The Bank Lending Channel and the Market for Banks' Wholesale Funding

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Abstract

The bank lending channel (BLC) holds that monetary policy is transmitted through the supply of bank loans. While the original formulation of the BLC stresses an imperfect substitution between reservable and non-reservable sources of banks' funding, as the transmission mechanism, recent contributions highlight changes of banks' risk premia as a more relevant link between monetary policy and loan supply. Using U.S. data, we quantify the relative importance of these two complementary channels with a SVAR approach. The differently transmitted monetary policy shocks are identified with sigh restrictions that disentangle different dynamics on the market for banks' wholesale funding. We find that policy shocks associated with dynamics on the wholesale funding market that are consistent with the traditional BLC or changes in banks' risk premia, contribute both to the variation of total loans, with the latter mechanism being nearly twice as strong as the traditional BLC.

Keywords: Bank Lending Channel, Risk-Pricing Channel, External Finance Premium, Structural Vector Autoregression, Zero and Sign Restrictions

JEL codes: E44, E52, G21

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1 Introduction

How does monetary policy influence the supply of bank loans? According to the traditional bank lending channel (BLC), monetary policy manipulates reserves in the banking system and, unless banks are able to fully off-set these fluctuations in reserves, they have to adjust the supply of loans (Bernanke and Blinder, 1988, 1992). More recently, endogenous changes in banks' funding costs have been stressed as a complementary channel through which monetary policy influences loan supply (Disyatat, 2011). This risk-pricing channel (Kishan and Opiela, 2012) stresses that the market for banks' non-reservable funding is subject to financial frictions and that a contractionary policy shock, for instance, increases the default risk of banks. Consequently, banks' external finance premia increase, which leads to a reduction of loan supply (see also Bernanke, 2007).

Although a large empirical literature documents that banks adjust loan supply in response to monetary policy shocks,[1] relatively little is known empirically about the precise channels through which policy shocks are transmitted to loan supply and ultimately output. In fact, Disyatat (2011) points out that most of the existing evidence in favor of the traditional BLC is essentially also consistent with a prominent role of the risk-pricing channel. In addition, although in the literature the existence of loan supply effects is well established, the macroeconomic implications may be weak (see Ashcraft, 2006) and the dynamics of loan volumes may be driven primarily by demand-side effects. In particular, Carpenter and Demiralp (2012) argue that firms increasingly use established credit lines in the aftermath of policy shocks and therefore, changes in loan volumes are mainly demand driven.[2]

The main objective of this paper is to study the characteristics of the different transmission channels and to quantify their relative contributions to the dynamics of loan volumes in the aftermath of a monetary policy shock. We estimate a vector autoregressive (VAR) model with quarterly U.S. data and identify shocks and transmission channels through a combination of a recursive identification scheme and a sign restrictions approach (see e.g. Faust, 1998; Uhlig, 2005).[3] While the recursive identification of monetary policy shock is well established (Christiano

[1]See e.g. Kashyap and Stein (1994, 1995, 2000), Bernanke and Gertler (1995), Kishan and Opiela (2000), Gambacorta (2005, 2008), and Gambacorta and Marques-Ibanez (2011), among many others.

[2]Sofianos et al. (1990) show that loan commitments are sufficient for borrowers to protect against loan supply constraints after policy contractions and hence, responses of loans agreed under commitment are mainly demand driven. Den Haan et al. (2007) and Giannone et al. (2012) also find that loans to non-financial cooperations (commercial and industrial loans) increase after a tightening of monetary policy.

[3]Combinations of zero and sign restrictions are also applied by e.g. Buch et al. (2014), Eickmeier and Hofmann

et al., 1999), we provide a novel approach to distinguish between different transmission channels. Unlike most papers in the literature on the BLC, our analysis is based on aggregated data, which allows us to study the transmission channels from a macroeconomic perspective and quantify their importance for the business cycle.

To distinguish between the traditional BLC and the risk-pricing channel, we impose sign restrictions on the market for large certificates of deposits (jumbo CDs), specifically on responses of interest rates and quantities of jumbo CDs. The jumbo CD market represents a common source for banks' wholesale funding (see e.g. Acharya and Mora, 2015; Kishan and Opiela, 2012). In terms of magnitudes, jumbo CDs account on average 14.06% of total deposits (the average is calculated for our sample across banks and time).[4] We argue that the traditional BLC and the risk-pricing channel are associated with different dynamics on the market for jumbo CDs. Consider for instance a monetary contraction. According to the traditional BLC, banks will try to keep up lending by raising non-reservable types of funding. In other words, we should observe higher demand for funding on the market for jumbo CDs. In contrast, if the monetary contraction is transmitted to banks through frictions on the market for uninsured funds, then jumbo CD purchasers require higher risk premia, which translates into a shift of the supply of funds. Thus, by disentangling supply and demand effects on the market for jumbo CDs, we are able to separate the channels through which policy shocks are transmitted to the banking sector and to the supply of loans. The identification with sign restrictions seems particularly well suited for our purpose as they allow us to disentangle supply and demand dynamics on the aggregate level.[5]

Note that although an increase in the demand for funding on the market for jumbo CDs is inconsistent with the risk-pricing channel, it does not necessarily indicate a dominant role for the traditional BLC since an increase in the demand for loans is likely to give rise to similar dynamics. As for instance firms exhaust credit lines, banks may have to obtain marginal funding on the market for jumbo CDs to meet the higher demand. While these two channels cannot be distinguished by their effect on the market for jumbo CDs, their implications for loan volumes

(2013), Jarociński (2010), and Peersman (2011).

[4]Using jumbo CD rates, Kishan and Opiela (2012) show that the pricing of uninsured bank debt responds endogenously to monetary policy, providing support for the risk-pricing channel.

[5]Sign restrictions are already widely used to distinguish between supply and demand side effects across various markets. Most prominent may be (in response to the recent financial crisis) the use of sign restrictions to distinguish between credit demand and supply shocks (see e.g. Gambetti and Musso, 2012; Hristov et al., 2012; Meeks, 2012, among others). In contrast, we identify policy shocks that are either simultaneously present with a change in the demand or supply of banks' wholesale funding. Hence, channels are distinguished in respect to the simultaneous dynamics on banks' market for wholesale funding.

differ. Thus, since we leave the response of loan volumes unrestricted, we are able to distinguish between the traditional BLC and the effects of credit lines, or higher demand for loans more generally.

Our results show that although policy shocks associated with dynamics that are consistent with the traditional BLC play some role in the transmission mechanism (in line with Kashyap and Stein, 1995, 2000; Kishan and Opiela, 2000; Gambacorta, 2005, 2008), their overall contribution to the variation of total loans remains limited. Although the contribution increases somewhat over time, on average over a three year horizon, they contribute roughly 15% to policy induced dynamics of total loans. Policy shocks that give rise to dynamics on the market for jumbo CDs consistent with the risk-pricing channel, account on average for roughly 25% to 30% over a horizon of three years, depending on the specification. Thus, although the traditional BLC as well as the risk-pricing channel both act as transmission mechanisms, the risk-pricing channel is quantitatively substantially more relevant. This finding supports the recent emphasis in the BLC literature on banks' risk premia as an important link between monetary policy and loan supply (see Disyatat, 2011; Kishan and Opiela, 2012). Furthermore, loan demand effects, as argued in Carpenter and Demiralp (2012), account for slightly more than half of the forecast error variance of total loans after monetary policy shocks.

The paper is structured as follows: In Section 2 we present our empirical model and explain our identification approach. Section 3 shows the main results and in Section 4 we provide intensive sensitivity checks. Finally, section 5 concludes.

2 Empirical Approach

The transmission channels of monetary policy are identified and quantified using a structural VAR approach.

2.1 Estimation and Data

Consider the VAR

$$Y_t = \sum_{j=1}^{2} A_j Y_{t-j} + e_t, \tag{1}$$

where Y is the vector of endogenous variables, A_j represents the coefficient matrix and e_t is a vector of white noise reduced-form residuals. According to the Bayesian (or Schwarz) information criterion we use two lags in our baseline estimation.[6] The vector Y includes real GDP (RGDP), the consumer price index (CPI), the federal funds rate (FFR), CD volumes (CDVOL), the CD rate (CDRATE), total loans (TOLN) and the volume of demand deposits (DDVOL).

We estimate the reduced form VAR with Bayesian methods using an uninformative Normal-Wishart prior on the coefficients and the variance-covariance matrix. As part of the family of conjugate priors the posterior distribution is Normal-Wishart as well and furthermore can be obtained analytically (see e.g. Uhlig, 1994). For the estimation we use U.S. data over the period from 1984Q1 to 2007Q3.[7]

The macroeconomic aggregates, real GDP, consumer price index, federal funds rate and demand deposits, are from the St. Louis Federal Reserve Economic Data (FRED). For total loans we use the H.8 table from the Board of Governors of the Federal Reserve System. Volumes and interest rates of jumbo CDs are obtained from the Consolidated Reports of Condition and Income (short Call Reports), in which all insured banks in the U.S. submit their income and balance sheet statements to the Federal Reserve. We calculate the aggregate volume of jumbo CDs (CDVOL_t) from the data reported for individual banks as:

$$\text{CDVOL}_t = \sum_{i=1}^{N_t} \text{CDVOL}_{it},$$

where N_t is the number of banks in each quarter t. Although the CD rate is not directly available in the Call reports, it can be calculated as the quarterly interest expenses associated with jumbo CDs (INTEX_{it}) over the volume of jumbo CDs (see also Acharya and Mora, 2015; Kishan and Opiela, 2012):

$$\text{CDATE}_t = 4\frac{\sum_{i=1}^{N_t} \text{INTEX}_{it}}{\text{CDVOL}_t}.$$

For easier interpretation of the results we multiply the CD rate by four to obtain an annualized rate.[8]

[6]As we use quarterly data for our estimation we also consider 4 lags in a robustness check. Results do not change (see Figure 9 and Table 10 in the Appendix).

[7]In the baseline estimation we consider a rather stable period excluding extreme economic events as the recent global financial crisis as well as the period of high interest rates before 1984. Also since the period after 2007 was characterized by the zero lower bound, this period complicates the identification of monetary policy shocks. Nevertheless, we also check results using an extended sample up to 2015Q1 (see Section 3).

[8]Interest expenses of jumbo CDs (INTEX_{it}) are not reported for the first two quarters of 1997. In the baseline we simply drop these periods. However, results and conclusions are consistent if we interpolate the missing values

For the the calculation of CDVOL and CDRATE, we follow Den Haan et al. (2002) and use only insured banks which are located in the US (1,040,066 bank quarters). Interest expenses of jumbo CDs are reported for 1,001,764 bank quarters. We clear the dataset by dropping negative interest expenses (5,043 observations). Volumes of jumbo CDs are available for each of the finally 996,721 bank quarters. To calculate the aggregate CD volume and the CD rate, we use data only from banks which report volumes as well as interest expenses. The remaining data preparation follows the literature (see Carpenter and Demiralp, 2012; Uhlig, 2005): We deflate nominal variables (total loans, CD volumes and demand deposits) by the consumer price index. All variables (except the federal funds rate and the CD rate) enter the VAR in logs and are seasonally adjusted.[9] The exact description of each variable is summarized in Table 1.

