Business Loans and the Transmission of Monetary Policy

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Abstract

We study the transmission mechanism of monetary policy through business loans and illustrate subtle aspects of its functioning that relate to loans' contractual characteristics and borrower-lender types. We show that the puzzling increase in business loans in response to monetary tightening, documented before the Great Recession, is largely driven by drawdowns from existing commitments at large banks. Spot loans also rise and take considerable time to adjust. Banks, nonetheless, indeed curtail credit supply by shortening maturities of new loans. Following the Great Recession, the mechanism has worked differently, with loan responses to monetary tightening displaying a significant downward shift.

Keywords: Monetary Policy Transmission, Business Loans, Commitments, Loan Maturity, Bank Lending Channel
JEL Classification: E50, E51, E44.

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1 Introduction

The basic lending channel of the transmission mechanism of monetary policy predicts a contraction of loan supply in response to tightening monetary conditions. den Haan, Sumner, and Yamashiro (2007) (DSY henceforth) study bank lending before the Great Recession and find this prediction is empirically confirmed for real estate and consumer loans, but it is strongly rejected for commercial and industrial (C&I) loans, which increase following a contractionary shock. In this paper we exploit a contractual feature of business loans, namely the difference between spot loan contracts and loans issued under commitment, to shed some light on this empirical finding and to improve our understanding of the transmission mechanism of monetary policy through the business loan market.

Our analysis adopts the same empirical framework as DSY and identifies monetary shocks in a VAR model using the strategy proposed by Christiano, Eichenbaum, and Evans (1999) (CEE hereafter). We primarily concentrate on the pre Great Recession period, for which the puzzling DSY result was originally documented. This period can be characterized as a standard business cycle regime, in which the Federal Reserve relies on conventional monetary policy to influence the economy using the federal funds rate as the policy instrument. Next, we explore the bank lending channel following the Great Recession, when the zero lower bound is predominantly binding and unconventional monetary policy prevails. We illustrate significant differences in the transmission mechanism under this second monetary regime.

In the main analysis, we emphasize three main aspects of the C&I loan market that bear a significant impact on the transmission mechanism of policy shocks. First, we document a remarkable difference in the dynamics of C&I loans for small and large banks. The findings in DSY are directly ascribable to the response of large banks loans, which represent about three quarters of the loan market. We conduct this part of the analysis using data on the U.S. market of commercial and industrial bank loans from the Federal Reserve Board of Governors Survey of Terms of Business Lending (STBL), which provides information on loans disaggregated by bank size and contract type. We treat large and small banks separately because large banks typically lend to larger and safer firms, which likely show different cyclical properties in their demand for credit. We focus our main analysis on large banks provided they can explain the bulk of the aggregate business loan market.

As a direct implication, we illustrate that the response of the C&I loans documented by DSY can be linked to demand-side effects. To a large extent, these effects are explained by the drawdowns from pre-existing commitments by firms that have access to unused credit lines and can thus secure funds in spite of tighter credit conditions. Borrowing under commitments represents around 80% of total loan flows in our sample. However, and to some extent more unexpectedly, we find that also the response of spot loans to a contractionary shock is positive and quite large, at least in the short term after the shock.

Second, and in relation to the previous point, we exploit the relative response of spot loans and loans extended under commitment to explore whether a supply-side channel of the transmission of policy shocks is readily observable from credit volumes. Under the assumption of uniform characteristics of the cyclical demands for these two categories of loans, the relative response can be used to identify shifts in the supply side consistent with the implications of the bank lending channel. This assumption is arguably more tenable if we limit our analysis to banks (and, by extension, borrowers) of comparable size. We focus

on large banks and find that a contraction in loan supply in response to a positive shock to the policy rate is not immediate, but it rather takes some time to build up. The relative response is positive in the short run, mostly reflecting a stronger response of spot loans; it then turns significantly negative only over the medium to long horizon, due to a drop in spot loans while the response of loans under commitment remains positive for a very prolonged period.

Third, we provide evidence that banks operate on other dimensions of loan contracts besides volumes. We investigate this point by examining the change in maturities of new loans issued after a monetary tightening and by comparing the responses of maturities of bank spot loans to those of non-convertible bonds. This adjustment of loan supply, broadly defined, helps reconcile the relative increase in spot loan volumes with the workings of a bank lending channel in response to a monetary contraction. For this portion of the analysis we rely on data from Thomson Reuters LPC's DealScan and Thomson Reuters SDC Platinum, as STBL does not provide enough detail on loan maturities for our purposes.[1]

We document two main facts. First, the average maturities of both loans and bonds drop significantly in response to a monetary tightening. When we focus on spot loans, we observe a clear migration of the volume of loans from longer than five-year maturities to much shorter maturities. Second, the relative response of spot loans to bonds with comparable maturities under five years is negative. Jointly, these two results provide evidence of a restrictive supply-side effect in banks actions, which could not be uncovered in the analysis that relied uniquely on volumes. In particular, the first result shows that the increase in spot loans after a monetary shock is driven by short term loans, while long term loans actually follow the behavior predicted by the bank lending channel. Assuming, once again, uniform characteristics of public firms' demand for spot loans and bonds, the second result strengthens the case that banks actively pursue a lending supply contraction.

The post-recession analysis reveals interesting differences in the characteristics of the C&I loan market and its response to monetary shocks. We illustrate two main points. First, business loans in this period are dominated by lending under commitment from large banks, which rises above 90% of total loans. Thus, our attention must be focused on this category of loans. Second, the lack of a unique, incontrovertible measure of unconventional monetary policy stance able to replace the fed funds rate in the model makes infeasible to identify with certainty the transmission mechanism of monetary policy to C&I loans after 2009. However, we can show that, in conjunction with the adoption of the new unconventional policy instruments by the Fed, C&I loan responses significantly shift downwards regardless of the specific policy measure adopted.

Our findings bear important policy implications for central bankers, as they suggest the bank lending channel is noticeably more complex than the standard textbook mechanism we usually think of. The policy transmission to the C&I loans through the reduction of loan volumes is a considerably slow mechanism that might be strongly watered-down by firms' funding needs in the aftermath of a policy shock. On one hand, firms might be willing to

[1]The DealScan dataset includes mainly syndicated loans, and it allows for an analysis consistent with the strategy adopted in the rest of the paper as it includes data on facilities originated by public firms, which compare reasonably well to the loans supplied by large banks in the STBL dataset. Furthermore, loans to public firms are directly comparable to non-convertible bonds, which are predominantly issued by public firms. We leave a more thorough description of our datasets for Section 3.

secure spot loans even at a higher cost, possibly because they anticipate further hikes in the interest rates or simply because they face increasing funding needs for working capital. At the same time, banks might prefer to reduce loan supply by operating on other terms, such as shortening maturities, rather than directly cutting back on loan volumes in the face of firms seeking funding in a tight market. While this mechanism has been mute during recent years, a period of near-zero interest rates and prevailing unconventional monetary policy, we could arguably expect this transmission channel to be back again once a more normal business cycle returns and the Federal Reserve progressively resorts to conventional monetary policy.

1.1 Related literature

The literature has several examples of studies that compare responses of different financial aggregates to better understand the monetary transmission mechanism and cyclicality of credit by disentangling supply-side from demand-side effects. Kashyap, Stein, and Wilcox (1993) argue they can identify a loan-supply channel by analyzing shifts in firms' financing mix from bank loans to commercial paper. More recently, motivated by the events of the latest financial crisis, Becker and Ivashina (2014) use the substitution between loans and bonds at firm-level; in a similar context, Adrian, Colla, and Shin (2013) study the shift in composition of credit between loans and bonds. Our identification approach is clearly inspired by this strand of the literature, even though our analysis focuses on bank loans and uses a sample that predates the financial crisis of 2008-09. More closely related to our work, Sofianos, Melnik, and Wachtel (1990) and Morgan (1998) exploit the differences between loans under commitment and spot loans to explore the monetary transmission mechanism, but our data sources and empirical approach differ from theirs. Berger and Udell (1992) conduct an exhaustive study on the importance of credit rationing deriving pre-1988 commitments data at the bank-level from the STBL.

There is more recent literature that focuses on commitments. Campello, Giambona, Graham, and Harvey (2011) extensively describe credit lines management in relation to external funds and corporate decisions during the financial crisis. Black and Rosen (2016) use information on commitments from STBL at the individual-loan level to show that the supply of commercial loans is affected by tightening monetary shocks through the shortening of loan maturity. Our results and the interpretation we give to them in the context of the bank lending channel are strongly consistent with theirs. Duca and Vanhoose (1990) and Woodford (1996) study optimal monetary policy in presence of lending commitments. Demiroglu, James, and Kizilaslan (2012) examine the relation between changes in bank lending standards and availability and use of credit lines for public and private firms. They find that private firms face a reduction in the access to new lines of credit relative to public firms when market conditions are tight, but are not penalized in the use of existing lines. We carefully take into account the insight of Demiroglu, James, and Kizilaslan (2012) that controlling for firms characteristics is critical in the supply-side effects identification exercise by restricting our comparisons only to banks within the same size category. Nevertheless, while these papers highlight the key role of credit lines in insulating and protecting firms from monetary tightening and credit crunches, they do not explicitly analyze the response of loans to structural monetary shocks.

We view our results as complementary to those in DSY: their work stresses the importance

of looking at different categories of loans to properly account for their aggregate behavior in response to monetary shocks. Our analysis provides a potential explanation for their findings on the dynamics of one such category, namely the C&I loans. In broader terms, our work contributes towards explaining the puzzling rise in bank lending to businesses following a monetary tightening, as early documented by Gertler and Gilchrist (1993), Gertler and Gilchrist (1994), and Christiano, Eichenbaum, and Evans (1996b). We shed light on the mechanism that makes large firms the drivers of the aggregate result (as in Gertler and Gilchrist, 1993, 1994), that is their intense use of commitments. While we document a surprisingly strong response of spot loans that at first sight weakens the bank lending channel view, we subsequently show that this response partly masks a more complex mechanism of the bank lending channel that operates through loan maturities as well.

Finally, our paper adds a new insight to the recent literature that studies the transmission mechanism of unconventional monetary policy. Wu and Xia (2016) and Francis, Jackson, and Owyang (2017), for instance, show that conventional and unconventional monetary policy have similar effects on the dynamics of the real economy. Our study, however, shows that conventional and unconventional monetary policy could have differing impact on the financial side of the economy, particularly on the bank credit market.

The rest of the paper is organized as follows. Section 2 briefly introduces the empirical VAR methodology used in our analysis, while Section 3 describes the data in detail and compares the different datasets. In Section 4, we discuss the main results of the paper on the bank lending channel transmission mechanism. Section 5 presents the post Great Recession analysis. We conclude in Section 6.

2 Empirical Methodology

Let Y_t indicate the vector of macroeconomic and financial variables of interest in the analysis. As it is standard in the monetary literature (see DSY for a recent application), we adopt a pth order VAR to model the reduced-form dynamics of Y_t

$$Y_t = \sum_{i=1}^{p} B_i Y_{t-i} + \varepsilon_t$$

where the VAR residuals ε_t have covariance matrix $\mathbb{E}_t(\varepsilon_t \varepsilon_t') = \Sigma$. The relation between the reduced-form residuals of the VAR, ε_t, and the fundamental structural innovations of the model, u_t, is assumed to be linear

$$\varepsilon_t = A_0 u_t$$

where the structural shocks are orthogonal and $\mathbb{E}_t(u_t u_t') = V$ is diagonal. We follow the framework of CEE and identify the monetary policy shock by imposing a block-recursive structure to the impact matrix A_0. First, the variables in Y_t are sorted into three blocks

$$Y_t = \begin{bmatrix} X_t \\ S_t \\ Z_t \end{bmatrix}$$

where X_t is an n_1-vector of macroeconomic aggregates, S_t represents the policy instrument of the Federal Reserve ($n_2 = 1$), and Z_t is an n_3-vector of monetary and financial variables that inform the policy decision. Second, the macroeconomic variables are assumed to respond with a lag to the other variables of the model, including S_t. At the same time, the contemporaneous values of X_t, but not those of Z_t, are assumed to be part of the information set of the Fed. Correspondingly, the impact matrix is block- triangular

$$A_0 = \begin{bmatrix} A_{11} & 0_{12} & 0_{13} \\ A_{21} & A_{22} & 0_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix}$$

where A_{ij} and 0_{ij} are matrices of parameters and zeros, respectively, with dimensions $n_i \times n_j$. The results presented in Sections 4 are based on four lags ($p = 4$) VAR models estimated with Bayesian techniques.[2] Different VAR specifications will be considered as described in detail in Section 3, and all data are available at quarterly frequency. The estimation sample of the pre Great Recession model starts in 1983:1, during Paul Volcker's chairmanship at the Federal Reserve, and ends in 2007:2, just before the onset of the financial crisis. The post-recession sample starts in 2009:3 and ends in 2017:1; we exclude, then, the years of the financial crisis from the analysis. We will say more about the sample choices and limitations in the next sections. The impulse response functions are then reported for the lower triangular normalization of A_0. The results are then invariant to the ordering of the variables within X_t and Z_t, since we are only interested in identifying the monetary shock (see CEE). What becomes important, then, is the selection of the variables to be included in the two non-policy blocks of Y_t; we turn to the discussion of this point in Section 3 as well.

