Business Loans and the Transmission of Monetary Policy

Internet Appendix

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Abstract

This document provides additional material to the submitted version of our paper *Business Loans and the Transmission of Monetary Policy* and it is meant for online publication in support to the analysis in the main manuscript. Section S1 includes robustness checks for Section 4 of the main manuscript, while section S2 does the same for Section 5 of the main text. In Section S3, we propose an exercise meant to investigate the impact of the liquidity programs provided by the Federal Reserve during the financial crisis on the transmission mechanism of monetary policy with a focus on the bank loan market.

S1 Robustness of the Main Results (Sections 4.1-4.4)

This Section of the Appendix reports important robustness checks for the main results of the paper for the pre-Great Recession sample in Sections 4.1-4.4. It also provides some useful comparison for the specifications adopted in Section S2 below.

The main empirical results about loan volumes reported in Figures 3 and 4 of the paper are very robust to a broad set of changes in the specification of the model. In Figures S1–S12, we illustrate the impulse response functions of the model for large banks, mostly using the ratio specification corresponding to Figure 4 for the following cases.

1. A VAR(1) model in which we use one lag instead of four is reported in Figure S1. We see that the dynamics of the ratio is not particularly affected by the number of lags.

2. A model with the term structure slope replacing the average loan rate and using four lags in Figure S2. This model is the benchmark for the use of this term structure variable in the post-Great Recession sample. We find that the main result about the spot loans to loans under commitment holds.

3. A model that reflects the main specification used in the post-recession analysis of the paper with: one lag, term structure slope, partitioned loans, identification scheme in which reserves are ordered before the fed funds rate. In Figure S3 we see that all these changes do not alter the main trajectories of loan responses.

4. Some robustness checks for the results discussed in Section 4.1 of the paper, in which the following two spread measures are included in the model in order to control for possible substitution between bank loans and market debt among publicly traded firms: the spread between the 3-month AA commercial paper rate and the 3-month Treasury constant maturity rate; the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. The models considered correspond to the specification with the ratio of spot loans to loans under commitment and the ratio of spot loans to bonds, alternatively. Figures S4–S7 confirm the results reported in the paper for the partitioned model (see Figures A5 and A6).

5. A robustness check for the ending quarter of the sample in the basic ratio model. We can extend the sample through 2008:1 and obtain virtually the same results. However, including the next couple of observations we find that the model is not invertible anymore and the estimation of the impulse responses is not feasible. This evidence suggests that the large shocks observed during the financial crisis must be interpreted as very influential outliers able to change the dynamics of almost three decades of data with just a few observations. Figure S8 reports the result for the 2008:1 sample, which closely matches the 2007:2 sample.

6. We provide the full set of responses for the model with the ratio of inventories to investment presented in Figure 8 of Section 4.4 of the paper and also for the model using inventories alone discussed in that section. These results are reported in Figures S9 and S10, respectively.

7. We also use the Divisia money aggregate in the post-Great Recession sample as another measure of policy stance. We illustrate in Figure S11 that the main pre-recession results are replicated by a model with the Divisia policy measure instead of the federal funds rate. Figure S12 shows the responses are robust to the VAR(1) specification including the term structure slope and with the change in position of reserves in the identification scheme for monetary shocks.

S2 Post-Great Recession Analysis (Section 5)

This Section of the Appendix relates to the post-Great Recession analysis and informs the discussion in Section 5 of the main manuscript, which includes a period of unconventional monetary policy and a new financial regulatory framework deriving from the Dodd–Frank Act. We provide further details and robustness analysis, especially with respect to Figures 9 and 10. The main purpose of this section is to show how sensitive the responses of C&I loans can be to the different measures of the monetary policy stance, and to assess the extent to which the conclusions of our paper might be affected by this issue.

Structural shift tests: In Figure 9 of the paper we report the tests for significant shifts in the responses of spot loans and loans issued under commitment for the Wu and Xia (2016) and the Krippner (2015) shadow rates (WX and K, respectively). We extend this analysis to other two measures: the shadow rate proposed by Lombardi and Zhu (2017) and the Divisia M4 money-index, which aggregates different assets by the value of the monetary services they provide and was introduced by Barnett (1980). We look at the following cases:

1. In Figure S13, we check the sensitivity of the results in Figure 9 to the inclusion of the observations corresponding to the Great Recession period (these are only four observations between 2008:3 and 2009:2). This sample change has some impact on the shape and significance of the response differences for the loans under commitment, however the main result regarding the downward shift of the responses remain valid. It is important to notice again, though, how these few observations are very influential on the estimation results.

2. Figure S14 replicates Figure 9 and adds to it the Lombardi–Zhu and Divisia index policy measures. The two new measures confirm the result obtained with the Wu–Xia and Krippner rates. The response differences are negative and significant for the majority of the cases and periods, with the exception of loans under commitment for the Lombardi–Zhu case which is negative but not statistically significant.

3. Finally, we illustrate the response differences for the entire set of variables in each model for these four measures of policy stance in Figures S15–S18. As mentioned in the main manuscript, we find that, while the loan variables display a similar downward shift, the responses of the real block variables are more similar across the two samples.

   The response differences are quite small and mostly not significant across the board for output, with the exception of a significant increase for the Krippner rate. Price level is only marginally significant for Wu–Xia and Divisia over the longer horizon, while commodity price is never significant. The remaining variables of the financial block are the term structure slope and total reserves. Differences in responses of reserves are typically not significant. The term structure slope's response is significantly different under the new policy regime (it is larger, in absolute value, in the post-recession). Interestingly, we observe a difference in the magnitude of the policy shock for Wu–Xia (larger in the post-recession) and the Divisia index (smaller in the post-recession).

   Our results for the real block of variables are in line with those reported in recent papers that study macro models in the post-Great Recession sample using shadow rate measures of monetary policy stance, which do not find large differences with the pre-Great Recession sample (see, for instance, Wu and Xia, 2016; Francis, Jackson, and Owyang, 2017). However, we document a significant structural shift in the relation between monetary policy shocks and the responses of business loans. Hence, we contribute to this nascent literature by showing that the conclusions drawn for the real block are unlikely to extend to financial and credit variables as well.

Model-specific gross effects: We report now the specific effects (not in-difference with respect to the pre-recession sample) for the full set of endogenous variables of the model for the four measures of policy stance.

Since we compare a broad set of measures of monetary policy stance, we use the following abbreviations in the discussion for sake of convenience: WX, K, and LZ stand for the Wu–Xia, Krippner, and Lombardi–Zhu shadow rates, respectively; D stands for Divisia money.

1. We start in Figures S19–S22 with the large bank model and partitioned loan aggregates. As we describe in the paper, loans under commitment in this model will give a very close representation of the responses of total C&I loans, which we do not report separately then. The first result in these Figures is that the responses of loans do critically depend on the policy measure used in the analysis. The responses are quite different from case to case, and it is difficult to identify useful common patterns. The second point is that the positive response of C&I loans to a tightening shock documented by DSY is not a clear-cut result anymore during the unconventional monetary policy regime.

   The response of loans under commitment is clearly negative and significant for two measures (WX, K), while it is briefly negative on impact and slightly positive after that in the other two cases (LZ, D).[1] In one case (K), the responses of spot loans and loans issued under commitment are both negative at the same time. In two cases, the pair of spot loans and loans under commitment respond roughly at the same time (LZ, D). In contrast, the responses for WX are somewhat counter-intuitive, since the response of spot loans is positive, although scarcely significant, while the response of loans under commitment is negative.

   Observing the other variables, we see that the response of reserves is negative in the majority of cases, but it turns positive for the Divisia money-index. This is not easy to explain either. The response of the term structure slope is also quite puzzling, because it is often positive, but negative only for WX.[2] On the real side of the model, prices and output are scarcely responsive to the monetary shocks in this period and typically largely not significant. With respect to output, however, the Krippner case is very unusual since we observe a positive and significant response of GDP for the first two years from the shock.

   The main point we illustrate with these plots is that responses vary substantially with the adoption of alternative measures of monetary policy stance. This makes it inadvisable to rely on a unique measure to interpret the policy transmission mechanism during the unconventional policy regime and helps explain our reluctance to favor a single popular measure, such as Wu–Xia, in presenting our results in the main paper.

2. Figure S23 helps to visualize differences across the shadow rates and gain an insight of the underlying reasons why results differ across the models above. This plot illustrates the time series of the three measures of policy stance for the sample starting from 2009:3. The differences at business cycle frequency might be quite large. For instance, the K rate has a major re-bounce in 2013, while the turning point for WX comes almost

[1] As a further robustness check, we have run this model using the Federal Reserve's holdings of Treasuries and Mortgage-Backed Securities as proxies for the unconventional monetary policy stance. In both cases, the response of loans issued under commitment is predominantly negative.

[2] It is also mostly negative in the unreported specifications using Federal Reserve's holdings of Treasuries and Mortgage-Backed Securities.

one and a half years later. LZ has major swings in the first part of the sample; both LZ and K fall much faster than WX, which initially declines gradually and later drops suddenly in 2013.

Table S1 suggests a similar assessment. It shows modest correlations between the three shadow rates (ranging from .3 to .6), while the Divisia money-index (in natural log-changes) is slightly negatively correlated with the WX and K shadow rates, but positively correlated with LZ.

Measures of Monetary Policy Stance: Pairwise Correlations

	(1)	(2)	(3)	(4)
(1) Wu–Xia	1.00			
(2) Krippner	0.47	1.00		
(3) Lombardi–Zhu	0.32	0.63	1.00	
(4) Divisia Index	-0.06	-0.13	0.41	1.00

Table S1: Wu–Xia, Krippner, and Lombardi–Zhu are shadow rates. Divisia Index corresponds to the M4 index. Sample is 2009:3–2017:1.

3. In spite of the differences across policy measures, alternative sets of responses may still be consistent with the bank lending channel. Therefore, we must rely on the responses of the spot loans to loans under commitment ratios in Figure S24 to understand which cases support the lending channel. We find very little evidence in favor of the bank lending channel in the post-Great Recession sample, with a less clear pattern of the ratio responses than in the pre-crisis one.

   The response of the ratio can be negative, but it is typically not very persistent and not significant as in K, LZ, and D. In the cases of LZ and D, we observe a mechanism comparable to the one we explored in Section 4 of the main paper, in which spot loans contract while drawdowns from commitments are positive. In the case of K, loans under commitments drop, but spot loans drop even more reflecting a contraction of bank lending supply (even though this contraction is not clear-cut). In the case of WX, on the contrary, the ratio response is positive and quite significant in the first two years after the shock; however, this case exhibits a negative response of loans under commitment, but not of spot loans in first place. The identification strategy based on the ratio analysis is not consistent with this specific combination of responses.

4. Finally, we show in Figures S25–S26 that the identification scheme of the monetary shocks might matter for the gross effects, but not for the responses in difference, again depending on the shadow rate used in the VAR. We do this for the Wu–Xia and Krippner shadow rates.

   For instance, in the Wu–Xia case in Figure S25, spot loans flip sign although they remain highly non-significant and the response of loans under commitments is now initially positive. However, reserves now increase in response to a monetary tightening, which does not seem quite justifiable as a response. For this reason, we interpret the restriction to zero on impact of the response of reserves as a better identification assumption.

On the contrary, in Figure S26 we have an example for the Krippner case in which the responses are virtually the same in both identification schemes. The use of this shadow rate suffers from other shortcomings though, as discussed in point 1 above.

S3 Effects of the Federal Reserve's Liquidity Programs

During the recent financial crisis, the Federal Reserve played a key role in stabilizing the financial markets by decisively fulfilling its Lender-of-Last-Resort (LOLR) mandate in an innovative way. In doing so, it implemented ten key programs meant to provide liquidity to several types of financial institutions, asset classes, and markets.[3] In this Section we aim at shedding some light on the matter of whether these liquidity programs could have influenced the transmission mechanism of monetary policy, particularly in its relationship with bank business lending.

The programs were launched between the second part of 2007 and November 2008, their aggregate outstanding liquidity provision peaked around December 2008, and they were winded down mostly by the first quarter of 2010. As one can ex-ante expect, it turns out to be infeasible to individually identify the effects of any one of these programs within our VAR framework of analysis. For this reason, we work with them in aggregate in the understanding that they were all meant to collectively relieve liquidity pressures in the financial markets.[4] The shortness of this sample and the dynamics of the economy during this period require us to shift from quarterly to monthly frequency of data and make some further adjustments to our models. We say more about these aspects below.

The main result of this exercise is that we find a moderately stronger effectiveness of monetary policy during the last financial crisis than during the pre-crisis period, especially through the response in the spot loan market.

S3.1 Programs Characteristics and Related Evidence on Their Effectiveness

The literature on the 2007–2009 financial crisis reviews its evolution in detail, as well as the role the Federal Reserve played in taming it. Excellent starting points for a review are Reis (2009), Brave and Genay (2011), Bernanke (2013), Gorton and Metrick (2013). We highlight

[3]Fleming (2012), who discusses in detail the facilities, lists them in order of announcement as follows: Discount Window, whose scope was extended during the crisis, Term Auction Facility, Central bank liquidity swaps, Single-tranche open-market operations, Term Securities Lending Facility, Primary Dealer Credit Facility, Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility, Commercial Paper Funding Facility, Money Market Investor Funding Facility, and Term Asset-Backed Securities Loan Facility.

[4]As we detail below, we exclude the Central bank liquidity swaps from the analysis, since the main effects of this program should be found abroad.

here some key events in what relates the triggers for liquidity pressures in different markets and the programs that were subsequently implemented by the Federal Reserve.

Early signs of a crisis emerged in summer 2007, when a spike in delinquencies on subprime mortgages led to a fall in demand and prices of Mortgage-Backed Securities (MBS henceforth). Many banks had significant exposures to these and other securitized instruments, which sent signals of fragility among counterparties. The perceived increasing counterparty risks soon threatened the commercial paper (CP henceforth) market functioning and interbank lending became increasingly more expensive, all of which heightened liquidity risks.[5] Amid market disruptions, the Federal Reserve was compelled to exert its role of Lender of Last Resort (LOLR henceforth) in full force, this time with the additional challenge of reaching out to a wide range of financial institutions. As Gorton and Metrick (2013) point out, over the previous decades the financial system had witnessed a significant growth of the shadow banking industry, whose participants – money market mutual funds, for instance – did not have direct access to the Discount Window (DW), the traditional mechanism of the LOLR. Consequently, during this crisis the Federal Reserve had to develop programs that could alleviate liquidity pressures on both banks and shadow bank institutions.

To assist early bank liquidity needs, in August 2007 the Federal Reserve initiated the Term Discount Window (TDW), an extension of the traditional overnight DW lending that offered loans of up to 30 days, initially, and later extended terms to up to 90 days. Tapping the DW, however, had historically carried a stigma among banks, hence discouraging its usage and potentially aggravating bank conditions (Armantier, Ghysels, Sarkar, and Shrader, 2015). In view of reluctance to borrow from the TDW and building liquidity pressures among banks, the Federal Reserve launched the Term Auction Facility (TAF) in December 2007. TAF anonymously auctioned and assigned limited amounts of loanable funds among sound depository institutions, initially for 28 days and from August 2008 for up to 84 days. Auctions took place between December 20, 2007 and March 11, 2010 and the success, in terms of offerings received, was immediate.[6] TAF was arguably the most significant of all liquidity programs for the domestic market, reaching a maximum outstanding amount of 493 billion dollars in early March 2009.

The literature has documented relieving effects of this program on the financial markets. Wu (2011) documents that TAF relaxed pressure on the money market by reducing banks' concerns for liquidity. Similarly, Christensen, López, and Rudebusch (2014) show that the liquidity facilities reduced the liquidity premium in term interbank rates, a finding McAndrews, Sarkar, and Wang (2017) corroborate for TAF. Taylor and Williams (2009), however, do not find evidence of TAF reducing the spread between overnight federal funds and longer-term interbank loans. Closely related to the exercise we propose here is the work by Berger, Black, Bouwman, and Dlugosz (2017). Using transaction-level data from TDW and TAF, combined with bank-level data from the STBL and Call Reports, the authors document that banks receiving TAF funding increased both short- and long-term lending in most loan

[5] Literature studying runs on specific markets and instruments during the crisis include, among others, Gorton and Metrick (2012), Copeland, Martin, and Walker (2014), and Krishnamurthy, Nagel, and Orlov (2014) for repurchase agreements and Covitz, Liang, and Suárez (2013) and Schroth, Suárez, and Taylor (2014) for asset-backed commercial papers.