2.2 Identification of Shocks

To identify shocks, we impose combinations of zero and sign restrictions on the impulse response functions applying the approach suggested by Rubio-Ramrez et al. (2010) and Arias et al. (2014). We identify monetary policy shocks using zero restrictions and impose additional sign restrictions to disentangle the the dynamics on the market for jumbo CDs according to supply or demand effects as discussed below.

The restrictions are summarized in Table 2. The zero restrictions preserve the standard recursive structure with the federal funds rate ordered after output and prices (see e.g. Christiano et al., 1999). Consistent wit a standard Taylor Rule, the ordering implies that monetary policy is contemporaneously influenced by changes in output and prices. With zero restrictions on output and prices, the three channel are not consistent with aggregate supply and aggregate demand shocks. The ordering of total loans behind the federal funds rate and the two CD variables also excludes the presence of credit supply or demand shocks, since loan volumes only respond to the three differently transmitted policy shocks but they do not influence the three channels on impact. Consequently, as the federal funds rate and the two CD variables do not simultaneously respond to exogenous changes in loan volumes, our channels do not represent credit shocks either.

To distinguish between different monetary policy transmission channels, we impose sign restrictions based on the idea that the different transmission channels give rise to different dy-

of the CD rate with the X-13 ARIMA method. Results are not reported but available upon request.

[9] The individual time-series are not detrended as all roots lie within the unit circle.

namics on the market for jumbo CDs. Consider first the traditional BLC. According to this interpretation of the BLC, banks substitute from reservable deposits to non-reservable funding after a monetary contraction. Consequently, the demand for wholesale funding in general, and also the demand for funds on the market for jumbo CDs should increase. A higher demand for funds at the jumbo CD market implies on the aggregate level higher prices and volumes of jumbo CDs. The second channel we are interested in, which emphasizes banks' risk premia (Kishan and Opiela, 2012; Disyatat, 2011), gives rise to different dynamics on the jumbo CD market. According to this risk-pricing channel, investors are only willing to supply funds on the market for jumbo CDs if they are compensated by a higher risk premium after a policy shock. In other words, the shift in the supply of funds on the jumbo CD market leads to an increase in the price of these funds and at the same time lower volumes.

All other dynamics on the jumbo CD market are captured by the residual channel of monetary policy. We separate the residual channel from the first two mechanisms by restricting the response of the jumbo CD rate to be negative.[10] The residual channel captures policy shocks associated with a simultaneous decline of CD volumes and CD rate, which is consistent with a decline of banks' demand for jumbo CDs, in response to a restrictive policy shock. These dynamics may arise if banks decrease their demand for wholesale funding in response to firms and households demanding fewer loans, as suggested by the standard interest rate channel, where a monetary tightening dampens economic activity and increases the cost of capital, which ultimately reduces firms' demand of bank loans. The residual channel also captures situations where a policy shock gives rise to an increase in the supply of funds on the jumbo CD market. This may occur if investors which perceive banks as a relatively safe borrowers due to e.g. too-big-to-fail considerations. In this case, prices of jumbo CDs decline while volumes increase.

In short, we distinguish between monetary policy shocks according to whether they are associated with (i) additional funding effects, (ii) the risk-pricing channel, or (iii) a residual channel of monetary policy not related to either (i) or (ii).

Importantly, however, the mechanism emphasized in the traditional BLC is not the only mechanism consistent with an increasing demand for funding on the market for jumbo CDs. Banks may also demand more funds if firms' demand for bank loan increases as they, for instance, exhaust existing loan commitments in response to a monetary tightening (Carpenter

[10]We also consider alternative restrictions that put slightly more or less structure on the residual channel. Results and conclusions actually appear to be very consistent across alternative specifications of the residual shock (all robustness checks are provided in Section 4).

and Demiralp, 2012; Peersman, 2011; Sofianos et al., 1990). In this case, additional funds are required to accommodate the higher demand for loans giving rise to the same dynamics on the market for jumbo CDs as the traditional BLC. Although the imposed restrictions do not allow us to distinguish between the traditional BLC and the effect of higher loan demand, the implications differ with respect to the dynamics of loan volumes. While the BLC predicts that loan supply, and ultimately loan volumes, to decline since insurable and non-insurable sources of funding are only imperfect substitutes for banks, firms' increasing use of credit lines should result in higher observed loan volumes after a policy shock. Thus, since we leave the response of total loans unrestricted, we are able to check whether the traditional BLC dominates the dynamics of loan volumes.[11]

Sign restrictions are imposed on impact and the subsequent period.[12] For the identification of the structural models we implement the selection algorithm as following: We draw 1,000 models from the posterior distribution and work through all draws sequentially. We start with the first model and derive a random factorization of the model, as described below. We check whether the random orthogonal shocks yield impulse responses that are consistent with the imposed sign restrictions. If yes, we save the responses as part of the restricted posterior distribution of impulse responses and continue with the next model. If not, we derive a new transformation of the model and check the impulses again. We do not check more than 10,000 transformations for each model. Using this algorithm, we found a factorization for each model satisfying our set of baseline restrictions. The restricted posterior distribution is finally used for inference.

The random factorizations are derived using following steps: The innovations from the reduced from model, stated in equation (1), are first orthogonalized using a standard Cholesky decomposition of the variance-covariance matrix. Accordingly, $u_t = P^{-1}e_t$, where $PP' = \Sigma_e$. An alternative orthogonalization of the model can be found, by using a different random decomposition of the variance-covariance matrix. Using a random orthogonal matrix Q, with $Q'Q = I$ and in respect of the imposed zero restrictions (see Arias et al., 2014), Σ_e can alternatively be decomposed to $PQQ'P'$. Hence, by premultiplying equation (1) with $(PQ)^{-1}$, another set of orthogonal shocks, $\tilde{u}_t = (PQ)^{-1}e_t$, is possible. Sign restrictions finally categorize wether $\tilde{u}_t$ represent structural shocks or not.

[11] In Section 3.3 we also impose additional restrictions on total loan volumes to quantify the traditional BLC and loan demand effects separately.

[12] We also check a specification in which we impose sign restrictions for 4 periods. Results are also robust to this variation (see Figure 10 and Table 11 in the Appendix).

3 Results

3.1 Impulse Response Analysis

Figure 1 shows the impulse response functions of the endogenous variables to the three different types of monetary policy shocks that we disentangle through imposing sign restrictions. The figure shows the point-wise median response (solid line) and the response of the closest-to-median model (dashed line).[13] The light gray and dark gray areas represent 90% and two thirds of the restricted posterior distribution in each period.

The first column shows the responses to a policy shock that is accompanied by an increase in the demand for funding on the market for jumbo CDs, as suggested by the traditional BLC. Following a contractionary policy shock, the federal funds rate, the CD rate and CD volumes increase. Although we only restrict the responses of the CD rate and the CD volume on impact and in the first period, responses of both variables move only slowly back to their steady state values. Therefore the increase in banks' demand for funds appears to be rather persistent.

Simultaneous with the increasing demand for funds, demand deposits decline significantly and persistently, which is in line with findings presented in Bernanke and Blinder (1992). The decline in deposits together with an increase in the demand for funding on the market for jumbo CDs corresponds to the mechanism described in the traditional BLC, according to which banks respond to a contractionary policy shock by switching from insurable demand deposits to non-insurable sources of funding, such as jumbo CDs. Nevertheless, the BLC also holds that banks are forced to reduce loan supply since non-insured sources of funding and demand deposits are only imperfect substitutes. We see, however, that loan volumes increase in response to the shock. While this outcome is at odds with a dominant BLC, it supports the view that firms exhaust credit lines when monetary policy tightens (Carpenter and Demiralp, 2012; Peersman, 2011; Sofianos et al., 1990). In other words, banks use funds obtained on the market for jumbo CDs to accommodate the higher demand for loans arising from borrowers exhausting credit lines. These results are also consistent with the rather weak responses of real GDP and prices. Although real GDP declines in response to policy shocks, the response is not pronounced in early periods, and prices remain essentially stable throughout. Thus, it seems that firms exhaust credit

[13] The closest-to-median model (also known as median target model) is selected as suggested by Fry and Pagan (2011). In principal, a single model is selected which produces impulse responses that are as close as possible to the point-wise median response. The point-wise median response corresponds to the median values of the restricted posterior distribution of impulse responses in each period.

lines to protect against uncertain funding conditions in the future (see Ivashina and Scharfstein, 2010), and to stabilize their level of activity to some extent.

The second column of Figure 1 shows the responses to a monetary policy shock that is accompanied by a shift in the supply of funds on the market for jumbo CDs, consistent with the risk-pricing channel. Recall that to identify these shocks, we restrict the CD volume to decline and the CD rate to increase. The CD rate again follows the federal funds rate although more sluggishly. It remains above its pre-shock level for 7 quarters. The response of CD volumes remains negative throughout. These findings support our interpretation in terms of a policy shock that is associated with persistent changes in the supply of funds on the market for jumbo CDs.

Turning to the unrestricted variables, we see again a decline in demand deposits, although the response is substantially less persistent as in the first case. More important, however, we see that the increase in banks' risk premia is accompanied by a decline in the volume of loans. This finding is clearly in line with the risk-pricing channel, which holds that higher funding costs should induce banks to reduce their loan supply, although the decline is quantitatively small and rather short-lived. The output effects of policy shocks transmitted through the risk-pricing channel are again limited, although in this case no compensating loan demand effects are present.

Finally, the last column of Figure 1 presents the responses to the residual channel of monetary policy. That is, a contractionary policy shock that is neither associated with an increase in banks' demand for funds, nor with a decline in investors' supply of funds. We see that the increase in the federal funds rate is more sluggish in this case and that the response of the CD rate remains negative only in periods for which we impose the restriction, indicating that this restriction, while necessary to identify the residual shock, seems to be less well supported by the data. CD volumes, which we leave unrestricted in this case, decline slightly. The response of demand deposits is marginally positive in early periods. In contrast to the previous two channels, the total loan response does not reveal any systematic pattern. This might indicate that the different policy effects, all captured by the residual channel, may cancel each other out.

In summary, we see that if policy shocks are associated with higher demand on the market for jumbo CDs, then loan volumes increase. We conclude that these responses indicate that policy shocks give rise to a higher demand for loans, perhaps due to credit lines, rather than a reduction in loan supply, as suggested by the BLC. Hence, the traditional BLC does not appear to feature prominently in the data. For policy shocks, which are transmitted through the risk-pricing channel, we find a decline of loan volumes as predicted, but the effect is only short lived. Turning to the macroeconomic implications, the output responses associated with either channel are rather limited. This conclusion is actually consistent with findings from previous research, which shows that the BLC seems not to reasonably determine output dynamics in the U.S. (see Ashcraft, 2006; Ciccarelli et al., 2015).