Our benchmark identification strategy for the pre-2007 sample reflects the underlying assumption that credit markets clear immediately after the observation of the policy rate, but their feedback to the monetary policy decision takes place with a lag. This ordering is consistent with the theoretical principles of a model in which the policy rate is set by the Central Bank according to a Taylor rule that primarily responds to inflation and output gap. It is also consistent with the VAR specification in Morgan (1998) and the baseline specification in DSY.[3] While this assumption is fair for "normal" economic times, it may be questionable when the economy is subject to large financial shocks and the monetary authority promptly reacts to prevent financial markets from freezing. An obvious case of this is the period that started with the financial shocks of fall 2007, which were followed

[2]The Bayesian VAR models are estimated using standard Litterman or "Minnesota" prior distributions for the B_i parameters. The Minnesota strategy (pioneered by Litterman, 1979, 1986; Doan, Litterman, and Sims, 1984) is one of the simplest and most convenient options to define the prior distributions for a VAR model. With Minnesota priors, the VAR residual covariance matrix is assumed to be known and a normal prior distribution is chosen for the VAR coefficients. This strategy gently models each endogenous variable included in the model fundamentally as a unit root in its first own lags; the posterior distribution of the parameters is then estimated combining the prior with the information provided by the likelihood of the data. This choice of the priors reduces the risk of estimation overfitting and provides parsimonious characterizations of the VAR coefficients, especially when large models are considered. For a brief introduction to the topic refer to Todd (1984) and Hamilton (1994).

[3]DSY use data at monthly frequency and they assume a baseline ordering where the FFR does not contemporaneously respond to *any* variable of the model. Their results are robust to the polar opposite specification too.

by years of unconventional monetary policy. To overcome this issue, the initial estimation sample excludes data from 2007:3 onwards. While other periods are potentially affected by the similar problems (for instance, the aftermath of the 2001 stock market crisis), they are arguably shorter and less dramatic in nature. Our pre-crisis analysis, hence, can be characterized as a study over business cycles in regular times.

It becomes evident, then, that the identification scheme requires some adjustment in the post-recession sample. During this period the federal funds rate is stuck at the zero lower bound and the Federal Reserve relies on large-scale asset purchases and long-term forward guidance to ease the stance of monetary policy. The fed funds rate as a policy instrument is clearly unsatisfactory, and it needs to be substituted in the VAR model with a policy stance measure that more broadly captures the unconventional monetary policy actions. The attention of the Central Bank for the liquidity provision to the banking system, which accumulated remarkably large amounts of excess reserves during this period, suggests it would be appropriate to include total reserves in the information set of the Fed, which implies moving this variable from block Z to block X. We further explain the rationale of this point in Section 5.

3 Data Description and VAR Specifications

The set of variables in Y_t for the most part corresponds to those commonly used in the VAR literature following CEE. Specifically, the policy instrument, S_t, is measured by the federal funds rate (FFR) and the real macroeconomic block, X_t, includes the logs of real GDP, GDP deflator, and a commodity price index. The commodity price is usually used to attenuate the price puzzle in the response of the price index to a monetary shock.[4] In a robustness check, real inventories and investment are added to this block too. These variables are obtained from the Federal Reserve Economic Data (FRED), the online dataset maintained by the Federal Reserve Bank of St. Louis; all variables are seasonally adjusted.

The specifications of the VAR model differ in the variables included in the financial/monetary block, Z_t. As standard in the monetary VAR framework, we always include the logs of real total bank reserves (which are, once again, obtained from FRED). In addition to that, we include a set of variables that aim to better characterize the "bank-lending channel." This subset of variables comprises a weighted market loan return rate and some combination of information about loans issued under commitment and spot loans, either from STBL or DealScan, and sometimes bonds too.[5] As above, we take the log-transformation of all these

[4] See Sims (1992), Christiano, Eichenbaum, and Evans (1996a), Hanson (2004), and Sims and Zha (2006) for discussions on this topic.

[5] DealScan reports data for spot loans and credit lines origination, but not for drawdowns on outstanding lines, and in this latter regard it differs noticeably from STBL data. Although neither are all C&I loans originated under syndication nor syndicated loans are exclusively issued to C&I borrowers, a significant portion of the stock of C&I loans held by commercial banks have been issued under syndication, and this portion is even higher among large banks. Based on data from the Shared National Credit Program of the Federal Reserve Board, Ivashina and Scharfstein (2010) report that in 2007 at least 26% of total C&I loans in the balance sheet of commercial banks operating in the U.S. corresponded to syndicated loans, and the corresponding figure was approximately 36% among large and foreign banks. DealScan spot loans issued to public firms are then conceptually comparable to STBL spot loans issued by large banks.

variables in real terms. In a robustness check, some yield spreads are added to the financial block to control for the effects of the risk premium on the substitution between bank loans and market debt among publicly listed firms. We use the spread between Moody's seasoned Baa corporate bond yield and the ten-year Treasury constant maturity rate and the spread between the three-month AA commercial paper rate and the three-month Treasury constant maturity rate from FRED.

In the baseline STBL specification we take 1983:1 as initial date of the sample, which corresponds to the switch from the monetary targeting regime to the subsequent fed funds rate targeting of the Federal Reserve during Volcker's tenure as its Chairman.[6,7] As for the DealScan data, the sample starts in 1988:1 due to data availability. Our main results are based on a sample ending in 2007:2, at the outset of the financial crisis, while the post-crisis sample covers the period 2009:3-2017:1 instead.

Finally, we consider alternative options to replace the policy rate and circumvent the restrictions imposed by the zero lower bound in order to correctly identify policy shocks in the post-crisis analysis. As previously done in the literature, we first consider three alternative measures of a shadow policy rate, provided by Wu and Xia (2016), Krippner (2015), and Lombardi and Zhu (2017). The shadow rate replaces the federal funds rate between 2009 and 2015, with the policy rate reverting to the federal funds rate for the last quarters of the sample. Alternatively, we include in the analysis a Divisia index of money introduced by (Barnett, 1980), which aggregates different assets by the value of the monetary services they provide.

The synthetic shadow rates and the Divisia index allow us to make a comparison of loan responses before and after the Great Recession and to formally test for shifts in the transmission mechanism across policy regimes. In principle, they would also allow one to extend the analysis through the full Great Recession period. However, the notoriously large financial shocks occurred between 2008:3 and 2009:2 caused a radical transformation of the structure of the economy and this prevents us from simply applying our linear VAR

[6]In the bank lending channel, reserves, deposits, and loans respond to policy innovations. Hence, taking 1983:1 as the starting period offers two additional benefits. First, it excludes the effects of ceilings on interest rates on time and saving deposits deriving from Regulation Q, which had come to existence with the Banking Act of 1933 for commercial banks that were members of the Federal Reserve System and extended to non-member banks by the Bank Act of 1935. The process of phasing out of Regulation Q started with the passing of the Depository Institutions Deregulation and Monetary Control Act in March of 1980. At the time of this passage, interest rate ceilings of 5.25 percent on time deposits were binding, in the sense that they were well below market rates offered, for instance, by money market mutual funds and 3-month Treasuries. The phasing out process was further accelerated with the passage of the Garn-St. Germain Act in 1982 – see, for instance, Allen and Wilhelm (1988), Berger, Kashyap, and Scalise (1995), Calem (1985), and Gilbert (1986) for further details. By 1983 most deposit interest rate ceilings had been lifted, as noted in Duca and Wu (2009). The elimination of interest rate ceilings allowed banks to better compete with market alternatives available to savers and counter an undergoing disintermediation process – DeYoung (2014), Duca (2016), and Mertens (2008). Second, it avoids any artificial friction in the mechanism we study that might arise from the credit controls used in 1980 to fight inflation. This policy was primarily focused on consumer credit and was very short-lived. The controls were announced on March 14, 1980, later eased on May 22, 1980 and finally phased out from July 3, 1980 on – see Schreft (1990) for a detailed recount of this policy event.

[7]We also conduct a robustness check moving the beginning of the sample to 1979:1. As discussed below, the distinction between large and small banks is not available for these first few years. However, including a period of monetary targeting in the analysis does not invalidate the main thrust of the results.

model to that period. A detailed discussion of this point is left for Section 5 and the online Appendix. Thus, we proceed excluding from the analysis the dates between 2007:3 and 2009:2, which correspond to the full recession period. We note that the pre-crisis results would not change if the sample was extended through 2008:2 (results reported in the online Appendix); nevertheless, we follow the fairly common view among applied macroeconomists that sets the beginning of the crisis to 2007:3.

3.1 The STBL Data

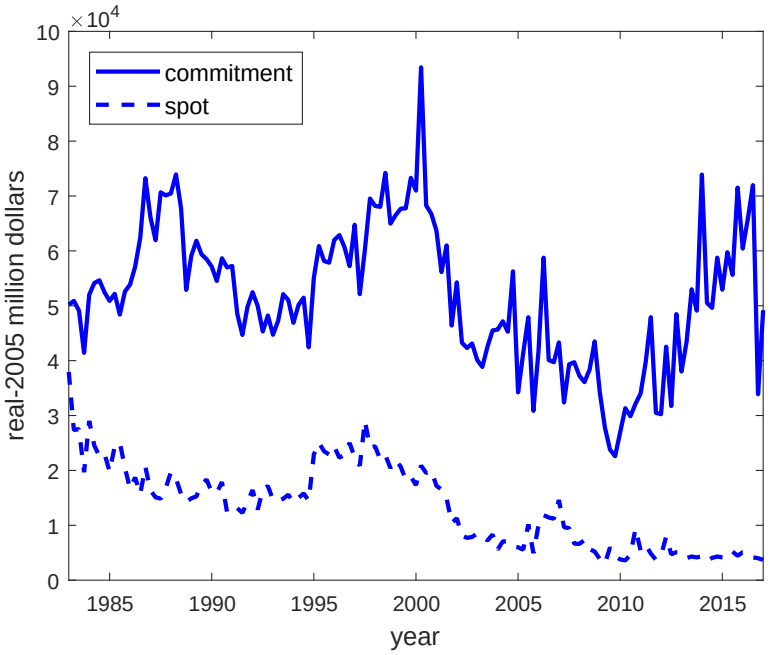
A more detailed description of our loan data is in order. The Survey of Terms of Business Lending is conducted by the Federal Reserve Board of Governors. The survey collects data on lending practices for loans issued during a representative business week in the second month of each quarter, for a sample of about 350 banks starting in 1977. Thus, the survey only provides information about loan *flows* in a period. Data are collected from participating banks through form FR 2028a; the data are blown-up to be representative of the total bank population, and then aggregated and published in report E.2 by the Board.

We consider total C&I loans disbursed by all domestic commercial banks, for which the share issued under bank commitments (formal and informal lines of credit) and a weighted-average effective loan rate are consistently available since the beginning of the survey in 1977:1. We also make use of separate series for small and large banks, currently defined as those banks with assets greater than $5 billion, in order to investigate the differences in the loan market related to bank size. This distinction is available only starting 1983:1, and we take this quarter as the initial date for the analysis in all the VAR models that use STBL data.[8]

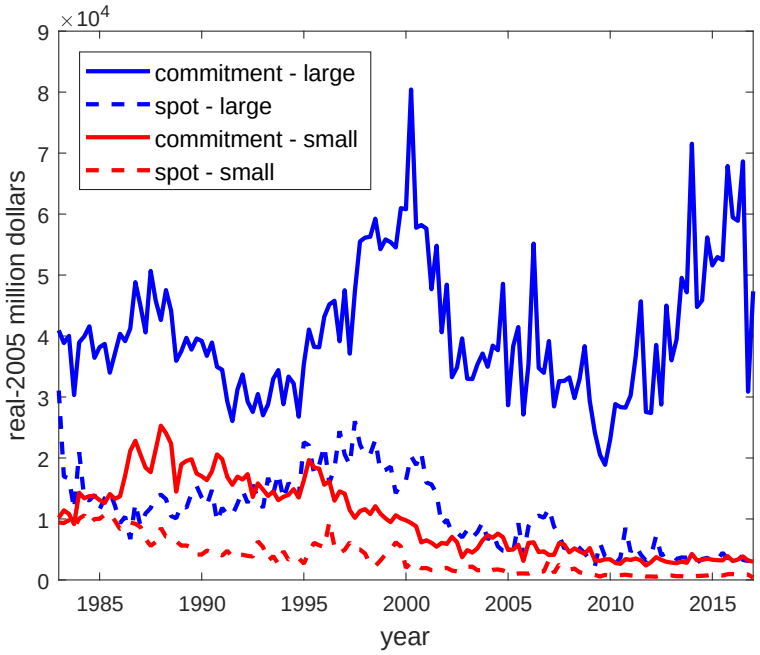
Panel (a) of Figure 1 plots the loan series under the two contractual forms and suggests that accounting for commitments is important if we want to correctly characterize a lending channel for C&I loans. Loans under commitment were about 60% of total loans at the beginning of the sample and grew substantially to about 80% in 2007, reaching more than 90% after the Great Recession. Panel (b) of Figure 1 illustrates the differences between small and large banks. Loans from large banks explain the bulk of the volume for both types of loans, especially since the early 90s, which coincides with a period of significant consolidation and asset concentration in the banking industry as documented, for instance, by Berger, Demsetz, and Strahan (1999), DeYoung (2014), and English (2002). By 2007, large banks accounted for more than 80% of all loans and, as we will show below, this concentration of loans among large banks has the power to explain the aggregate business loans dynamics observed in the extant literature. The share of large bank loans remained largely predominant, between $80 - 90\%$, also during and after the financial crisis.

Other previous works have used the STBL survey and other similar Federal Reserve surveys to study the bank credit to businesses and the transmission of monetary policy. Berger and Udell (1992) use commitment data from the STBL, disaggregated to bank-level,

[8]STBL data are publicly available only starting in 1997. In response to our requests, the Board of Governors kindly assembled these series over the longest sample for us. We are particularly grateful to William English for putting us in contact with Thomas Allard at the Federal Reserve Board and Thomas Spiller and Sam Haltenhof at the Division of Monetary Affairs - Banking Analysis, who provided us with outstanding assistance in obtaining the data used in this paper.