[6] See Armantier, Krieger, and McAndrews (2008) for a detailed explanation on the workings of this program.

categories. Furthermore, small banks increased their lending to small businesses while large banks increased their lending to large businesses. Their empirical strategy relies on panel regressions and, alternatively, a control group matching procedure. Importantly, the authors control for the effects of other liquidity facilities such as the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), Term Securities Lending Facilities (TSLF), and the Primary Dealer Credit Facility (PDCF). They also control for funding received from the Troubled Asset Relief Program (TARP), advances from the Federal Home Loan Bank (FHLB), and for two programs sponsored by the Federal Deposit Insurance Corporation (FDIC), namely the Debt Guarantee Program (DGP) and the Transaction Account Guarantee Program (TAGP). In a related work, Wu (2015) conducts a study of the impact of TARP, DW, and TAF on bank lending in the syndicated loan market and finds that these programs played only marginal roles in fostering business lending.

Another significant program was the Commercial Paper Funding Facility (CPFF henceforth), which was meant to provide liquidity in the CP market, thus improving liquidity conditions among financial and nonfinancial firms relying on this source of funding – Anderson and Gascon (2009) report that in 2006 financial CP, nonfinancial CP, and ABCP represented 41.4%, 16.4%, and 42.2% of the market, respectively. The outstanding amount of this facility peaked during the third week of January 2009, when it reached 351 billion dollars. The program operated via CPFF LLC, a special-purpose vehicle created and financed by the Federal Reserve, which purchased highly-rated CP and ABCP directly from issuers.

This program effectively reduced the pressure on the commercial paper market during the crisis. Duca (2013) shows that CPFF cushioned declines in commercial paper issuance, thus avoiding a collapse of this market comparable to that experienced during the Great Depression. The study starts in 2001 and relies primarily on cointegrating models; short-run models flexibly accommodate several significant economic events that could have altered the usage of commercial paper, such as the August 2007 halt of redemptions on hedge funds or the failure of Lehman Brothers in September 2008.

Another related program was the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), which funded depository institutions and bank holding companies purchasing ABCP from money market mutual funds. This program offered the means for money market mutual funds to meet redemptions by selling their assets at reasonable prices. Duygan-Bump, Parkinson, Rosengren, Suárez, and Willen (2013) study the effectiveness of the AMLF. Relying on a difference-in-difference approach, they document that the facility effectively eased outflows from the money market mutual funds and significantly reduced yields on ABCP.

A relatively small facility, yet intrinsically related to bank lending, was the Term Asset-Backed Securities Loan Facility (TALF). The program became operative in March 2009 and, although targeted to investors, it was ultimately meant to boost bank credit supply. The facility offered loans of up to 5 years to investors willing to purchase newly issued highly-rated asset-backed securities that were backed by consumer or small business loans. Campbell, Covitz, Nelson, and Pence (2011) study TALF and document that the program improved conditions in the securitization markets by lowering interest rate spreads on some categories of asset-backed securities.

Other programs were intended for primary dealers. With the Single-Tranche Term Repurchase Agreements, primary dealers could borrow from the Federal Reserve for up to 28 days using repos. Under the Term Securities Lending Facilities (TSLF), the Federal Reserve lent Treasury securities to primary dealers for a month in exchange for a fee and less liquid, eligible collateral. And the Primary Dealer Credit Facility (PDCF) offered dealers overnight loans. The Money Market Investor Funding Facility (MMIFF), on the other hand, was meant to provide liquidity to money market investors, but it was never used.

Taken as a whole, evidence suggests that the role played by the Federal Reserve as a back-stop liquidity provider during the financial crisis significantly improved market conditions. Furthermore, extant literature also suggests that some of these programs could have helped foster bank lending. Virtually all liquidity facilities could have arguably somehow affected, directly or indirectly, bank lending conditions. And fully and individually identifying their effects in this regard is beyond the scope of this exercise, as we recognize data and methodological issues pose insurmountable challenges to our framework of analysis. As Fleming (2012) duly points out, it is intrinsically demanding to tease out individual effects from these programs given the sheer number of relevant events in this period and their endogenous nature. Hamilton (2009) and Duygan-Bump, Parkinson, Rosengren, Suárez, and Willen (2013) stress the additional difficulties of such endeavors for time-series methods relying on aggregate data. Nonetheless, with all these caveats in mind, in the next Subsection we investigate potential changes in responses of C&I loans to monetary shocks during the period in which key liquidity programs were implemented, and we also explore how C&I loans directly responded to liquidity shocks from the programs. In this exercise, we adopt the same empirical strategy as in the main manuscript, with some necessary adjustments that we describe in detail below. Notice, that although rigorous and focused on very precise questions, this analysis should be considered strictly as suggestive, rather than conclusive.

S3.2 VAR Analysis and Results

We construct and use in this analysis a dataset at monthly frequency in order to cope with the relatively short period of time during which the programs were active. Unfortunately, the quarterly frequency of the data we use in our main study would be insufficient for any type of estimation based on a VAR model. We define the period of analysis as 2007:12–2010:3, using as a starting point the month in wich TAF was implemented and going through March 2010 to broadly encompass the unwinding of the liquidity facilities. Using this period and switching to a monthly frequency yields enough observations to work with a small VAR model with two lags. Clearly, in this case the lag order is determined by a restriction in the number of observations, and we acknowledge it might not be the most appropriate lag order for a macro monthly model. Nevertheless, the model can be used, at the minimum, to infer some suggestive regularity in the responses of the loan market to monetary and liquidity shocks.

1. We begin with a simple check of the properties of the new dataset by reporting the responses of the same models used in the paper for the pre and post-Great Recession samples. Specifically, we use the samples 1983:1–2007:11 and 2010:4–2017:5, and we set aside the middle sample for the analysis of the programs. The model we estimate includes six variables: the industrial production index, the personal consumption expenditures price index (excluding food and energy), the monetary policy rate, the slope

of the term structure, and total C&I loans.

The choice of these variables is dictated by the monthly frequency requirement: industrial production is typically used to replace GDP at higher frequency, the real GDP deflator is replaced by a consumption-based price index, the federal funds rate is used before 2008 and it is replaced by one of the shadow rates after 2010, the term structure slope is the difference between the 10-year and 3-month Treasury constant maturity rates, and the stock of total C&I loans is used given that STBL data on spot loans and loans under commitment are not available at monthly frequency. To study spot loans in particular, we construct a monthly series from DealScan, which we do in the next point.

Figure S27 illustrates the responses of a VAR(12) in the pre-recession period, while Figure S28–S30 illustrate the results for a VAR(6) in the post-recession using the three alternative shadow rates. The fewer years after 2010 prevent us from estimating a 12-lag model in this last period. We simply adopt the same identification assumptions as in the main paper. Before the Great Recession, loans increase in response to a monetary tightening. After the Great Recession, the responses significantly shift downward, with the specific effects depending on the shadow rate used. The responses largely replicate the results of the main paper, confirming the applicability of the analysis to monthly data.

2. We now turn to the analysis of the sample in which the programs are implemented. The financial instability, the large financial shocks, and the high level of uncertainty of this period suggest some modifications to the specification of the model.

   First, a measure of the term structure slope does not seem to help capture the monetary policy stance in this period. This is probably the result of the fact that shadow rates already incorporate information in this regard. In addition to that, the heightened risks suggest including a variable that controls for conditions in the credit markets, which we do using the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Alternatively, and with the purpose of specifically accounting for the banking sector conditions, in unreported tests we use the average expected default frequency of financial firms in lieu of this spread; we obtain similar results.[7] Second, we adjust reserves by the outstanding amounts of the Federal Reserve's liquidity facilities (excluding liquidity swaps) in order to disentangle in the information set of the Fed possible demand-driven gaps between excess reserves and supplied liquidity.

   We answer two main questions. The first one is whether the transmission mechanism of policy shocks changes during the recession period. We answer this question by computing the responses of loans to a shock in the policy rate. The second one is whether the facilities seem to have effectively provided liquidity to the business loan

[7] The expected default frequency (EDF) is a convenient proxy for financial distress that estimates the probability of default of a firm based on traditional option pricing theory. We construct this measure following Crosbie and Bohn (2003) and using quarterly balance sheet data from Compustat and monthly stock price data from CRSP for firms with Standard Industrial Classification (SIC) codes between 6000 and 6999.

market. We look to provide an answer by illustrating the response of the ratio of the spot loans to bonds following both a monetary shock and a shock to the liquidity facilities.

3. We focus on the first question here. In Figures S31–S34 we illustrate the responses of total C&I loans and spot loans with maturity less than 5 years to a tightening shock to the policy rate. Part of the rate corresponds to the Wu–Xia or the Krippner shadow rate because the zero lower bound is reached during the sample. We stop reporting the output for the Lombardi–Zhu shadow rate because we cannot estimate an invertible VAR model in this short sample with this shadow rate in the model.

   The Figures show a difference between the response of total loans and spot loans only. The responses of C&I loans are still positive and similar to those found for the pre-recession sample. They are significant, although less persistent. On the contrary, the responses of spot loans are fundamentally zero and not significant except for a larger impact effect. We saw in the paper that borrowing under commitment explains the bulk of the dynamics of aggregate loans, and the same result applies to this period of recession and programs implementation.

   In principle, reading the relative response of spot loans and total C&I loans in these Figures, the evidence would point to a possibly stronger contraction of loan supply than the one found in the paper for the pre-recession period, provided loan growth is arguably driven entirely by drawdowns on pre-existing commitments. This would be a rather effective bank lending channel.

4. In order to answer the second question, we consider the response of the ratio of spot loans to bonds (with maturity below 5 years, as in the main paper) to two types of shocks: monetary shocks and liquidity shocks. A monetary shock is measured as a change in the policy rate, as usual. A liquidity shock is measured as a change in the outstanding amount of all liquidity facilities in the Federal Reserve's balance sheet, net of the effect of the central bank liquidity swaps.[8]

   We report the results in Figures S35–S37. First, we show the effects of a policy rate tightening on the spot-to-bond ratio in Figures S35 and S36 for the Wu–Xia and Krippner shadow rates, respectively. When we use the Wu–Xia shadow rate, the initial part of the response is negative and significant for about four months after the shock; then it becomes not significant. When we use the Krippner shadow rate, we do not find a significant response in the ratio, though. Figure S37 shows the result for a tightening shock to the total Federal Reserve liquidity facilities – that is, a contraction of the outstanding balance of these facilities in the Fed's balance sheet. As in the Wu–Xia

[8] Data for this measure are publicly available from the Board of Governors. In its website, the Board reports "Credit Extended through Federal Reserve Liquidity Facilities". The main data item we use is called "All Liquidity Facilities", which includes the following components: Term Auction credit; Primary Credit; Secondary Credit; Seasonal Credit; Primary Dealer Credit Facility; Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility; Term Asset-Backed Securities Loan Facility; Commercial Paper Funding Facility; and Central Bank Liquidity Swaps. From the main data item, we substract the last component, Central Bank Liquidity Swaps, which is also reported separately.

specification, also in this case the response of the ratio is negative and significant for the first four months; it later on turns positive for the following eight months.

Some caution must be used when interpreting the response of this last model for two reasons. First, the response of output is largely positive, which suggests that our identification of the monetary shock might not be entirely correct. Some relevant forward-looking element might be missing from the information set used by the Fed in making decisions about the liquidity programs. Second, as discussed above, the total liquidity facilities include multiple programs with different timing and targets which might confound the dynamic of the responses.[9]

Overall, putting the results from these three models together, we find evidence that monetary policy had a stronger supply-side effect on the bank loan market than on the bond market at least in the short run, while we have mixed evidence pointing to the conclusion that the effect did not last through the medium- and long-run.

5. We discuss in the main paper the role that large shocks and nonlinear components may possibly have on the dynamics and estimation of the model through the Great Recession period. Following the view expressed by Sims (2012), among others, our empirical strategy has been to use a linear model to separately analyze the pre and post samples, without explicitly considering the Great Recession period.

   We provide an example of this point using the residuals of the model in Figure S27. The model is estimated over the full sample 1983–2017 and includes the policy rate (Wu–Xia for the post crisis), industrial production, the price index, the term structure slope, and reserves in addition to total C&I loans.

   Figure S38 illustrates the plots of the residuals standardized by their historical standard deviation for the time period 2004-2015. With the exception of the price index, all the other variables exhibit very large shocks during the 2008-2009 period. These shocks get to up to 7 times the standard deviation for output, 4 times for the policy rate, 6 times for loans, and even 8 times for reserves. They come in small clusters and after the Great Recession ends they are not observed anymore.

   These shocks do not appear like large deviations simply feeding through the same linear dynamics of the model. The linear model generates some very large shocks followed by other large shocks, and a nonlinear approach would be likely more suitable to encompass this part of the sample as well. Furthermore, in a small sample estimation including these observations, it is plausible to expect them to have a biasing effect on the estimation similar to that of influential outliers.

In summary, the results in this section provide evidence suggesting moderately stronger effectiveness of monetary policy during the last financial crisis than during the pre-crisis, especially through the response of the spot loan market.

[9] We tried to address this second issue by narrowing the liquidity shocks to the TAF program, which was specifically directed to depository institutions. Unfortunately, we find an unstable root of the system while estimating this model over this short sample period.

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Figures for Section S1

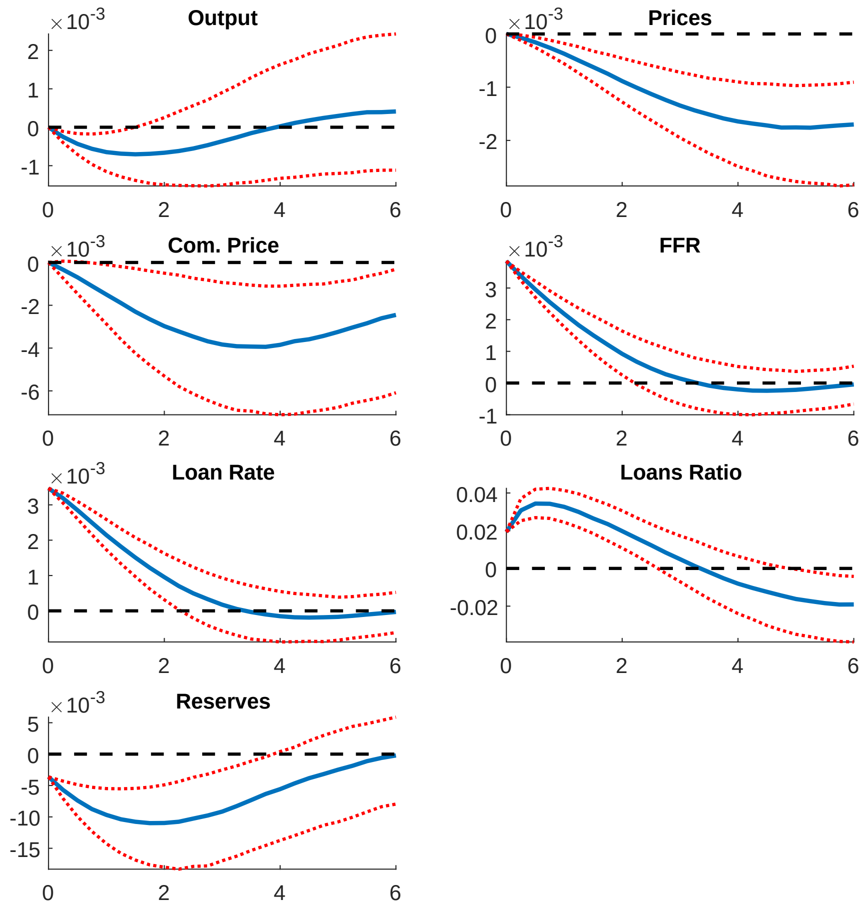

Figure S1: Responses to a 1-standard-deviation monetary shock - VAR(1) model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. Years from the shock on the x-axis. Sample 1983:1–2007:2.