3.2 Variance Decomposition

To quantify the relative contributions of the individual channels to the transmission of monetary policy, we compute the forecast error variance decomposition (FEVD) for total loans. Figure 6 shows the contributions of the three types of monetary policy shocks for different forecast horizons. The black area shows the contribution of shocks accompanied by an increase in the demand for funding on the CD market. The dark gray area accounts for shocks which coincide with changes in the risk-pricing on the CD market, and the light gray area is the contribution of the residual policy channel. To keep the figure easy to interpret, only the shares of the identified shocks are shown.[14] The values correspond to the median FEVD at each forecast horizon.[15]

The overall influence of monetary policy, i.e. the sum of the three transmission channels, explains about 6.99% on average over the forecast horizon of 3 years. Other studies which identify monetary policy shocks and study the FEVD of total loans as well, find slightly higher values (see e.g. Hristov et al., 2012; Peersman, 2011). However, results are generally hard to compare, as identification approaches and data sets vary substantially across studies. Therefore we also perform an estimation with a standard recursive identification of the policy shock (without additional sign restrictions and separate transmission channels) representing a common benchmark for monetary policy. Indeed, monetary policy appears to have only a limited influence on the dynamics of total loans in our sample.[16] Importantly, as monetary policy in general follows systematic rules to stabilize the economy, exogenous monetary policy shocks are rare. Therefore, while we are able to identify causal effects of monetary policy (Ramey, 2015), the FEVD only measures contributions of the nonsystematic part of monetary policy. In the

[14] Table 8 in the Appendix shows contributions of all shocks at selected horizons.

[15] Results and conclusions are also consistent with the FEVD of the closest-to-median model (see Figure 8 in the Appendix).

[16] Results are not presented in the paper but available upon request.

following discussion, consequently, we focus on the relative contribution of the individual channels, since the channels most likely contribute to a similar extend also to the transmission of systematic monetary policy.

On impact, the risk-pricing channel dominates the transmission of monetary policy and its contribution remains roughly constant, while the contributions of the additional funding effects and the residual policy shock increase over time. Over the entire forecast horizon of three years, the three channels account on average 53.00%, 25.71% and 21.29% of the transmission of monetary policy shocks. Clearly, the additional funding effects represent for total loans the most relevant transmission mechanism of policy shocks. Hence, changes in monetary policy are mainly transmitted to loan volumes due to banks' increasing demand for wholesale funding. The risk-pricing channel captures one fourth of the overall transmission of monetary policy shocks, representing an important mechanism in influencing loan supply dynamics. The remaining transmission effects, captured by the residual channel, account for roughly one fifth of the transmission effects of monetary policy.

Although the contributions of the additional funding effects are about twice as large as the contribution of the risk-pricing channel, it has to be kept in mind that the former channel comprises the traditional BLC and loan demand effects.[17] From the impulse response analysis we know that the additional funding effects are dominated by an increasing demand for bank loans, most likely due to the presence of credit lines. Therefore, the risk-pricing channel seems to be at least as important as the traditional BLC in the transmission of monetary policy although the quantitative effects of both channels are not (yet) so clear. In the next subsection we qualify our conclusions providing an extended identification approach in which we separate the traditional BLC and higher loan demand effects using additional restrictions on total loans.

3.3 Additional Restrictions on Loan Volumes

As argued above, loan volumes should decline when a contractionary policy shock is transmitted through the traditional BLC or risk-pricing channel, while in contrast loan volumes increase

[17] With more recent data up to 2015Q1, the influence of the risk-pricing channel actually increases and becomes equally important as the additional funding effects (results are presented in Figure 11 and Table 12 in the Appendix). Although this finding principally supports Disyatat's (2011) conclusion, namely that the risk-pricing channel is gaining more importance in more developed financial markets, result should be interpreted with caution as monetary policy hit the zero lower bound after 2007 and shocks may no longer be appropriately identified during this time.

with the presence of credit lines, or an increasing loan demand more generally. We can use these differences to clearly separate higher loan demand effects from the other two transmission channels, simply by imposing sign restrictions on total loans. In particular, we require that total loans respond negatively when the policy shock is transmitted through the traditional bank lending or risk-pricing channel, while we restrict the response to be positive with a transmission through an higher loan demand. The restrictions are summarized in Table 3.

However, the separate identification of higher loan demand and traditional BLC effects come at some costs. With the additional restrictions on total loans we impose a relatively rich set of sign restrictions which narrows the restricted posterior distribution. While we find a transformation of each model drawn from the unrestricted posterior distribution in our baseline estimation, now admissible transformations are only available for every fifth model. Nevertheless the restricted posterior still represents a reasonable share of the unrestricted posterior.[18] Furthermore, by splitting up the additional funding effects we cannot longer identify a separate residual channel of monetary policy as well. Therefore, the overall influence of monetary policy might not be fully captured. However, with the additional structure we can explicitly disentangle transmission effects due to the traditional BLC and a higher loan demand.

The impulse responses are presented in Figures 2. The responses with the risk-pricing channel are very similar as compared to our baseline specification. Concerning our two newly identified channels, we see that responses associated with higher loan demand look also similar to the responses linked to the previously identified additional funding effects. This supports our previous interpretation that additional funding effects are dominated by an increasing demand for bank loans. Similar to the responses associated with higher loan demand, the rate and volumes of jumbo CDs respond also persistently with the traditional BLC. Furthermore, demand deposits also clearly decline after a tightening of monetary policy. In contrast, policy shocks that coincide with dynamics consistent with the traditional BLC are very short lived and exert no contractionary effects on real GDP. Also the negative effect on total loans just disappears after the restriction terminates. Therefore, the transmission effects from the traditional BLC seem relatively weak on the aggregate level.

The FEVD of total loans (presented in Figure 7) supports our conclusions so far.[19] Monetary policy influences total loan volumes mainly through an increasing demand for loans. Further-

[18] In detail, we find 1,054 models which fulfill restrictions out of the 5,000 posterior draws.

[19] Again Table 9 in the Appendix presents contributions of all shocks at selected forecast horizons.

more, a transmission of monetary policy through the traditional BLC on total loans seems indeed very muted. Over the entire forecast horizon of three years, the originally formulated BLC captures on average only 15.57% of the transmission effects of monetary policy on total loans. The risk-pricing channel captures again about one fourth (27.20%) of the overall influence of monetary policy (again over the forecast horizon of three years). Therefore, the transmission effects on total loans from the risk-pricing channel are nearly twice as large as compared to the traditional BLC. This finding clearly supports the new focus in the BLC literature on bank investors' risk-pricing, as the relevant transmission mechanism linking loan supply and monetary policy (Disyatat, 2011; Kishan and Opiela, 2012). Nevertheless, the strongest transmission effects of monetary policy appear to materialize through an increasing demand for bank loans, most likely due to firms' possibility to draw down existing credit lines. On average 57.23% of the transmission effects of monetary policy are attributed to the increasing demand for bank loans in the aftermath of policy changes. Hence, consistent with previous research we also find that loan demand responses are relatively more important as the BLC (Carpenter and Demiralp, 2012).[20] However, in contrast to a general weak relevance of the BLC on the macro level (Ashcraft, 2006; Ciccarelli et al., 2015) we find that especially the more recent formulated risk-pricing channel also substantially contributes to the transmission of monetary policy.

4 Sensitivity Checks

In this section we provide several sensitivity checks: First, we test whether the causal ordering of total loans influences our results and then we check additional specifications of the residual shock of monetary policy. Due to the mentioned limitations of our more specific identification approach in Section 3.3, we perform all our sensitivity checks on our baseline identification. In general, results are very consistent across these variations.

[20] To qualify the interpretation of the rise of total loans in favor of credit lines we also perform an estimation including aggregated unused loan commitments (series RCON3423 from Call reports) instead of total loans. Unfortunately, data on used or total loan commitments are not publicly available. Nevertheless, unused loan commitments decrease when policy shocks are associated with additional funding effects and therefore support the presence of credit lines and the increasing exhaustion of these commitments after a policy contraction. Results are available upon request.

4.1 Alternative Ordering

While banking variables are commonly ordered behind the policy rate (see Christiano et al., 1999; Den Haan et al., 2007; Eickmeier and Hofmann, 2013), Ciccarelli et al. (2015) emphasize that monetary authorities monitor credit markets closely and consider any changes in their policy decisions (see also Buch et al., 2014). We can address this concern by simply ordering total loans (TOLN) before the monetary policy block. The federal funds rate can now respond on impact to exogenous changes in total loans, while policy shocks do not influence loan volumes simultaneously. Although monetary policy is now allowed to respond to changes in loan volumes, with the zero restrictions on total loans, the transmission channels – similar as in our baseline identification – do not represent exogenous credit shocks. The identification with the alternative ordering of total loans is summarized in Table 4.

Figure 3 shows results with total loans ordered before the monetary channels. Across all three shocks, responses are very similar to our baseline, both in terms of magnitude and persistence of the responses. Concerning total loans we see that the increase in loan volumes associated with the additional funding effects is slightly weaker but of similar magnitude as in our baseline. The short lived negative response of total loans in the risk-pricing channel becomes less relevant however. Although the point-wise median and the closest-to-median responses are both still negative in the first period, the zero restriction on impact clearly limits the scope of the total loan responses to be systematically below zero. No changes are present for the response of total loans in the residual channel of monetary policy. The restricted posterior distribution is again clearly centered around zero.

The forecast error variance decomposition of total loans is represented in Table 6. As in our favored specification, the additional funding effects are again the most relevant transmission mechanism of monetary policy. Furthermore, with the positive response of total loans, higher loan demand seems again relatively more dominant as the traditional formulation of the BLC. Therefore, also with the alternative ordering of the VAR, monetary policy influences the dynamics of total loans mainly through firms' increasing demand of loans and banks need to fund the additionally demanded credit.

Different to our baseline, the influence of monetary policy on the dynamics of total loans shifts from the first half of the forecast horizon toward the second half. Hence, in the first six quarters the three channels explain a smaller fraction of the variation in total loans, while they explain a higher fraction between the sixth and twelfth forecast horizon. Furthermore, the relative strong influence of the risk-pricing channel during the first two quarters is no longer present. These changes, however, are agin consistent with the motivation of the alternative ordering, namely that monetary policy influences loan volumes only with a delay.

4.2 Residual Shock of Monetary Policy

In our baseline the residual shock of monetary policy captures two different dynamics on the jumbo CD market. Namely, a decline in the demand and an increase in the supply of funds. With the negative restriction on the CD rate, the residual shock is clearly separable from the additional funding effects and the risk-pricing channel. However, as we discussed previously, empirically the negative restriction on the CD rate seems rather strong. Therefore, we consider two further specifications of the residual channel to qualify our initial restriction. First, we do not impose any sign restrictions on the residual channel leaving the jumbo CD market unrestricted. While this approach is clearly less restrictive, the residual shocks is then no longer a prior distinguishable from the other two channels (see Peersman, 2011, for the same approach in a different context).[21]

Furthermore, we also check a specifications in which we impose more structure on the residual channel. In particular, we additionally restrict the impulse response of CD volumes to be negative (in addition to the negative restrictions on the response of the CD rate in our baseline). Therefore, the residual channel of monetary policy now coincides with a decline in the demand for funds. With this additional restriction, the residual shock may also be interpreted as a separate demand channel. Given that firms' demand for bank loans decreases after a monetary tightening, banks require less marginal funding and therefore demand less funds on the jumbo CD market. This interpretation is consistent with the classical interest rate channel: With a tightening of monetary policy, economic activity slows down and the cost of credit increase, which ultimately decreases firms' demand for bank loans. The alternative specifications of the residual channel of monetary policy are summarized in Table 5.

