* (decrease). These adjustments are consistent with a tightening in credit conditions as predicted by standard economic theory. After a monetary contraction loan supply decreases (tightening of nonprice terms) and the price terms (slowly) adjust to reach the new equilibrium. Given that C&I loan rates do not adjust as fast as government bond rates, this implies a decrease in the C&I loan spread and other price terms.

Furthermore, note the timing of the changes in the credit conditions. While the tightening in the loan contract terms happens immediately upon the shock, the increase in the excess bond premium happens with a lag. I interpret this as evidence of an important interaction between the corporate loan and bond markets. The lagged increase in the excess bond premium suggests that firms turn to the (corporate) bond market to raise funds after they are unable to get funds from banks due to the tightened lending conditions.

Note that this interaction between these two markets is absent in the standard mechanisms à la Kiyotaki and Moore (1997) and à la Bernanke, Gertler, and Gilchrist (1999) commonly used for modeling financial frictions. These mechanisms provide theoretical foundations for thinking about a tightening in loan market credit conditions "as if" it resulted in an increase in lending spreads. My results suggest that the lending spread actually decreases.

At this point it should be clear that several loan contract terms adjust in response to monetary policy surprises. I next consider if these adjustments are relevant for monetary policy *transmission*. Figure 4 presents the IRF counterfactual described in section 4.2. The solid (blue) line in the left and middle panes corresponds to

Figure 4. Contribution of C&I Loan Terms to Monetary Transmission



Notes: The IRFs correspond to one standard deviation of the monetary policy shock. The shaded area represents the 90 percent confidence interval.

the original IRFs.[22] The line with (red) dots corresponds to the counterfactual responses where transmission via the loan contract

[22]For figures in color, see the online version of the paper, available at http://www.ijcb.org.

term has been shut off. The right pane corresponds to the difference between the original response in GDP and its response under the counterfactual. If adjustments in the different loan contract terms are relevant for monetary transmission, then the responses in the right pane should be nonzero and statistically significant.

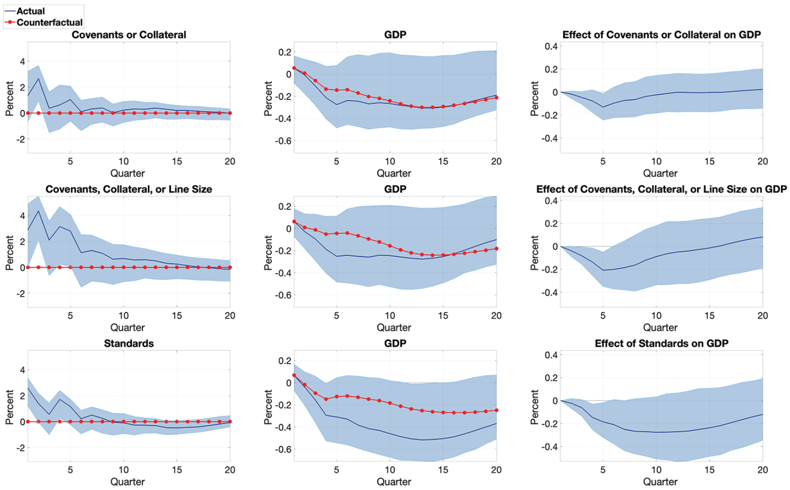
The results from figure 4 suggest that changes in lending standards and loan spreads are relevant for monetary transmission. Given that a tightening in standards together with a relaxation in loan spreads is consistent with a decrease in loan supply, these results imply that the contraction in loan supply following the monetary surprise accounts for a statistically significant decrease in GDP of up to 0.3 percentage point.

Recall that the lending standards capture adjustments in loan contract terms *other* than changes in interest rates; they capture changes in the nonprice terms such as maximum line size, covenants, and collateral requirements (see section 3.2). Therefore, the results from figure 4 suggest that changes in these nonprice terms are relevant for monetary transmission. Nonetheless, nonprice terms are not *separately* relevant for monetary transmission; the individual series in the right column of figure 4 all include zero.