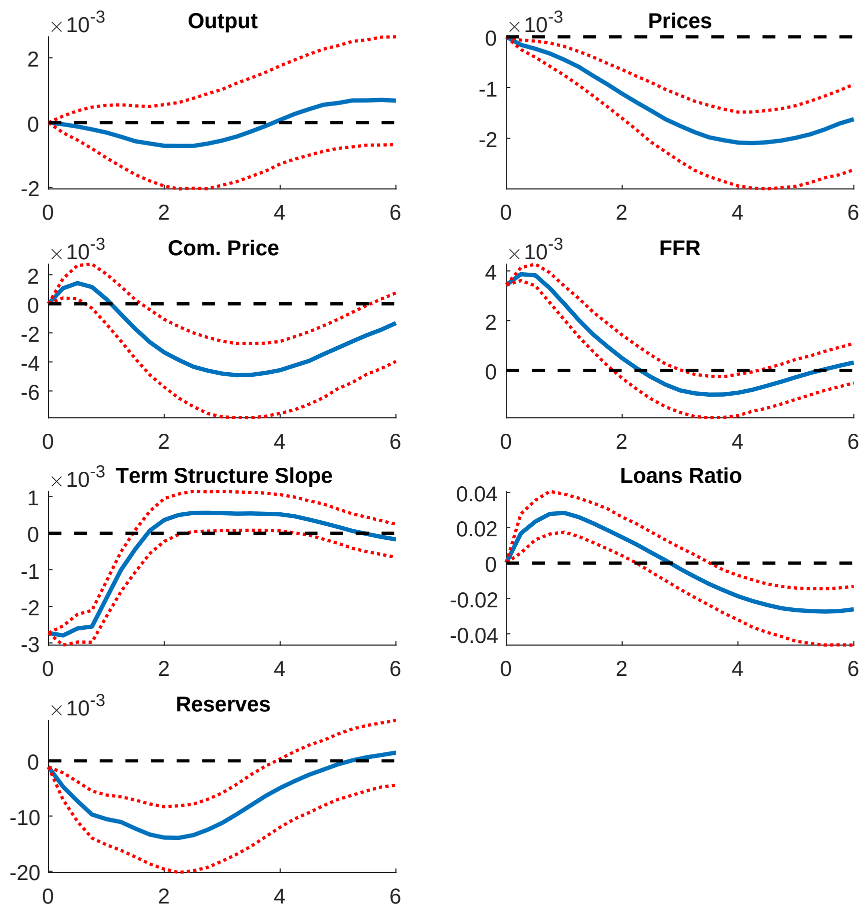

Figure S2: Responses to a 1-standard-deviation monetary shock - VAR(4) model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. The loan rate variable is replaced by the term structure slope. Years from the shock on the x-axis. Sample 1983:1–2007:2.

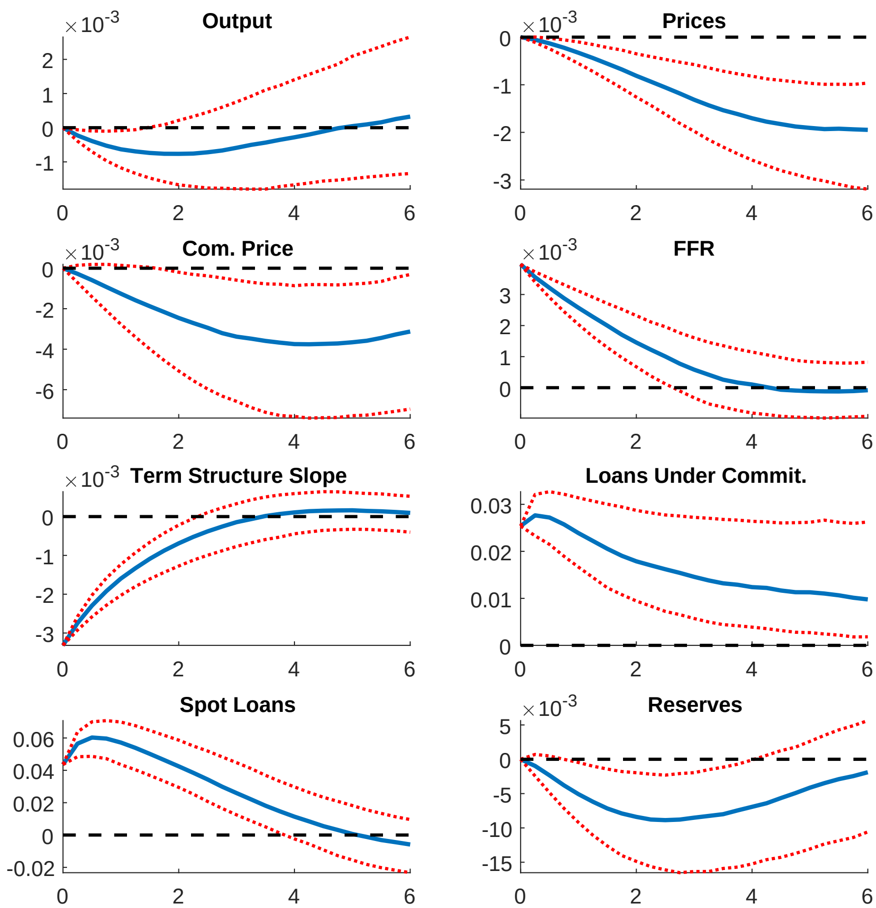

Figure S3: Responses to a 1-standard-deviation monetary shock - VAR(1) model with partitioned spot loans and loans under commitment for large banks from the STBL dataset. The loan rate variable is replaced by the term structure slope. Identification scheme with reserves ordered before the fed funds rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

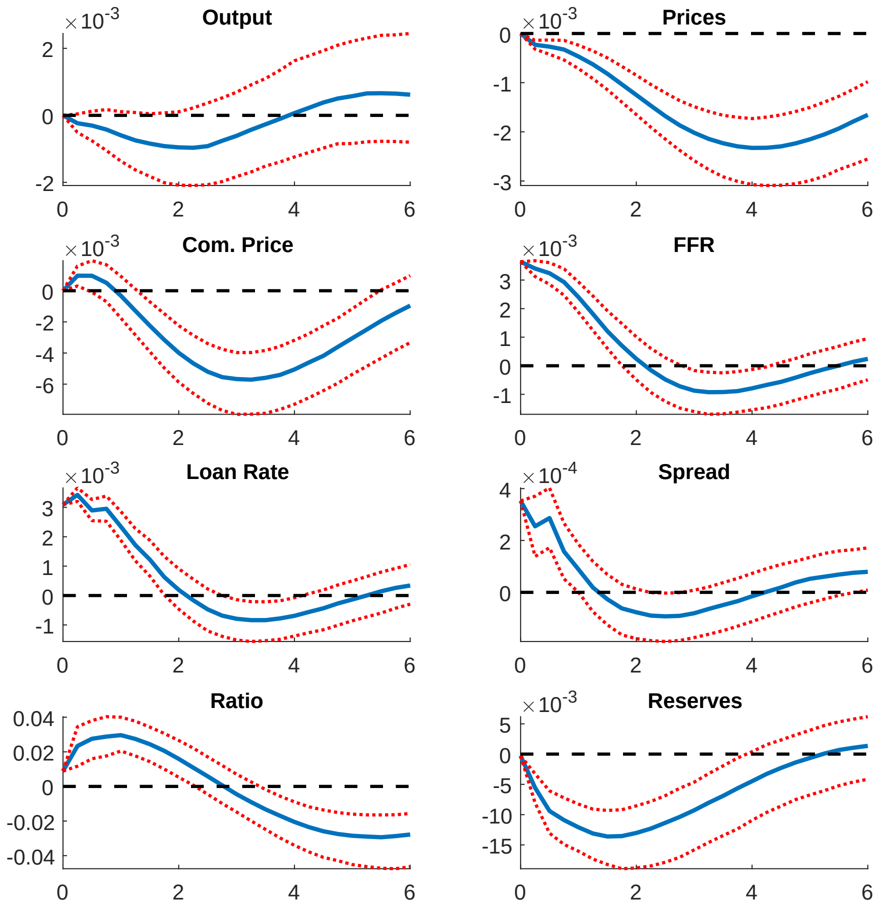

Figure S4: Responses to a 1-standard-deviation monetary shock - VAR model with spot loans to loans under commitment ratio for large domestic banks from STBL dataset. Spread between the 3-month AA commercial paper rate and the 3-month Treasury constant maturity rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

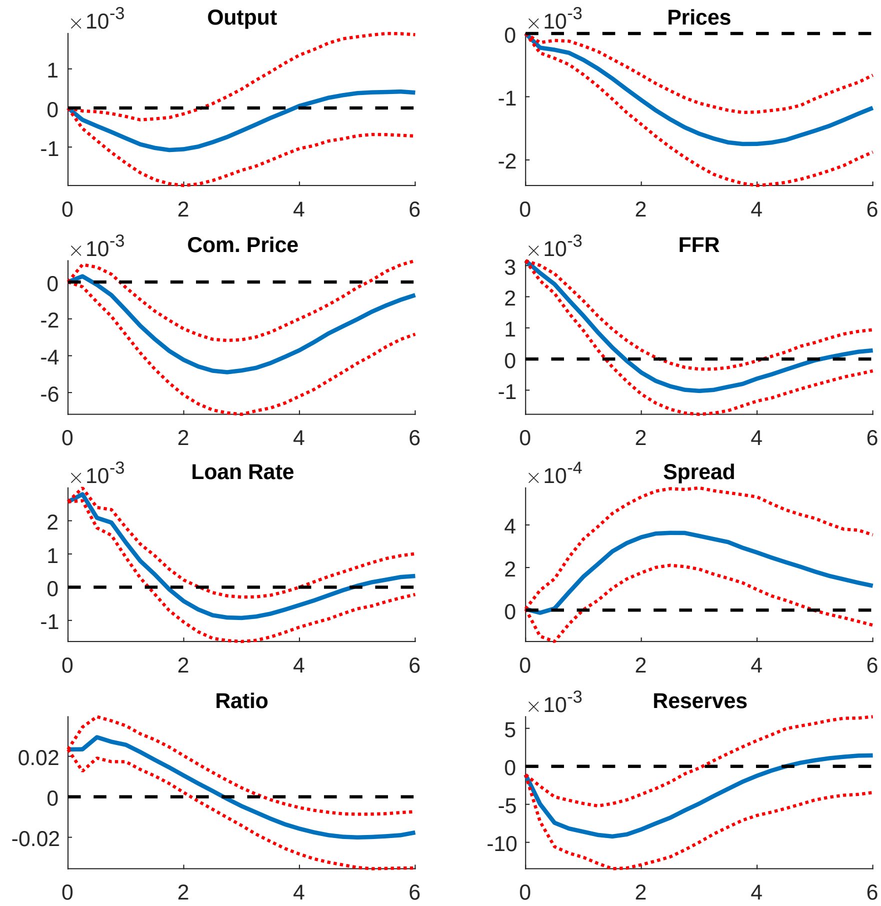

Figure S5: Responses to a 1-standard-deviation monetary shock - VAR model with spot loans to loans under commitment ratio for large domestic banks from STBL dataset. Spread between a 3-month AA commercial paper rate and the 3-month Treasury constant maturity rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

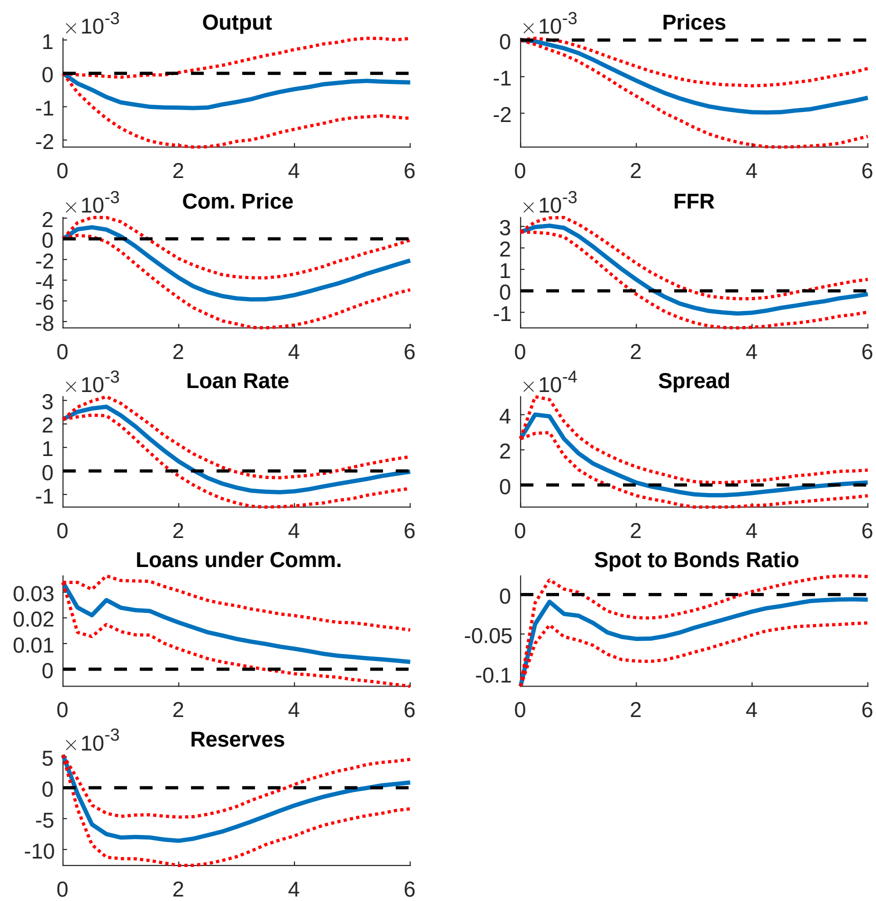

Figure S6: Responses to a 1-standard-deviation monetary shock - VAR model specification with loans under commitment for large banks and the ratio between public firms spot loans and bonds, both with maturities shorter than 5 years. Loans under commitment are from the STBL dataset; spot loans are from DealScan; bonds from SDC Platinum. Spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

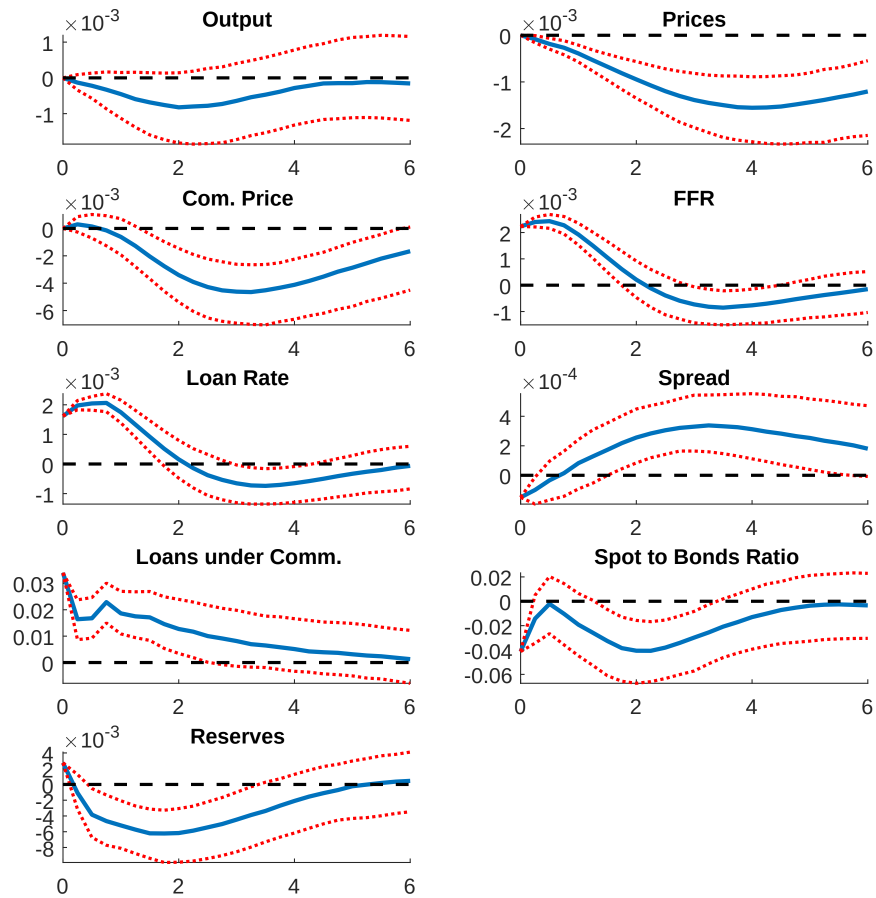

Figure S7: Responses to a 1-standard-deviation monetary shock - VAR model specification with loans under commitment for large banks and the ratio between public firms spot loans and bonds, both with maturities shorter than 5 years. Loans under commitment are from the STBL dataset; spot loans are from DealScan; bonds from SDC Platinum. Spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

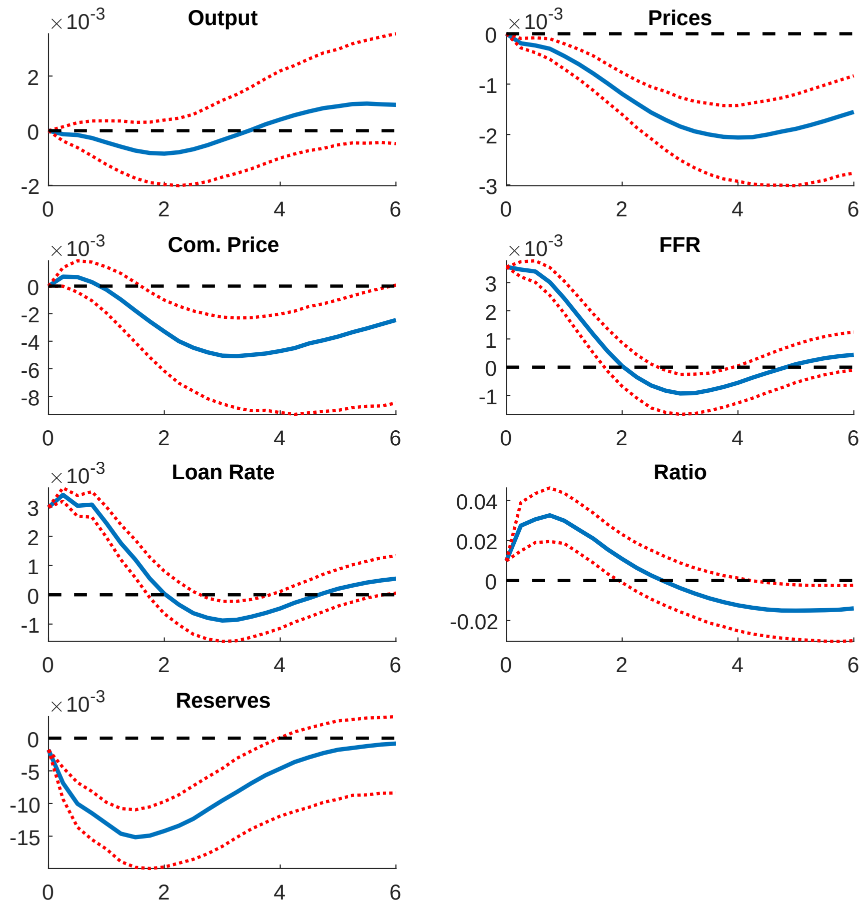

Figure S8: Responses to a 1-standard-deviation monetary shock - VAR model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. Years from the shock on the x-axis. Sample 1983:1–2008:1.