(a) All domestic banks



(b) Domestic banks: large vs. small

Figure 1: C&I borrowing under commitment and spot loans from the STBL dataset. Period 1983:1–2017:1.

to study the empirical existence of credit rationing during the period 1977-1988. Black and Rosen (2016) also rely on the STBL, this time using micro data at loan level, to study the effects of monetary policy on bank credit. These two studies are based on panel regression models. Sofianos, Melnik, and Wachtel (1990) and Morgan (1998) use a VAR framework to analyze the credit channel. Their commitment data come from the Survey of C&I Loan Commitments at Selected Large Commercial Banks, which is limited to the sample 1975-1987.

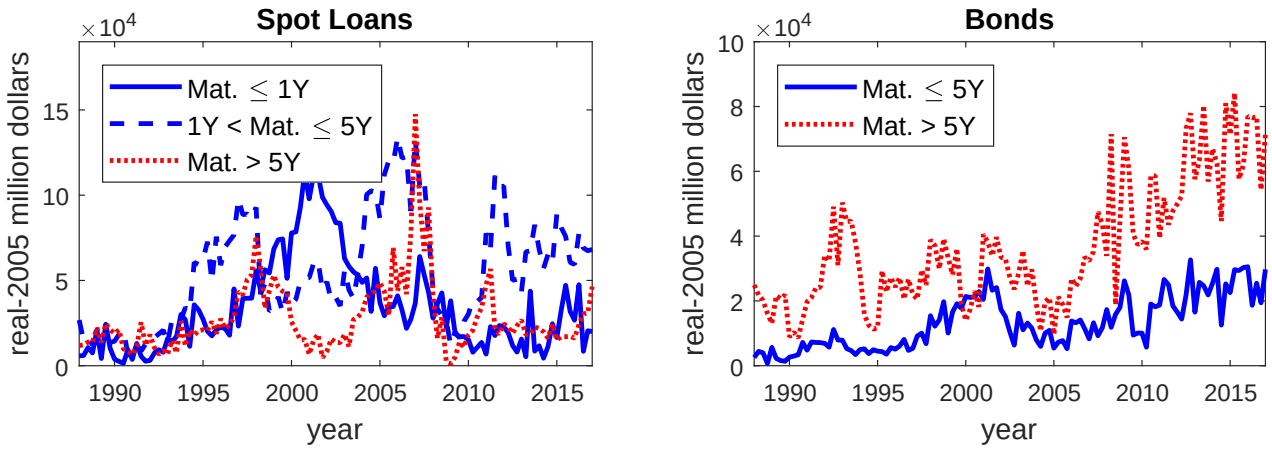
3.2 DealScan and SDC Platinum Datasets

Recent literature on the transmission of monetary policy suggests that banks can operate on terms other than volume when determining loan supply. Noticeably, Black and Rosen (2016) document that a monetary tightening can lead to shorter bank loan maturities. In our framework, shortening maturities could offer a plausible explanation to some seemingly puzzling results. We incorporate maturities to our analysis by extrapolating information from the Thomson Reuters LPCs DealScan dataset, which contains information on syndicated loan originations in the U.S. loan market. In a syndication, a group of banks finance a facility or a deal to a single borrower. Because syndication offers an efficient way for banks to diversify their credit risk, the syndicated loan market has grown steadily since the late 1980s. According to the SLOOS (2007), in two thirds of all surveyed banks syndicated loans account for between 5 and 50% of the outstanding C&I loans. Syndicated loans can also be traded in a secondary market, which makes them all the more attractive to banks participating in the syndication. Large banks can rely heavily on syndications for business loans origination; for instance, Ivashina (2009) can recreate 75% of Bank of America's domestic C&I loans portfolio from the DealScan dataset.

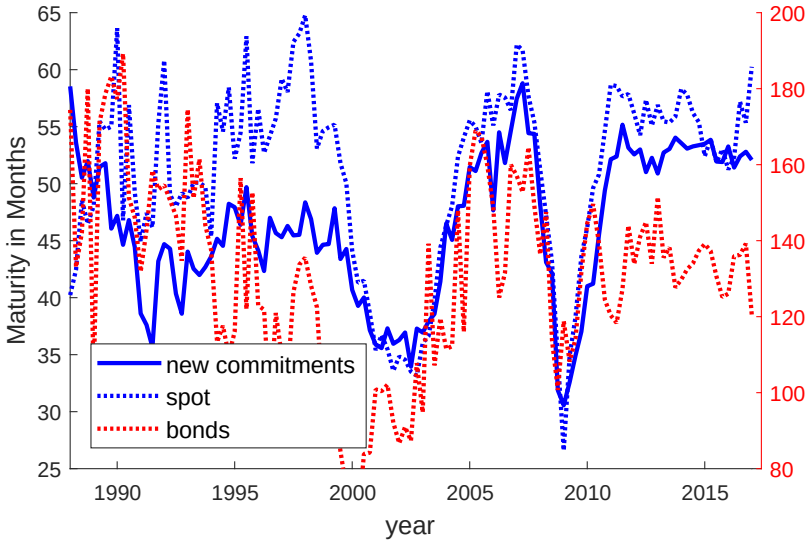
In order to obtain a sample of DealScan borrowers that is comparable to both borrowers from large banks in the STBL dataset and issuers in the non-convertible bond market (more on this below), we keep facilities originated to non-financial public firms, which excludes SIC codes between 6000 and 6999. We keep only facilities issued in U.S. dollars, to U.S.-based firms, and syndicated in the U.S. market. As with STBL data, we separate spot from commitment loans. For this purpose, we identify facilities as belonging to the latter group if they carry some type of commitment fee. A caveat applies at this point: while a spot loan in the DealScan dataset compares well to a spot loan in STBL, commitment loans recorded in DealScan can differ significantly from loans extended under commitment in the STBL dataset. Specifically, while STBL records *disbursements made under commitment* during a particular period of time, DealScan records *commitment originations* that do not necessarily carry drawdowns on the lines, let alone immediate drawdowns.

We incorporate maturities into our VAR framework in two ways. On one hand, we compute series of average loan maturity. The results presented in Section 4 use equally-weighted average maturity. In unreported results we also run the VAR analysis using size-weighted average maturity, where facility size comes from its amount, obtaining similar conclusions. On the other hand, we compute series of loan volumes by maturity group. We define maturity groups as short-, mid-, and long-term and they include those loans with maturity of less than a year, between one and five years, and over five years, respectively.

In identifying a bank lending channel while exploiting these data on loan maturity, we



(a) Spot loan and bond volumes



(b) Average maturities

Figure 2: Loans from the DealSCan dataset and bonds from the SDC Platinum dataset. Top panel: volume of spot loans to public firms and bonds by maturity group. Bottom panel: average maturity of new commitment contracts and spot loans to public firms (left vertical scale) and bonds (right scale) – all maturities. Period 1988:1–2017:1.

want to set a reference point for dynamics in the credit markets outside the banking system. For this purpose, we use data on bonds from the Thomson Reuters SDC Platinum non-convertible bonds dataset. As with DealScan facilities, we keep bonds issued in the U.S. market by non-financial U.S.-based public firms, in U.S. dollars.

In Figure 2 we explore the maturity of loans and bonds. In panel (a) we plot the market volumes of spot loans and bonds by maturity group. The main point we want to make here is that the proportions of the different maturity groups change significantly over time, both for loans and bonds, and we aim at exploiting these variations with our VAR analysis. Panel (b) shows the distinct maturity structure of spot and commitment loans, on the one hand, and bonds on the other. Loan maturity is consistently shorter than bond maturity, typically about one third of the latter. This reflects the risks maturity transformation imposes on banks, as they issue short-term liabilities and originate long-term assets. The figure also shows that, despite this difference in average maturity, all three series of maturities seem to move in tandem over time.

4 Empirical Results

Large part of this Section focuses on the pre Great Recession analysis, for which the positive response of total C&I loans to a monetary tightening was documented by DSY. We discuss three main empirical results in Sections 4.1-4.4.

The first result of the analysis is that these responses of aggregate C&I loans are attributable to the dynamics of loans originated by large banks – we document a striking difference in the behavior of loans across small and large banks. When we focus on large banks, we argue that the increase in loans after a monetary contraction is mostly explained by demand driven effects. Specifically, firms with access to pre-existing credit lines draw down funds from these lines when credit conditions tighten. The second result is that a volume contraction in loan supply consistent with the implications of the bank lending channel in response to a positive shock to the policy rate takes some time to build up. We identify these supply effects through the relative response of spot loans and loans extended under commitment for large banks. The third one is that restrictions of the bank lending supply can occur on other dimension besides loan volumes. In particular, the maturity of loans decreases due to a substitution of long term loans with short term ones, and spot loans grow less than the bonds with corresponding maturities issued by firms. We discuss these results in detail below to depict a rich transmission mechanism of the monetary policy.

In Section 5, we extend our study of the business loan market to the period following the recent financial crisis. The goal of this exercise is to assess whether the transmission mechanism we describe remains the same during the unconventional monetary policy regime.

4.1 Bank Size and Loan Commitments

We first verify that the puzzling responses of total C&I loans to a positive monetary shock documented by DSY using data on stock loans can also be extended to the STBL flow data for all banks. We report this first result in the top panel of Figure 3 for a one s.d. contractionary shock. Total loans increase on impact and remain significantly positive for a

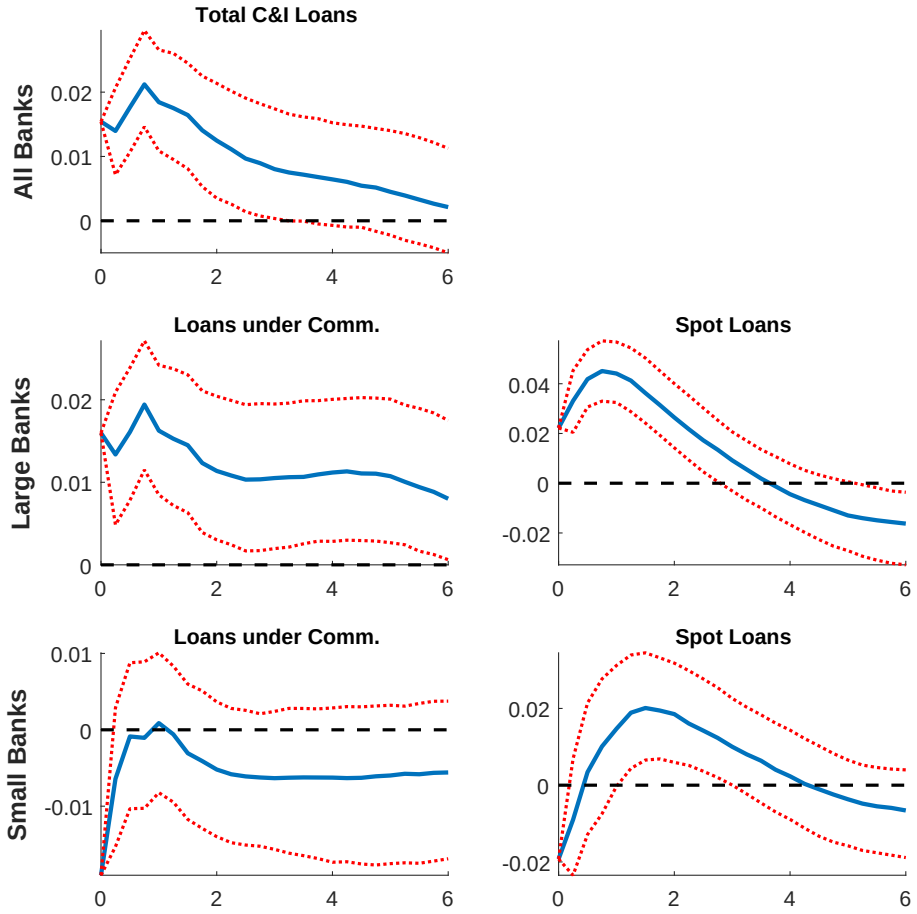


Figure 3: STBL dataset – Responses to a one s.d. monetary shock. VAR models with total C&I loans for all domestic banks (first row); loans under commitment and spot loans for large domestic banks (second row) and small banks (third row). Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

prolonged period. For clarity of exposition, we only report the impulse response functions of loans here, while the full set of responses for this and the following cases is available in Appendix A (Figures A1–A4).

In all these Figures, the solid lines correspond to the median response of a variable to the shock, whereas the dashed lines represent the 16/84th percentile bands of the posterior distribution of the responses.[9] Years from the shock are measured on the horizontal axis. Figure A1 illustrates that the responses of the other variables of the model are in line with what has typically been found in the monetary VAR literature. The loan rate follows the fed funds rate, but it exhibits higher stickiness at the very beginning of its response. Prices

[9]Our choice of 16/84th percentile bands follows a long-standing standard in the literature of Bayesian VAR models that goes back to, at least, Sims and Zha (1998). For a more recent example see, for instance, Giannone, Lenza, and Primiceri (2015)

drop, while the responses of output are quite small and not very significant, with a median response which is negative only for the first three years after a shock.[10]

We then turn to specifications in which total loans are replaced by loans under commitment and spot loans. We do this for the subsets of large and small banks. The main purpose of this exercise is to explore the role of pre-existing commitments in the transmission of policy shocks, but also to account for differences across bank types. The response functions for these cases are illustrated in Figure 3 as well. Two main observations can be made.

First, there is a striking difference between small and large banks in the responses of both loans under commitment and spot loans. The responses for large banks are larger, more significant, and persistent than for small banks; moreover, while loans under commitment for small banks respond negatively to a monetary tightening, they respond positively for large banks. A possible explanation for the difference across the two types of banks can be given in terms of differences in demand for funds. Large banks are more likely to serve large firms, which issue commercial paper and use backup credit lines to secure repayment in case rolling commercial paper over is either infeasible or too expensive. Following a monetary tightening, these firms can then draw down on the existing lines to repay maturing commercial paper.