Figure 4 shows impulse responses of the estimation with the unrestricted residual channel. The impulse responses linked to the additional funding effects and the risk-pricing channel are

[21] Peersman (2011) combines a recursive identification approach with sign restrictions on the credit market to disentangle different lending channels. In this study the residual shock of bank lending is not explicitly separated from other lending channels.

principally consistent with the baseline specification. The distribution of the impulse responses might be slightly broader but the interpretation of the results does not change. In contrast, the impulse responses of the residual channel look now different to our baseline estimation. In particular, no response is systematically different from zero in this case. As we do not impose any sign restrictions, the residual channel captures all dynamics on the jumbo CD market and therefore a broad set of responses are possible. This increased variation is now present in the impulse responses.

In Figure 5 we present impulse responses from the specification with the additional restriction on the residual channel. The responses look actually very similar to our baseline estimation. Also the responses of the residual channel reveal very similar pattern. Only the volumes of jumbo CDs are now negative on impact and the first period, as imposed by the additional restriction. Interesting, although volumes of jumbo CDs decrease, loan volumes do not show a systematic reaction. Hence, a contractionary policy shock which is present with a decline in the demand for marginal funds exerts no influence on total loan volumes. Consequently, a general decline of loan demand seems not to influence loan volumes in any systematic way.

The forecast error variance decompositions of total loans in our two alternative specifications are very similar to our baseline estimation (see Table 7). Therefore, our results are also consistent regardless of the exact identification of the residual channel of monetary policy.

5 Conclusion

A broad empirical literature supports the presence of the traditional BLC, showing that the supply of bank loans responds to changes in monetary policy (see Kashyap and Stein, 1995, 2000; Kishan and Opiela, 2000; Gambacorta, 2005, 2008). However, from these micro studies it remains unclear to what extend the identified loan supply shifts contribute to the dynamics of aggregated total loan volumes in response to a monetary policy shock. Furthermore, the existing empirical evidence, while originally motivated with the traditional BLC, seems also consistent with the more recently formulated risk-pricing channel (Disyatat, 2011). We address both concerns by providing a novel approach that separately quantifies the two complementary transmission mechanisms on the macro level.

We find empirical evidence that the traditional BLC contributes to the dynamics of total loans supporting the existence of the originally formulated transmission mechanism. However, the traditional BLC captures on average only 15% of the overall effect of monetary policy shocks on total loans over a forecast horizon of three years. In contrast, the more recently formulated risk-pricing channel accounts over the same forecast horizon roughly between 25% and 30% of the combined effect of monetary policy shocks on total loans, depending on the specification. Hence, loan supply responses together account for nearly half of the variations in total loans after a policy shock. Furthermore, the risk-pricing channel appears to be nearly twice as strong as the traditional BLC. This finding supports the recent emphasis in the BLC literature on the response of banks' external financing premia to policy shocks, as the deeper link between monetary policy and loan supply (Disyatat, 2011; Kishan and Opiela, 2012). Changes in loan demand, as described by Carpenter and Demiralp (2012), account for slightly more than half of the variation in total loans caused by policy shocks. Therefore, our results show that dynamics of total loans in response to policy shocks are nearly equally influenced by changes in the supply as well as the demand for bank loans.

Table 1: Variable description

Variables	Name	Source	Code	Period
$RGDP_t$	Real gross domestic product (quarterly, seasonally adjusted, chained 2009)	FRED	GDPC1	1984Q1-2007Q3
CPI_t	Consumer price index: Total all items for the United States (quarterly, end of period, seasonally adjusted)	FRED	CPALTT01USQ661S	1984Q1-2007Q3
FFR_t	Effective federal funds rate (quarterly, end of period, not seasonally adjusted)	FRED	FEDFUNDS	1984Q1-2007Q3
DDVOL	Demand Deposits at Commercial Banks (quarterly, end of period, seasonally adjusted)	FRED	DEMDEPSL	1984Q1-2007Q3
$TOLN_t$	Loans and leases in bank credit (monthly, domestically chartered commercial banks seasonally adjusted)	H8	B1020NDMAM	1984Q1-2007Q3
$CDVOL_{it}$	Quarterly average of time certificates of deposit in denominations of $100,000 or more in domestic offices	CALL	RCON3345	1984Q1-1996Q4
	Quarterly averages of time deposits of $100,000 or more	CALL	RCONA514	1997Q1-2007Q3
$CDVOL_t$	Quarterly sum of $CDVOL_{it}$ across banks			1984Q1-2007Q3
$INTEX_{it}$	Interest on time certificates of deposit of $100,000 or more issued by domestic offices	CALL	RIAD4174	1984Q1-1996Q4
	Interest on time deposits of $100,000 or more	CALL	RIADA517	1997Q3-2007Q3[1]
$INTEX_t$	Quarterly sum of $INTEX_{it}$ across banks			1984Q1-2007Q3
$CDRATE_t$	$(INTEX_t/CDVOL_t) \cdot 4$			1984Q1-2007Q3

Notes: Federal Reserve Economic Data (FRED); Reports of Condition and Income (CALL reports); H.8 Assets and Liabilities of Commercial Banks in the United State (H8); [1]Officially, this series starts in 1997Q1 but no data is available in the first two quarters; The interest expenses on jumbo CDs (RIAD4174 and RIADA517) cumulate yearly and therefore we take first differences within each year to obtain quarterly interest expenses. The CD rate is multiplied by four to annualize the CD rate.

Table 2: Zero and sign restrictions on the impulse response functions

Pertubations	RGDP	CPI	FFR	CDVOL	CDRATE	TOLN	DDVOL
Innovation (RGDP)							
Innovation (CPI)	0						
MP Residual	0	0	↑		↓		
MP Risk-Pricing	0	0	↑	↓	↑		
MP Additional Funding	0	0	↑	↑	↑		
Innovation (TOLN)	0	0	0	0	0		
Innovation (DDVOL)	0	0	0	0	0	0	

Notes: The innovations represent orthogonal shocks of the respective variables without a structural interpretation; monetary policy (MP) shocks are either transmitted through the residual channel, risk-pricing channel or additional funding effects; sign restrictions hold on impact and the next period; all shocks are normalized to be positive.

Table 3: Alternative identification with sign restrictions on total loans

Pertubations	RGDP	CPI	FFR	CDVOL	CDRATE	TOLN	DDVOL
Innovation (RGDP)							
Innovation (CPI)	0						
MP Risk-Pricing	0	0	↑	↑	↓	↓	
MP Traditional BLC	0	0	↑	↑	↑	↓	
MP Higher Loan Demand	0	0	↑	↑	↑	↑	
Innovation (TOLN)	0	0	0	0	0		
Innovation (DDVOL)	0	0	0	0	0	0	

Notes: The innovations represent orthogonal shocks of the respective variables without a structural interpretation; monetary policy (MP) shocks are either transmitted through the risk-pricing channel, traditional BLC or higher loan demand; sign restrictions hold on impact and next period; all shocks are normalized to be positive.

Table 4: Alternative ordering with total loans before FFR

Pertubations	RGDP	CPI	TOLN	FFR	CDVOL	CDRATE	DDVOL
Innovation (RGDP)							
Innovation (CPI)	0						
Innovation (TOLN)	0	0					
MP Residual	0	0	0	↑		↓	
MP Risk-Pricing	0	0	0	↑	↓	↑	
MP Additional Funding	0	0	0	↑	↑	↑	
Innovation (DDVOL)	0	0	0	0	0	0	

Notes: Please refer to notes of Table 2.

Table 5: Alternative specifications of the monetary policy residual channel

Pertubations	RGDP	CPI	FFR	CDVOL	CDRATE	TOLN	DDVOL
(A) No sign restrictions on residual channel							
Innovation (RGDP)							
Innovation (CPI)	0						
MP Residual	0	0					
MP Risk-Pricing	0	0	↑	↓	↑		
MP Additional Funding	0	0	↑	↑	↑		
Innovation (TOLN)	0	0	0	0	0		
Innovation (DDVOL)	0	0	0	0	0	0	
(B) Additional sign restriction on residual channel							
Innovation (RGDP)							
Innovation (CPI)	0						
MP Residual	0	0	↑	↓	↓		
MP Risk-Pricing	0	0	↑	↓	↑		
MP Additional Funding	0	0	↑	↑	↑		
Innovation (TOLN)	0	0	0	0	0		
Innovation (DDVOL)	0	0	0	0	0	0	

Notes: Please refer to notes of Table 2.

Table 6: FEVD of Total Loans (alternative ordering)

Horizon	DDVOL	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	TOLN	CPI	RGDP
0	0.00	0.00	0.00	0.00	67.34	22.62	9.07
	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(59.47, 75.32)	(15.61, 30.03)	(4.03, 15.45)
4	4.69	1.78	1.45	0.73	51.78	13.03	21.64
	(1.70, 9.22)	(0.68, 5.07)	(0.43, 4.01)	(0.17, 2.70)	(40.47, 63.06)	(6.34, 21.84)	(12.24, 32.62)
8	4.87	2.57	2.19	1.30	37.94	20.43	23.87
	(1.31, 11.00)	(1.23, 5.74)	(0.48, 6.51)	(0.26, 4.70)	(25.47, 51.86)	(10.55, 31.42)	(12.76, 36.53)
12	4.83	4.44	2.76	2.00	28.08	24.61	23.53
	(1.17, 12.38)	(1.55, 10.57)	(0.54, 8.51)	(0.42, 7.01)	(15.70, 43.76)	(12.90, 36.88)	(11.10, 37.63)