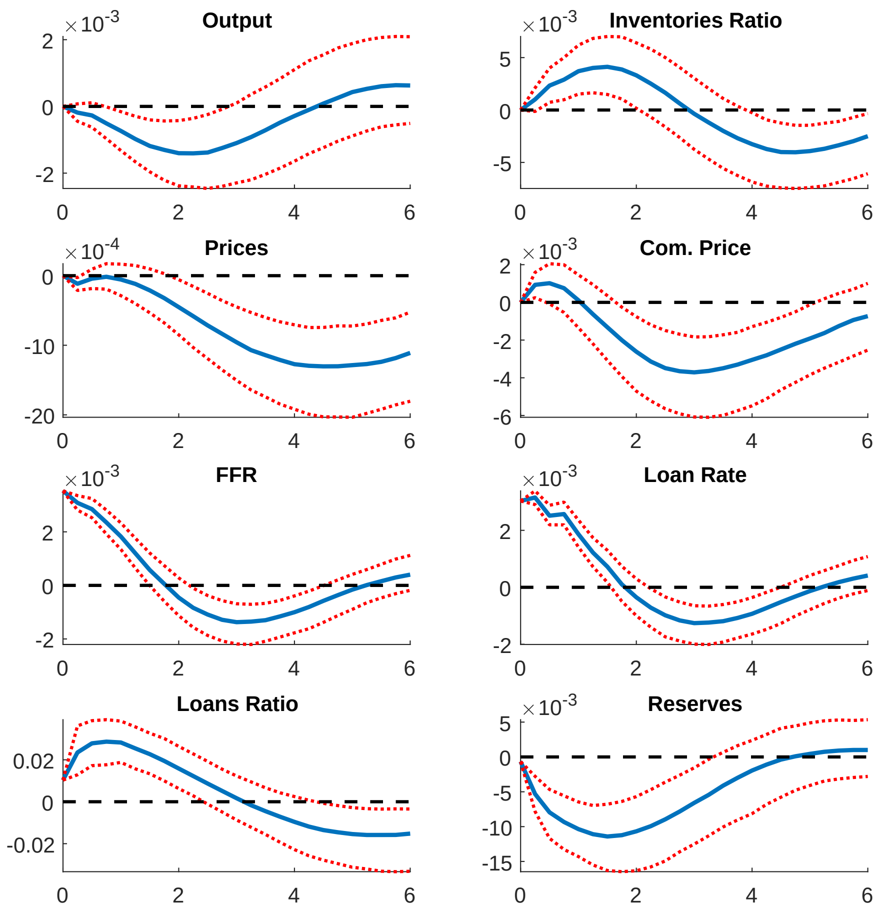

Figure S9: Response to a 1-standard-deviation monetary shock - The inventories to investment ratio is added to the VAR model specification with the spot loans to loans under commitment ratio for large banks. Loans under commitment are from the STBL dataset; spot loans are from DealScan; private (non-farm) inventories and private domestic investment are from FRED. Years from the shock on the x-axis. Sample 1983:1–2007:2. This Figure extends the result in Figure 8 of the main paper.

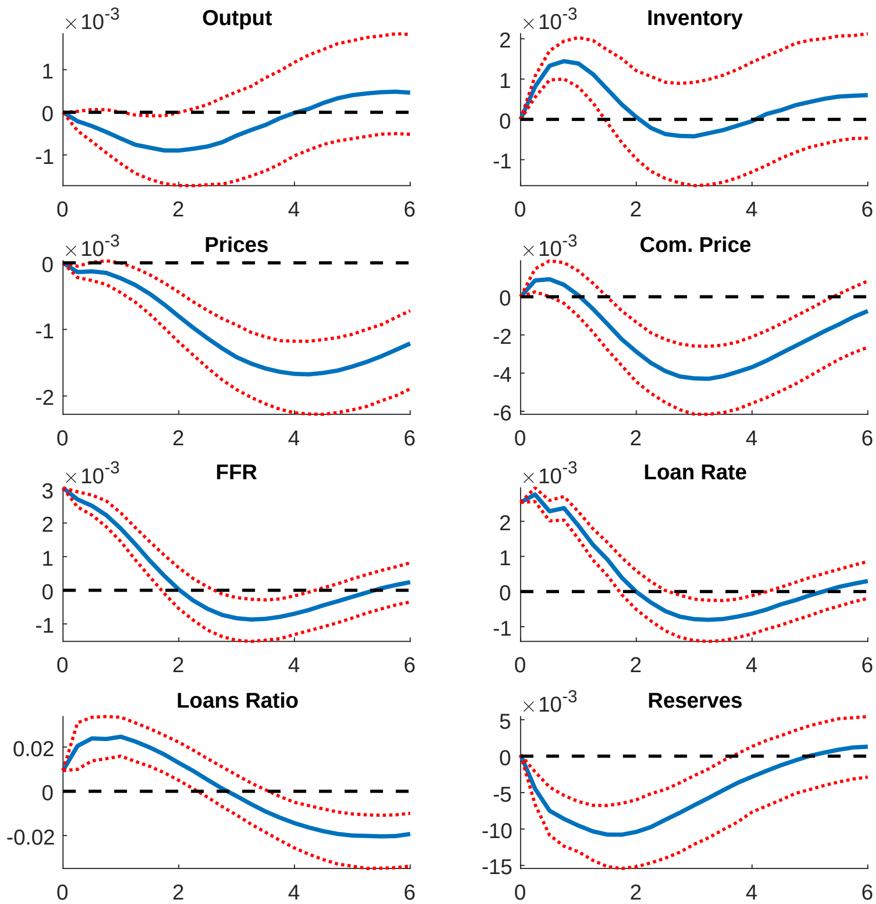

Figure S10: Response to a 1-standard-deviation monetary shock - The inventories only are added to the VAR model specification with the spot loans to loans under commitment ratio for large banks. Loans under commitment are from the STBL dataset; spot loans are from DealScan; private (non-farm) inventories and private domestic investment are from FRED. Years from the shock on the x-axis. Sample 1983:1–2007:2.

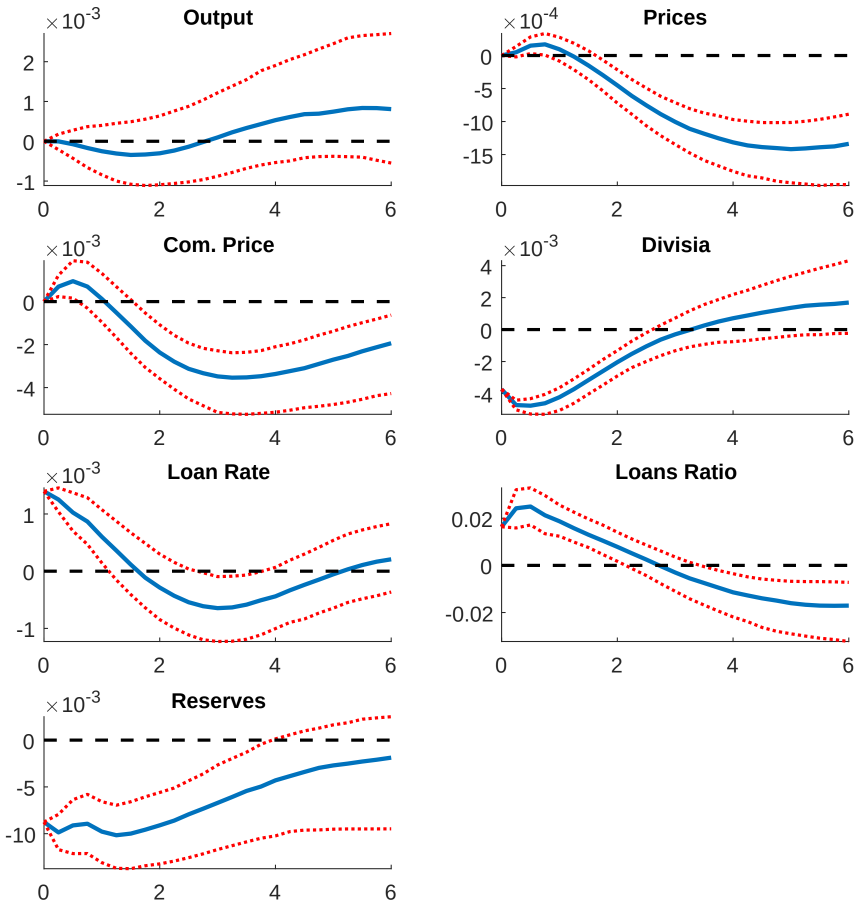

Figure S11: Responses to a 1-standard-deviation monetary shock - Divisia money replaces fed funds rate. VAR model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. Loan rate replaced by slope. Years from the shock on the x-axis. Sample 1983:1–2007:2.

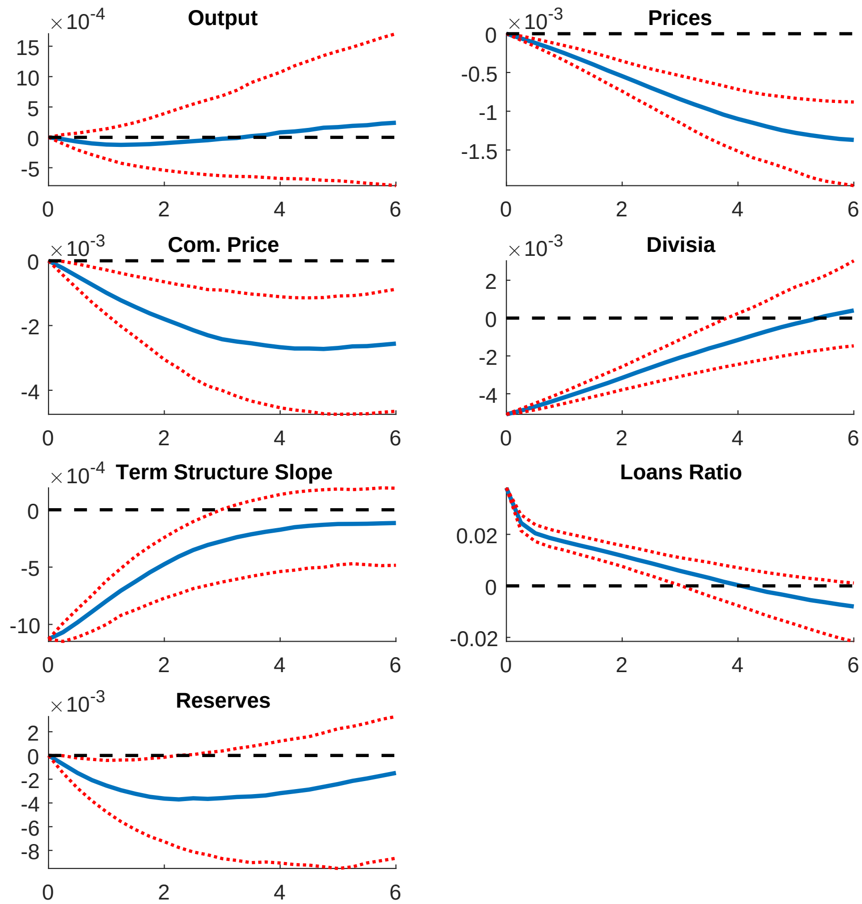

Figure S12: Responses to a 1-standard-deviation monetary shock - Divisia money replaces fed funds rate. VAR(1) model with the ratio between spot loans and loans under commitment for large banks from the STBL dataset. The loan rate variable is replaced by the term structure slope. Identification scheme with reserves ordered before the fed funds rate. Years from the shock on the x-axis. Sample 1983:1–2007:2.

Figures for Section S2

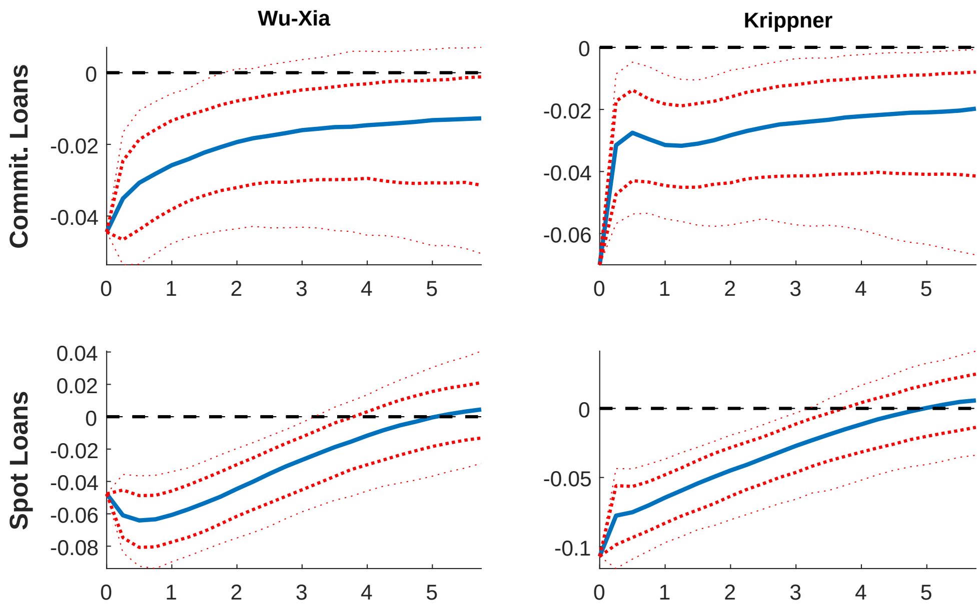

Figure S13: Shift in the Loan Responses after 2008 - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures are the shadow rates by Wu–Xia on the left column and Krippner 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 comparison sample is 2008:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

