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Identifying structural shocks behind loan supply fluctuations in Russia

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Contents

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Identifying structural shocks behind loan supply fluctuations in Russia[c]

Abstract

We examine the drivers behind loan supply fluctuations in Russia using Bayesian vector autoregressive model with sign restrictions on impulse response functions. We identify two types of structural innovations: loan supply shock and monetary stance shock. We find that contractionary shocks of both types contributed significantly and in the roughly equal measure to the decrease of bank lending after the Lehman Brothers collapse.

JEL classification: C11, C32, E51

Keywords: Loan supply, Bayesian VAR, sign restrictions, financial crisis, Russia.

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Tiivistelmä

Tutkimuksessa tarkastellaan liikepankkien lainantarjonnan vaihteluita Venäjällä käyttäen Baysiläistä vektoriautoregressiomallia, mikä identifioidaan käyttäen merkkirajoitteita impulssivastefunktioissa. Määrittelemme kahdentyyppisiä rakenteellisia innovaatioita: lainan tarjontashokin ja rahapolitiikkashokin. Tutkimuksessa osoitetaan, että molemmat shokit vaikuttivat merkittävästi ja jokseenkin yhtä paljon pankkien lainanannon supistumiseen Lehman Brothersin konkurssin jälkeen.

JEL: C11, C32, E51
Asiasanat: lainantarjonta, Baysian VAR, finanssikriisi, Venäjä.

1 Introduction

Russia witnessed drastic loan supply fluctuations over the past decade. Rapid growth of credit aggregates in 2006−2008 drove a credit boom that fuelled high economic growth. The global financial crisis of 2007−2009, while inducing a long period of financial stress in deleveraging developed countries, was weathered by Russia and many emerging economies with fairly modest impacts on real sector growth. Nevertheless, after the collapse of Lehman Brothers in September 2008 financial stress intensified on Russia's financial markets and bank lending plummeted. At the culmination of the crisis in early 2009, the outlook for the real sector had seriously deteriorated. This situation became a concern for the Central Bank of Russia (CBR), which made several attempts at reviving Russian credit markets. It also proved instructional to policymakers on the challenge of identifying drivers of loan supply dynamics.

So to what extent should changes in credit be attributed to demand or supply shifts? How does one tell whether a credit drought is caused by supply factors related to changes in bank behavior (e.g. changes in credit risk perception due to increased level of uncertainty) or deterioration of bank balance sheets? To resolve these questions, we estimate a Bayesian vector autoregressive (VAR) model comprising GDP, GDP deflator, loans to non-financial corporation (NFCs), interest rate on loans, and monetary stance variable (money stock) for the period prior to 2008Q4. Given its problematic nature, we discuss our choice of monetary policy stance variable in detail and compare the model results using alternative monetary policy stance variables. Sign restrictions are imposed on impulse response functions to identify structural innovations that might be considered loan supply or monetary stance shocks. Structural innovations are estimated with historical decomposition of lending trends into cumulated loan supply, monetary stance, and unidentified shocks. These are interpreted for both in-sample and out-of-sample periods. The obtained results suggest that lending trends were subject to negative loan supply shocks of unprecedented magnitude from the start of 2009. Exceptionally cautious bank behavior remained in place until the end of the reviewed period (i.e. 2010Q1). The effect stemming from monetary policy stance shocks was mainly expansionary before the crisis and contractionary afterwards. We also observe large expansionary monetary innovations in the end of the reviewed period. Our results appear to justify the use of a monetary stimulus to boost the loan supply and show that lending trends in the period were to a large extent determined by the changes in the behavior of the banks in the altered macroeconomic environment.

The paper is structured as follows. Section 2 provides the general description of the Russian banking sector, analyzing the relevant aspects CBR monetary policy in recent years. Section 3 presents the formal model and discusses the choice of variables. Section 4 presents the empirical evidence and discusses policy implications. Section 5 concludes.

2 Recent trends in the Russian banking sector

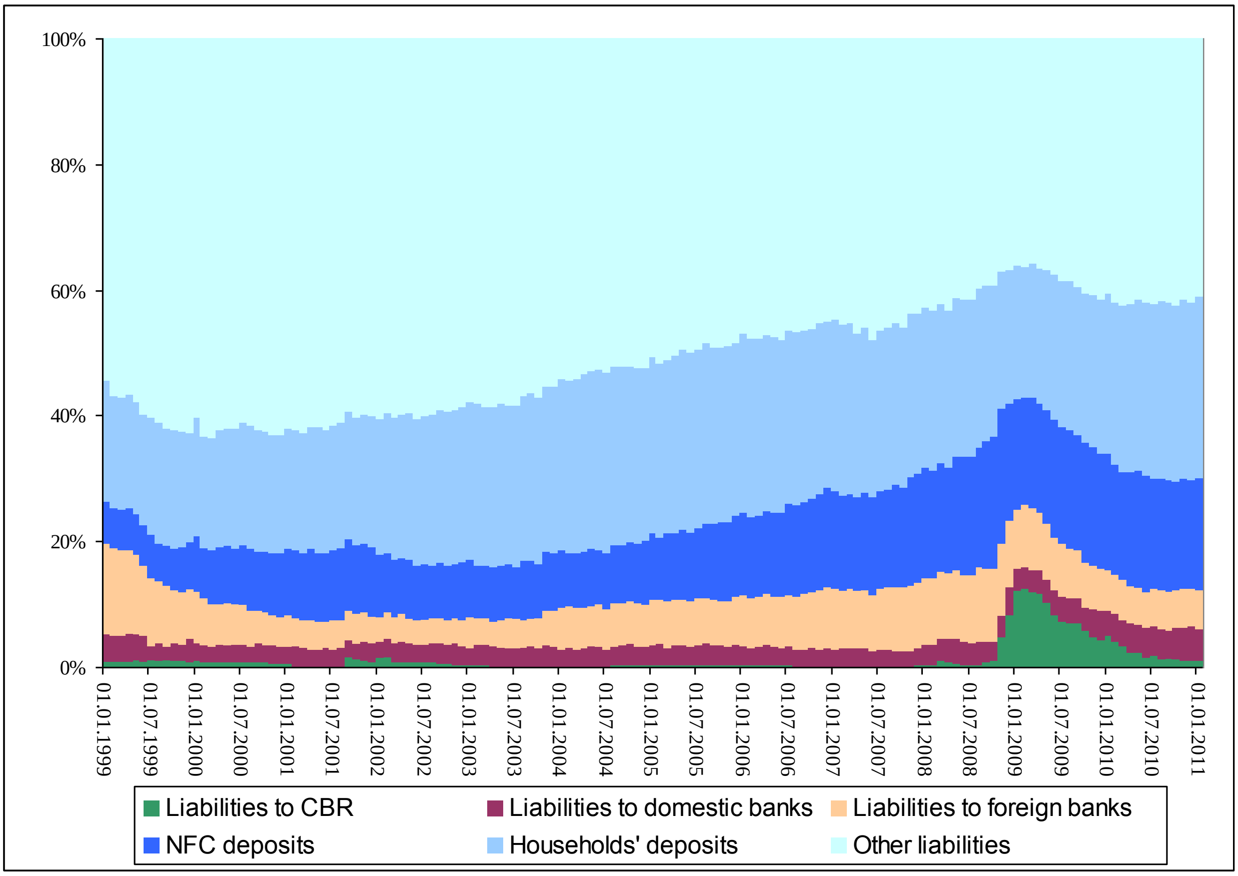
The expanded role of intermediation in Russian banking is rather new. Before the 1998 financial crisis, Russian banks were mostly involved in speculation in foreign exchange and government debt markets or acting as treasuries for their parent corporations. Channeling resources to the real sector was of minor significance. During the 2000s, Russian banking moved increasingly into traditional retail banking roles, particularly loan provision. Although the Russian banking sector remains small in terms of net assets to GDP when compared to other emerging economies (Fungáčová and Solanko, 2009a), credit flows to the real sector have increased rapidly in recent years and become an important determinant of cash flows in the economy. The rapid growth of deposits resulting in part from a heavily managed exchange rate regime and CBR forex purchases have provided banks with a rich resource for lending. Similar conditions have been seen in Asian economies with similar monetary policy regimes (Mohanty and Turner, 2010). Russia turned to the fiscal mechanism of the sovereign wealth fund to absorb foreign currency from central bank interventions. This approach proved insufficient to prevent rapid money stock growth in the face of an expansion in government spending and large capital inflows that triggered additional forex purchases. Moreover, the amount of foreign currency earnings diverted into sovereign wealth funds was linked by design solely to oil price fluctuations.