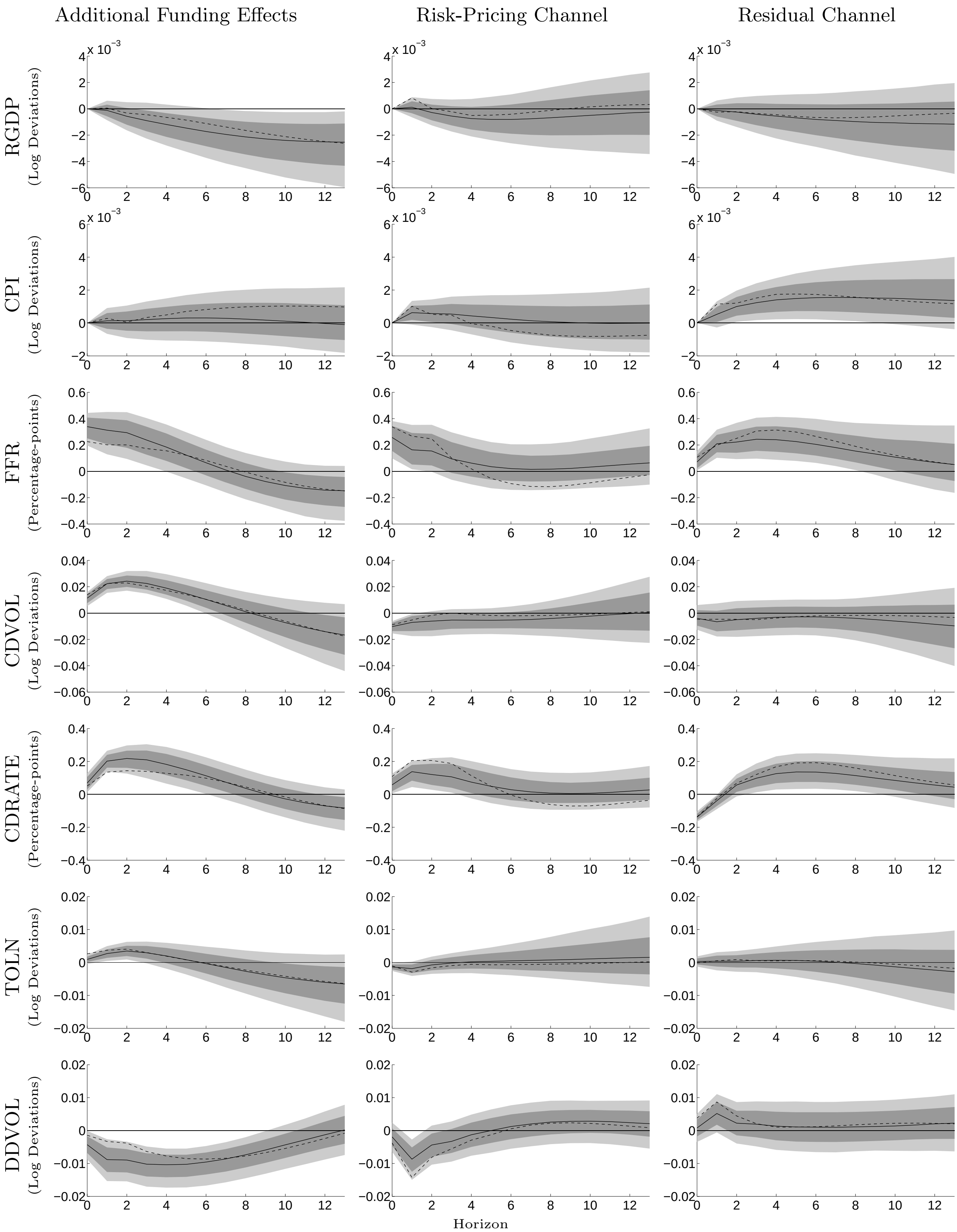
Notes: Values are derived from the point-wise median FEVD; values in parentheses correspond to the 16^{th} and 84^{th} percentile of the FEVD distribution at each forecast horizon.

Table 7: FEVD of Total Loans (alternative MP residual channels)

Horizon	DDVOL	TOLN	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	CPI	RGDP
(A) Residual channel without sign restrictions							
0	0.00	60.93	1.00	2.65	0.69	22.57	8.97
	(0.00, 0.00)	(53.28, 68.42)	(0.10, 3.55)	(0.61, 6.17)	(0.06, 2.91)	(15.66, 30.02)	(3.99, 15.45)
4	4.73	47.22	3.55	1.69	1.74	13.19	21.35
	(1.69, 9.02)	(36.83, 57.94)	(1.03, 9.68)	(0.66, 4.36)	(0.40, 5.94)	(6.53, 21.80)	(11.48, 32.75)
8	4.93	38.68	2.76	1.40	1.91	20.37	23.53
	(1.26, 10.84)	(26.51, 51.49)	(1.27, 6.00)	(0.48, 4.07)	(0.52, 5.32)	(11.07, 31.59)	(12.04, 36.98)
12	4.71	31.24	3.37	1.56	2.51	24.91	23.21
	(1.12, 12.34)	(17.53, 46.70)	(1.23, 8.07)	(0.43, 5.00)	(0.64, 7.33)	(13.66, 37.34)	(10.61, 37.71)
(B) Residual channel with an additional restriction							
0	0.00	60.93	1.22	2.90	0.46	22.57	8.97
	(0.00, 0.00)	(53.28, 68.42)	(0.13, 4.11)	(0.71, 6.33)	(0.04, 1.94)	(15.66, 30.02)	(3.99, 15.45)
4	4.73	47.22	4.52	1.70	1.16	13.19	21.35
	(1.69, 9.02)	(36.83, 57.94)	(1.42, 11.31)	(0.70, 4.36)	(0.27, 4.11)	(6.53, 21.80)	(11.48, 32.75)
8	4.93	38.68	3.11	1.44	1.46	20.37	23.53
	(1.26, 10.84)	(26.51, 51.49)	(1.54, 6.09)	(0.49, 3.94)	(0.34, 5.05)	(11.07, 31.59)	(12.04, 36.98)
12	4.71	31.24	3.98	1.56	1.96	24.91	23.21
	(1.12, 12.34)	(17.53, 46.70)	(1.68, 8.81)	(0.45, 4.98)	(0.41, 6.50)	(13.66, 37.34)	(10.61, 37.71)

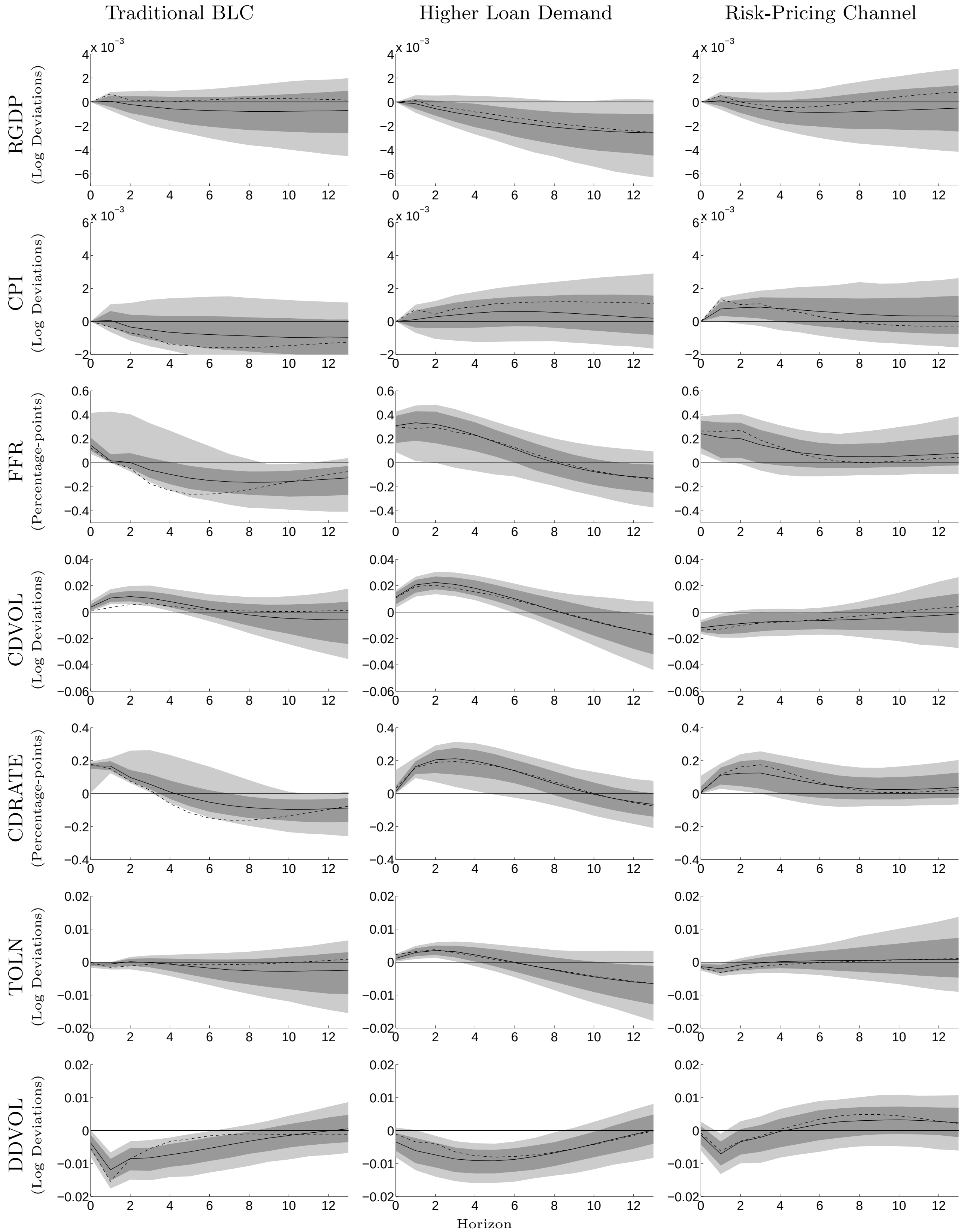
Notes: Please refer to notes of Table 6

Figure 1: Responses to differently transmitted monetary policy shocks (baseline)