Second, most of the dynamics of aggregate C&I loans in the first panel of Figure 3 is captured by the response of loans under commitment for large banks. Since these loans represent 70 to 80% of total loans, it is fair to conclude that the seemingly puzzling positive response of C&I loans to tightening monetary shocks is likely explained by demand-side rather than supply-side factors, such as shifts in banks' loan portfolios (as suggested by DSY). However, we also document a statistically significant increase in spot loans in response to a contractionary monetary shock. This response is even larger than that of loans under commitment for the first couple of years after the shock, but it then turns significantly negative over the medium and long term.[11]

We conclude this Section with two robustness checks on the specification of the VAR model. Given the potential relevance of a substitution effect between bank loans and market debt for the transmission mechanism we study, we check how including a yield spread among the financial variables of block Z_t of the model for large banks in Figure 3 would affect our results. We alternatively use the spread between a three-month AA commercial paper rate and the three-month Treasury constant maturity rate and the spread between the seasoned Baa corporate bond yield and the ten-year Treasury constant maturity rate. As expected,

[10] This response of output is exclusively due to the particular estimation sample of the VAR models, and not the specification of the model, the inclusion of the loan variables, or the identification scheme of the monetary shocks. For example, extending the sample by a few years in order to include in the estimation the late seventies is already sufficient to obtain significantly negative responses of output. At the same time, it is not uncommon in the literature to find modest or unclear effects of contractionary monetary shocks on output when alternative structural identification strategies are adopted (see, for instance, the discussion of this point in Uhlig, 2005; Sims and Zha, 2006).

[11] As illustrated in Figures Figures A2 – A3, the responses of the other variables of the VAR display only minor changes when we separate small from large banks. We also consider different orderings of the variables in the recursive identification scheme of the shocks of the VAR. As a main alternative, we move all the loan variables to the X_t block, forcing them not to respond to the monetary shock on impact. This change does not remarkably affect the shape of the response of the different loan aggregates. We also check the responses of loans under commitment and spot loans for all banks, for which data are available starting in 1977. For the 1983 sample, the responses are simply combinations of those in Figure 3 for small and large banks. Over the longer sample, the response of spot loans instead becomes smaller and not significant.

the response of the spread is mostly positive and significant, while the responses of the loan variables are fundamentally unaltered. We report these results in Figures A5-A6 in the Appendix. The same conclusion holds for the ratio specification in Section 4.2 and for the model used for the comparison with the bond market discussed in Section 4.4 (reported in the online Appendix, Figures S4-S7). We, hence, opt for the more parsimonious specification of this Section as the baseline model of the analysis.

4.2 Bank Lending Channel: The Loan Volume Dimension

We now turn to the analysis of supply side responses consistent with the bank lending channel. The bank lending channel of the transmission of monetary policy predicts a contraction of the supply of C&I loans in response to a tightening monetary shock. We test for these effects by including the ratio of spot loans to loans under commitment in the Z_t vector of the VAR. Although we do not develop an explicit theoretical model, this approach can be justified by an argument analogous to that in Kashyap, Stein, and Wilcox (1993), among others. Intuitively, since banks are contractually constrained to serve pre-existing commitments, they are only free to operate on the supply of spot loans. Therefore, taking common movements across different types of loans as reflecting demand-side factors, a negative response of the ratio would suggest the presence of a supply-side loan contraction that affects spot loans but not loans under commitment.

The key assumption for the validity of this identification strategy is that loan demand has uniform cyclical properties across the two types of contracts. There are two reasons to believe this assumption is plausibly satisfied in our setup. The first is that we are limiting the use of this strategy to loans originated by large banks only. The goal is to narrow down the analysis, by extension, to firms of comparable size. As documented in Figure 3, there are large differences in the responses to monetary shocks of loans by small and large banks, and these differences suggest that demand for loans faced by small banks is likely to be very different as well.[12] The banking literature has shown that larger banks tend to lend to larger firms, the most important rationale for this association being the relative advantage of small banks in collecting and acting on soft information that is typically associated with small firms, as documented by Berger, Miller, Petersen, Rajan, and Stein (2005).

The second reason is purely empirical and it is supported by the loan responses for large banks in the middle row of Figure 3. One concern regarding possible differences in the cyclical properties of demand for the two types of business loans is that drawdowns on existing commitments can increase significantly in response to a monetary tightening due to substitution between commercial paper and backup credit lines. After all, credit lines provide both backstop liquidity and stickier interest rates to borrowers. This substitution effect, however, does not seem to prevent loan demand from being comparable across loan types for large banks, at least in the short run. At the same time, this effect can explain the difference in the utilization of loans under commitment across bank size since small firms typically do not have a need to back up paper issuances.[13]

[12] A possible reason might be, for example, the different utilization of credit lines by smaller firms which usually borrow from small banks.

[13] It is worth mentioning that credit lines in general can potentially condition a bank's ability to supply new credit. In particular, not only commercial and industrial firms but also financial intermediariaries in

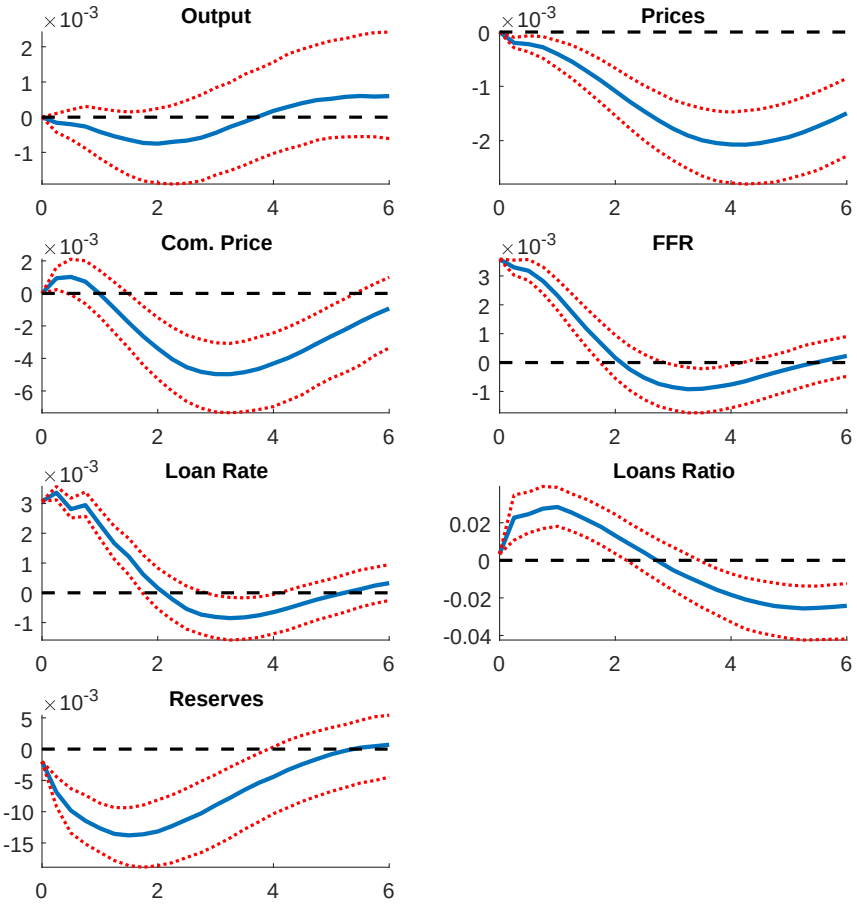


Figure 4: Responses to a one s.d. monetary shock - VAR model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

Figure 4 illustrates the responses for a VAR specification in which the ratio between spot loans and loans under commitment replaces the two loan aggregates for large banks. We find a statistically significant negative response of the ratio only in the medium to long run. The median response becomes negative after three years from the shock. The eventual fall of the ratio is the result of a drop in spot loans, while drawdowns from credit lines remain significantly positive; this is consistent with what we would expect if the bank lending channel were in place. On the other hand, we do not find support for the channel in the shorter run, as the response of the ratio is significantly positive because of the large response of spot loans. We further discuss this point and its interpretation in relation to the bank lending

the shadow banking system can rely on bank credit lines to secure backstop liquidity. This demand from the shadow banking intermediaries is described in Pozsar, Adrian, Ashcraft, and Boesky (2013) and theoretically accounted for in Geanakoplos (2010) and Luck and Schempp (2015). Duca (2016) makes this point more relevant documenting the increasing size of the shadow banking sector.

channel in Sections 4.3 and 4.4. Finally, we note that the responses of the other variables in the model are not affected by the change in specification we employed in this exercise.[14,15]

4.3 Bank Lending Channel: The Loan Maturity Dimension

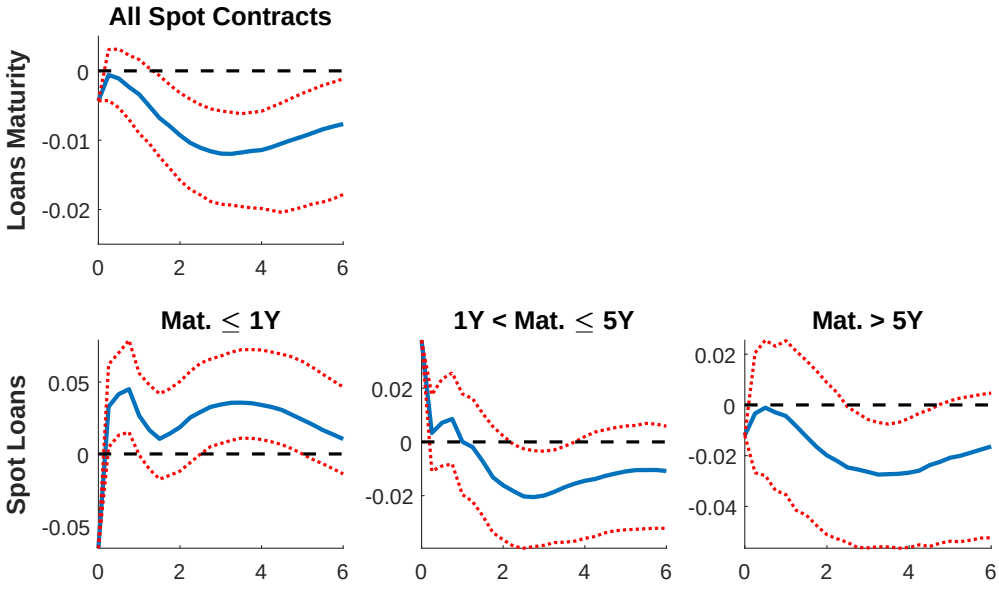


Figure 5: Responses to a one s.d. monetary shock. Top Row: response of average maturity from a VAR specification in which the average maturity of spot loan originations by public firms from DealScan replace loan volumes. Bottom Row: responses of spot loans originated by public firms from a VAR specification with loan volumes partitioned by maturity in three groups: short term loans – with maturity shorter than 1 year; medium term – maturity between 1 and 5 years; and long term – greater than 5. Years from the shock on the x-axis. Sample 1988:1 - 2007:2.

The response of spot loans warrants further investigation, especially given the short-run increase in the loan ratio that resulted from our previous VAR analysis, which seems at odds with the credit contraction predicted by the bank lending channel. In this section, we

[14]The response of the ratio of spot loans to loans under commitment is significantly negative when earlier years are included in the estimation sample (starting, for instance, in 1979). This specification uses loans for all banks since, as we recall, the partition of loans by bank size is available only after 1983. Based on our discussion above, however, it would be harder in this case to defend the assumption of uniform demand across loan types. Even though the observed composition of the loan aggregates would suggest this result is driven mostly by large banks loans, we can only take this as suggestive evidence in favor of the bank lending channel. The lack of information by bank size pre-1983 does not allow us to verify such conjecture more unambiguously.

[15]The ratio analysis for the small banks case is reported in Figure A4 of the Appendix. Not surprisingly, given the negative demand for loans under commitment illustrated in Figure 3, the response of the ratio is largely positive and significant at any point in time and we do not find any support for the bank lending channel from small banks. We do not have a clear interpretation of this result and we think it requires further investigation.

illustrate how banks can implement a contraction of credit supply operating on dimensions of lending other than just amount. In this respect, we sustain that the sole information about new originations of loans might neglect important aspects of the overall dynamics of loan supply, making volume data less effective for the identification of a bank lending channel. We proceed in two steps: we first explore the adjustment in loan maturity, and then we compare spot loan movements to the responses of other funding with comparable characteristics, namely bonds issued on the capital markets.

We study the role of loan maturity in the supply of credit in Figure 5. Since the STBL data do not provide sufficiently detailed information on loan maturity for our analysis, we resort to syndicated loans from the DealScan dataset. Although the two sources present some differences (as we discussed in Section 3.2), we maintain our analysis consistent across the two datasets by focusing on spot loans secured by public firms, under the implicit assumption that their loans are more likely supplied by large banks.

The top row of Figure 5 illustrates the response of the average maturity of spot loans originated by public firms. In this VAR specification, average loan maturity replaces loan volume in the financial block Z_t. The response shows that following a monetary tightening loan maturity drops, though not significantly, on impact and it then significantly falls for an extended period of time afterwards. The shortening of maturity entails a shift in the distribution of loan originations towards facilities with shorter maturities, as we show in the next row. The bottom row of Figure 5 corresponds to a VAR model where the financial block Z_t includes three series of spot loan volume corresponding to contracts with maturity under a year, between one and five years, and over five years. The responses of volume of these groups make evident the progressive migration of loans towards shorter maturities.

Three observations are noteworthy. First, the response of long term loans is always negative, and significantly so after two years from the shock. Second, at the beginning of the response horizon, all loans with maturity shorter than five years increase; however, the substitution of loan maturities progressively involves only the very short maturity group. After two years from the tightening shock, the response of the medium term loan group is also significantly negative, while that of the short term group remains significantly positive. Third, we can link this result to the responses of large banks documented in Figure 3 and conclude that the increase in spot loans is likely to be driven by short term loans only, whereas long term loans do follow the behavior predicted by the bank lending channel.