Figure 5 presents further evidence to support the claim that nonprice terms are *collectively* relevant for monetary policy transmission. The VAR specifications used to construct these IRF counterfactuals reflect adjustments in covenants or collateral requirements (first row) and adjustments in covenants, collateral requirements, or the maximum line size (second row).[23] As can be seen from the figure, the effect of the nonprice terms on GDP

[23]Effectively, this amounts to creating new variables adding the net percent of banks tightening covenants, the net percent of banks tightening collateral requirements, and the net percent of banks tightening the maximum line size. I then include the transformed version of these variables (i.e., with the principal component removed) as the SLOOS variable in the baseline VAR specifications. Note that this series reflects aggregate tightening in any of the nonprice margins. If a bank tightened more than one margin simultaneously, it would be “double” counted, thus reflecting the simultaneous tightening in multiple margins. If a bank tightened one margin but relaxed another one, it would be “washed out,” thus reflecting the simultaneous tightening in both margins (i.e., no tightening at all). This assumes all three margins are equally relevant. Given that adjustments in collateral requirements seem to matter most, using these series might actually underestimate the results.

Figure 5. Contribution of Adjustments in Covenants or Collateral Requirements to Monetary Transmission



Notes: The IRFs correspond to one standard deviation of the monetary policy shock. The shaded area represents the 90 percent confidence interval.

becomes statistically significant when thinking about them collectively. Furthermore, the results show that collective response of the nonprice terms has a very similar effect on GDP as that predicted by the lending standards (third row).

The previous results are corroborated when the contribution of the different loan terms is evaluated using the forecast error variance or historical decompositions.[24]

5.2 Robustness

One potential concern is that omitted variables in the VAR specifications might be (partially) driving the previous results. I use the excess bond premium as the indicator for the overall credit conditions precisely to attenuate this concern. Several studies, including Gilchrist and Zakrajšek (2012), have shown that the excess bond

[24]The results for the forecast error variance and historical decompositions can be found in online appendixes E and F).

premium outperforms every other financial indicator in its forecasting ability for economic activity. Thus the excess bond premium conveniently summarizes the information from variables that might be left out of the VAR specifications.

Furthermore, I show that the results are robust when using other indicators of overall credit conditions.[25] To the extent that these indicators contain *less* information about the economy than the excess bond premium, these alternative specifications are more prone to omitted variables by construction. Although the actual GDP responses are somewhat different when the excess bond premium is not included, the responses of the loan terms remain remarkably similar and the results about the contribution of the different loan terms to monetary transmission are virtually unchanged. In other words, the results are robust to omitted variables.

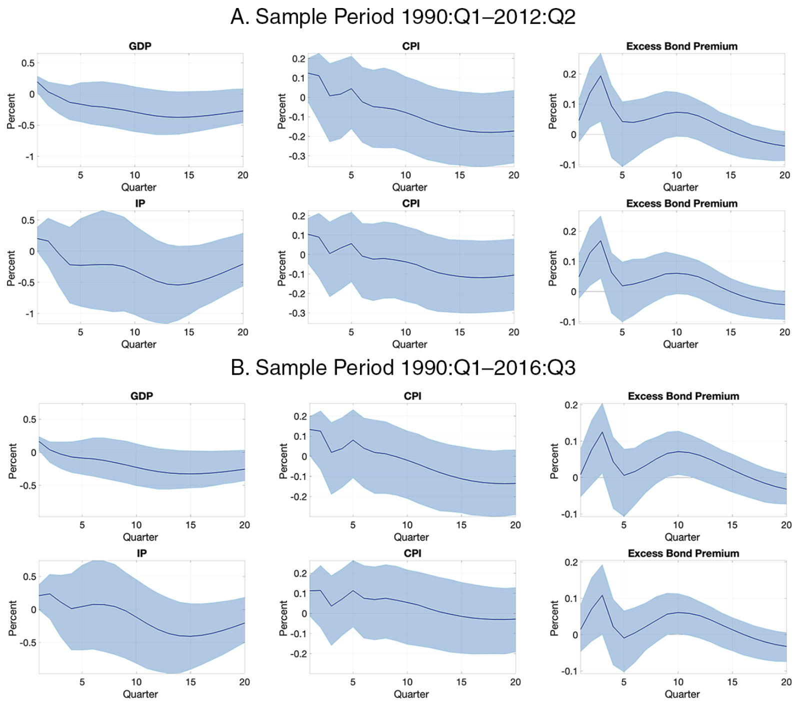
Another potential concern is related to the validity of the SLOOS variables. The previous results rely on the different SLOOS terms actually capturing the margin of adjustment to which they allude. Section 3.2 presented evidence that showed the SLOOS variables are indeed valid and that changes in the lending standards capture changes in the nonprice terms. Furthermore, figure G.3 in online appendix G shows that the response of the *actual* C&I spread is consistent with the response of the SLOOS net percent of banks tightening the spread. I interpret this as further evidence of the validity of the SLOOS terms.