Table 1 Nominal increases in banks deposits and credit in 2001-2007 (% of cumulative GDP)

	Bank deposits	Domestic banks credit to private sector
Industrial countries	5.4	5.5
Asia	14.8	11.3
Latin America	5.1	4.6
Baltics	7.1	16.4
Russia	**9.3**	**10.9**

Sources: Mohanty and Turner (2010); CBR

Figure 1 Composition of bank liabilities (% of total)

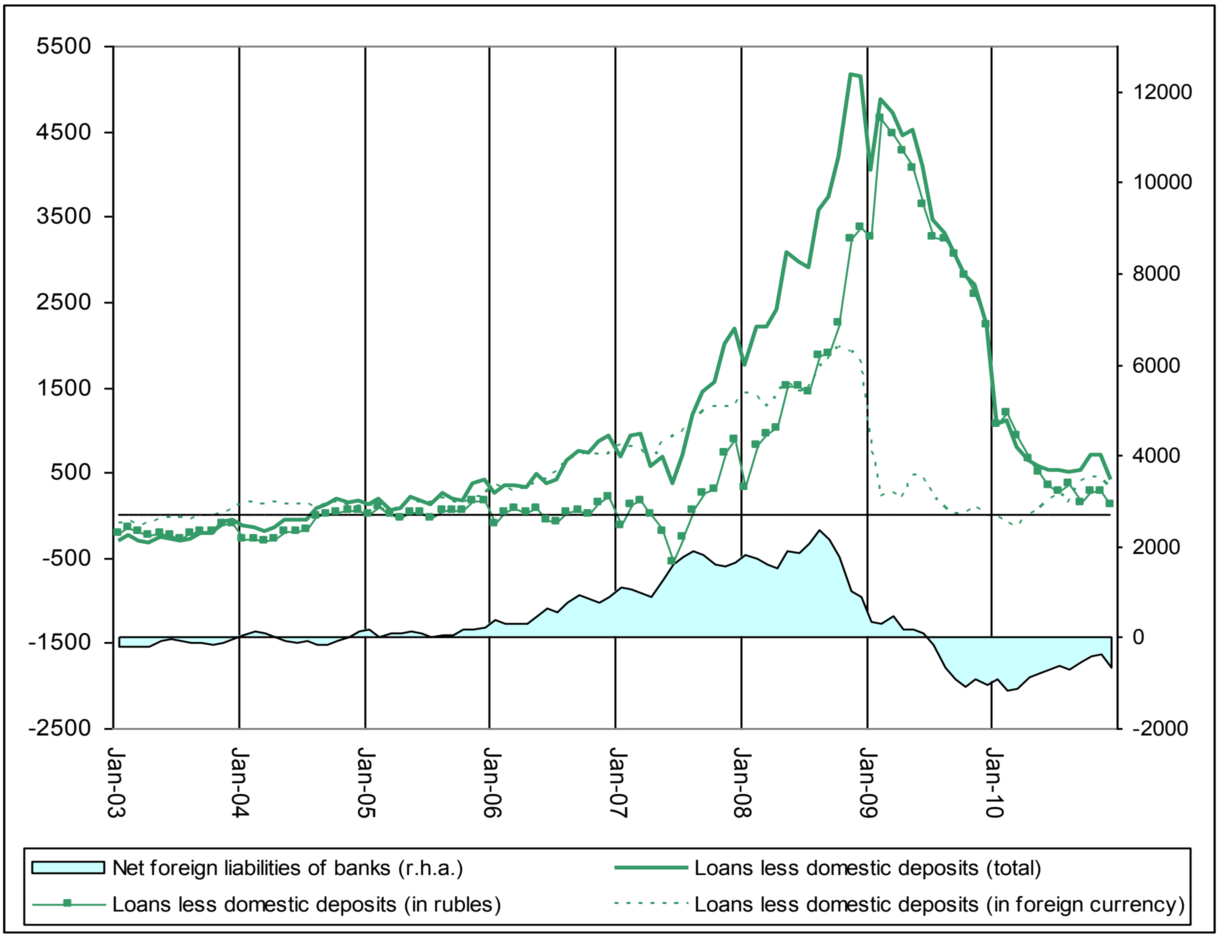


Source: CBR

An important distinction between Russian and Asian banks was that the size of the lending booming exceeded deposit growth in 2006−2008, causing funding gaps to emerge. Russian banks relied on external borrowing to finance this gap; interbank lending in particular became dominated by transactions with foreign counterparties (Fungáčová and Solanko, 2009b). As the world financial crisis unfolded, Russia found it increasingly difficult to tap foreign funding sources that had been major channels of financial stress transmission to Russian financial markets. This forced domestic banks to reduce lending (Cetorelli and Goldberg, 2010).

Matters came to a head with the Lehman Brothers collapse in September 2008. Capital flows reversed and the erosion of the trade balance from falling oil prices put significant depreciation pressure on the ruble. Concerned about the possibility of the deterioration of balances in case of sharp depreciation, the CBR implemented a "controlled devaluation" in approximately 1% increments against its dual-currency basket. That strategy involved substantial forex sales that depleted the CBR's gold and currency reserves by US$ 213 billion. The performance of the US dollar from August 2008 to April 2009 helped the private sector (and in particular, the banking sector) offset currency mismatches created by large foreign debt accumulated over previous years. As implemented, this strategy reinforced expectations of further depreciation and induced additional demand (including speculative) for foreign currency. Combined with the general loss of confidence in the banking system, ruble deposits shrank by 15% during 2008Q4−2009Q1. The CBR was forced to raise interest rates to stem capital outflow.

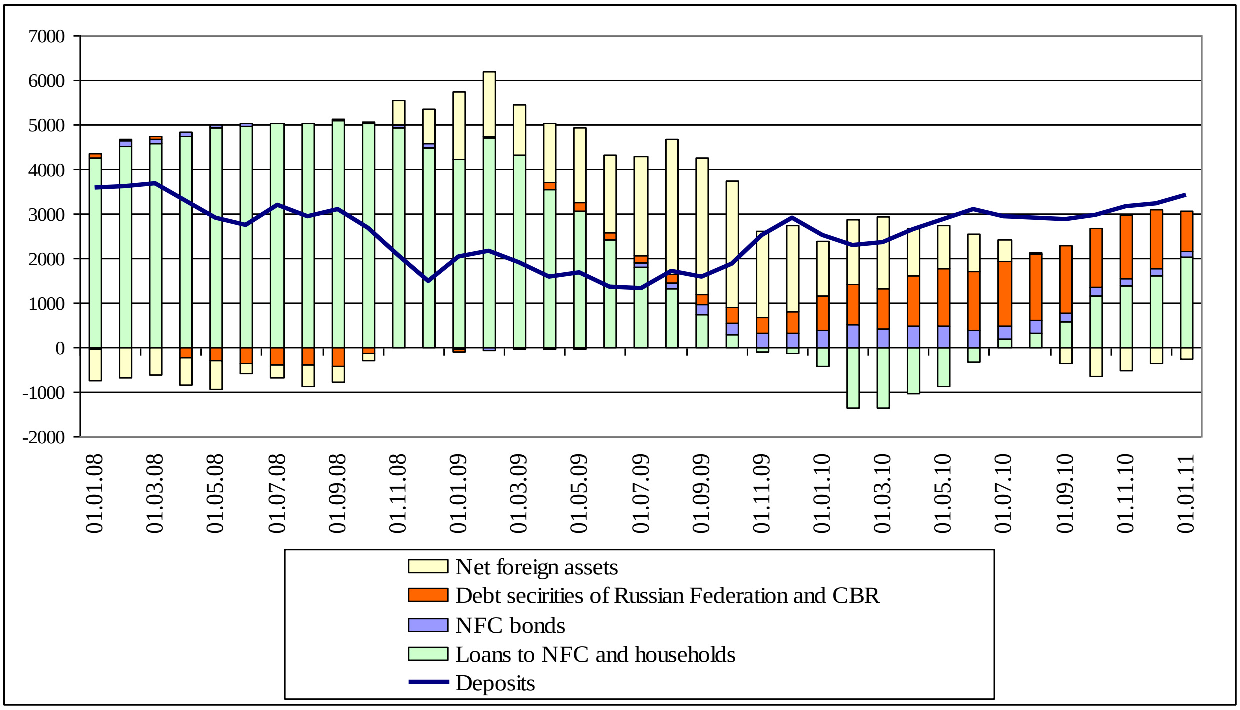
Figure 2 Funding gaps and foreign liabilities of the banking sector (billion rubles)



Source: CBR

Tightening was only a temporary measure against depreciation pressures on the ruble. As soon as the forex market stabilized in February 2009, the CBR started to lower interest rates. The CBR and Russian government also introduced a package of measures aimed at providing additional liquidity (see CBR, 2009; Fidrmuc and Süß, 2009). These measures not only sought to preserve financial stability but also implement the monetary stance. Along with the recommencement of CBR forex purchases in the latter half of 2009, these steps led to rapid accumulation of excess liquidity in the banking sector. Money market rates dropped sharply and soon were again fluctuating near CBR's overnight deposit standing facility rates as before the crisis. Remarkably, financing the government budget deficit directly from the sovereign wealth funds had a mechanical effect on the broad money stock. Deposits growth resumed in 2009 with virtually no support from the banking system. In fact, the preferences of banks for different types of assets evolved noticeably during the post-crisis period. With the reversal of the ruble's exchange rate dynamics in mid-2009, investor preference for foreign assets as risk-free (and extremely profitable during the depreciation period) investments was replaced with purchases of government securities (treasury notes and CBR bonds). Interestingly, demand of banks for corporate bonds also increased somewhat (Fungáčová and Kurronen, 2009). Increased bank lending was not observed until 2010Q2.