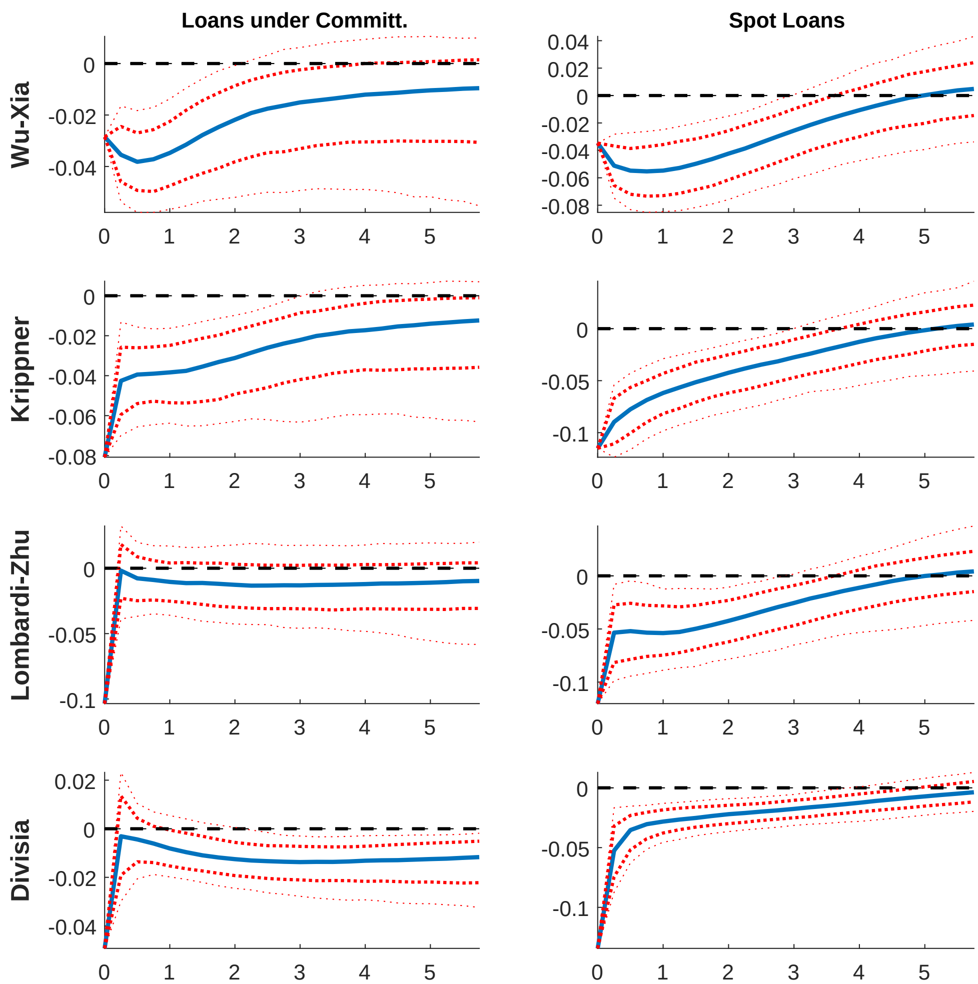

Figure S14: Shift in the Post-Great Recession Loan Responses - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures are the shadow rates by Wu–Xia, Krippner, and Lombardi–Zhu, in post-recession and the FFR in the pre-recession sample; or thethe Divisia indexfor the two samples. 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 comparison sample is 2009:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

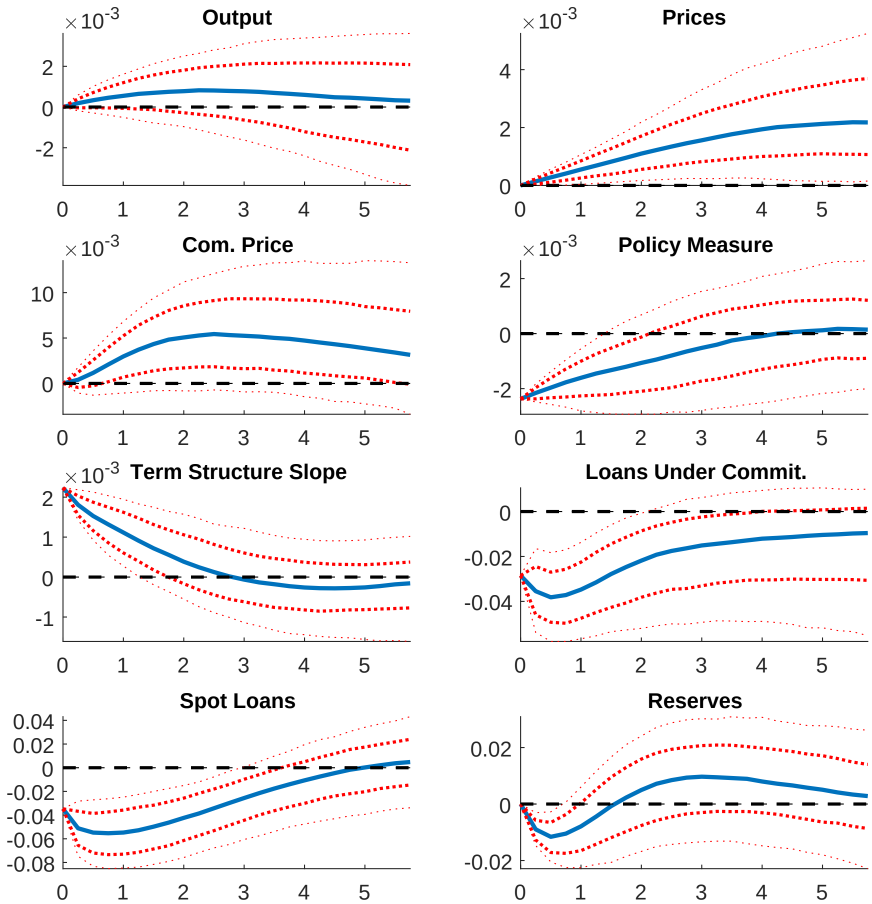

Figure S15: Shift in the Post-Great Recession Loan Responses - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measure is the Wu–Xia shadow rate in the post-recession. VAR(1) models with partitioned loans for large banks only, term structure slope; 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 comparison sample is 2009:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

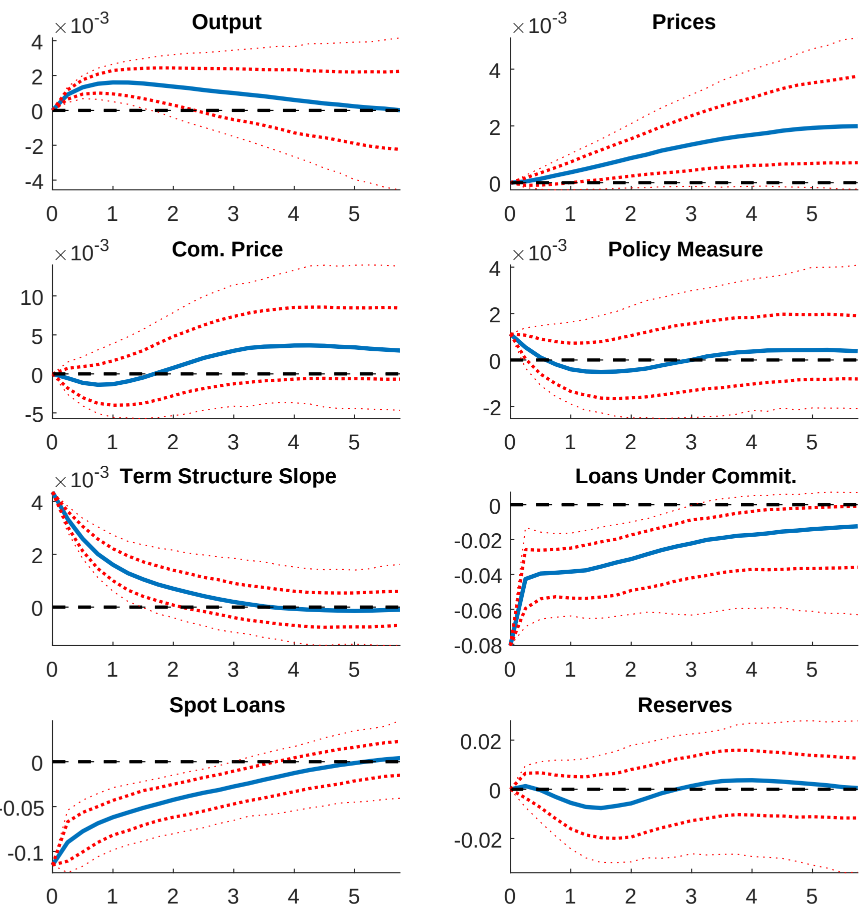

Figure S16: Shift in the Post-Great Recession Loan Responses - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures is the Krippner shadow rate in post-recession. VAR(1) 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 comparison sample is 2009:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

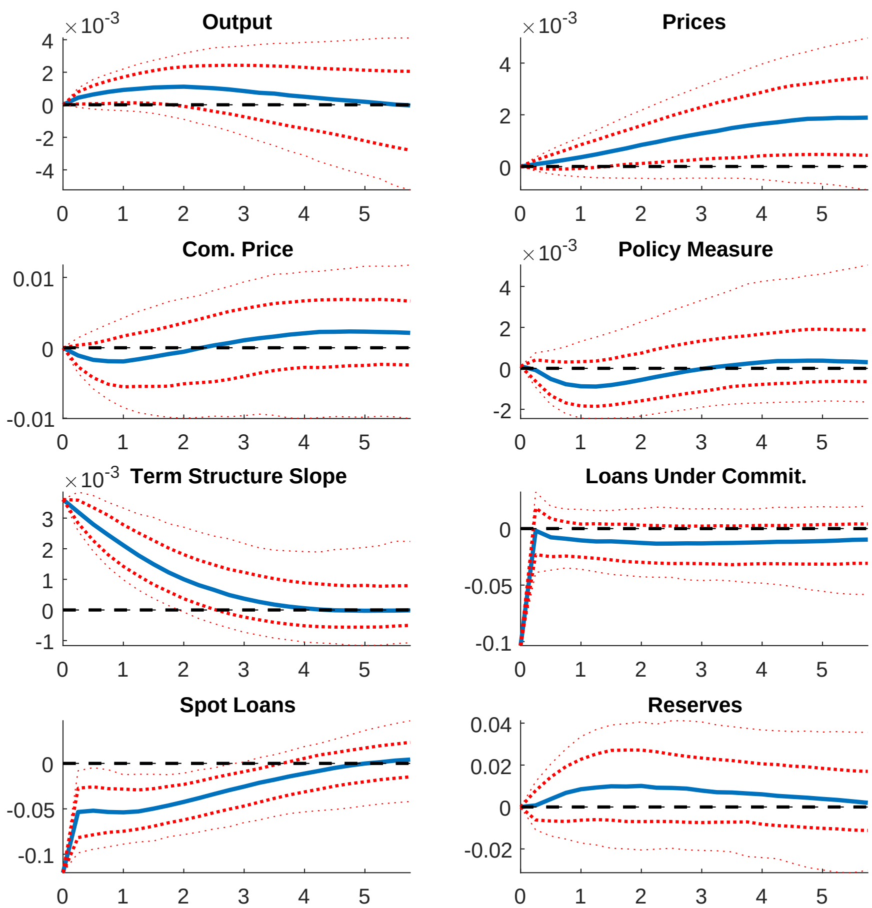

Figure S17: Shift in the Post-Great Recession Loan Responses - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures is the Lombardi–Zhu shadow rate in post-recession. 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 comparison sample is 2009:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

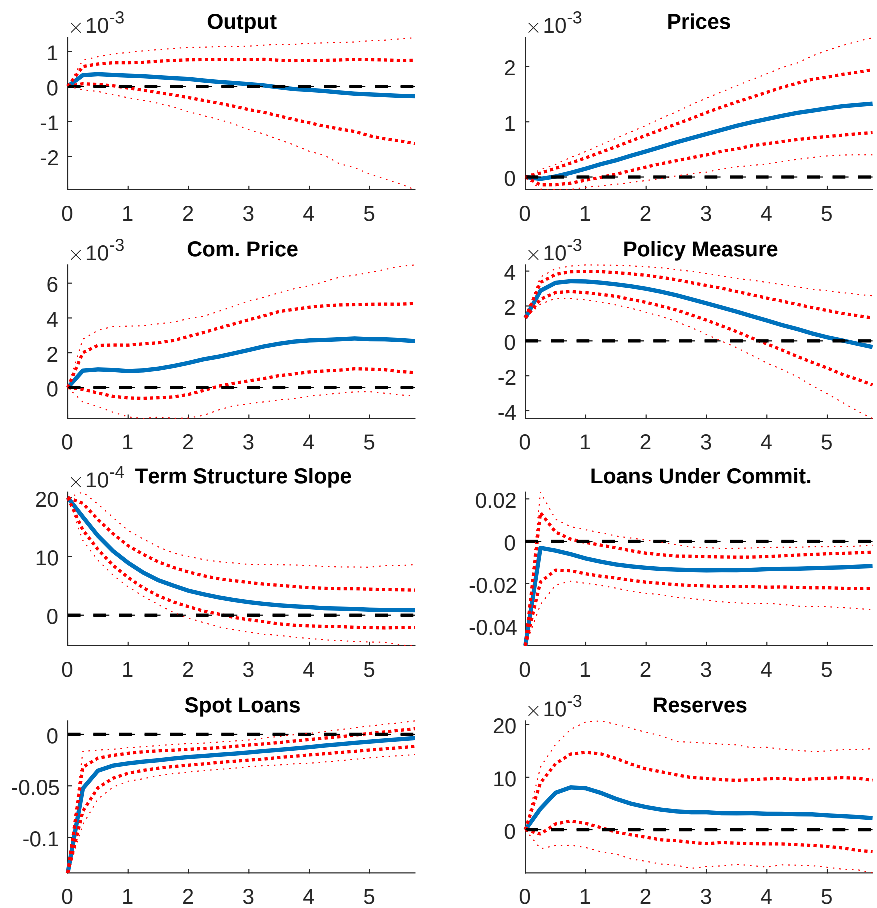

Figure S18: Shift in the Post-Great Recession Loan Responses - Difference between the responses to a 1-standard-deviation shock to the policy measure before and after the Great Recession for spot loans and loans under commitment. The policy measures is the Divisia money-index. VAR(1) models with partitioned 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 comparison sample is 2009:3–2017:1. Thick (thin) dotted lines correspond to the 16/84-th (05/95-th) percentiles of the posterior distributions.

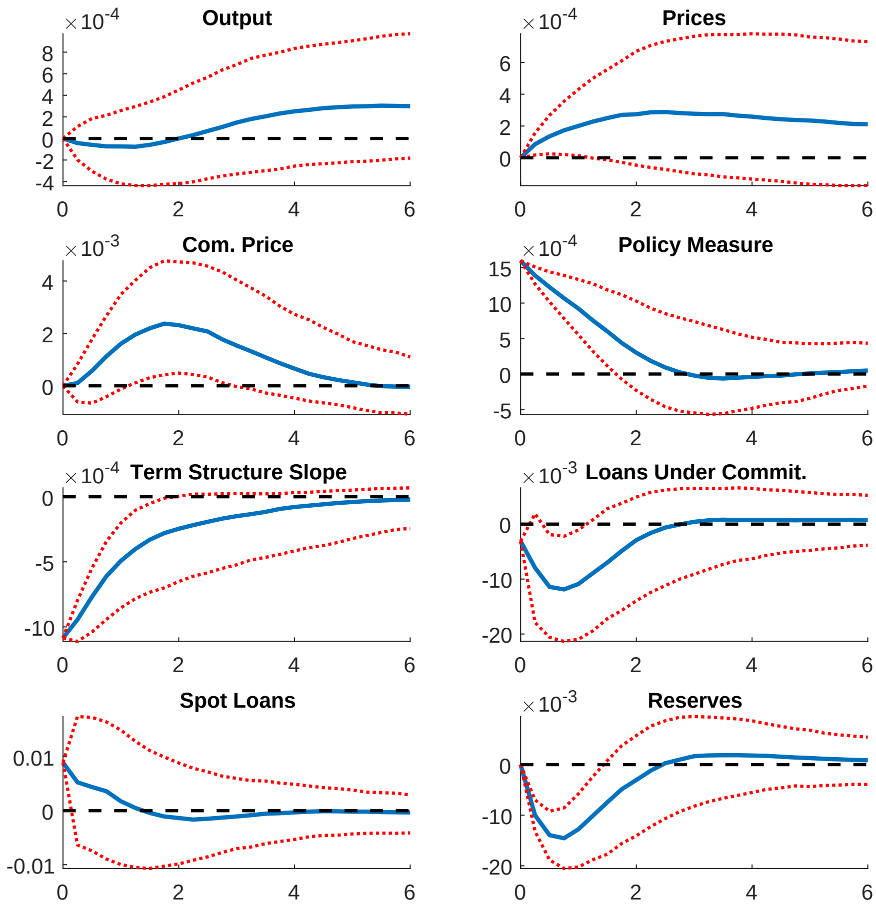

Figure S19: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Wu–Xia shadow rate. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