We turn next to the analysis of non-convertible bonds issued by public firms, which offer a point of reference for our analysis on bank lending. Non-convertible bonds, as spot loans, offer immediate liquidity to the issuer, which makes these two sources of funding close substitutes. We find that the response of bonds to monetary shocks is broadly consistent with the picture seen for the loan market. Figure 6 reproduces the results of Figure 5 for the bond market. All information for bonds is drawn from the SDC Platinum dataset, which is described in detail in Section 3.2. The average maturity of bonds, as reported by the top row of Figure 6, exhibits a negative response that is always statistically significant for six years after the shock. Bond maturities migrate from long to short term too, although an important difference is found in the dynamics of long term bonds. The response of bonds with maturity below five years is positive and strongly significant.[16] Long term bonds respond

[16]We consider all maturities together since the share of the maturity group shorter than one year is

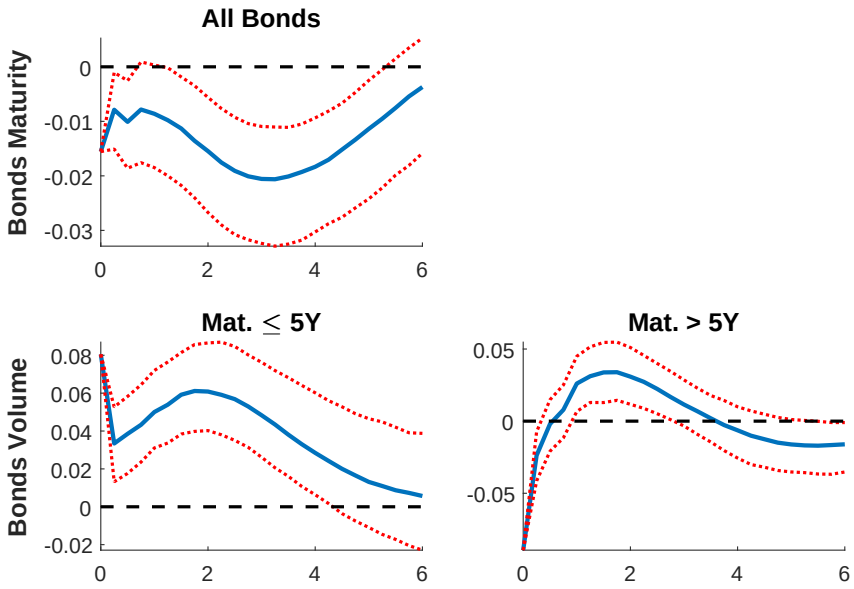


Figure 6: Responses to a one s.d. monetary shock. Top Row: response of average maturity of all bonds from a VAR specification in which the average maturity of non-convertible bonds from SDC Platinum replaces loan volumes. Bottom Row: responses of bond volumes from a VAR specification with bonds partitioned by maturity in two groups: short and medium term – with maturity shorter than 5 years; and long term – maturity greater than 5 years. Years from the shock on the x-axis. Sample 1988:1 - 2007:2.

with a very large drop on impact, but they temporarily turn significantly positive over the medium horizon, before finally falling again in the long run.

Although they depict similar effects to those reported in Figure 5 for the loan market, these responses of bond volumes appear to be less contractionary. We exploit the differences between the two markets to further identify a restriction in banks' lending in response to a monetary shock. The identification strategy is based on the same principles we adopted when we discussed the ratio of spot loans to loans extended under commitment. We take a drop of the ratio between spot loans and bonds to be indicative of a supply-side contraction of bank loans consistent with the effects of a bank lending channel. The maintained assumption is, once again, that firms' demand has uniform properties across these two types of funding. We argue we have an even tighter test in this case, because we compare spot loans secured by public firms to bonds issued in the capital market predominantly by public firms. In addition, both of these sources of funding are secured by firms for immediate use. Thus, satisfy the same liquidity need. Finally, we also improve the matching between funds by limiting the analysis to loans and bonds with maturity shorter than five years, so we control for the shifts in maturities discussed above.

The results are reported in Figure 7, where we consider a VAR model that includes loans under commitment for large banks and the ratio between spot loans to public firms and bonds. This model otherwise preserves the same statistical framework as the VAR

negligibly small for bonds.

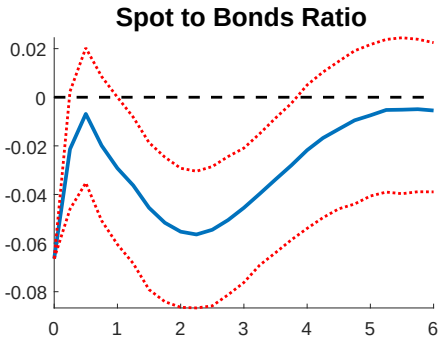


Figure 7: Response to a one s.d. monetary shock - VAR model specification with loans under commitment for large banks and the ratio between public firms spot loans and bonds, both with maturities shorter than five years. Loans under commitment are from the STBL dataset; spot loans are from DealScan; bonds from SDC Platinum. Years from the shock on the x-axis. Sample 1988:1 - 2007:2.

for large banks in the second row Figure 3, and it allows us to test for the bank lending channel effect with a simple modification of that main model. The response of the spot loans to bonds ratio is large, negative, and strongly significant, which provides support to the bank lending channel cause. At the same time, the responses of the other variables, especially the drawdowns from commitments, remain largely unaltered (as illustrated by A7 in the Appendix). The strategy we adopt to identify supply-side effects and the results we obtain are a natural and consistent extension of the approach proposed by Kashyap, Stein, and Wilcox (1993), which is also based on the comparison of loans with external funding opportunities. By comparing bank loans to commercial paper, instead of bonds, they too show that the supply of bank loans is more negatively affected by a tightening shock, and they argue this is evidence in favor of the bank lending channel.

4.4 Discussion of the Results

The evidence in the previous Sections points to a way banks can restrict loan supply, namely by shortening maturities of loans in combination with rising interest rates, that could not be simply uncovered in a basic analysis of loan volumes. In this section, we discuss some underlying mechanism consistent with the supply contraction interpretation and provide some more evidence in favor of it.

A suitable interpretation of these results is that firms keep demand for their loans relatively high in response to a monetary contraction, as suggested by Bernanke and Gertler (1995), since they experience inertia in their funding needs for working capital or they expect further interest rate hikes after a shock as monetary tightenings are typically implemented by gradual increases of the policy rate. On the other side of the market, banks continue to satisfy the funding demands from firms facing deteriorating market conditions, and opt for modifying other terms of the overall loan supply. This interpretation would be also consistent with the conclusions of previous studies, such as Black and Rosen (2016), who use STBL data at disaggregated level and show that banks prefer to rapidly reduce the maturity of their lending rather than cutting back on quantities in response to a monetary tightening,

and Morgan (1998), who argues in favor of the contraction of overall credit supply by showing that bank lending standards are concurrently tightened during a monetary restriction. More recently, Dell'Ariccia, Laeven, and Suárez (2017) also show that banks tighten (loosen) credit conditions when monetary policy is tight (accommodating) using disaggregated STBL data. This result is also consistent with the view in DSY that banks would shift towards a portfolio of loans with shorter maturities following a monetary contraction (in their case, towards C&I loans and at the expense of real estate loans) since they provide relatively safer assets with higher short-term interest rates. Finally, Correa, Paligorova, Sapriza, and Zlate (2017) document a similar shift towards safer assets studying cross-border bank flows in response to monetary innovations.

To substantiate this interpretation we explore the role of bank loans in funding working capital, especially inventories, as a possible explanation for the increase in spot loans in the short-run after a monetary tightening and for the substitution of short-maturity for long-maturity loans. Since firms often borrow to finance the accumulation of inventories, Bernanke and Gertler (1995) conjecture, a positive response of C&I loans to a monetary tightening would still be consistent with a contraction in C&I lending if inventories rose after a monetary shock shifting up the demand for loans. Similarly, trade credit could have the same effect on the C&I loans response. The need of firms to fund delayed payment of accounts receivable from (or extend trade credit to) liquidity constrained firms could be more pressing following a tightening shock. The rise in shorter term bank spot loans and market securities issuance we observe would be compatible with an inventory effect for short-run debt, while the eventual decline in longer-term bank loans and securities issuance can be explained with a drop in long-run investment.

We test for this conjecture adding aggregate private inventories and investment to the macroeconomic block of variables in the VAR model for large banks in Figure 4. Figure 8 considers a model with the inventories to investment ratio, which captures the relative substitution of funding purposes over time. The response of the ratio is positive and significant in the short-run; it then turns negative after three years from the shock. This response is consistent with the funding mechanism discussed above. A further corroboration of this interpretation is provided by the individual response of inventories from a model in which inventories are included in place of the ratio; for brevity here, we report it in Figure S10 of the online Appendix. The response of inventories is strongly positive in the first two years, and is arguably the driver of the short-term response of the ratio.

An indirect support of this interpretation is also provided by the differences in the spot loan response in the large and small bank models in Figure 3. The increase in loans is significant and persistent only among large banks and, by association, large firms; while it is not so among small banks – small firms. Following a tightening, large firms are more likely to face increasing needs of funds to finance trade with smaller firms, usually more credit-constrained, which would contribute towards explaining the differing responses. As mentioned above, DSY argue that the supply of C&I loans actually increases following a tightening because banks might shift the composition of their portfolios towards loans with shorter maturities, primarily moving out of mortgages and into C&I loans. Although we do not explicitly investigate this possibility, our results on maturity migration are compatible with banks not only moving from mortgage loans to C&I loans to hedge their positions, but also moving towards shorter maturities within the latter group of loans.

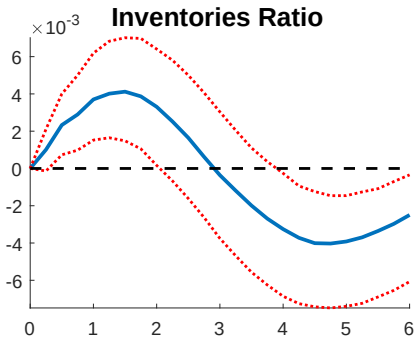


Figure 8: Response to a one s.d. monetary shock - The inventories to investment ratio is added to the VAR model specification with the spot loans to loans under commitment ratio for large banks. Loans under commitment are from the STBL dataset; spot loans are from DealScan; private (non-farm) inventories and private domestic investment are from FRED. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

Interestingly, our finding on shortening maturities has echos of previous works in the literature on runs on financing instruments, such as the Gorton and Metrick (2012) 2008-2009 run on the repurchase agreement (*repo*) market. Gorton and Metrick (2012) find that investors in the repo market, worried about potentially insolvent counterparties, effectively reduced credit supply by raising the haircuts on collateral. Haircuts are meant to promote solvency and play in securitized banking a role equivalent to that of reserves in traditional banking. Hence, in times of higher counterparty risk, creditors in the repo market not only raise spreads to reflect higher credit risks, but also raise haircuts to secure adequate hedging of their positions. Similarly, we show that banks curtail credit supply in response to a monetary tightening not only by raising interest rates, but also by shortening loan maturities. As in Gorton and Metrick (2012), also in our study, shortening maturity, in combination with raising interest rates, likely reflects a bank's response to rising counterparty risk for two reasons.[17]

First, notice that increases in loan rates raise the cost of both *existing* and *new* debt, which can in time lower the likelihood of loan repayment, heightening credit risk. For instance, increasing costs of existing debt with variable rates can induce moral hazard and entrepreneurial risk-taking, ultimately making loan repayment less likely (Jaffee and Russell, 1976). Furthermore, increasing costs of new debt can lower the creditworthiness among the pool of prospect borrowers, aggravating adverse selection problems (Stiglitz and Weiss, 1981).[18] Second, prospect lenders can foresee these potential problems, reducing the demand for corporate liabilities and making debt rollover increasingly more difficult for borrowers, thus reinforcing the increasing credit risk spiral (a process akin to that in He and Xiong, 2012). In these cases, monitoring costs and probability of default increase, and shortening debt maturity is a device banks can resort to in order to reduce exposure to counterparty risk by increasing the frequency of screening, thus palliating problems that stem from asym-

[17] Also closely related to this insight is the work by Covitz, Liang, and Suárez (2013), who document that the 2007 run on the asset-backed commercial paper market (ABCP) entailed both a spike in spreads and a fall in maturity of ABCP programs, particularly among those with riskier characteristics.

[18] For more detailed discussions on this topic see Freixas and Rochet (2008) and Tirole (2006).

metric information and moral hazard.[19] The empirical mechanism we describe here finds a rationale in Diamond (1991), whose agency-based analysis predicts that risky-enough firms with private information about their future conditions and whose projects offer rents that cannot be contractually assigned to lenders will be constrained to borrow short-term. Goyal and Wang (2013) highlight the supply-side nature of this maturity restriction and Barclay and Clifford W. Smith (1995) and Stohs and Mauer (1996) provide empirical support to it.[20]

5 Post Great Recession Analysis

In this Section we conduct a final exercise to investigate whether the transmission mechanism described so far also holds in the post Great Recession period. This question is of particular interest in light of the unprecedentedly large financial shocks that hit real and financial markets between 2007:3 and 2009:2 and the switch of the Federal Reserve from conventional to unconventional monetary policy instruments once the fed funds rate reached the zero lower bound, which possibly entail a shift in the way monetary policy affects the economy and the loan market.