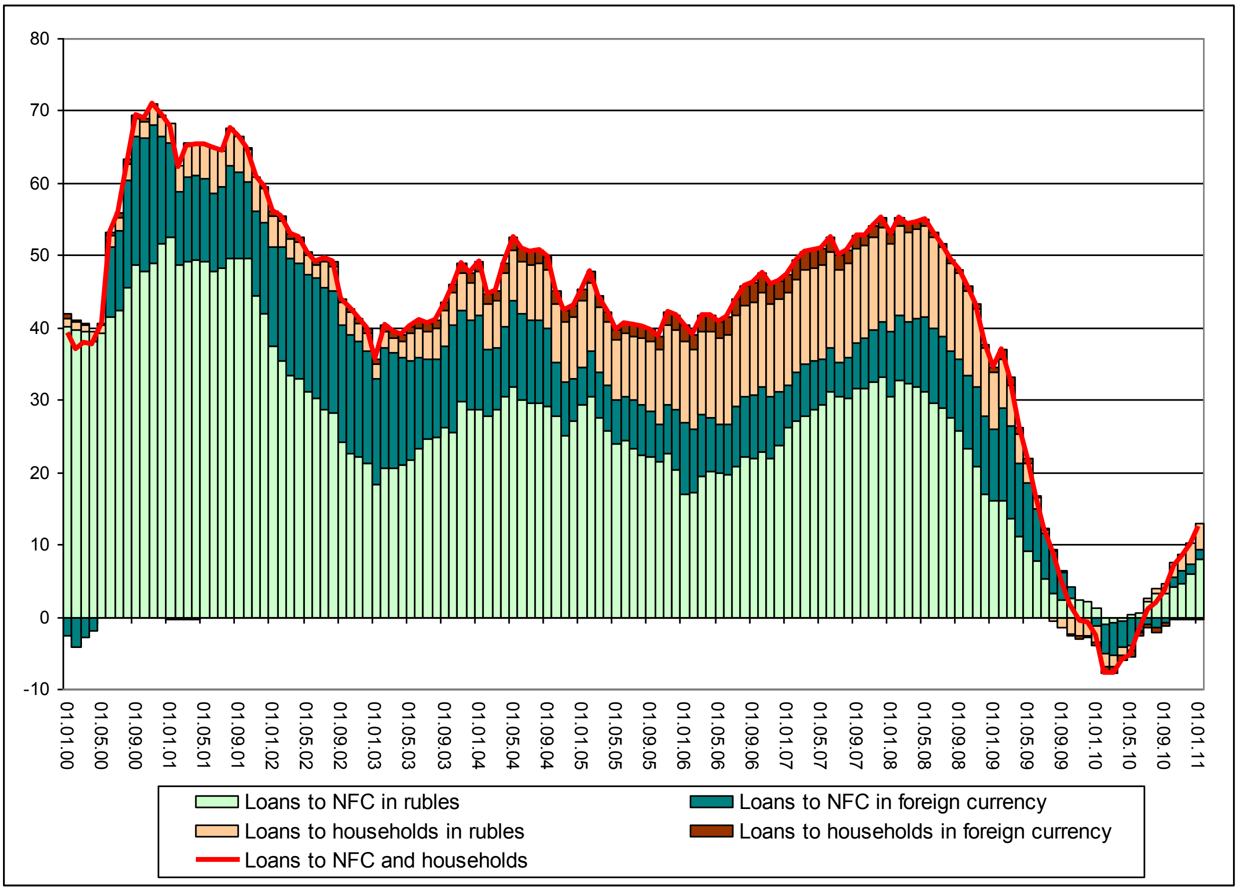
Figure 3 Bank assets and deposits (annual growth, billion rubles)



Source: CBR

The lending situation was constantly monitored by the Russian authorities from the latter half of 2008. The sharp decline of lending of all categories was viewed as a substantial cause of the real sector's contraction, and state support measures failed to produce immediate results. Yet it was unclear whether the observed drop of loans growth rates was actually inconsistent with other macroeconomic indicators − the Russian economy was, after all, in the midst of a severe recession. It is also unclear if monetary tightening was the main cause of these developments and, accordingly, the extent to which bank lending could be stimulated by providing more liquidity. In the next sections, we address these questions using a formal model.

Figure 4 Loans to NFC and households (contributions to annual growth rates, %)



Source: CBR

3 Model specification and data issues

The empirical literature offers several approaches to modeling lending trends. Perhaps the most conventional is simply to estimate the loan demand function based on the relationship between loans and macroeconomic fundamentals (e.g. GDP and interest rates). The results of such an exercise in the Russian context (CBR, 2010) show lending trends to be generally in line with the fundamentals, i.e. actual loan growth does not deviate substantially from the estimated path. Such results, however, fail to distinguish whether the lending trend is purely demand driven or that the loan supply shocks simply coincide with (or cause) the recession. To tease out better insights, we need a method for disentangling loan supply and demand effects. One potential approach is to rely on microeconomic bank-level data in analyzing the impact of financial crisis on loan supply (e.g. Calani et al., 2010); Del Giovane et al., 2010). While promising, this approach is hard to apply given the lack of appropriate data for Russian banks (particularly with regard to credit conditions surveys).

Identification of a loan supply shock on the basis of available aggregate data may be also attempted. De Mello and Pisu (2010) estimate six variables VECM for two cointegrating relationships, representing separate loan demand and loan supply equations for Brazil. This approach is replicated by Yudaeva et al. (2009) for Russia, who find that in 2009 actual loans were significantly higher than the equilibrium level implied by loans demand relationship, but lower than implied by loan supply relationship.

An obvious caveat is that large VECM models are data intense, and here we must deal with a fairly short time series of Russian data. To overcome this, we assume that Bayesian estimation is more appropriate then canonical econometrics. We will also apply an agnostic identification scheme by imposing sign restrictions on the impulse response functions. Although somewhat subjective, this approach allows us to disentangle different types of shocks using the data in a very parsimonious way.

Our empirical strategy is closely related to the method proposed by Busch *et al.* (2010), which can be briefly summarized as follows. Consider the conventional reduced-form VAR

$$Y_t = B(L)Y_{t-1} + u_t \,, \tag{1}$$

where Y_t is an $n \times 1$ vector of time series; $B(L)$ is a matrix polynomial in the lag operator L; u_t is an $n \times 1$ vector of residuals with variance-covariance matrix $E[u_t u'_t]=\Sigma$. This model is estimated using a Normal-Wishart distribution prior for (B,Σ) as in Uhlig (2005).

To decompose u_t and obtain economically meaningful structural innovations, we need to find a matrix A such that $Ae_t= u_t$, where e_t an $n \times 1$ vector of structural innovations assumed to be independent so that $E[e_t e'_t]=I_n$. The only restriction on A is

$$\Sigma =E[u_t u'_t]= AE[e_t e'_t]A'=AA' \,. \tag{2}$$

We need at least n x (n-1)/2 restrictions on A to achieve identification. We therefore restrict A to be a lower triangular as implied by Cholesky decomposition. For any orthogonal matrix Q with QQ′= In, Σ= AQQ′A′ is an admissible decomposition for Σ. As we cannot discriminate among different Q-matrices from the data, we select only those data that fulfill the a priori imposed restrictions on impulse responses. For that purpose, we first draw n times from the posterior distributions of (B,Σ) and obtain n models. We then randomly select one from these and start combining it with randomly (as proposed in Rubio-Ramirez et al., 2005) generated Q-matrices, until the impulse responses implied by this combination fulfill the restrictions. Following Busch et al. (2010), we discard the model and draw again if after p attempts sign restrictions are not fulfilled. We next iterate until we have m accepted sets consisting of VAR parameters, variance-covariance matrix of residuals and the appropriate identification scheme. Unlike Busch et al. (2010), we do not define the representative model as proposed in Fry and Pagan (2007). We find this approach yields results that are highly sensitive to the model's setup (including the initial values for the random numbers generator used in the estimation algorithm). Instead, we report the median output (i.e. impulse response functions, identified structural innovations and the historical decomposition of loans developments) of the collection of all accepted models. The results obtained by this approach seem more robust.