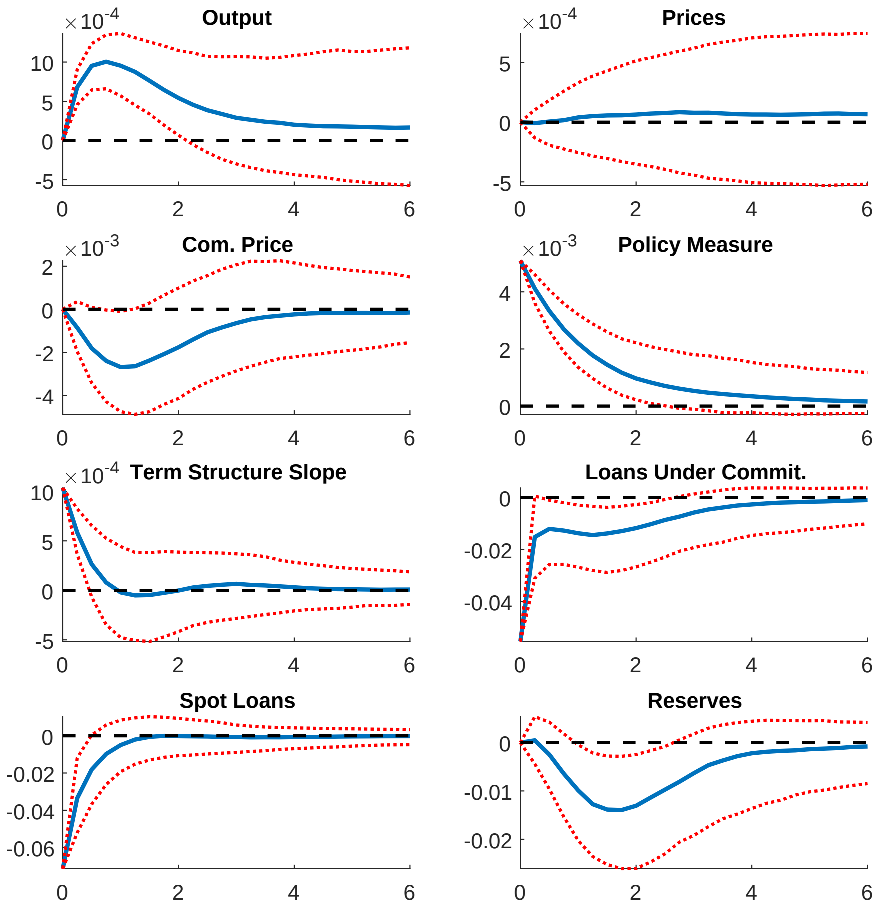

Figure S20: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Krippner shadow rate. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

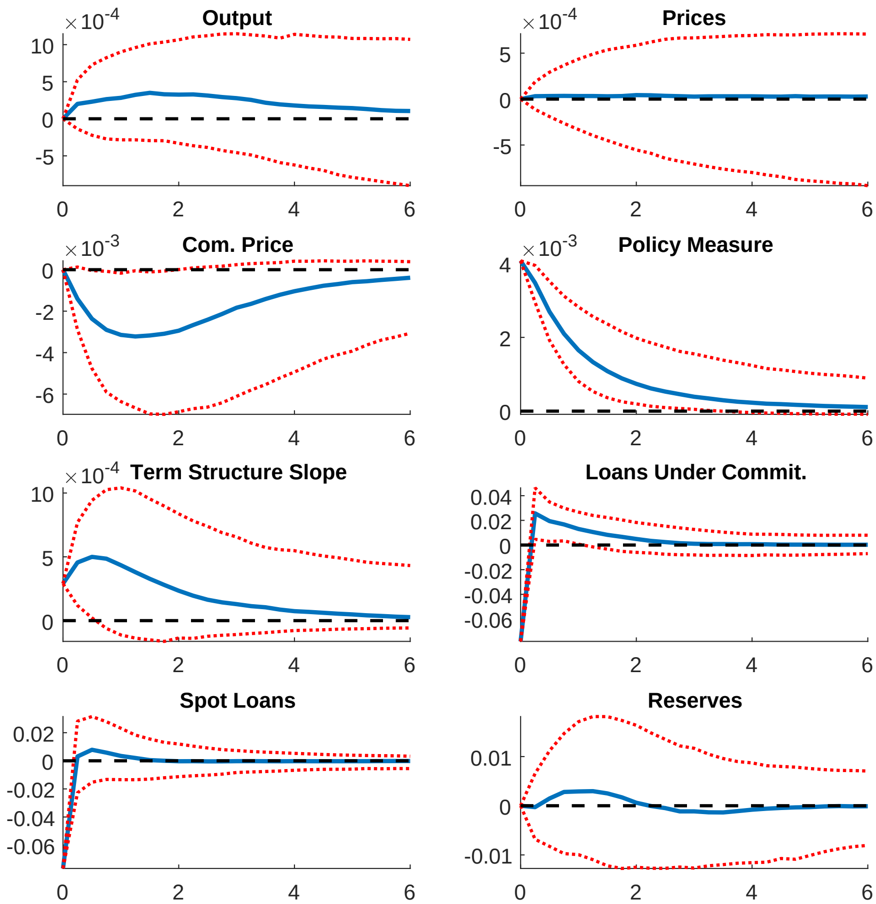

Figure S21: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Lombardi–Zhu shadow rate. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

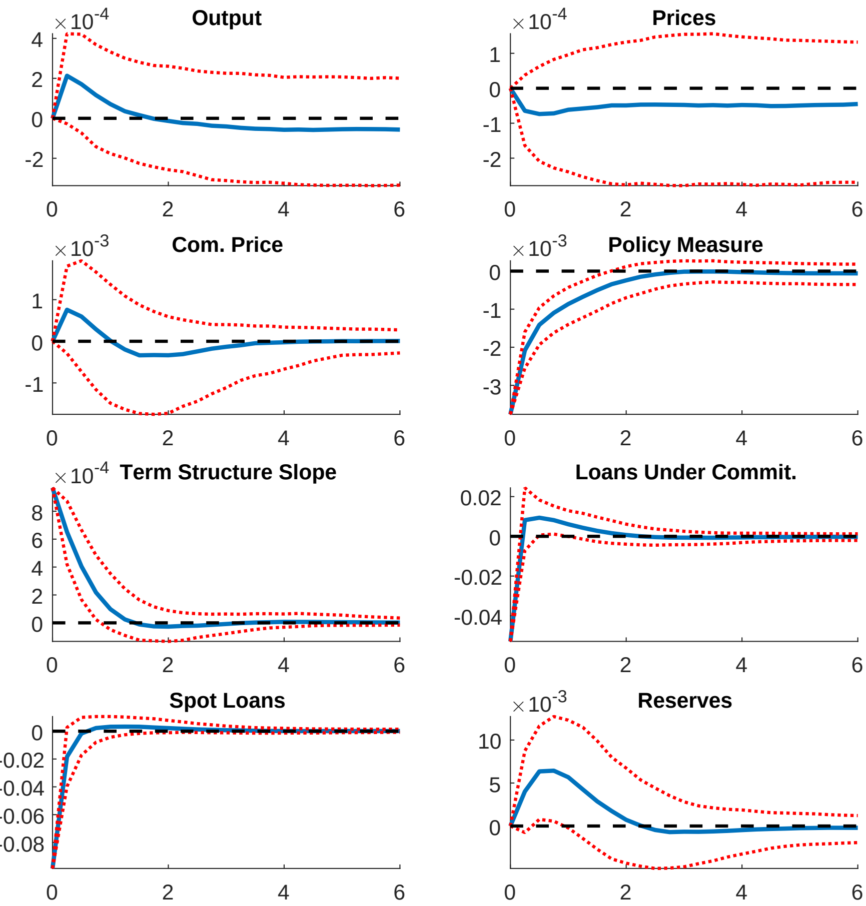

Figure S22: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Divisia money-index. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered before the policy measure in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

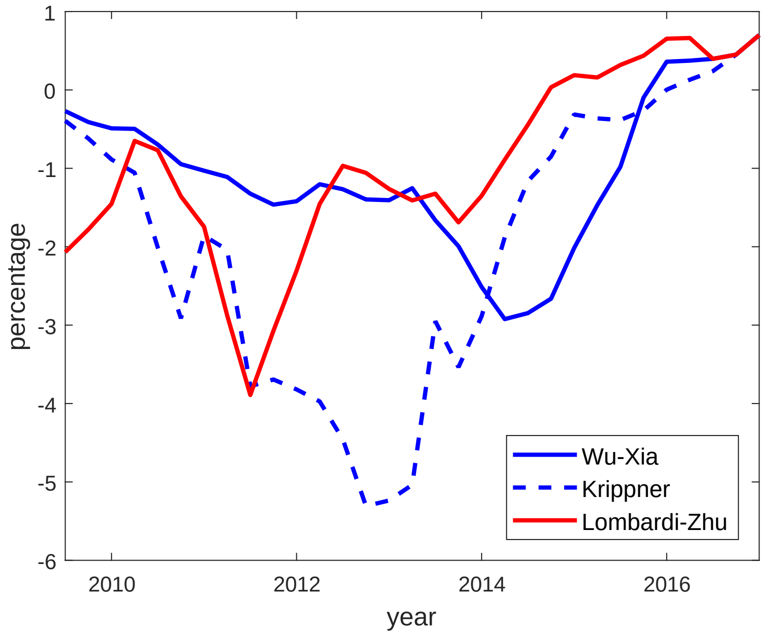

Figure S23: The three shadow rates – Sample is 2009:3–2017:1.

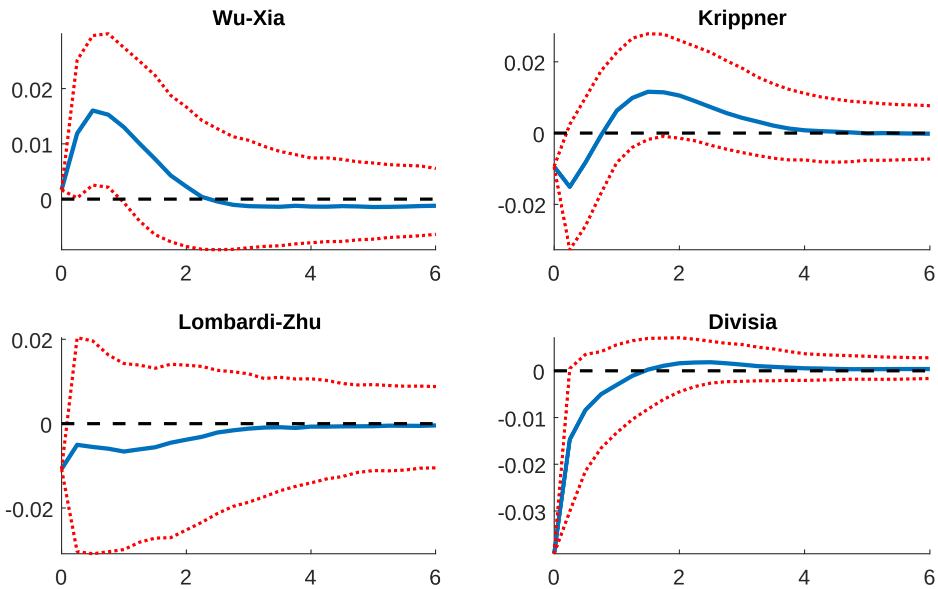

Figure S24: Post-Great Recession - Responses of the spot loans to loans under commitment ratio to a 1-standard-deviation shock to the unconventional monetary policy measure. The measures are the Wu–Xia (WX), Krippner (K), and Lombardi–Zhu (LZ) shadow rates; the Treasury and MBS holdings of the Fed (TB and MBS); the Divisia money (D). VAR(1) models with 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.

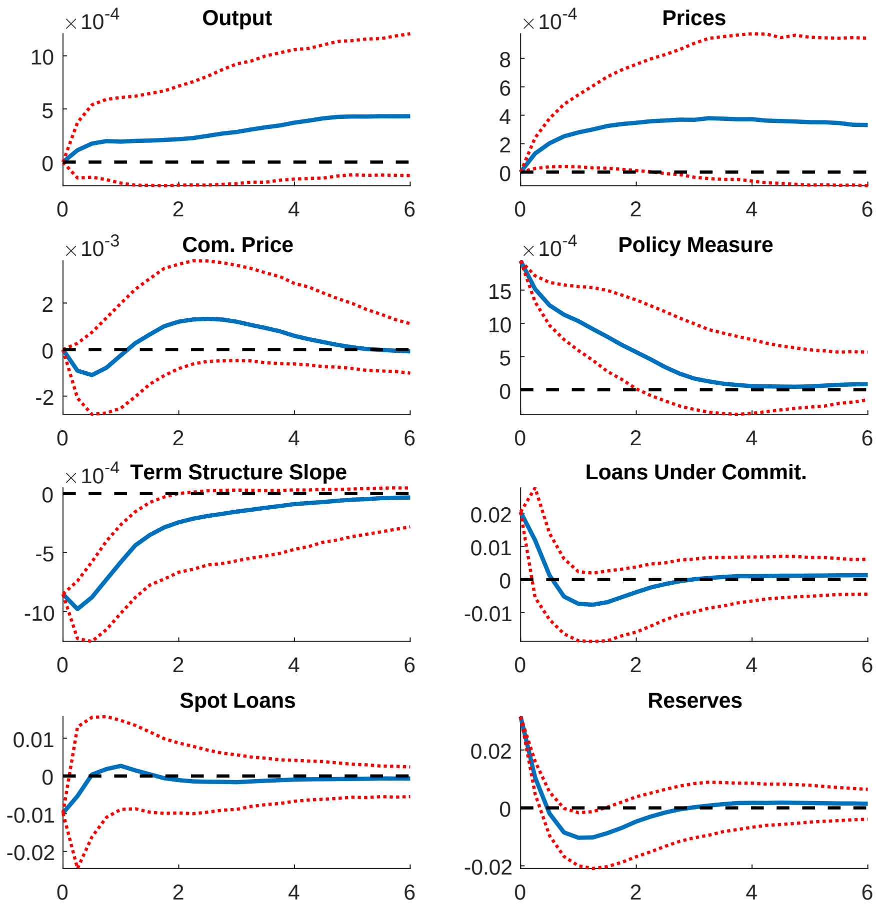

Figure S25: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Wu–Xia shadow rate. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered last in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

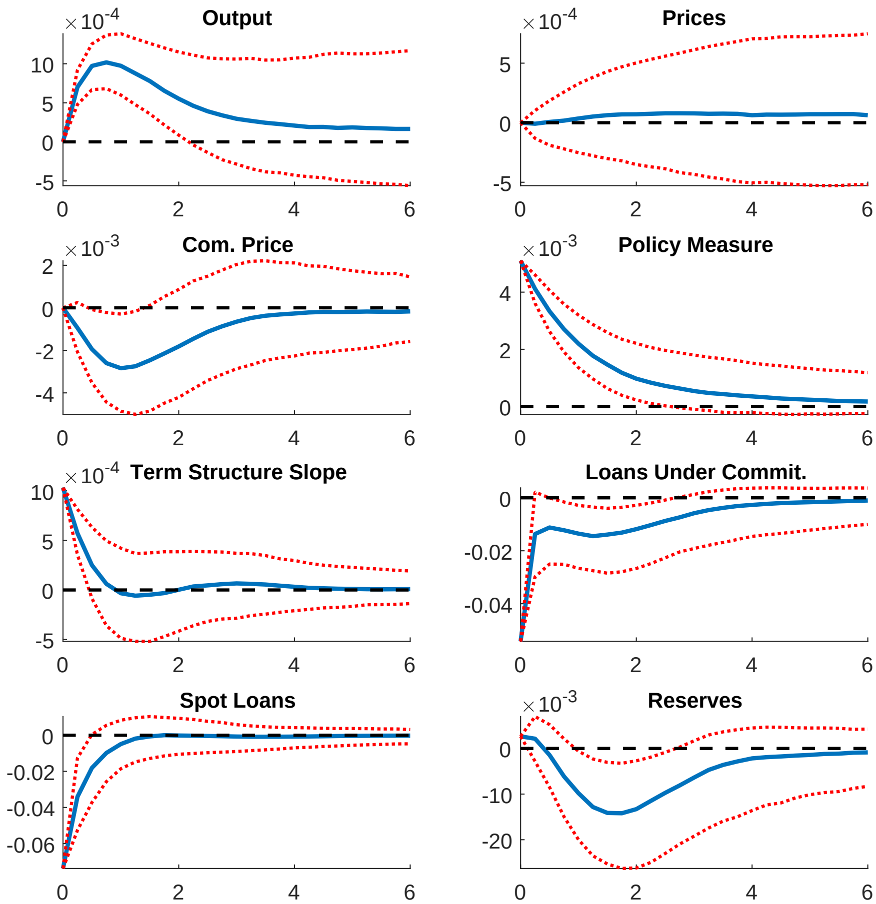

Figure S26: Post-Great Recession Loan Responses - Response to a 1-standard-deviation shock to the measure of monetary policy stance. The policy measures is the Krippner shadow rate. VAR(1) models with partitioned loans for large banks only, term structure slope, and reserves ordered last in the recursive identification scheme. Years from the shock on the x-axis. Sample is 2009:3–2017:1.