The empirical strategy we propose for this exercise consists of modelling the period following the Great Recession as a distinct policy regime and fit our VAR model on the sample 2009:3-2017:1. The impulse response functions of this model can be then formally compared to those from the pre-crisis regime in order to test for a structural shift in the policy transmission mechanism (see Bianchi, Lettau, and Ludvigson, 2017, for a similar application). This strategy aims to preserve the linear structure of the VAR model adopted in the main analysis, but at the same time acknowledges the possibility of non-linear dynamics of the economy during the years of the recent financial crisis. For this reason, the Great Recession remains out of the sample of the regime shift, provided that it would require some ad-hoc non-linear approach to be correctly modeled.[21]

[19] The rationale that shorter debt maturity entails more frequent scrutiny and a higher level of monitoring is well established in the literature, particularly in cases of asymmetric information. For instance, Datta, Iskandar-Datta, and Raman (2005) reason that self-interested managers would prefer longer debt maturity in order to reduce the frequency of external scrutiny and lower monitoring, while Lin, Ma, Malatesta, and Xuan (2013) argue that owners with significant divergence between control and ownership would also prefer longer maturity to avoid monitoring.

[20] In line with this argument of credit supply-side restriction, it is worth noticing that our result of large firms securing more spot loans than small firms following a monetary tightening is also consistent with Bester (1985), who shows that credit rationing arising from adverse selection can be eliminated when firms have enough collateral to pledge. By the end of 2016, the largest 10% non-financial firms in Compustat Annual had a fixed asset ratio of 39% while the bottom 10% had one of 16%, which makes apparent that large firms are better equipped to pledge collateral than small firms. Also, the empirical evidence on corporate capital structure consistently shows that firms with higher asset tangibility rely on higher levels of financial leverage. For instance, this is documented among U.S. firms by Titman and Wessels (1988), among firms from developed countries by Rajan and Zingales (1995), and among firms from large panels of developed and developing countries by Fan, Titman, and Twite (2012) and Oztekin (2015).

[21] Although technically feasible, this treatment of the non-linearity of the data would be beyond the scope of this exercise. In Section S2 of the online Appendix, we show that the result about the shift in the loan market responses would be robust to including the Great Recession period in the unconventional policy regime. In this respect, our strategy could be considered a conservative choice. However, the direction of the estimated gross effects is affected by this handful of observations which have the typical impact of influential

This modeling approach finds support in the recent empirical literature dealing with the consequences of the Great Recession. Sims (2012) argues that the standard linear models do not explain the dynamics of economic and financial variables in the months around the peak of the crisis, but after that period linear models work reasonably well again, once financial markets have stabilized. He concludes that we should resort to non-linear approaches to model time-varying volatilities and their interaction with mean dynamics during this period.[22] Similarly, Wu and Xia (2016) compare the impact on the economy of their shadow policy rate in the post June 2009 sample to that of the fed funds rate prior to December 2007 using a linear VAR. Their rationale for omitting the Great Recession from the comparison is that it is very different in nature from previous recessions; their shadow rate, hence, can be used as a summary of the policy stance after the financial crisis when the "policy returned to a new normal." Ng and Wright (2013) document how recessions caused by economic shocks differ from those driven by financial shocks as the Great Recession, and they discuss the potential role of non-linear effects in prediction models. Non-linearity is explicitly taken into account by Baumeister and Benati (2013), which propose a time-varying parameter structural VAR to explore the changes in the macroeconomic impact of monetary policy during the 2007-2009 period. Francis, Jackson, and Owyang (2017), in contrast, find evidence of sufficient parameters stability across the two policy regimes for a fixed-coefficient VAR using 2008:1 as break point. Their evidence, however, is primarily focused on the interaction between monetary policy and macroeconomic variables.[23]

An important aspect to take into account when extending the analysis through 2017 is how to circumvent the zero lower bound that the federal funds rate reaches between the end of 2008 and 2015. At the zero lower bound, the identification of monetary shocks based on the policy rate would no longer be adequate. We, then, consider a number of alternative measures of monetary policy stance to replace the fed funds rate used in the VAR of Section 4. The results presented here are based on two shadow policy rates, respectively proposed by Wu and Xia (2016) and Krippner (2015), which are arguably the most popular in this empirical literature. We then try to corroborate our results with further evidence using the shadow rate from Lombardi and Zhu (2017) and the Divisia index of money.[24]

outliers on the estimation.

[22] Sims (2012) analysis is based on a monthly VAR with financial and economic variables in levels, broadly consistent with our model. It is worth mentioning that his conclusions are at odds with those by Stock and Watson (2012), who find that a linear dynamic factor model provides an adequate representation of the economic dynamics also during the crisis. The application of this model, however, requires a heavy pre-filtering of the data that might affect the results about linearity.

[23] In the context of a different framework, Dell'Ariccia, Laeven, and Suárez (2017) also study bank lending during the conventional and unconventional monetary policy periods, identifying the beginning of the unconventional regime in 2009. They use a panel model to investigate the response of loan spreads to different measures of monetary policy stance, finding a decline of spreads in response to monetary loosening in both policy regimes.

[24] Although the shadow rates should conceptually correspond to the same measure of policy stance, they differ in the way they are constructed. Both Wu and Xia (2016) and Krippner (2015) develop a shadow rate term structure model, but with different solution methodologies. The Wu-Xia shadow rate employs an analytical approximation to a multifactor term structure model and it can be applied directly to discrete-time data, while the Krippner rate is derived from a continuous time approximation that requires numerical integration and simulation methods. Lombardi and Zhu (2017), on the contrary, construct their shadow policy rate from the factors of a dynamic factor model that summarizes the information of a set of variables

The main result we find is clear evidence of a significant and robust structural downward shift in the responses of business loans to a tightening monetary shock with respect to the pre-recession sample. In terms of the monetary loosening shocks that were extensively observed during this period, this result implies relatively more expansionary effects of loosening shocks on business loans under the unconventional policy regime. It must be noted, however, that we also show that the choice of the policy measure adopted in the analysis bears important implications for some of the other conclusions. In particular, the responses of spot loans and loans under commitment in the post Great Recession regime specifically depend on the chosen policy measure. Moreover, the monetary shocks identified relying on these policy measures can generate contradictory responses for other variables in the model too. The difficulty of discriminating ex-ante between these plausible alternative measures strongly limits our chances of coherently interpreting the effects of the post-recession monetary policy on the business loan market. For this reason, the discussion on the post-recession policy transmission mechanism in the second part of the next Section should be deemed as suggestive rather than conclusive.

5.1 Results

The following results are based on VAR(1) models in which the term structure slope, measured by the spread between the ten-year and the three-month maturity Treasury rate, substitutes the loan rate of the baseline specification. We cope with the shorter sample by reducing the lags of the VAR, while the term structure slope helps us to better characterize the monetary policy stance when unconventional strategies based on large-scale security purchases are predominant. The identification scheme of monetary shocks is also adjusted by allowing the Fed to contemporaneously respond to shocks to bank reserves.

This modification of the identification scheme is justified by the different structural role played by reserves in this period. Before the crisis, reserves were almost exclusively composed by required reserves, moving in tandem with the monetary base. The predictability of reserves was a key part of the basic money supply multiplier mechanism. In stark contrast, during the financial crisis banks started accumulating unprecedented amounts of excess reserves since the third quarter of 2008, arguably in response to heightened risks and mounting uncertainty about future economic and financial conditions. This trend continued almost uninterruptedly through the third quarter of 2014, well after the economy had stabilized.[25] In light of the new dynamics of reserves and the repeated interventions of the Federal Reserve meant to prevent credit markets from freezing, it seems more suitable to allow for contemporaneous responses of the unconventional monetary policy measures to movements in reserves.[26]

representing different aspects of both conventional and unconventional monetary policy. Thus, this measure reflects the various aspects of quantitative easing, including the balance sheet policies that have been deployed by the Fed. The differing nature and methodologies of these measures yield series that characterize the policy stance differently. To offer a better insight into such differences, in the online Appendix we directly compare the three shadow rates in the plot in Figure S23 and report their pairwise correlations in Table S1.

[25]Reserves grew by ten times in about a quarter at the end of 2008, from 50 Billion dollars in August to 800 in December, exceeding 2.5 Trillion dollars by 2014.

[26]In Section S1 of the online Appendix, we illustrate the effects of these modifications on the pre-2008 sample. We show that the results in our main model specification are not weakened by the new identification

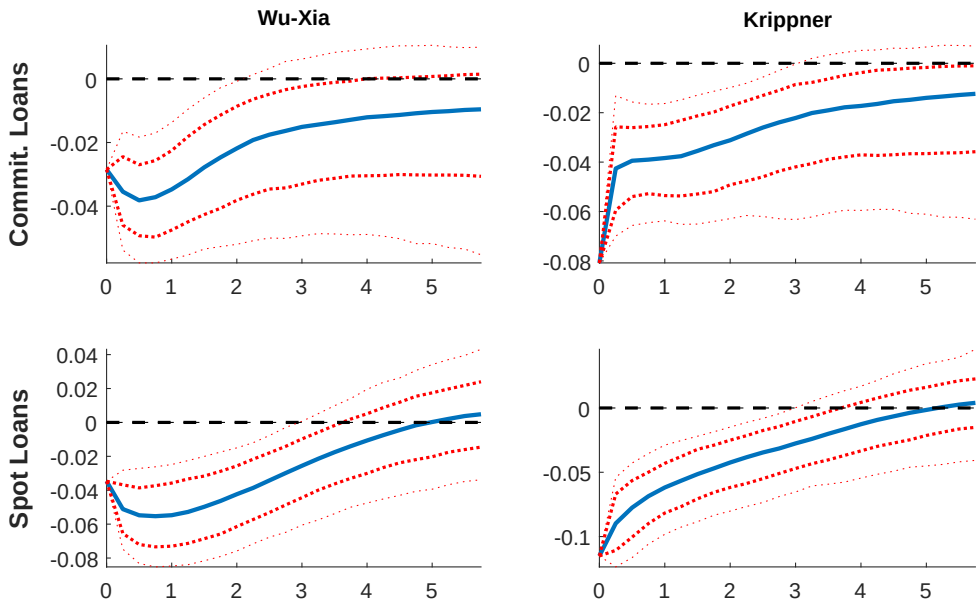


Figure 9: Shift in the Post Great Recession Loan Responses - Difference between the responses to a one s.d. shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures are the shadow rates by Wu-Xia on the left column and Krippner on the right column in the post-recession sample, and the FFR in the pre-recession sample. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Pre Great Recession sample is 1983:1 - 2007:2 and post-recession sample is 2009:3 - 2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

The main question we tackle in this Section is whether a significant shift in the response of business loans is observable after the Great Recession in conjunction with the switch to the unconventional monetary policy regime. We answer this question recurring to a test devised following the approach proposed by Bianchi (2016), in which posterior moment distributions are used to compare regimes in regime-switching models. This type of approach has been recently applied by Bianchi, Lettau, and Ludvigson (2017), for instance, to study changes in the impulse responses of a Markov-Switching VAR in which potential break points were determined externally to the model.[27]

Figure 9 illustrates the results of the test for the model with partitioned loans for large

scheme and the use of a VAR(1). Similarly, the substitution of the loan rate with the term structure slope does not alter the responses of the credit variables. We also show that similar results can be obtained using Divisia index instead of the fed funds rate. Overall, these checks give us confidence in the comparability of the models across the two regimes.

[27]The advantage of this approach with respect to a full Bayesian model comparison is that it is more flexible and allows one to directly focus on the aspects of interest of the comparison, i.e. the impulse response functions of business loans in our case. Furthermore, we can easily distinguish between the effects of the switch to the unconventional policy regime on the real economy, on the one side, and bank lending, on the other. These specific differences might not significantly emerge when the overall fit of a model is assessed, especially when large models are estimated in relatively small samples.

banks, which corresponds to the second model of Figure 3. We would get analogous results with total C&I loans though, since large bank loans under commitment closely reflect total loans – as better explained in Figure 10. The same model is first separately estimated on the two samples. Then, for each draw from the parameter posteriors of each model, we obtain the response of each variable to a one standard deviation monetary tightening shock, and subtract the pre-recession response from the post-recession one. In Figure 9, we report the posterior distribution of the response differences for loans under commitment and spot loans, with their 68% and 90% confidence bands. The model on the left panel of the Figure uses the Wu-Xia shadow rate, whereas the right panel uses the Krippner rate.

The 90% credible set of the differences is non-zero and negative in all four cases, which implies that we document a significant downward shift in the post Great Recession responses of both types of loans for both shadow rate measures. Put in other words, monetary tightening (loosening) has relatively more contracting (expansionary) effects on bank lending in the post-recession sample. This result is robust to the use of the Lombardi-Zhu shadow rate and the Divisia money-index reported in Figure S14 of the online Appendix. Figures S15-S18 of the Appendix show the test for the full set of variable of the VAR models instead.

Two observations are noteworthy. First, the shift in responses is typically significant for the financial variables, with the exception of reserves, but not for the variables in the real block of the model. This result is consistent with the analysis by Wu and Xia (2016) and Francis, Jackson, and Owyang (2017), who do not find significant breaks across samples in the basic monetary models with only real variables. Second, we observe a change in the size of the policy shocks in the post-recession sample for the Divisia index and Wu-Xia shadow rate measure. Even though these changes go in opposite directions, they confirm that shifts in volatility might be important non-linear effects to account for when modeling different regimes.

Next, we explore the characteristics of the loan responses in the post Great Recession sample in an effort to better understand the underlying reasons of the shifts we document in Figure 9. Figure 10 replicates the results of the first two models of Figure 3 for the new sample given a tightening shock on the Wu-Xia (left) and Krippner (right) shadow policy rates. The top row of the Figure illustrates the response for the model with total C&I loans; the two bottom rows, the responses corresponding to the model with partitioned loans for large banks.

Two main results are apparent. First, as documented for the pre-recession sample, the loans issued under commitment explain the bulk of the response of total C&I loans here too. This is not unexpected, since the bank loan market in this period becomes even more dominated by lending under commitment from large banks, which grows to represent over 90% of total business loans (see Figure 1). For this reason, we can safely focus on large banks in the analysis of the shift above. Second, the positive loan response to a monetary tightening disappears in the post Great Recession sample. All the responses are now significantly negative, with the exception of the response of spot loans in the Wu-Xia specification which, however, is not significant.