We include into our model the standard set of variables that generally capture loan supply and loan demand factors. These are GDP, price level (GDP deflator), interest rates (interest rate on ruble loans to NFCs with up to 1-year maturity) and loans (ruble loans to NFCs). Choice of a monetary stance variable for Russia is less trivial. For outsiders, the obvious candidate would appear to be short-term money market interest rate (e.g. Busch et al., 2010). However, considering the relative insignificance of interbank money markets (particularly domestic) in Russia and the high volatility of short-term interest rates, it is doubtful that overnight money market interest rate or any CBR interest rates per se would be adequate for this task. Juurikkala et al. (2009) come up against this challenge when modeling the bank lending channel in Russia. Their quite plausible solution is to use money stock as the monetary stance variable. Looking farther afield, the basic model by Bernanke and Blinder (1988) assumes bank deposits as the loan supply determinant. Brissimis and Delis (2009) include deposits into the empirical model that utilizes bank-level data. In aggregate-level modeling, however, deposits are usually avoided due to the possibility of spurious correlation that does not adequately reflect structural relationships (Hülsewig et al., 2004). At the same time, when the deposits trend may be considered with certainty as exogenous, this indicator is appropriate for the purpose of loan supply modeling (for examples, see Khwaja and Mian, 2008; Paravisini, 2008; and Imai and Takarabe, 2009). Given that the CBR's forex purchases and fiscal policy measures have direct effect on money stock in Russia, we see the supposition of exogeneity as plausible. Indeed, the choice of money stock as a monetary policy stance variable for modeling bank lending is quite common for the economies with managed exchange-rate regime even at aggregate level (e.g. Sun et al., 2010). We thus choose the stock of ruble bank deposits as the monetary stance variable for our model.

We believe that using the indicator of deposits may be superior to other money measures (i.e. broad money or monetary base) as the composition of monetary aggregates was unstable during the observation period. Specifically, the use of the deposits variable allows us to not only capture the gradual replacement of cash holdings by bank deposits that occurred in Russia at that time but also the episodes of massive withdrawing of deposits such as during the 2004 "crisis of confidence." We also cross-check our results from the benchmark model against those obtained using alternative monetary stance variables (monetary base and overnight interest rate). [1]

We generally follow Busch et al. (2010) with regard to imposing sign restrictions on impulse response functions (Table 2). By design, both expansionary loan supply and monetary stance shocks are reflected by a decrease in interest rates and increases in lending, GDP and price levels. [2] We identify monetary stance shocks as those preceded by deposit increases. Unlike Busch et al. (2010), who require a tightening of the monetary stance in response to an expansionary loan supply shock, we do not do that here as we lack adequate evidence to believe that CBR monetary policies were based on such an assumption during the reviewed period. Thus, we simply leave the monetary stance variable's reaction unrestricted in the case of a loan supply shock.

Table 2 Sign restrictions on impulse response functions

Shock	**Loan supply shock**			**Monetary stance shock**		
Period	t = 0	t = 1	t = 2	t = 0	t = 1	t = 2
GDP		+	+		+	+
GDP deflator			+			+
Interest rate	-	-			-	-
Loans	+	+			+	+
Deposits				+	+	

We estimate the model on our time sample for 1999Q1−2010Q4. While including crisis observations into the sample may cloud the results, estimating the model with the relatively short pre-crisis data series would limit us to analyzing only the favorable side of the economic cycle. Adding observations from the recession period seem reasonable in our pursuit of adequate results. Moreover, the imposed theoretically founded sign restrictions are validated on the full time sample; they are not supported by the pre-crisis time sample (see Annex II).

Except for interest rate, all variables are in logs and seasonally adjusted with X-12. Quarterly data are used. We set the lag length to 3 as adding further lags would cause the instability of

[1] The results obtained using the model with monetary base are reported in Annex III. The model with the short-term interest rate did not produce adequate results, affirming our choice of the money stock variables instead of interest rates.
[2] We use the term "monetary stance shock" rather than "monetary policy shock." Given how CBR monetary policy was implemented in the period, our monetary stance variable takes in factors beyond the CBR's defined decision-making scope (such as capital flows and fiscal policy setting).

the model and growing oscillation in the impulse responses. We set the number of initially drawn sets of VAR parameters to n = 1000, the number of attempts made to find the appropriate Q-matrix before the model is discarded to p = 1000 and the number of accepted models to m = 5000. Remarkably, the results show convergence at this level; increasing these parameters further does not change the outcome significantly.

4 Results

We commence by estimating the median impulse responses, along with the 16% and 84% quantiles, to loan supply and monetary stance shocks that conform to the imposed sign restrictions. The resulting impulse responses (Figs. 5 and 6) for each type look quite similar. Both loan supply and monetary stance shocks cause the positive impact on GDP, GDP deflator and loans, as well as a persisting negative impact on the interest rate (particularly in case of monetary stance shock) that lasts noticeably longer than the sign restrictions require. The impact of the shocks upon the loans peaks after about 6 quarters, signifying prolonged transmission. IN contrast, the impact on other variables starts to die out after the 2 or 3 quarters. The reaction of these variables is largely determined by the sign restrictions, so it is hardly surprising that both loan supply and monetary stance shock are similar in terms of GDP, prices, loans and interest rates responses. The impact of loan supply shock on deposits is unrestricted, however, and could thus be the main distinction between the two shocks. Notably, we find that both types of shocks are associated with the increase of deposits (although more pronounced in case of monetary stance shock). While this is by definition in the case of monetary stance shock, this could be due to the direct effect of lending growth on money stock growth in case of the loan supply shock.

This result may make it harder to distinguish between the two types of shocks. Interestingly, there is no such effect when the monetary base is used as a monetary stance variable (see Annex III). This seems theoretically plausible; an expansion of lending only directly influences the money stock, not the monetary base.

Figure 5 Impulse responses to the expansionary loan supply shock (shaded area = sign restrictions periods)