Figures for Section S3

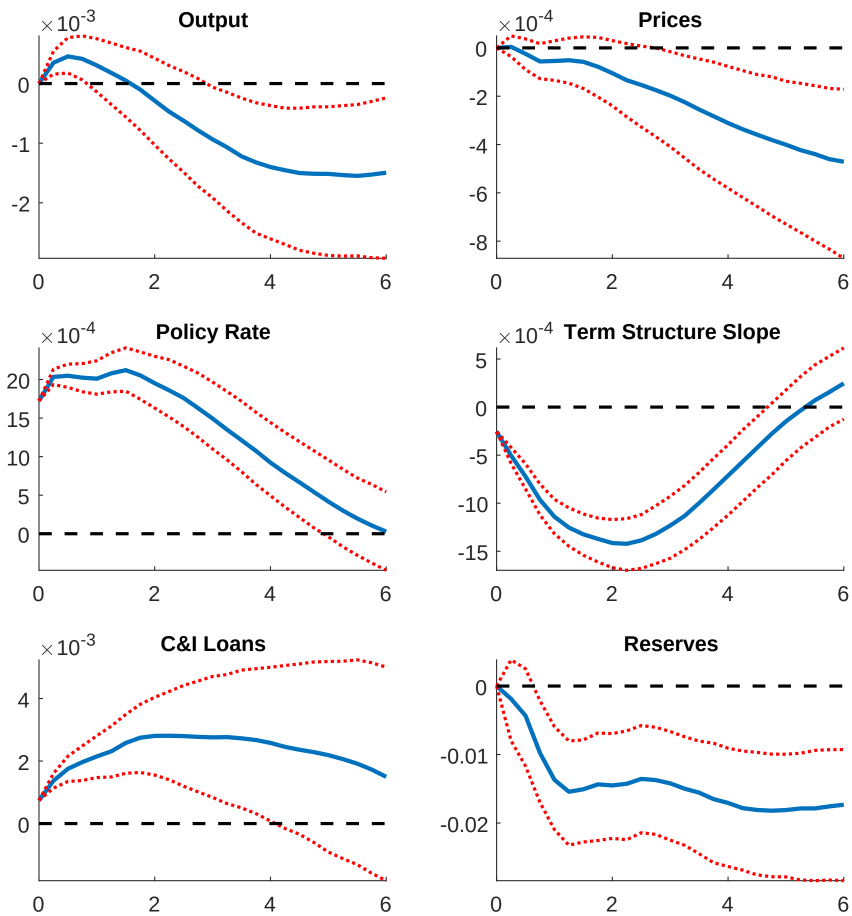

Figure S27: Responses to a 1-standard-deviation monetary shock in the pre-Great Recession - VAR(12) model at monthly frequency with total C&I loans, industrial production, consumer price index, and term structure slope. Identification scheme with reserves ordered after the policy rate. Four-month periods from the shock on the x-axis. Sample 1983:1–2007:11.

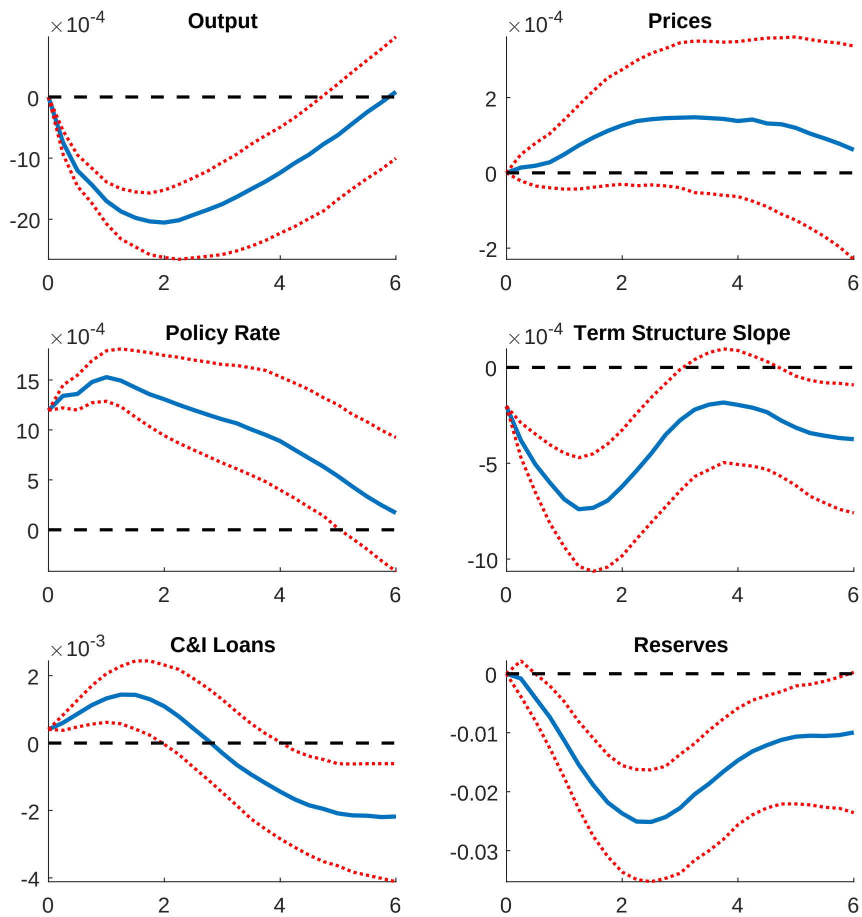

Figure S28: Responses to a 1-standard-deviation monetary shock in the Post-Great Recession - VAR(6) model at monthly frequency with total C&I loans, Wu–Xia shadow rate, industrial production, consumer price index, and term structure slope. Identification scheme with reserves ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2010:4–2017:5.

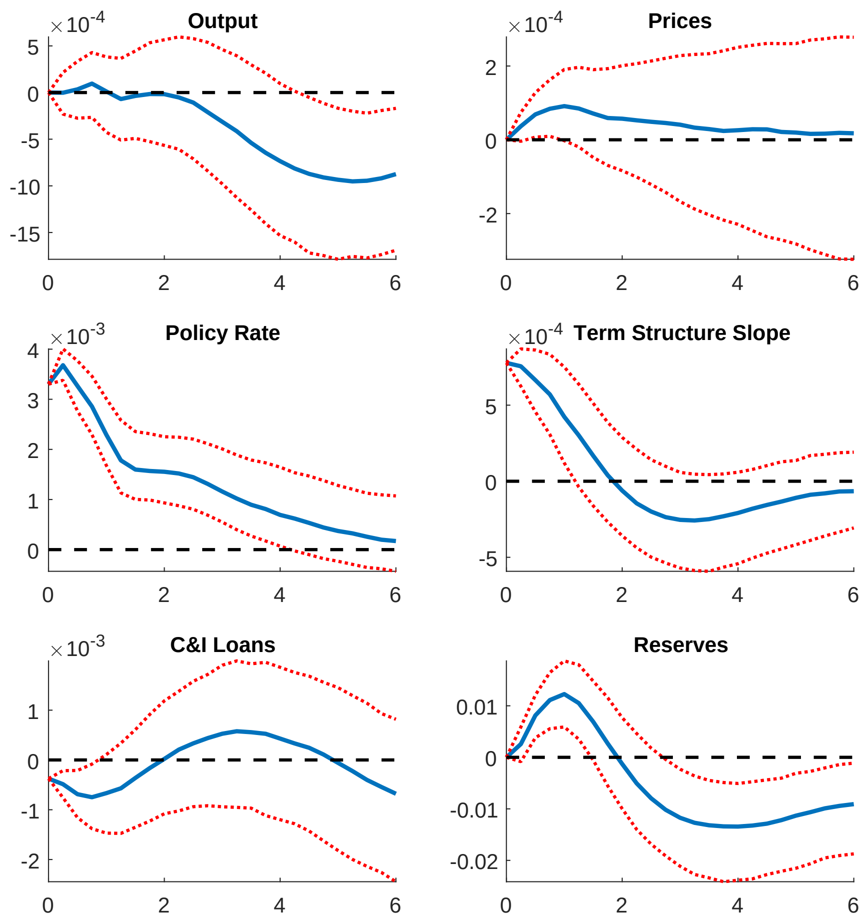

Figure S29: Responses to a 1-standard-deviation monetary shock in the Post-Great Recession - VAR(6) model at monthly frequency with total C&I loans, Krippner shadow rate, industrial production, consumer price index, and term structure slope. Identification scheme with reserves ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2010:4–2017:5.

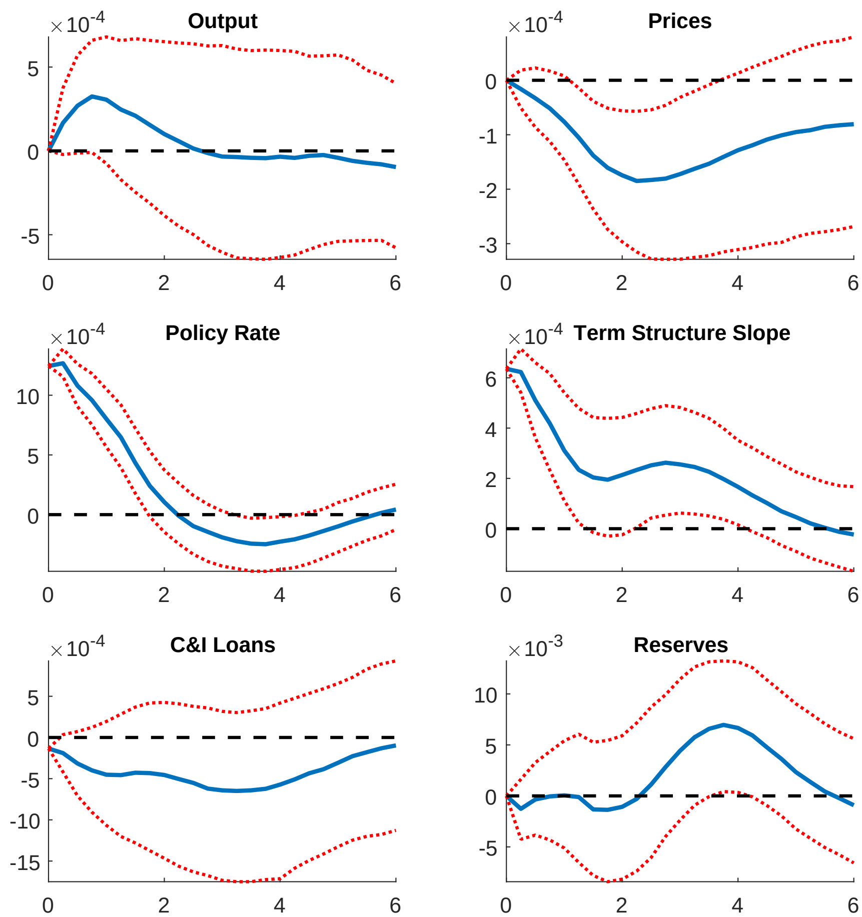

Figure S30: Responses to a 1-standard-deviation monetary shock in the Post-Great Recession - VAR(6) model at monthly frequency with total C&I loans, Lombardi–Zhu shadow rate, industrial production, consumer price index, and term structure slope. Identification scheme with reserves ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2010:4–2017:5.

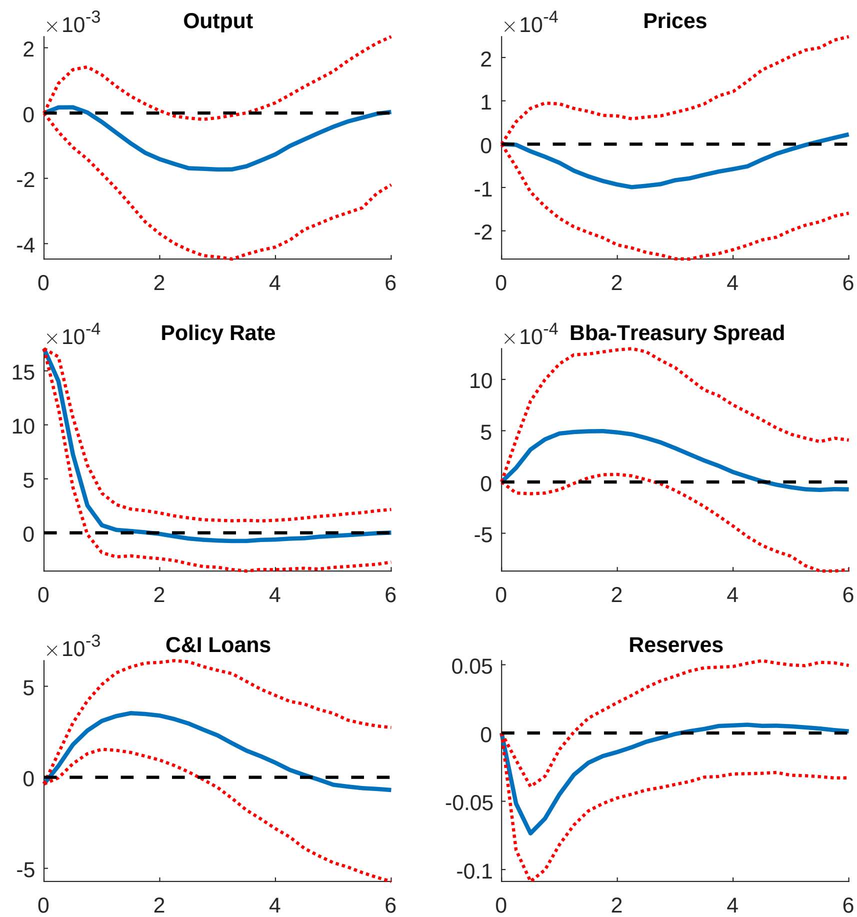

Figure S31: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with total C&I loans, Wu–Xia shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

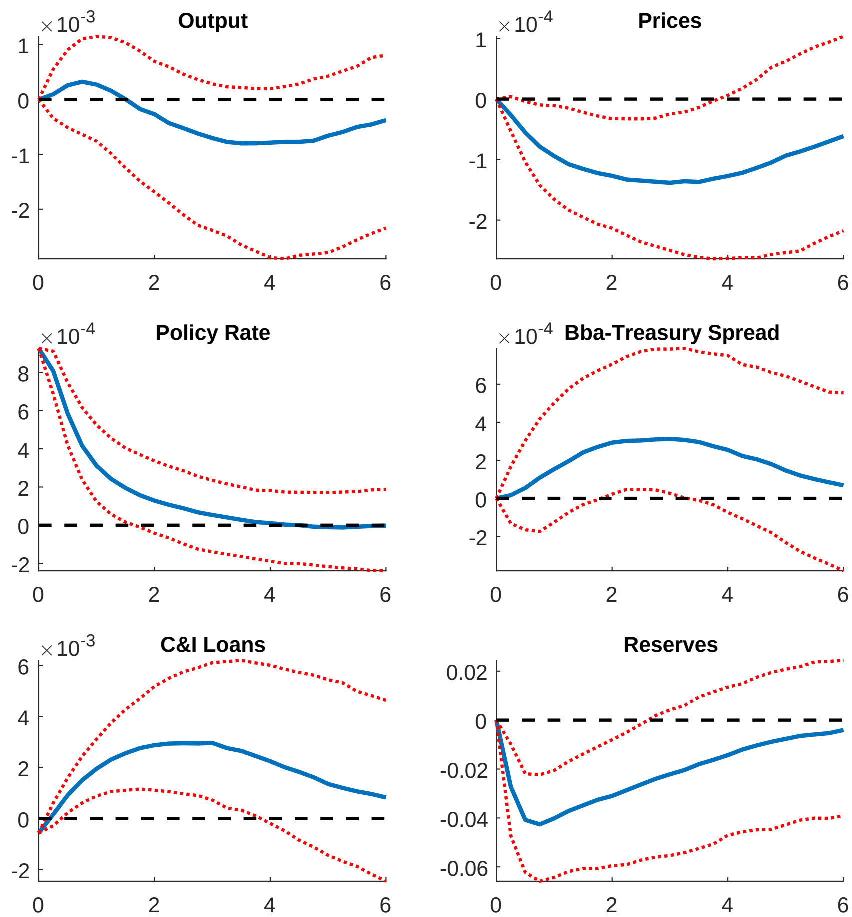

Figure S32: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with total C&I loans, Krippner shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