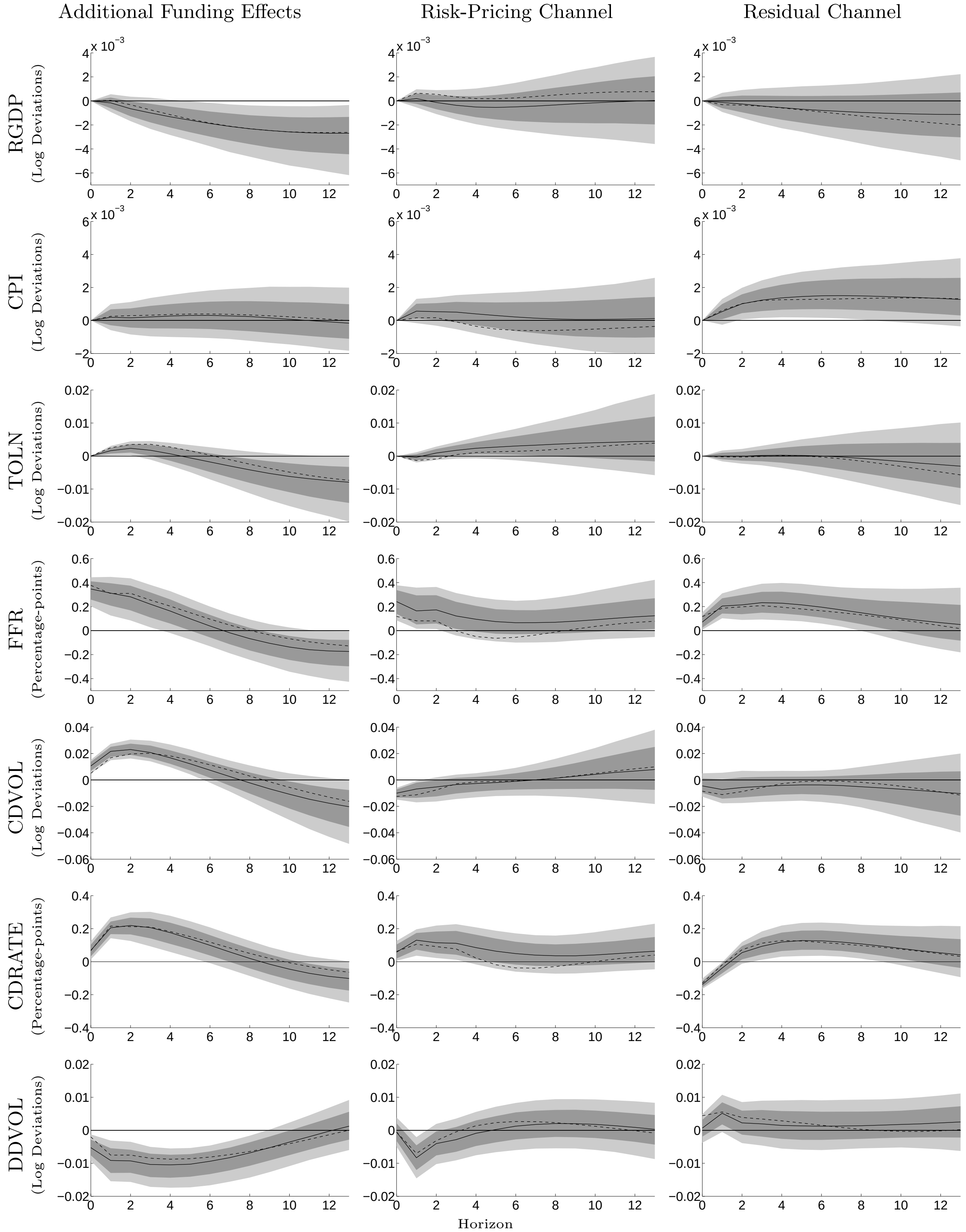
Notes: The responses are either measured in log-deviations or percentage-points. The light gray and dark gray areas represent 90% and two third of the restricted posterior distribution. The solid line represents the point-wise median response and the dashed line shows the responses of the closest to median model, which is calculated as suggested by Fry and Pagan (2011).

Figure 2: Responses to differently transmitted monetary policy shocks (with sign restrictions on total loans)



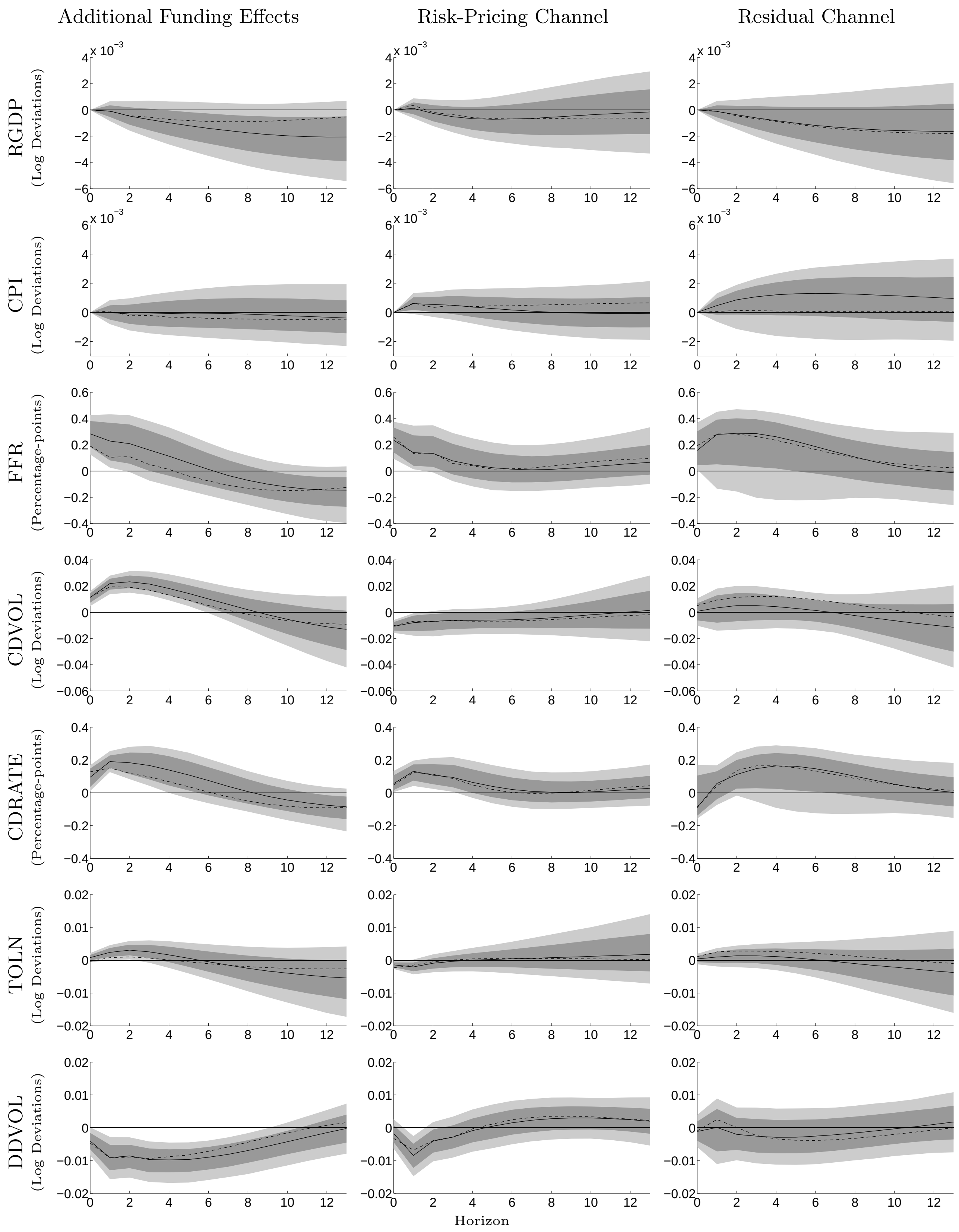
Notes: Please refer to notes of Figure 1.

Figure 3: Responses to differently transmitted monetary policy shocks (alternative ordering)



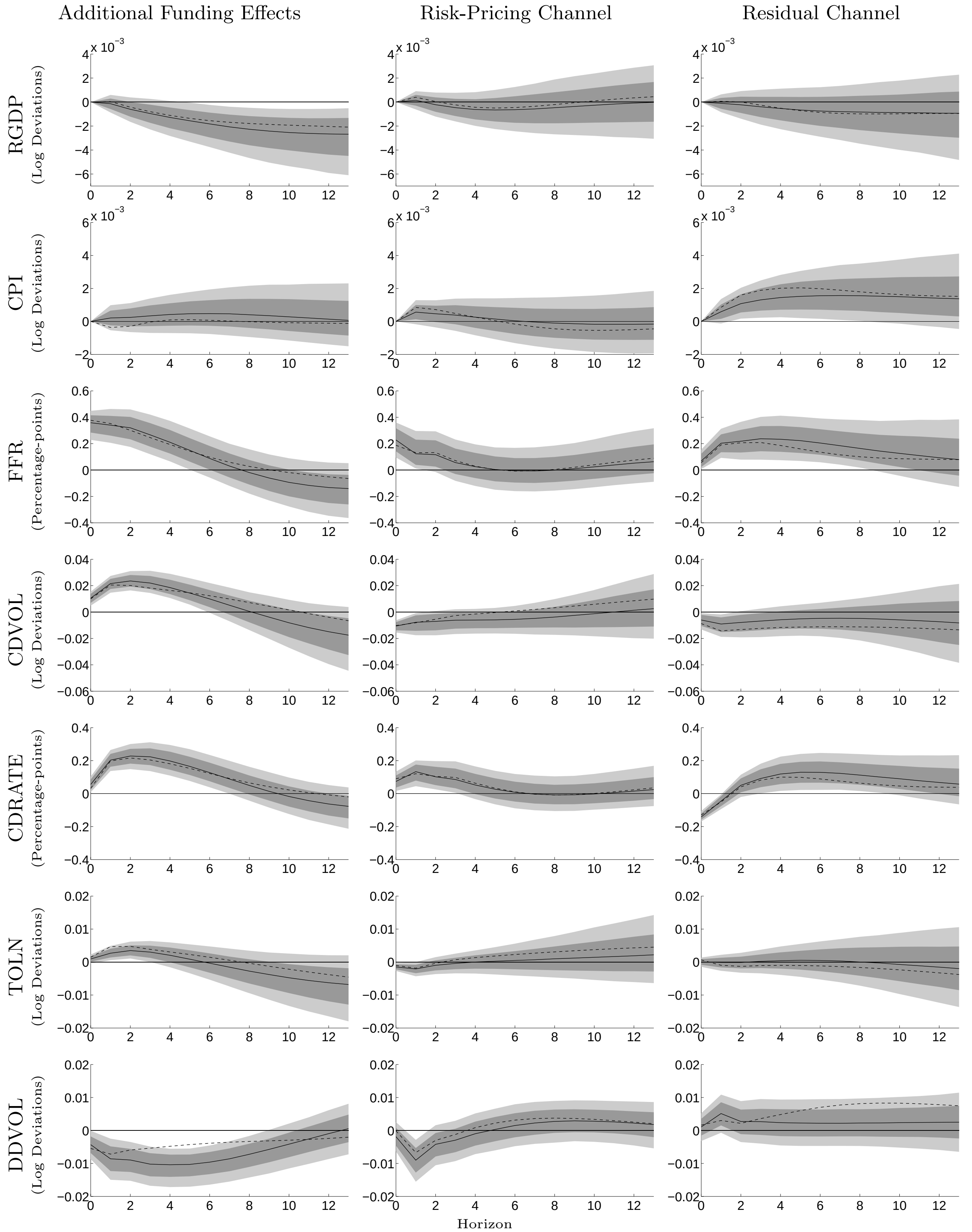
Notes: Please refer to notes of Figure 1.

Figure 4: Responses to differently transmitted monetary policy shocks (without sign restrictions on the residual channel)



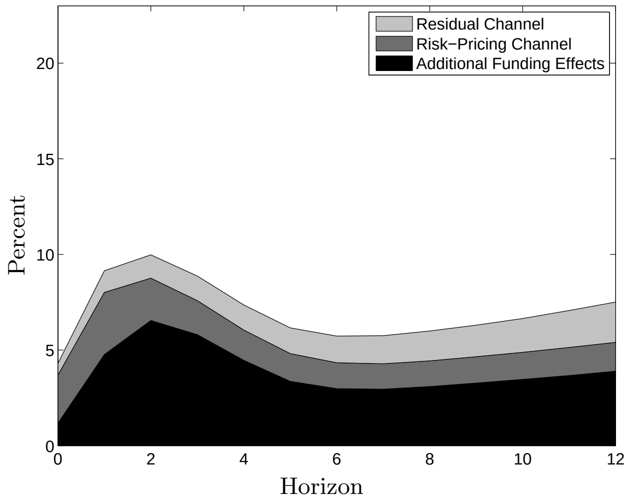
Notes: Please refer to notes of Figure 1.