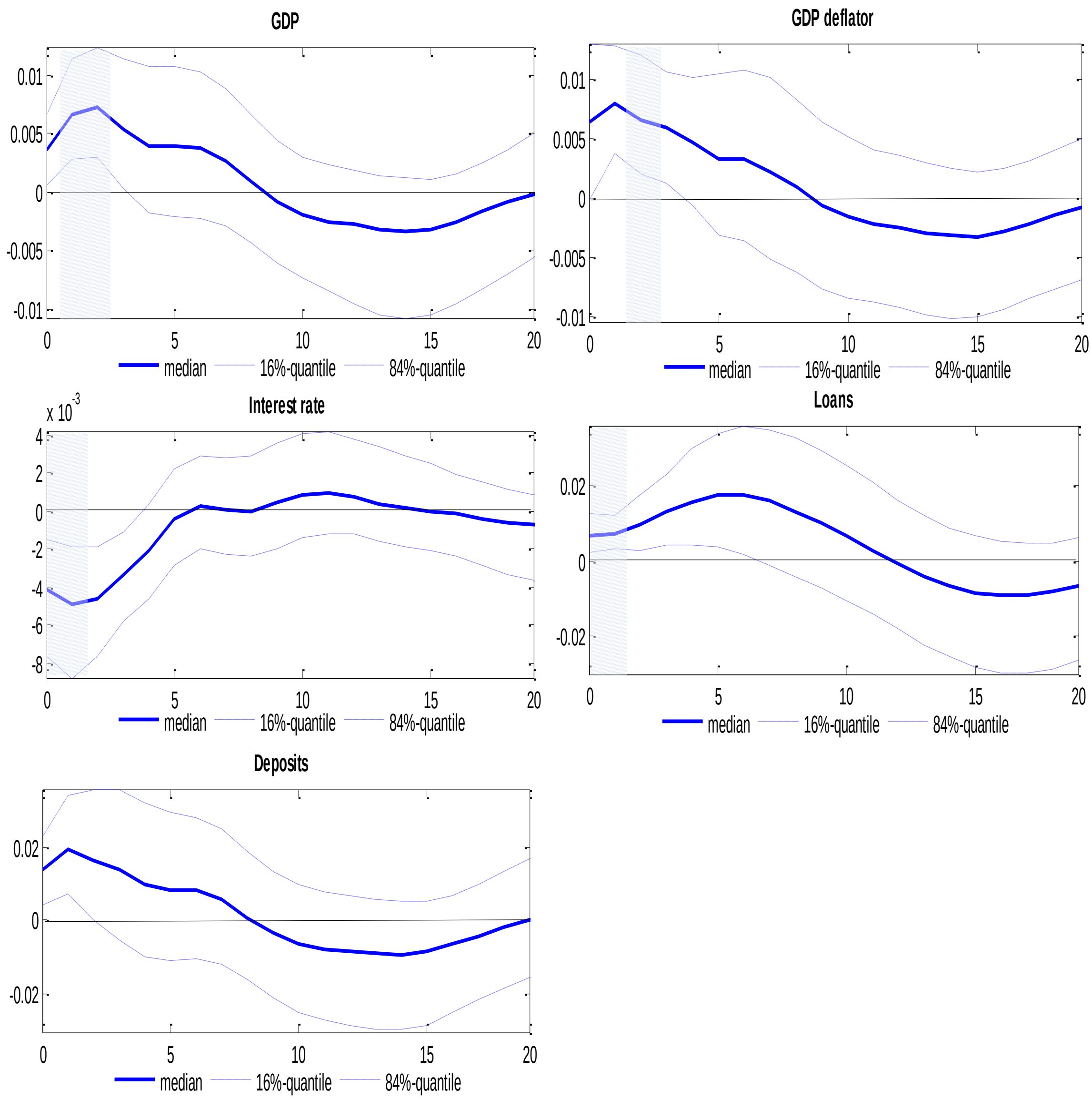
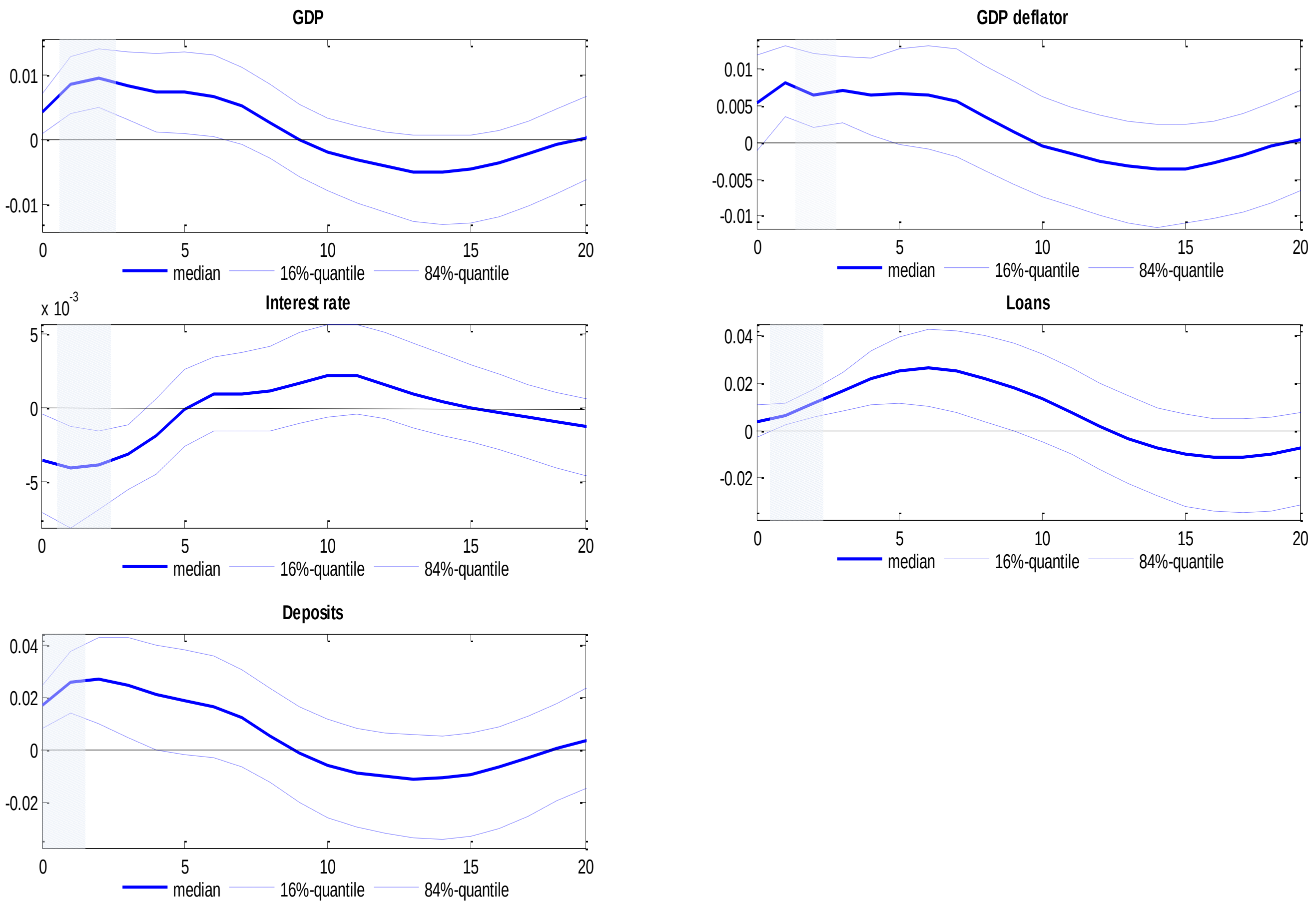


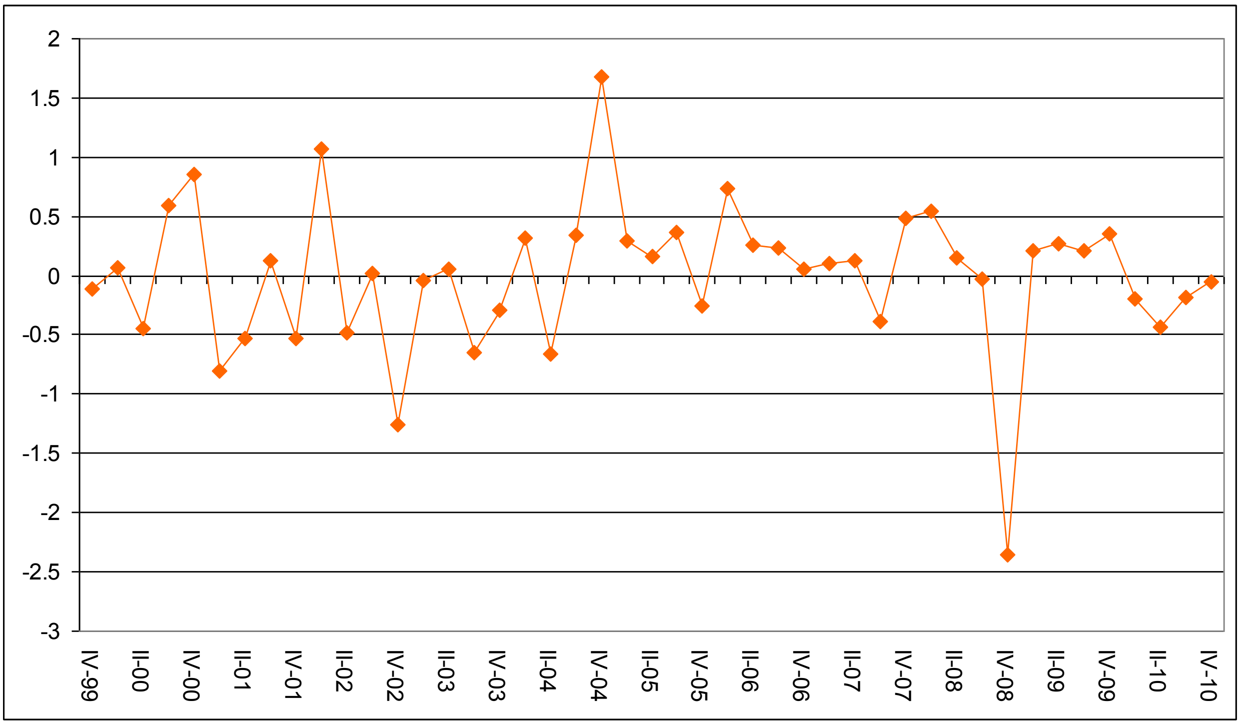
Figure 6 Impulse responses to the expansionary monetary stance shock (shaded area = sign restrictions periods)



Next, we calculate the median structural innovations identified as loan supply and monetary stance shocks. While the identified loan supply innovations (Fig. 6) fluctuate around zero for most of the pre-crisis period, we can readily pick out the large positive shock in 2004Q4 that marks the turning point after the 2004 credibility crisis of 2004 and the period of positive shocks that prevailed in 2005–2007.[3] This finding concurs with the growing appetite for risk on the part of banks that were tapping into global excess liquidity on the international markets to expand the loan supply further. During the recent financial turmoil, a negative loan supply shock of extremely large magnitude is observed in 2008Q4 following the Lehman Brothers' collapse. We also note a series of positive loan supply shocks in 2009 (possibly related to the easing of lending policy by state-controlled banks at that time) before new negative shocks emerge.