These results point to a demand-driven type of transmission mechanism of monetary shocks. In response to a tightening, firms reduce the use of their available commitments in clear contrast with their behavior before the Great Recession. A couple of interpretations of this change in response are possible. For instance, in an environment with high

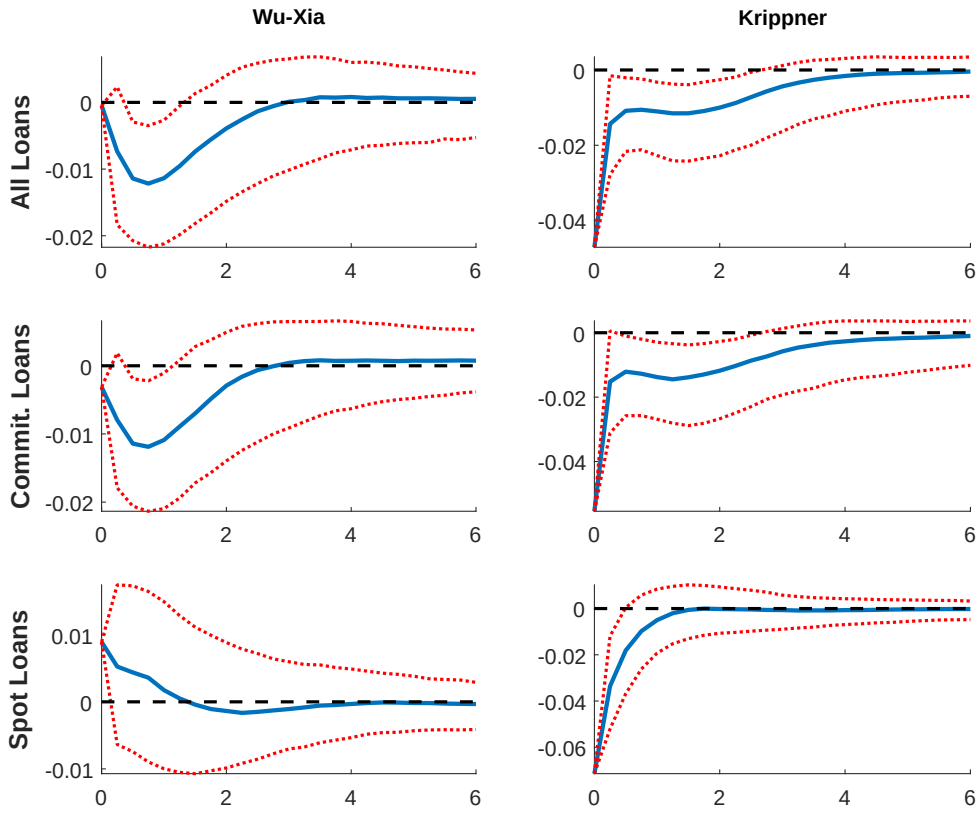


Figure 10: Post Great Recession - Responses of loans to a one s.d. shock to the shadow rate policy measure. The shadow rates are by Wu-Xia on the left column and Krippner on the right column. Top row model: VAR(1) with total C&I loans, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Bottom two rows model: VAR(1) with partition between spot loans and loans under commitment for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Sample 2009:3 - 2017:1.

economic uncertainty and deflationary concerns, a monetary tightening increases the uncertainty about a future recovery and can induce firms to postpone activities such as hiring or investing in new projects, both of which would require additional funding. Furthermore, in an environment in which the government is committed to provide liquidity to the financial system and maintain low costs of funding in the medium- and long-term, firms could have an incentive to refrain from immediately drawing down on their existing commitments in spite of observing a tightening shock today.[28] This borrowing behavior would contrast with that observed during normal times when, facing a tightening, firms would rather draw down on existing commitments and take advantage of still relatively low cost of debt before further

[28]In fact, the Federal Reserve made significant efforts to maintain rates low in the medium- and long-term via its large-scale asset purchases programs during the post Great Recession, particularly with the Quantitative Easing programs. As a result, the 10-year Treasury constant maturity rate has remained on or below 3% since July, 2011.

tightenings follow – as our pre-crisis analysis shows.

A clearcut interpretation of the spot loan responses is more difficult. For instance, in the context of our identification strategy based on the ratio of spot loans to loans under commitment, the large negative response of spot loans in the Krippner specification would indicate a supply-side contraction consistent with the bank lending channel, while the Wu-Xia specification would suggest an increase in supply. With respect to this point, we must notice that important differences between the two specifications are not limited to the spot loans, but they actually extend to other variables of the model as well. For example, the response of GDP to the Krippner shock is positive and significant in the short term, which casts some doubts on the correct identification of monetary shocks by the model with this specific policy measure. Similarly, it is difficult to make a sense of the opposite sign of the response of the term structure slope in the two cases. These responses are reported in Figures S19-S20 of the online Appendix.

Extending the analysis to the other two measures of policy stance for robustness (Figures S21-S22 of the online Appendix), we find an even broader set of combinations of responses. With the Lombardi-Zhu shadow rate, for instance, the response of loans under commitment becomes actually positive. The dependence of the responses on the adopted measure of policy stance prevents us from finding a coherent interpretation of the transmission mechanism that provides a rationale of the shift in responses in the post-recession period. Without a convincing way to determine which shadow rate represents the unconventional monetary policy regime more reliably, our evidence is necessarily not conclusive.

6 Conclusion

This paper contributes to the literature on the transmission of monetary policy with an analysis of subtle aspects of the transmission mechanism working through business loans across different contract and borrower-lender types. In the process, we provide a plausible interpretation of some seemingly puzzling empirical results for the responses of business loans to monetary tightening that are typically found in the literature of conventional monetary policy.

In the first part of the paper we illustrate three main points. First, we show that the puzzling responses of the C&I loans to a tightening shock found by DSY can be explained by loans extended by large banks (by extension, to large firms), which display sensibly different lending dynamics from small ones. We argue that the increase in loans is likely explained by demand-side effects that prevail despite the tightening of credit conditions. These effects are in large part due to firms drawing down on their existing credit lines. Second, using the response of the ratio of spot loans to loans extended under commitment among large banks, we find evidence in favor of the bank lending channel only in the medium and long term. In the short term, the response of loans contradicts what we would expect from a standard bank lending supply-side contraction, where interest rates and volumes are the key observable cogwheels of the transmission channel. Third, we show that restrictions in bank lending supply can, however, occur on dimensions other than rates and volumes. In particular, banks can adjust the overall supply of loans by reducing their average maturity, as they progressively substitute long-term loans with short-term ones. This is a means to

effectively curtail maturity transformation and loan supply in response to the tightening. Concurrently, firms use this short-term funding to finance rising inventories that typically follow monetary tightenings.

The main point we aim to convey is that adjustments in the overall lending supply can be achieved in multiple ways, and can sometimes result in a slow process. This has direct implications for monetary policy making and the correct timing of implementation and assessment of policy decisions. Nevertheless, ours is merely a first step in this type of analysis. More data and further investigation are necessary to better understand the noticeable differences in the responses of loans supplied by small banks for example. Our findings on inventories and further preliminary work of ours suggest that the corporate purpose – or intended use – of loans can play a significant role in shaping business credit responses. We consider this dimension of bank credit a promising topic for further research on the empirical aspects of monetary policy.

The last part of the paper studies the transmission mechanism during the post Great Recession era, when monetary policy switches to an unconventional regime. The federal funds rate, stuck at the zero lower bound for most of this period, needs to be replaced in our analysis with an indirect measure of monetary policy stance. Our contribution to the literature in this respect is twofold. On one hand, we consider a set of competing measures of monetary policy stance and document that the responses of business lending depend on the measure in use. On the other hand, we document that, regardless of the policy measure in use, the responses of C&I loans to a tightening significantly shift downwards relative to the conventional period. This suggests that monetary tightening (loosening) has stronger contracting (respectively, expansionary) effects on business lending under this new regime. Although the recession caused by the financial crisis formally ended by mid-2009, the economy still faced considerable uncertainty for most of the following years. Whether this is a permanent shift in the way loan markets respond to monetary policy or simply the prolonged, but temporary, consequence of those extremely large financial shocks and unconventional policies is still a very open question.

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Appendix

A Additional Figures

We use this Appendix to illustrate the full set of impulse response functions for the VAR models discussed in Section 4 of the main body of the paper.

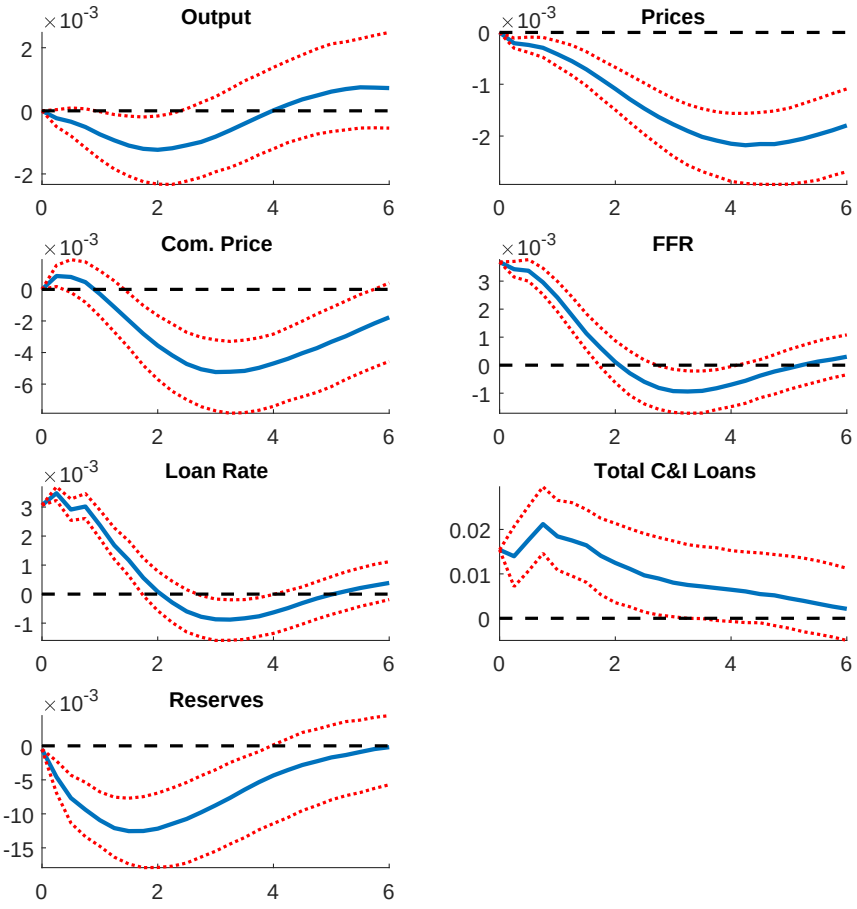

Figure A1: Responses to a one s.d. monetary shock - VAR model with total C&I loans for all domestic banks from STBL dataset. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

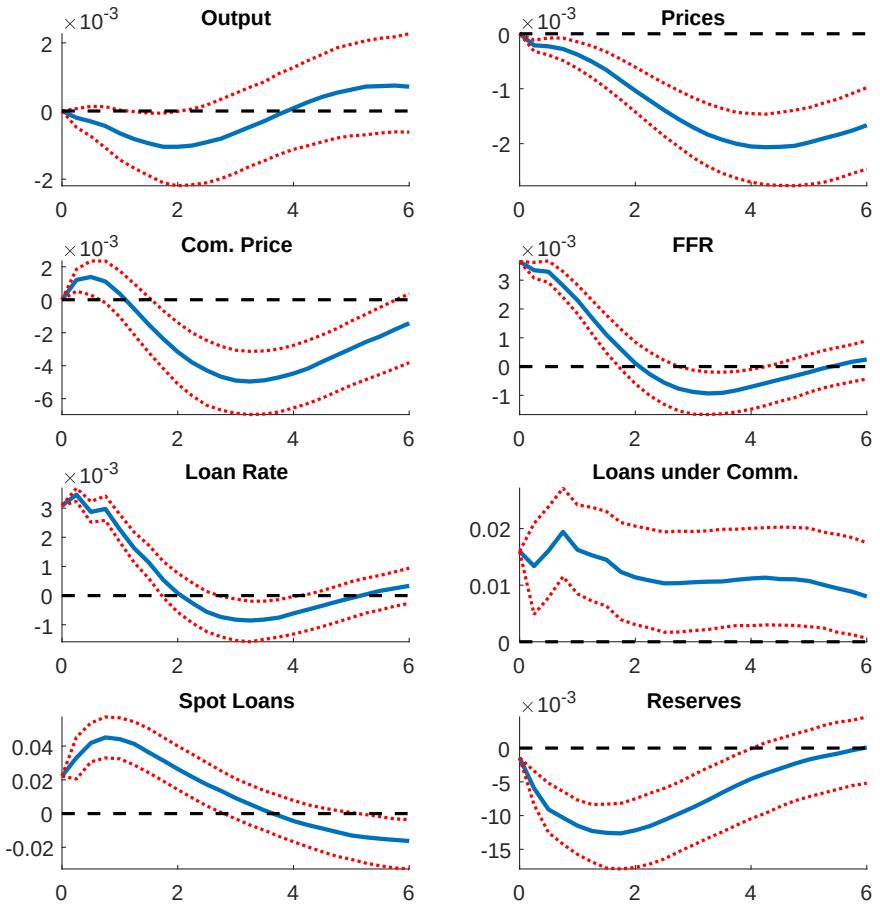

Figure A2: Responses to a one s.d. monetary shock - VAR model with loans under commitment and spot loans for large domestic banks from STBL dataset. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