Figure 5: Responses to differently transmitted monetary policy shocks (with an additional sign restriction on the residual channel)



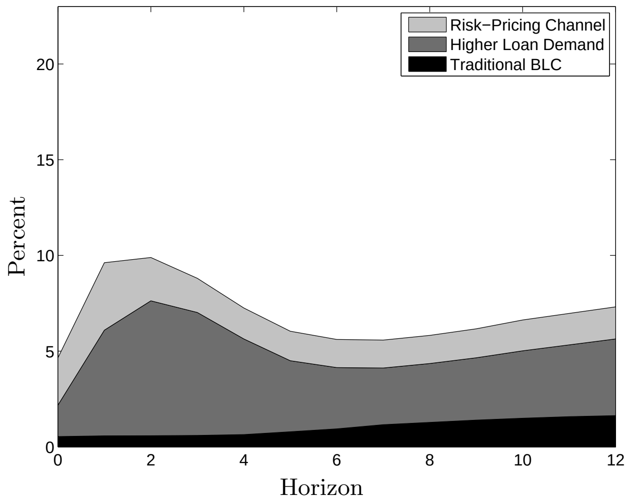
Notes: Please refer to notes of Figure 1.

Figure 6: FEVD of total loans (baseline)



Notes: Only the identified channels are shown; areas correspond to the median values of the FEVD of total loans at each forecast horizon.

Figure 7: FEVD of total loans (with sign restrictions on total loans)



Notes: Please refer to notes of Figure 6.

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Appendix

Table 8: FEVD of Total Loans (baseline)

Horizon	DDVOL	TOLN	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	CPI	RGDP
0	0.00	60.93	1.18	2.51	0.61	22.57	8.97
	(0.00, 0.00)	(53.28, 68.42)	(0.13, 4.13)	(0.58, 5.88)	(0.05, 2.56)	(15.66, 30.02)	(3.99, 15.45)
4	4.73	47.22	4.47	1.58	1.31	13.19	21.35
	(1.69, 9.02)	(36.83, 57.94)	(1.32, 11.11)	(0.65, 4.10)	(0.32, 4.49)	(6.53, 21.80)	(11.48, 32.75)
8	4.93	38.68	3.09	1.34	1.56	20.37	23.53
	(1.26, 10.84)	(26.51, 51.49)	(1.55, 6.26)	(0.46, 3.80)	(0.39, 5.25)	(11.07, 31.59)	(12.04, 36.98)
12	4.71	31.24	3.90	1.51	2.10	24.91	23.21
	(1.12, 12.34)	(17.53, 46.70)	(1.62, 8.57)	(0.42, 4.86)	(0.49, 6.78)	(13.66, 37.34)	(10.61, 37.71)

Notes: Please refer to notes of Table 6

Table 9: FEVD of Total Loans (with sign restrictions on total loans)

Horizon	DDVOL	TOLN	Traditional BLC	Higher Loan Demand	Risk-Pricing Channel	CPI	RGDP
0	0.00	61.12	0.54	1.64	2.47	22.46	8.52
	(0.00, 0.00)	(53.65, 68.53)	(0.05, 1.98)	(0.25, 5.05)	(0.56, 5.76)	(15.72, 29.44)	(3.75, 15.15)
4	4.72	47.80	0.65	4.99	1.62	13.30	21.04
	(1.67, 8.87)	(37.23, 58.69)	(0.20, 2.14)	(1.70, 11.57)	(0.63, 3.94)	(6.66, 22.38)	(10.91, 32.70)
8	4.81	39.00	1.28	3.07	1.47	20.85	22.90
	(1.31, 10.46)	(26.65, 51.47)	(0.28, 5.01)	(1.53, 6.03)	(0.46, 3.93)	(11.31, 32.13)	(11.33, 37.70)
12	4.49	31.06	1.64	4.00	1.67	25.44	22.24
	(1.14, 12.03)	(17.34, 46.63)	(0.34, 7.08)	(1.69, 8.30)	(0.44, 5.14)	(14.11, 38.51)	(10.16, 37.55)

Notes: Please refer to notes of Table 6

Table 10: FEVD of Total Loans (four lags)

Horizon	DDVOL	TOLN	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	CPI	RGDP
0	0.00	62.21	3.76	3.49	1.04	18.60	6.54
	(0.00, 0.00)	(54.51, 70.27)	(0.85, 8.53)	(0.75, 8.09)	(0.10, 4.28)	(11.92, 26.05)	(2.47, 12.57)
4	3.87	47.22	9.02	2.28	2.29	16.68	10.78
	(1.22, 8.78)	(36.25, 58.77)	(3.16, 17.61)	(0.80, 6.70)	(0.80, 6.67)	(7.79, 27.02)	(3.82, 20.76)
8	2.38	42.88	4.21	2.29	3.48	24.47	9.43
	(0.64, 7.24)	(29.53, 56.47)	(1.55, 11.11)	(0.61, 7.99)	(0.96, 9.57)	(11.47, 39.59)	(2.55, 21.10)
12	2.99	37.04	3.39	2.83	3.94	29.88	6.45
	(0.66, 9.51)	(22.11, 53.48)	(1.06, 9.53)	(0.61, 10.48)	(0.86, 11.41)	(14.20, 48.12)	(1.72, 17.71)

Notes: Please refer to notes of Table 6

Table 11: FEVD of Total Loans (sign restrictions are imposed for four periods)

Horizon	DDVOL	TOLN	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	CPI	RGDP
0	0.00	61.36	1.03	2.53	0.44	21.98	9.72
	(0.00, 0.00)	(53.75, 68.33)	(0.15, 4.03)	(0.59, 6.08)	(0.03, 2.10)	(15.67, 28.61)	(4.24, 16.30)
4	4.63	47.46	4.90	1.51	1.65	12.30	22.08
	(1.67, 9.08)	(36.22, 58.79)	(1.51, 11.65)	(0.64, 3.72)	(0.31, 5.09)	(5.85, 20.74)	(11.23, 33.97)
8	4.73	38.28	3.02	1.27	1.94	19.14	24.39
	(1.20, 10.24)	(25.93, 51.78)	(1.54, 6.13)	(0.45, 3.78)	(0.41, 6.65)	(9.81, 30.72)	(11.99, 38.54)
12	4.22	30.73	4.03	1.37	2.17	24.01	23.66
	(0.98, 11.89)	(17.28, 46.79)	(1.82, 8.20)	(0.40, 4.84)	(0.42, 8.11)	(12.04, 37.09)	(10.28, 40.16)

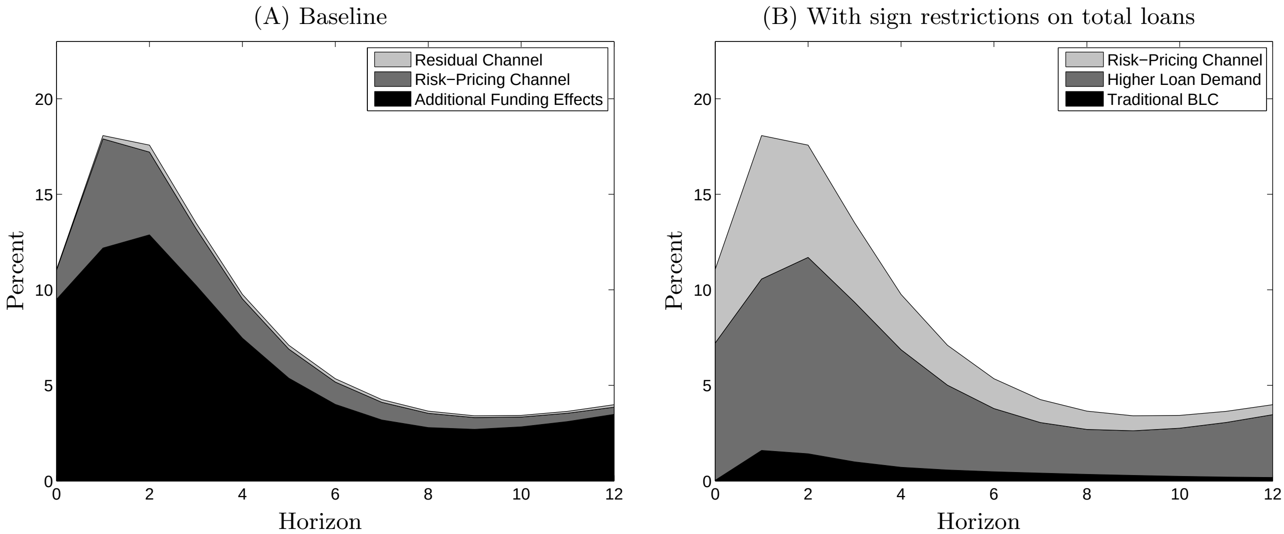
Notes: Please refer to notes of Table 6

Table 12: FEVD of Total Loans (extended sample up to 2015Q1)

Horizon	DDVOL	TOLN	Additional Funding Effects	Risk-Pricing Channel	Residual Channel	CPI	RGDP
0	0.00	48.66	1.36	4.41	0.76	41.89	0.43
	(0.00, 0.00)	(42.56, 55.11)	(0.15, 4.04)	(1.90, 8.09)	(0.07, 3.00)	(35.11, 48.42)	(0.04, 1.82)
4	0.29	47.44	5.54	5.05	2.04	28.46	4.54
	(0.07, 1.06)	(38.07, 56.64)	(1.44, 12.75)	(1.25, 11.95)	(0.43, 7.09)	(19.52, 37.84)	(1.27, 10.64)
8	0.60	38.64	3.56	4.32	2.31	33.39	10.08
	(0.16, 1.89)	(28.92, 49.10)	(1.62, 8.22)	(1.12, 10.91)	(0.57, 7.38)	(23.25, 43.64)	(3.49, 19.23)
12	1.41	30.52	4.41	4.49	2.64	35.76	13.30
	(0.35, 4.36)	(20.62, 42.07)	(2.23, 8.52)	(1.25, 11.49)	(0.81, 7.37)	(25.60, 46.13)	(4.85, 24.26)