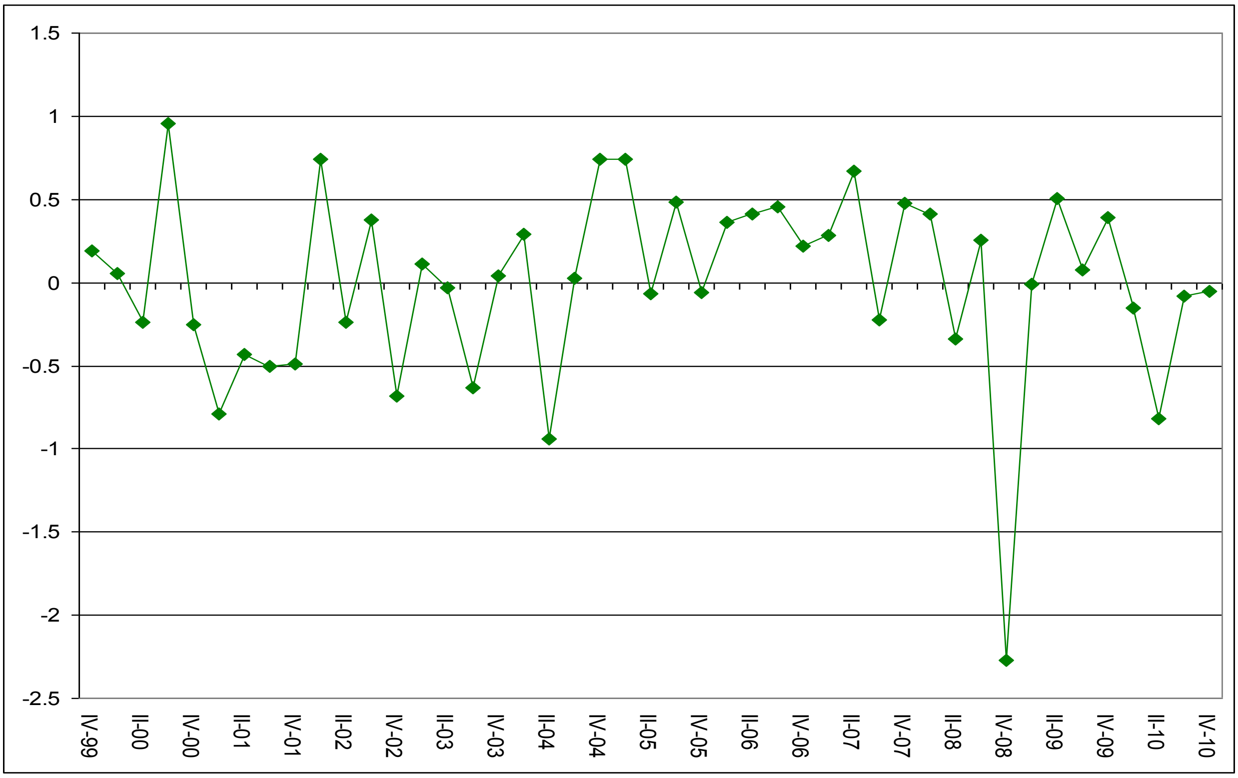
[3] During this event, the wave of largely unfounded rumors and conjectures about impendent liquidity problems in the banking sector eroded household confidence in the national banking system and impeded financial intermediation.

Figure 7 Identified loan supply shock innovations



Our identified monetary stance innovations (Fig. 8) are mostly positive during the period 2004−2007, and seem to represent adequately the accommodative monetary policy conducted over the period. Starting in the latter half of 2008, we observe negative shocks (including one of unprecedented magnitude in 2008Q4). These are followed by positive shocks in 2009. This pattern plausibly mirrors the rapid shrinking of the money stock in late 2008 and early 2009, as well as its exogenously resuscitated growth after the CBR recommences forex buying and the government's fiscal measures start to fray. As these processes fade in 2010, we observe a series of negative monetary stance shocks.

Figure 8 Identified monetary stance shock innovations

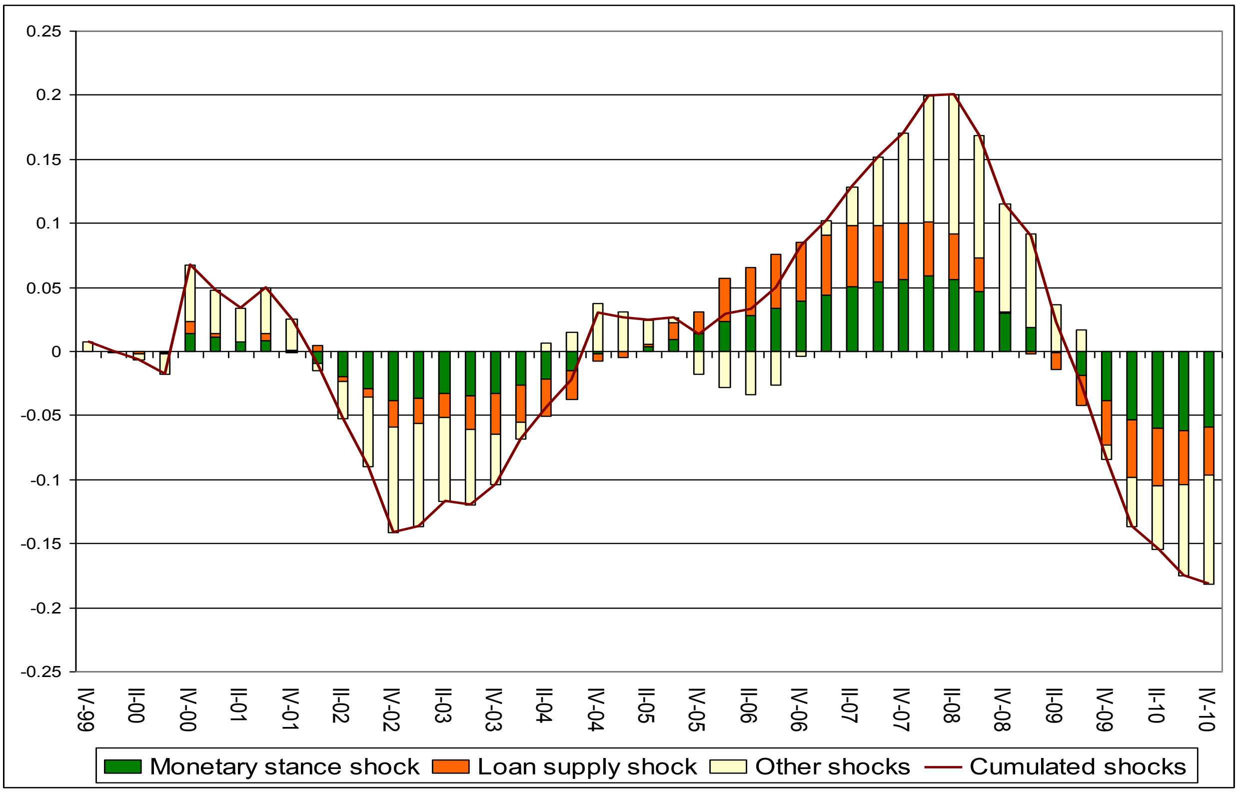


As shown in Busch *et al.* (2010), the deviations of loans from the baseline projection of the model may be decomposed into the cumulated sum of the identified structural shocks. We present this historical decomposition (Fig. 9) to get an insight into the drivers behind lending trends.

While the comovement of shocks may indicate insufficient distinction of the two types, our results seem generally plausible and are confirmed by the estimates of the alternative model (Annex III). The decomposition shows that the impact from the monetary stance shocks is positive in the period preceding the crisis and reaches its peak at the beginning of 2008. Following the contractionary monetary stance shock, the impact turns negative in 2009. Recalling the prolonged transmission length, we expect the impact to remain negative for some time. This finding contrasts with the results of Busch *et al.* (2010), who, based on German data, suggest the monetary policy shocks were essentially neutral during the crisis. As explanation, we again note that Russia's monetary stance in this period was not determined exclusively by the CBR.