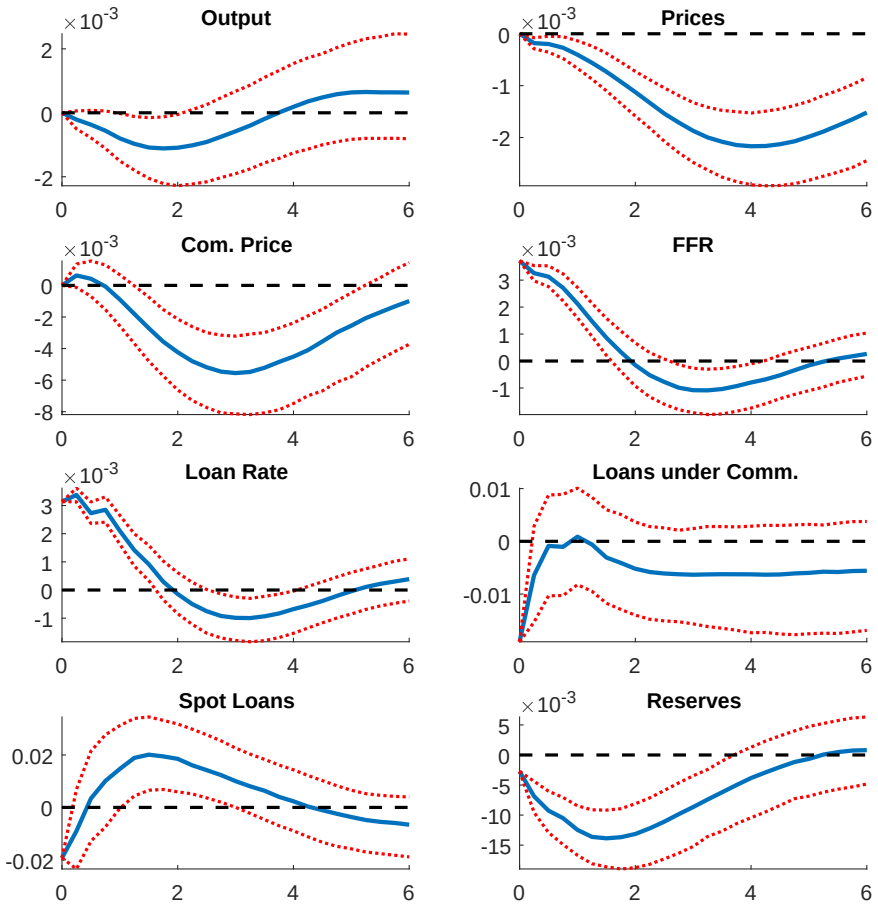

Figure A3: Responses to a one s.d. monetary shock - VAR model with loans under commitment and spot loans for small domestic banks from STBL dataset. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

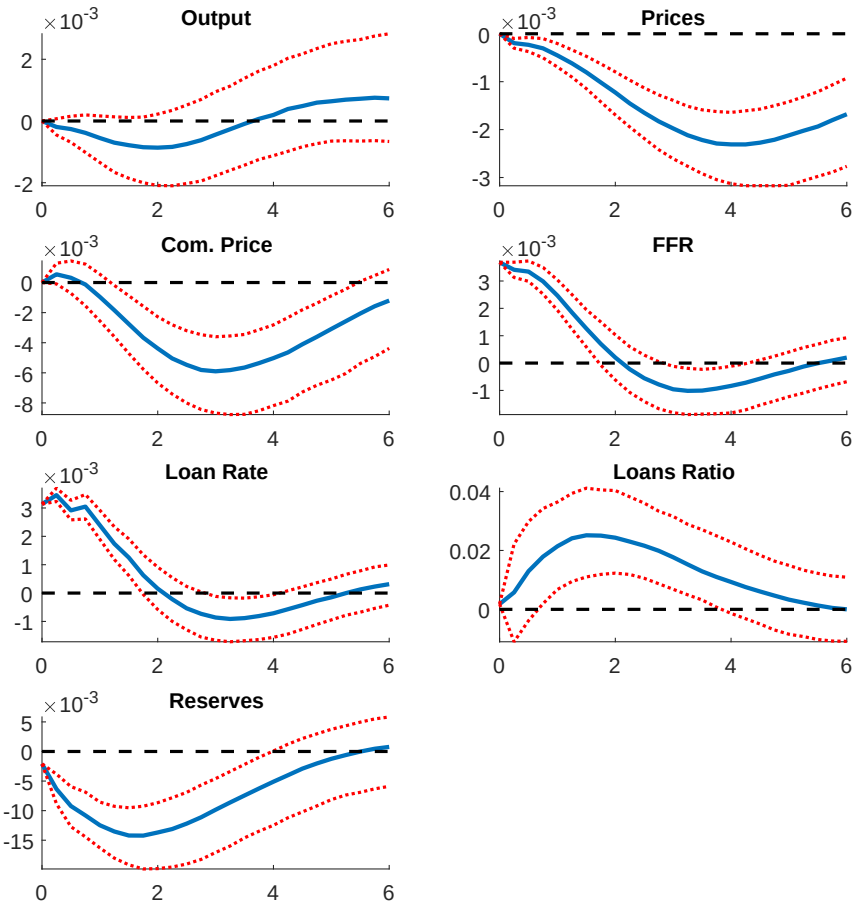

Figure A4: Responses to a one s.d. monetary shock - VAR model with the ratio between spot loans and loans under commitment for small banks from the STBL dataset. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

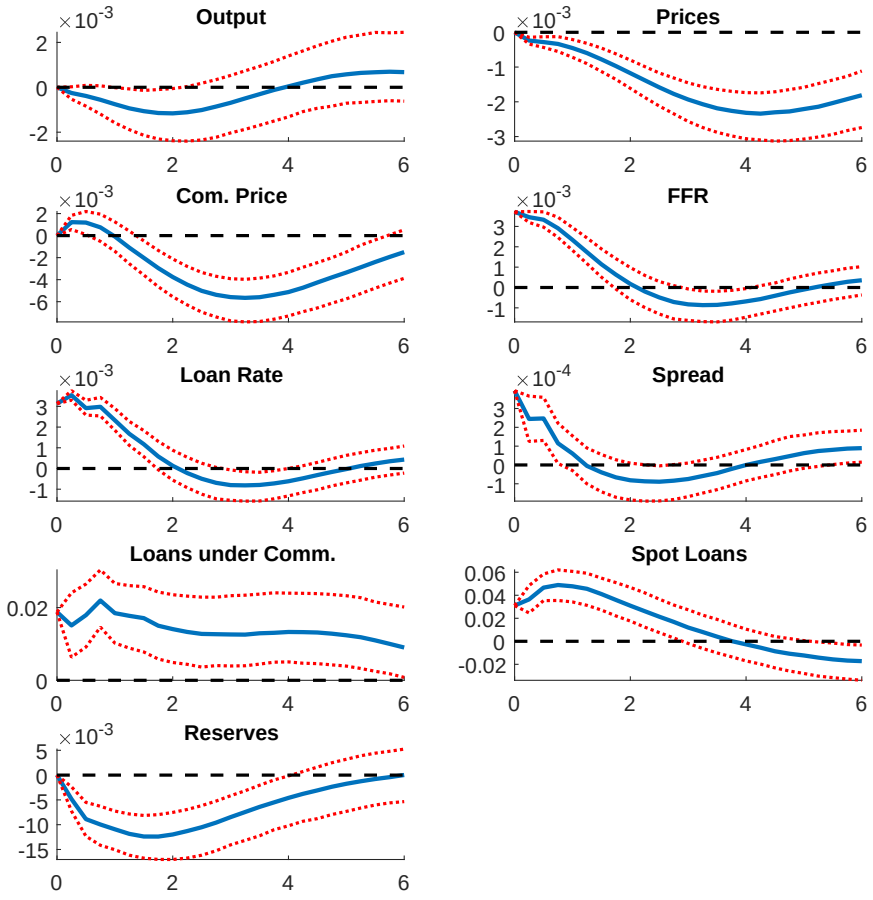

Figure A5: Responses to a one s.d. monetary shock - VAR model with loans under commitment and spot loans for large domestic banks from STBL dataset. Specification with the spread between a three-month AA commercial paper rate and the three-month Treasury constant maturity yield. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

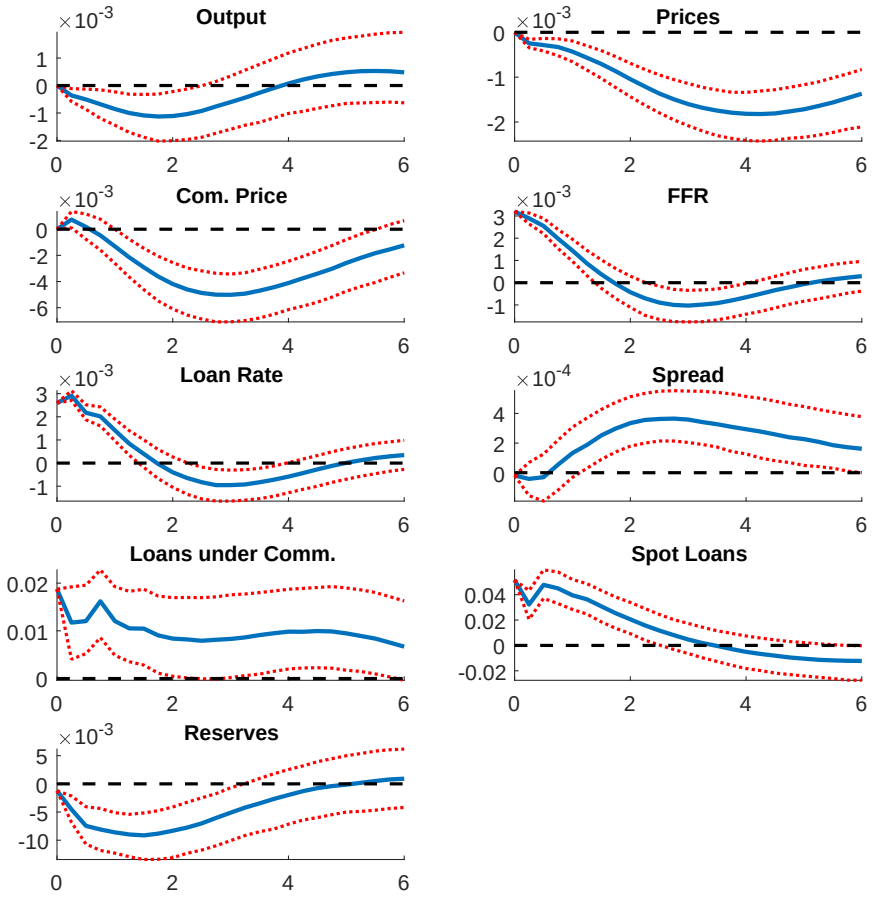

Figure A6: Responses to a one s.d. monetary shock - VAR model with loans under commitment and spot loans for large domestic banks from STBL dataset. Specification with the spread between the Moody's seasoned Baa corporate bond yield and the ten-year Treasury constant maturity rate. Years from the shock on the x-axis. Sample 1983:1 - 2007:2.

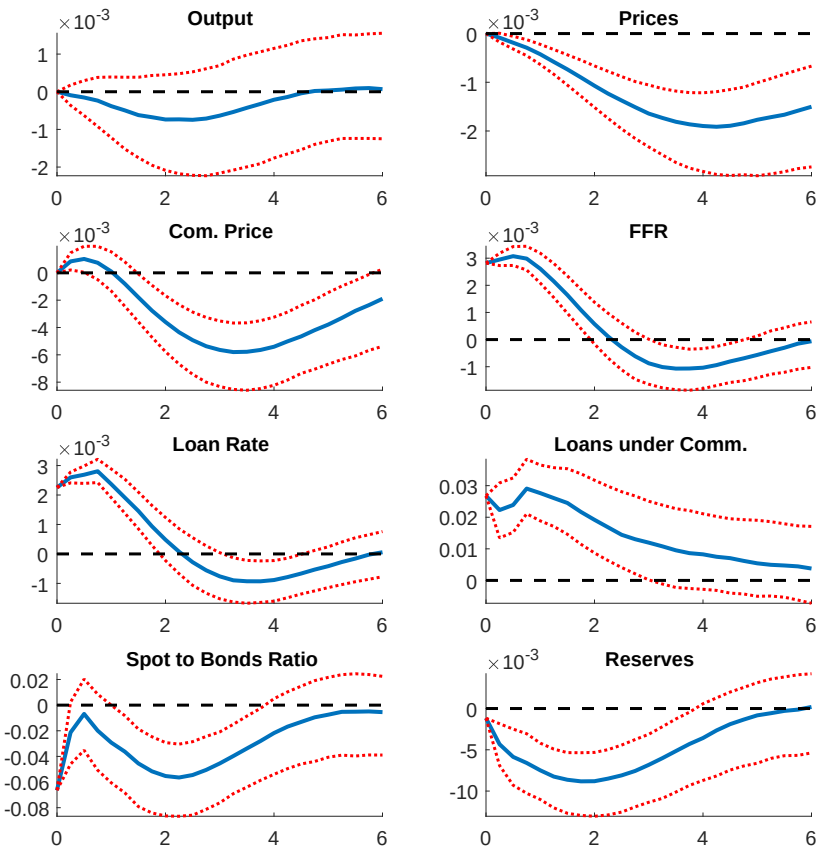

Figure A7: Responses to a one s.d. monetary shock - VAR model with loans under commitment for large banks and the ratio between public firms spot loans and bonds, both with maturities shorter than five years. Loans under commitment are from the STBL dataset; spot loans are from DealScan; bonds are from SDC Platinum. Years from the shock on the x-axis. Sample 1988:1 - 2007:2.