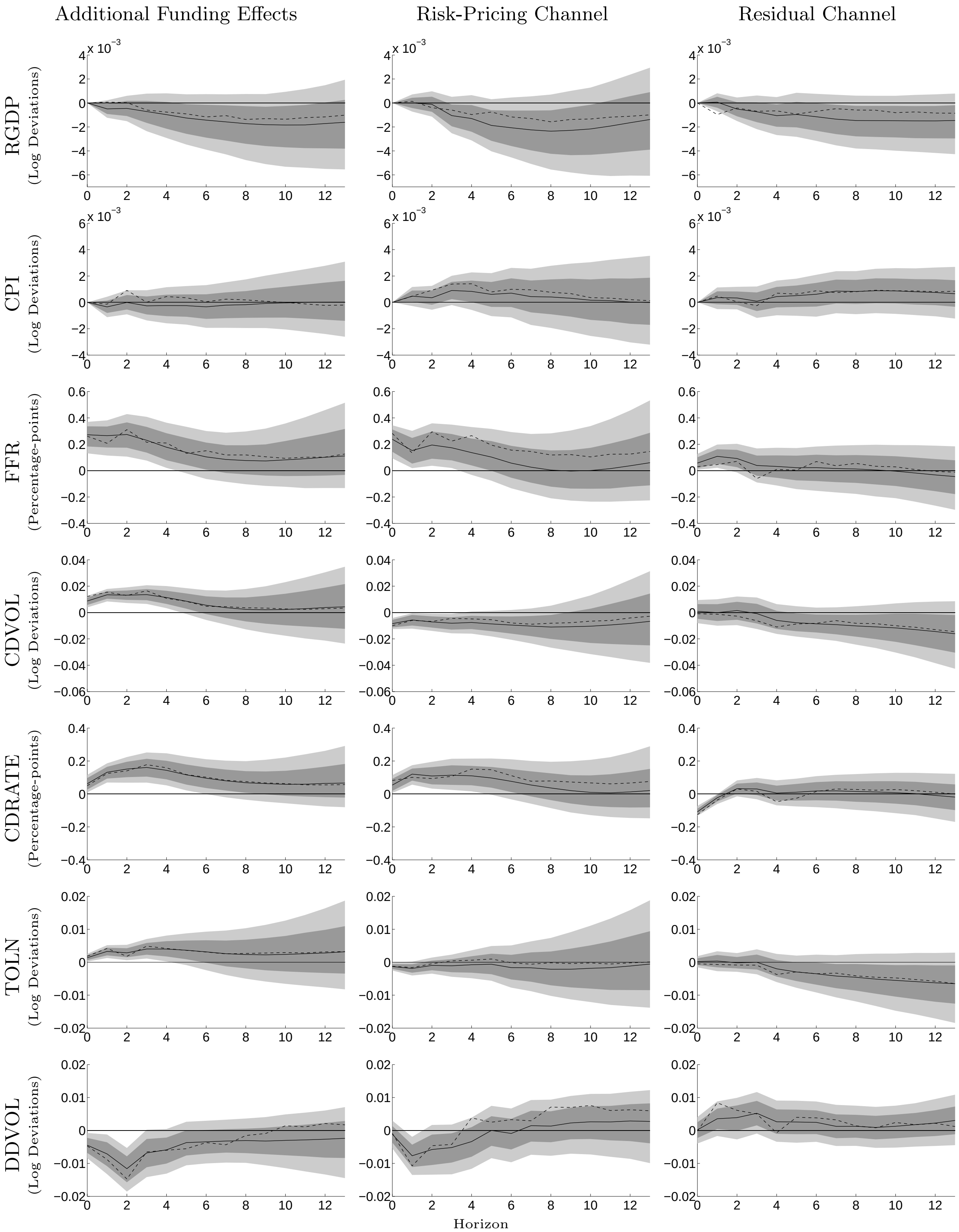
Notes: Please refer to notes of Table 6

Figure 8: FEVD of total loans (closest-to-median model)



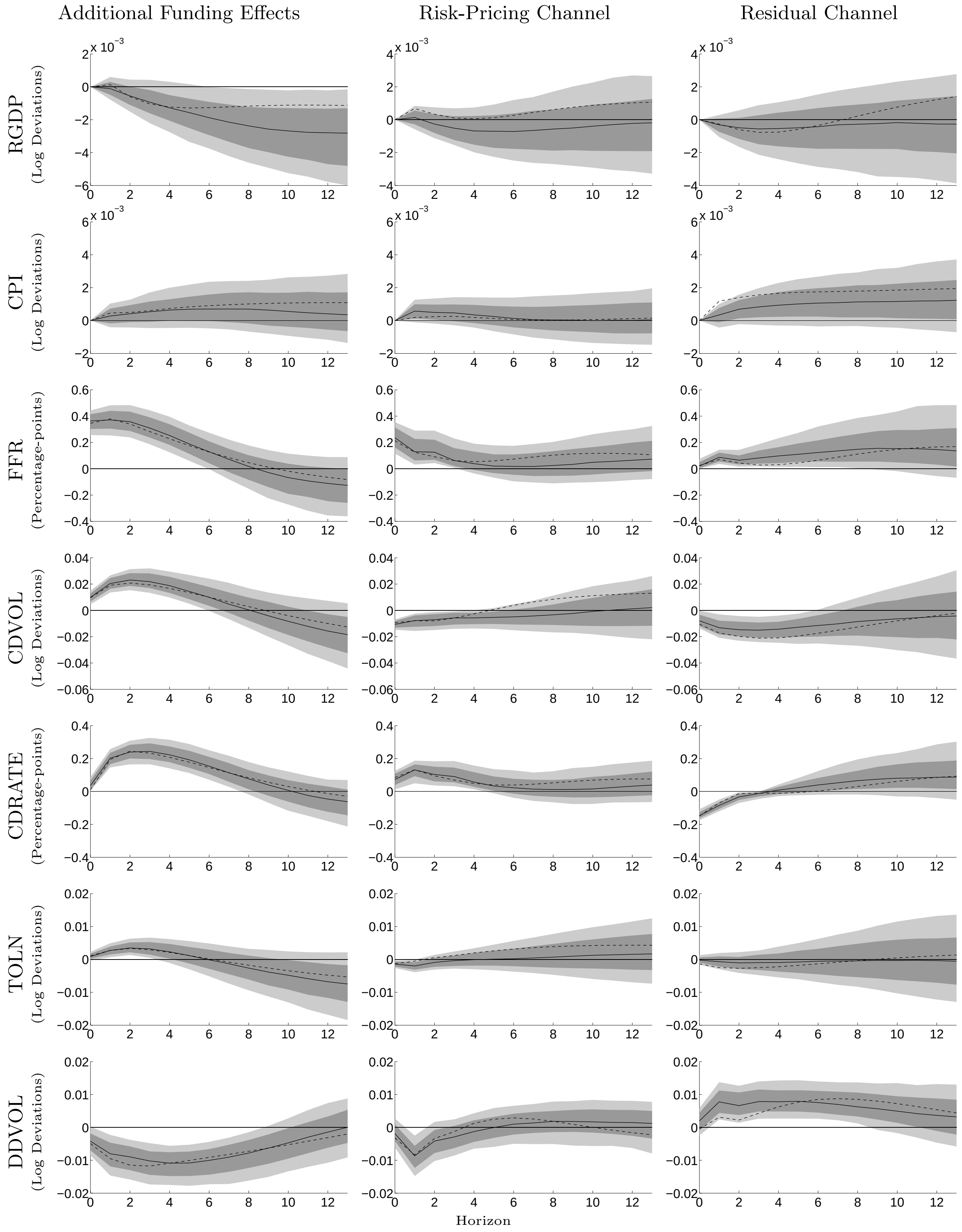
Notes: Only the identified channels are shown; areas correspond to the FEVD values of the closest-to-median model.

Figure 9: Responses to differently transmitted monetary policy shocks (four lags)



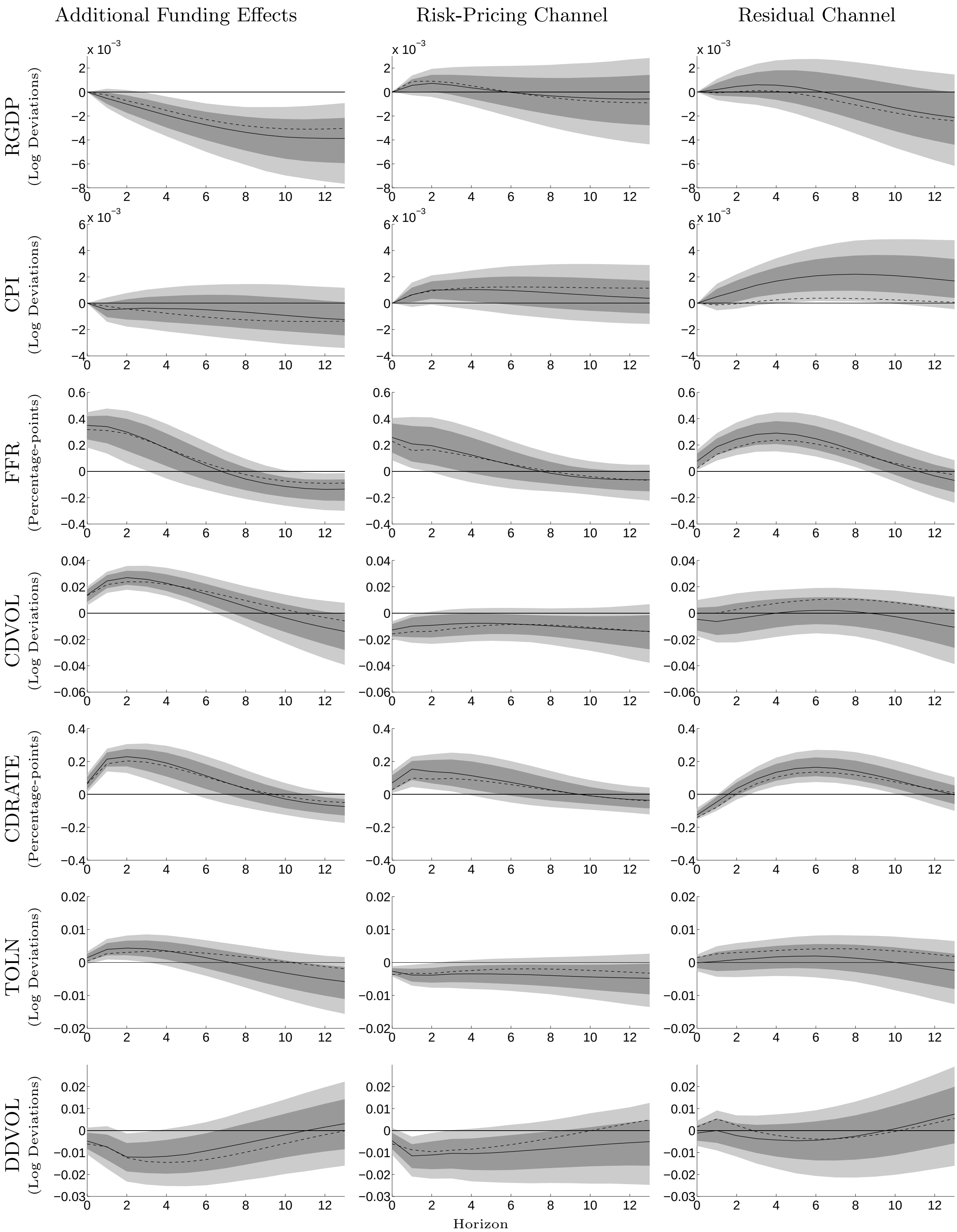
Notes: Please refer to notes of Figure 1.

Figure 10: Responses to differently transmitted monetary policy shocks (sign restrictions are imposed for four periods)



Notes: Please refer to notes of Figure 1.

Figure 11: Responses to differently transmitted monetary policy shocks (extended sample)



Notes: Please refer to notes of Figure 1.