Thus, the driving forces behind the rapid fall of loans are not just monetary shocks. The magnitude the impact of the loan supply shocks in 2009 is comparable to that of monetary shocks. The estimates using an alternative monetary stance variable generally confirm these findings (Annex III). The historical decomposition produced by the model with monetary base variable indicates that loan supply shocks contribute significantly to the credit contraction starting from 2009. The impact of monetary stance shocks is expansionary until 2009, and negative thereafter. The alternative model also indicates that loan supply and monetary stance shocks contribute to the credit contraction in roughly equal measure.

Figure 9 Historical decomposition of loans into loan supply, monetary stance and other shocks



5 Conclusions

The rapid growth in bank lending that took place in Russia over the last decade was largely fuelled by exogenous growth of money stock as determined by the CBR's forex purchases. Russian banks also exploited the availability of foreign borrowing to boost the domestic lending growth even further. In late 2008, capital flows reversed and the ruble money stock shrank in response to severe monetary tightening. In addition, increased general uncertainty as to international financial markets and the domestic real sector caused the banks to restrict access to loans.

Using a formal model, we find that both these factors contributed significantly to the contraction in lending in 2008−2009. The expansionary monetary stance ended in late 2008, further curtaining lending growth. We further note that the resumption of rapid growth in the money stock caused by recommencement of FX purchases by the CBR and direct financing of the budget deficit from the sovereign funds was reflected by expansionary monetary innovations in 2009Q4. Even so, these developments only partially explain the decline in lending growth as the important drivers behind recent lending trends have not been directly related to the monetary stance. Finally, we identified a contractionary loan supply shock of unprecedented magnitude that contributed in roughly equal measure to the contraction in lending.

References

Bernanke, B.S., and A.S. Blinder (1988). "Is it money or credit or both or neither? Credit, money, and aggregate demand." *American Economic Review* 78, 435-459.

Brissimis, S.N., and M.D. Delis (2009). "Identification of loan supply function: A cross-country test for the existence of bank lending channel." *International Financial Markets, Institutions and Money* 19, 321-335.

Busch, U., M. Scharnagl, and J. Scheithauer (2010). "Loan supply in Germany during the financial crisis." Deutsche Bundesbank Discussion Paper, Series 1: Economic Studies No. 05.

Calani, M.C., P.S. Garcia, and D.Z. Oda (2010). "Supply and demand identification in the credit market." Central Bank of Chile Working Papers No. 571.

CBR (2009). "Bank of Russia operations to refinance credit institutions in January-April 2009." *The Central Bank of the Russian Federation Quarterly Inflation Review* Q1, 19-20.

CBR (2010). "Assessment of the level of demand for loans in the Russian economy." *The Central Bank of the Russian Federation Quarterly Inflation Review* Q1, 25-26.

Cetorelli, N., and S.G. Goldberg (2010). "Global Banks and International Shock Transmission: Evidence from the Crisis." Federal Reserve Bank on New York Staff Report No. 446.

Chadha, J., L. Corrado, and Q. Sun (2008). "Money, prices and liquidity effects: Separating demand from supply." Kent University Working Paper.

Del Giovane, P., G. Eramo, and A. Nobili (2010). "Disentangling demand and supply in credit developments: A survey-based analysis for Italy." Banca d'Italia Working Papers No. 764.

Fidrmuc, J., and P.J. Süß (2009). "Outbreak of the Russian banking crisis." University of Munich, Department of Economics, Discussion Paper 10996.

Fry, R., and A. Pagan (2007). "Some issues in using sign restrictions for identifying structural VARs." NCER Working Paper No. 14.

Fungáčová, Z., and S. Kurronen (2010). "Bonds gaining ground as a finance tool in Russia." BOFIT Focus/Opinion 1/2010.

Fungáčová, Z., and L. Solanko (2009a). "Has financial intermediation improved in Russia?" BOFIT Online No. 8.

Fungáčová, Z., and L. Solanko (2009b). "The Russian banking industry after financial crisis – Where to next?" Bank of Finland Bulletin 2, 19-29.

Hülsewig, O., P. Winker, and A. Worms (2004). "Bank lending in the transmission of monetary policy: A VECM analysis for Germany." *Jahrbücher für Nationalőkonomie und Statistik* 224(5): 511-529.

Imai, M., and S. Takarabe (2009). "Transmission of Liquidity Shock to Bank Credit: Evidence from the Deposit Insurance Reform in Japan." Wesleyan University Working Papers No. 001.

Juurikkala, T., A. Karas, and L. Solanko (2009). "The role of banks in monetary policy transmission: Empirical evidence from Russia." BOFIT Discussion Papers 8.

Khwaja, A. I., and A. Mian (2008). "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market." *American Economic Review* 98(4), 1413-1442.

Mann, H. B., and D.R. Whitney (1947). "On a Test of Whether One of Two Random Variables is Stochastically Larger than the Other." *Annals of Mathematical Statistics* 18(1), 50-60.

de Mello, L., and M. Pisu (2010). "The bank lending channel of monetary transmission in Brazil: A VECM approach." *The Quarterly Review of Economics and Finance* 50, 50-60.

Mohanty, M.S., and P. Turner (2010). "Banks and financial intermediation in emerging Asia: Reforms and new risks." BIS Working Papers No. 313.

Paravisini, D. (2008). "Local Bank Financial Constraints and Firm Access to External Finance." *Journal of Finance* 63(5), 2161-2193.

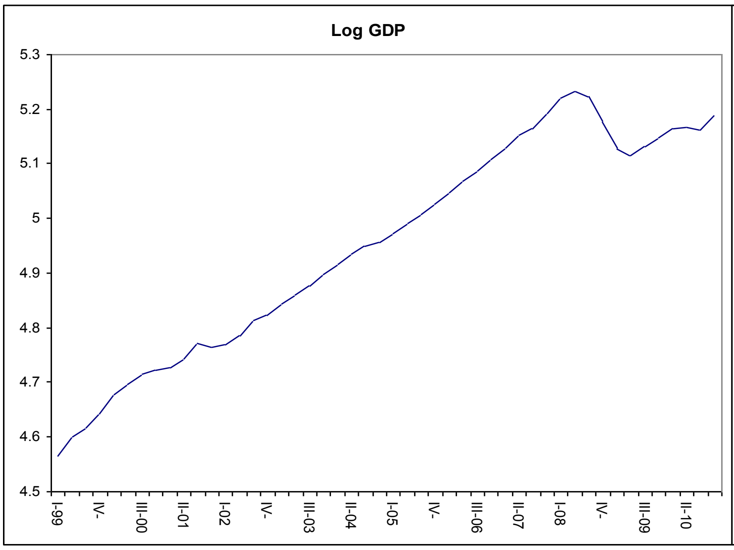
Rubio-Ramirez, J., D. Waggoner, D., and T. Zha (2005). "Markov switching structural vector autoregressions: Theory and application." Federal Reserve Bank of Atlanta Working Paper 27.

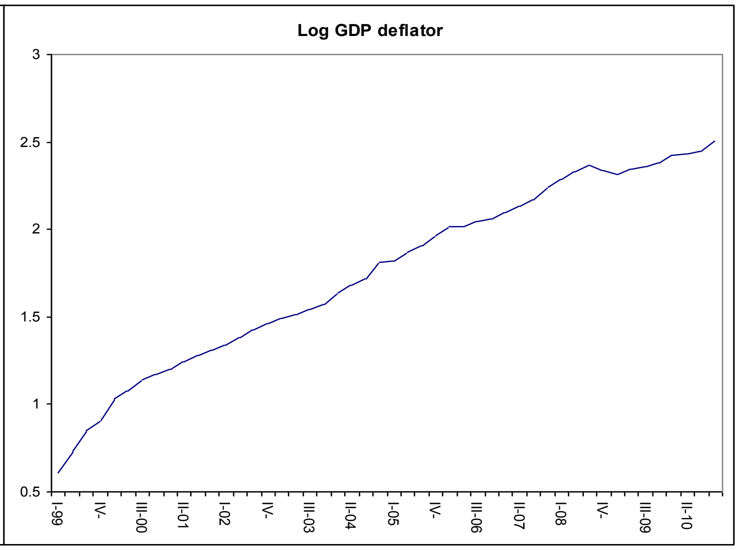
Sun, L., J.L. Ford, and D.G. Dickinson (2010). "Bank loans and the effect of monetary policy in China: VAR/VECM approach." *China Economic Review* 21, 65-97.