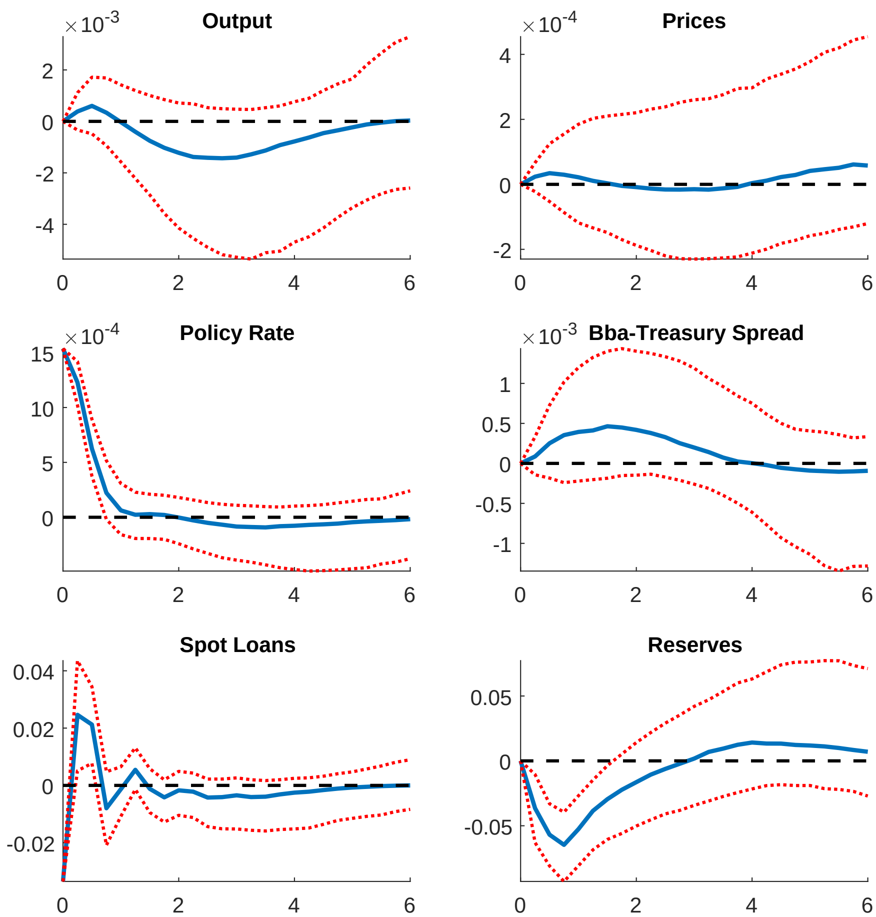

Figure S33: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with spot loans loans, Wu–Xia shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

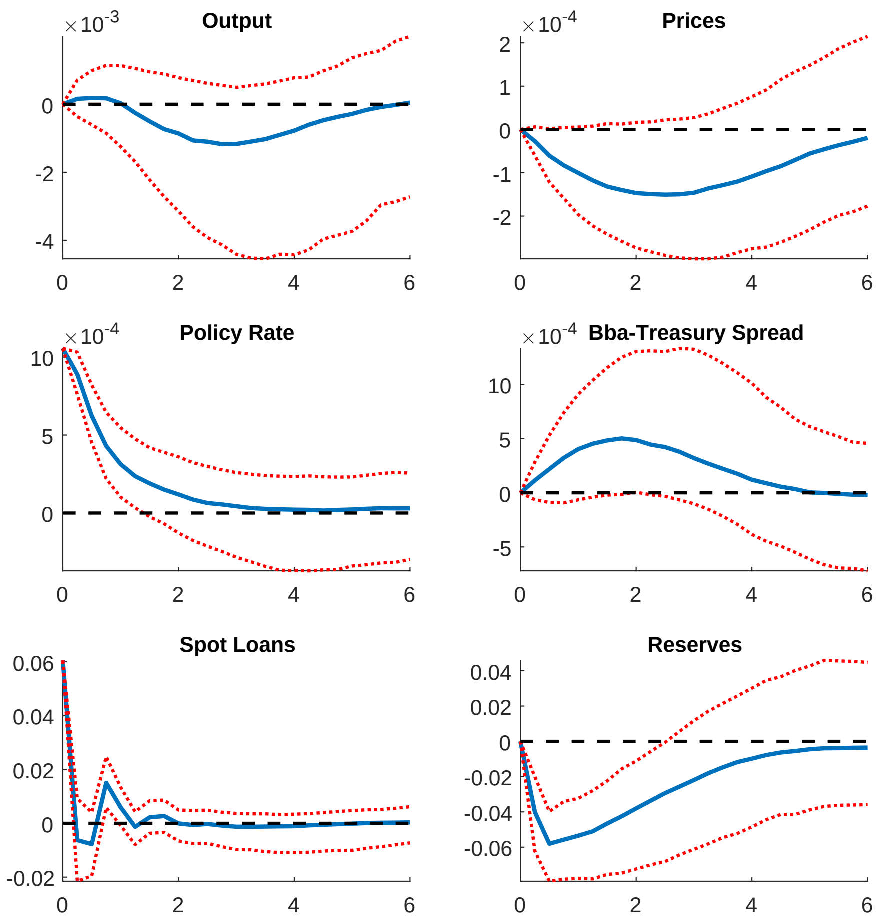

Figure S34: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with spot loans, Krippner shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

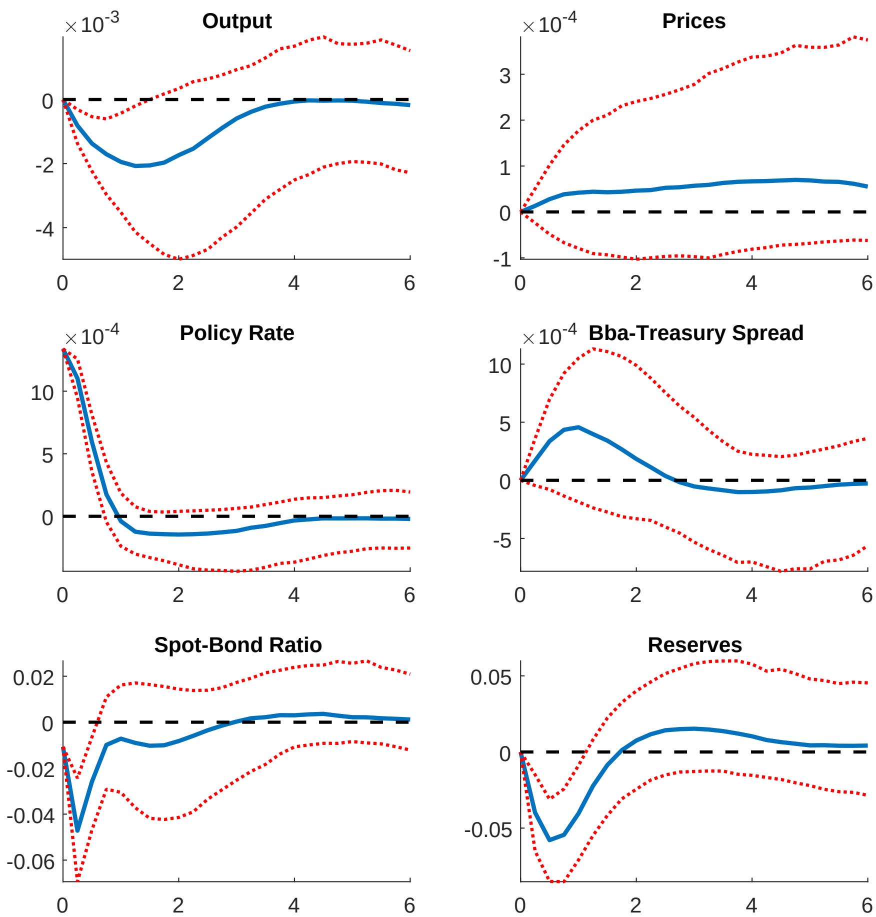

Figure S35: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with spot loan to bonds ratio, Wu–Xia shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

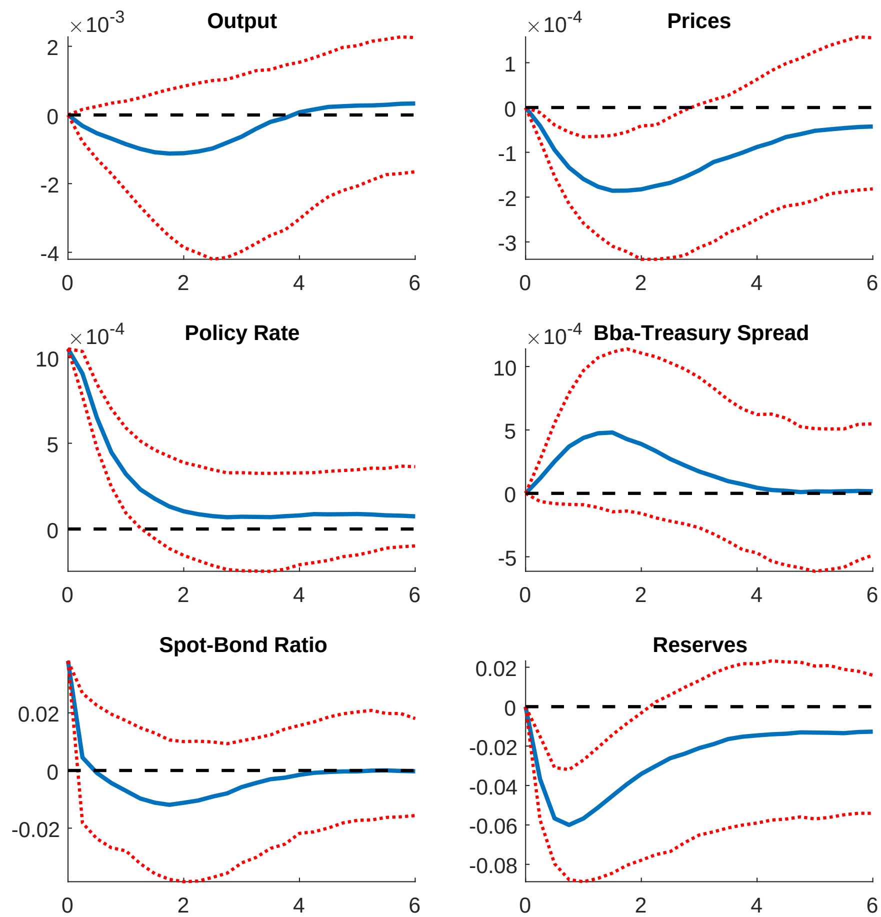

Figure S36: Responses to a 1-standard-deviation monetary shock during the Great Recession - VAR(2) model at monthly frequency with spot loan to bonds ratio, Krippner shadow rate, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Reserves are adjusted by total Fed's facilities. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

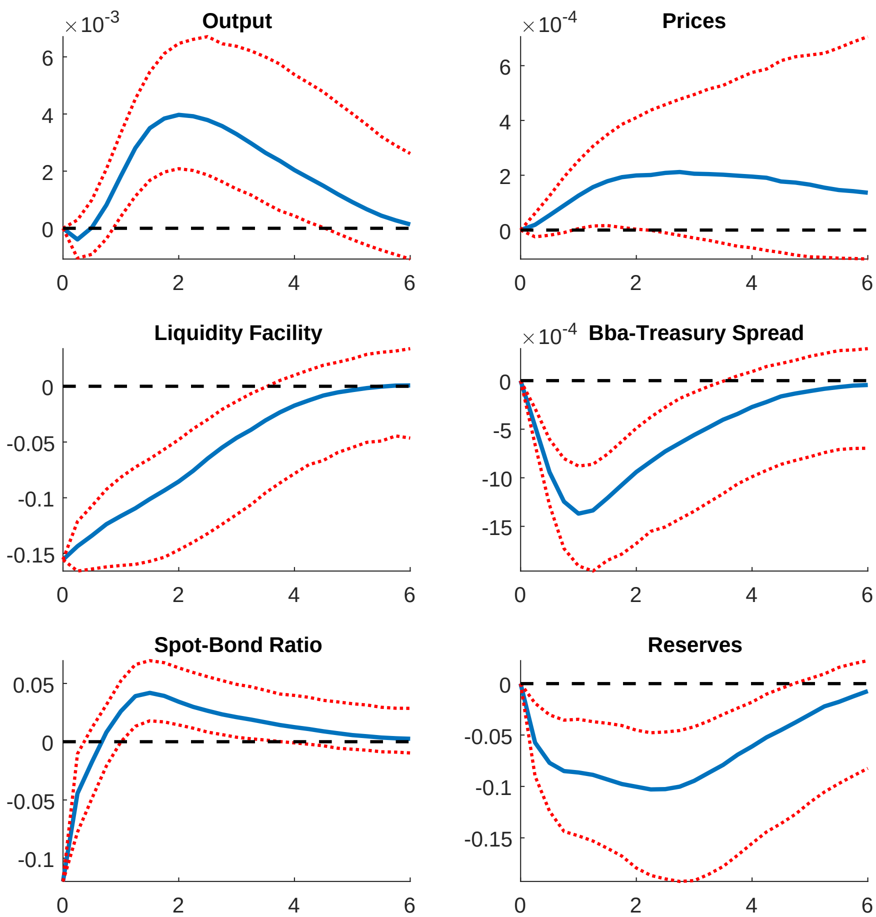

Figure S37: Responses to a 1-standard-deviation liquidity shock during the Great Recession - VAR(2) model at monthly frequency with the ratio of spot loans to bonds, tightening shock to total Fed's liquidity facilities, industrial production, consumer price index, and the spread between the Moody's seasoned Baa corporate bond yield and the 10-year Treasury constant maturity rate. Identification scheme with reserves and spread ordered before the policy rate. Four-month periods from the shock on the x-axis. Sample 2007:12–2010:3.

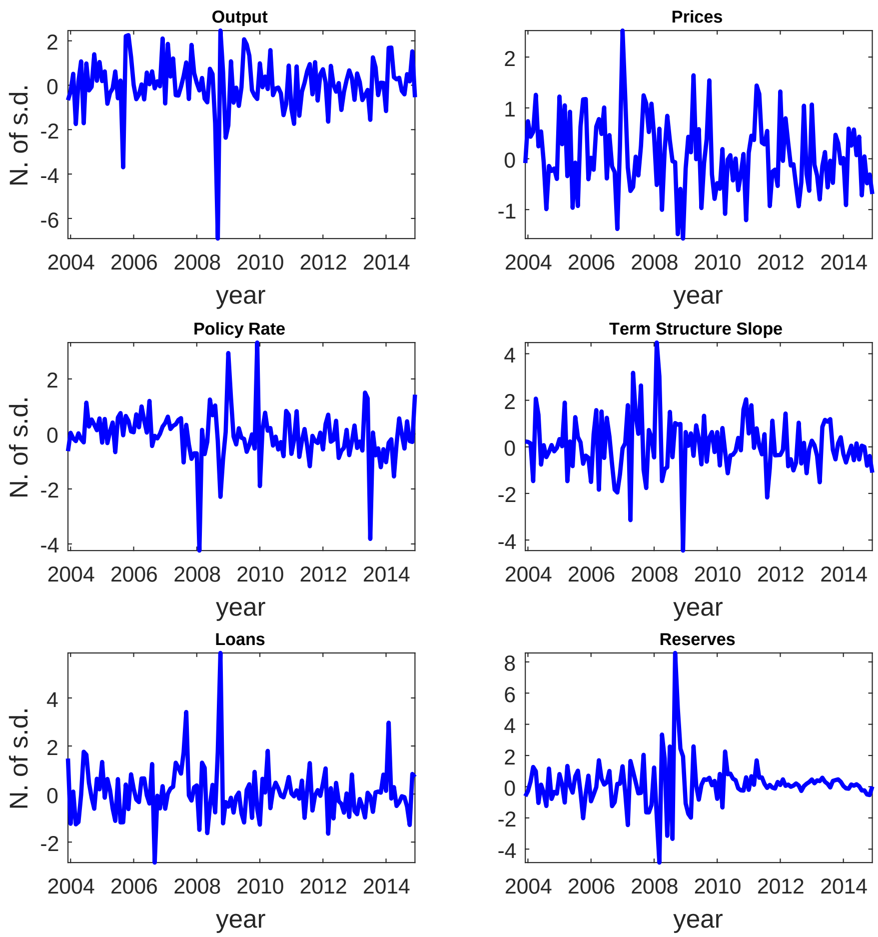

Figure S38: Residual plot for the model in Figure S27 estimated over the sample ample 1983:1–2017:5. VAR(12) model at monthly frequency with the policy rate (Wu–Xia for the post crisis), industrial production, the price index, the term structure slope, and reserves in addition to the total C&I loans.