A third concern is related to the identification of the monetary policy shock using the surprise in the three-month-ahead federal funds futures (FF_3) as the external instrument. Panel A in figure 6 shows that my empirical setup yields similar results to those from Gertler and Karadi (2015).[26] Keep in mind that they use monthly data, they include the industrial production index (IP) as the measure of macroeconomic activity, they include the mortgage and commercial paper spreads as additional controls, and their sample period ends in 2012:Q2. In order to make the comparison, I use IP instead of real GDP as the macroeconomic indicator (although I keep the quarterly frequency) and I restrict my sample period to 1990:

[25]See online appendix G.

[26]See figure 1 on page 61 of their paper.

Figure 6. Reproducing the Results from Gertler and Karadi (2015)



Notes: The IRFs correspond to one standard deviation of the monetary policy shock. The shaded area represents the 90 percent confidence interval.

Q1–2012:Q2. However, I don't include the mortgage and commercial paper spreads.

The responses of the CPI and EBP are fairly similar to those from Gertler and Karadi (2015); there is no statistically significant change in the CPI, while the EBP experiences a statistically significant increase between 5 and 25 basis points during the first three quarters. The IP response is also qualitatively and quantitatively similar, although Gertler and Karadi (2015) find it to be statistically significant. Altogether, I interpret this as evidence of the monetary policy shock being properly identified within my setup.

Figure 6 also includes the responses using real GDP as the macroeconomic indicator and using the full sample period 1990:Q1–2016:Q3. I provide this for reference and to show that the responses are similar to the responses from the actual VARs I use in my study (see figure 3).

It must also be noted that I can safely rule out a weak instrument problem when using FF_3 in the identification procedure. To attenuate any remaining concerns, I conduct a robustness check and verify that the main results remain unchanged when using the surprise in the current-month federal funds future (FF_0) as the instrument.[27]

I also address concerns about overfitting by considering two alternative VAR specifications. In the first one I use only two lags instead of four. In the second one I drop the SLOOS demand controls to reduce the number of regressors.[28] In both cases the nonprice terms remain relevant for monetary transmission, and adjustments in these terms lead to significant changes in GDP. Interestingly, changes in collateral requirements become relatively more important within the nonprice terms. This finding suggests that adjustments in collateral requirements are more persistent than adjustments in the other margins and are more strongly associated with changes in loan demand.

Lastly, the results remain robust when using different subsamples in the estimation procedure.[29] For instance, the adjustment in the nonprice loan terms becomes even more relevant for monetary transmission when restricting the sample to the pre-crisis period (1990:Q1–2007:Q4). Not only is their contribution to changes in GDP statistically significant, but it almost doubles in magnitude. This is not surprising given that the zero lower bound and other factors might have hindered the overall effectiveness of monetary transmission during the crisis and post-crisis periods.

6. Conclusion

I study the transmission of monetary policy shocks via changes in nonprice contract terms for C&I loans. I use the external instrument approach from Gertler and Karadi (2015) and data from the Senior

[27]Refer to online appendixes H and I for further details.

[28]Refer to online appendixes J and K for further details.

[29]Refer to online appendix L for further details. Additionally, a previous version of this paper used the federal funds surprises and excess bond premium series from Gertler and Karadi (2015), which effectively restricted the sample period to 1990:Q1–2012:Q2. The main results from this earlier version are consistent with the current results.

Loan Officer Opinion Survey to identify changes in loan contract terms.

I find that a surprise monetary contraction leads to a decrease in loan supply characterized by a relaxation in the loan interest rate spread and a tightening in the nonprice terms (maximum line size, covenants, and collateral requirements). The decrease in the spreads is a consequence of loan rates not adjusting as fast as (government) bond rates. The tightening in the nonprice terms is responsible for a statistically significant decrease in GDP of about 0.3 percentage point. Although the contribution of adjustments in collateral requirements is the largest, my results suggest that the changes in nonprice terms are not individually, but collectively, relevant for monetary transmission.

My results also shed light on the interaction between the loan and bond markets for monetary transmission. I find that the tightening in the loan contract terms happens immediately upon the monetary contraction, while the increase in the excess bond premium happens with a lag. The lagged increase in the excess bond premium suggests that firms turn to the (corporate) bond market to raise funds after they are unable to get funds from banks due to the tightened lending conditions.

My study provides empirical support for modeling financial frictions à la Kiyotaki and Moore (1997) and à la Bernanke, Gertler, and Gilchrist (1999) and it uncovers two avenues that could be useful to resolve the critique that these types of financial frictions are quantitatively unimportant. The first one is considering other nonprice margins of adjustments in addition to collateral requirements. The second one is explicitly modeling the interaction between the corporate bond and loan markets.

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