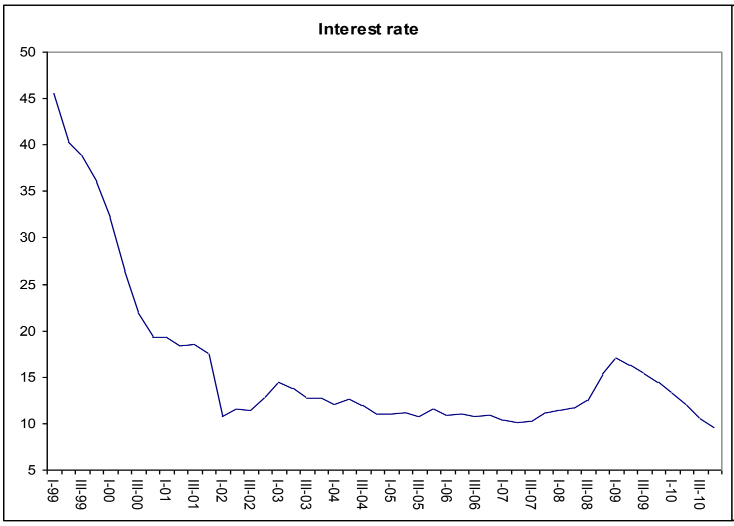
Uhlig, H. (2005). "What are the effects of monetary policy on output? Results from an agnostic identification procedure." *Journal of Monetary Economics* 52, 381-419.

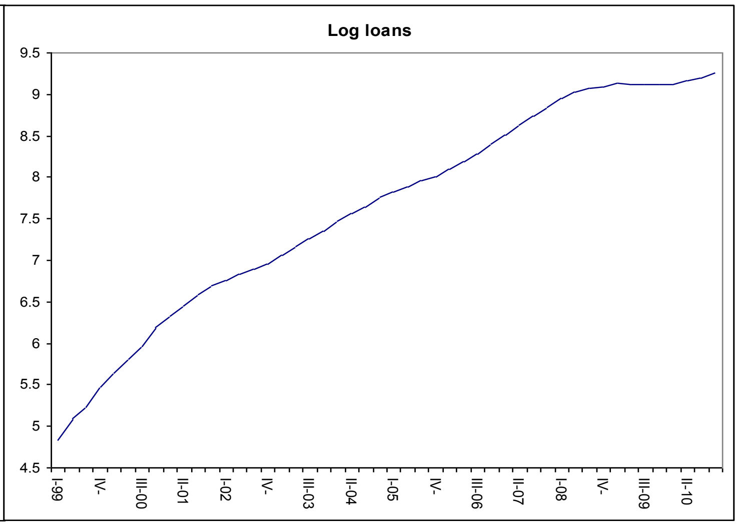
Yudaeva, K.V., N.S. Ivanova, K.K. Kozlov, and M.V. Kamenskih (2009). "Dinamika kreditovaniya v padayushei ekonomike: kreditnoe szhatie ili padenie sprosa na kredity?" *Obzor Centra makroekonomicheskih issledovanij Sberbanka Rossii, Dekabr'*. (in Russian)

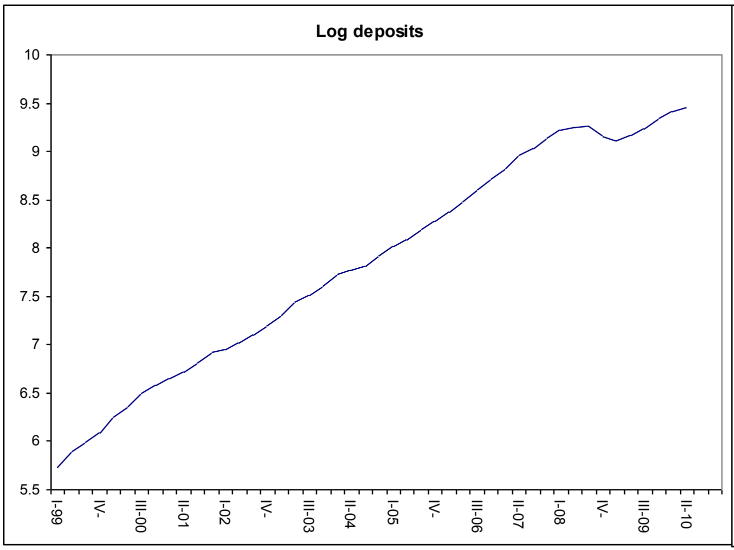
Annex I: Data

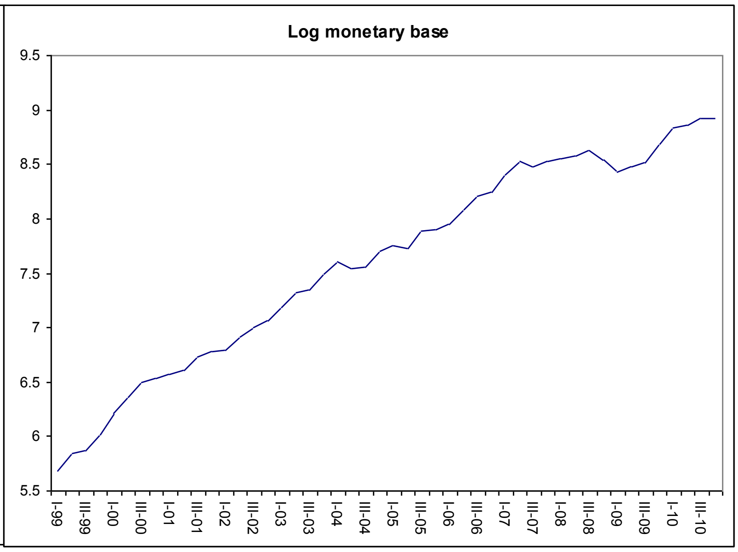

Log GDP
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
I-99
IV-
III-00
II-01
I-02
IV-
III-03
II-04
I-05
IV-
III-06
II-07
I-08
IV-
III-09
II-10


Log GDP deflator
3
2.5
2
1.5
1
0.5
I-99
IV-
III-00
II-01
I-02
IV-
III-03
II-04
I-05
IV-
III-06
II-07
I-08
IV-
III-09
II-10


Interest rate
50
45
40
35
30
25
20
15
10
5
I-99
III-99
I-00
III-00
I-01
III-01
I-02
III-02
I-03
III-03
I-04
III-04
I-05
III-05
I-06
III-06
I-07
III-07
I-08
III-08
I-09
III-09
I-10
III-10


Log loans
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
I-99
IV-
III-00
II-01
I-02
IV-
III-03
II-04
I-05
IV-
III-06
II-07
I-08
IV-
III-09
II-10


Log deposits
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
I-99
IV-
III-00
II-01
I-02
IV-
III-03
II-04
I-05
IV-
III-06
II-07
I-08
IV-
III-09
II-10


Log monetary base
9.5
9
8.5
8
7.5
7
6.5
6
5.5
I-99
III-99
I-00
III-00
I-01
III-01
I-02
III-02
I-03
III-03
I-04
III-04
I-05
III-05
I-06
III-06
I-07
III-07
I-08
III-08
I-09
III-09
I-10
III-10

Annex II: Empirical validation of sign restrictions

Here, we check whether the imposed sign restrictions on impulse response functions are supported or contradicted by the data. This is quite relevant as our empirical strategy implies shuffling not only through the structural shocks identification matrices but also through the VAR coefficients. We propose a couple simple exercises to gain insight into the extent the imposed sign restrictions are validated by the observed data. We report the results for estimates on the full time sample (1999Q1−2010Q4) and on the pre-crisis time sample (1999Q1−2008Q2).

Following Chadha *et al.* (2008), one criterion could be the percentage of accepted draws out of total draws needed to accept 5,000 conforming models. The suggested benchmark is 15%. Our results stand at:

Full time sample – 99.9% (5,000 out of 5,004)
Pre-crisis time sample – 3.5% (5,000 out of 142,207)

The results indicate our suggested sign restrictions are valid. However, estimating the VAR-model only on the pre-crisis time sample drastically decreases the chances of obtaining results conforming to the sign restrictions.

We now move to a few formal tests to analyze whether the distribution of VAR parameters of 5,000 accepted models (*B_acc*) deviate significantly from the distribution of parameters of initially drawn 1,000 models (*B*). We perform the tests for each of 80 individual VAR parameters, as well as for the aggregate distribution of all standardized parameters.[4]

First, we test if the means of two distributions are equal: H_0: b_i-b_acc_i = 0. For this purpose, we use the standard t-statistic:

$$t = \sqrt{\frac{mn(m+n-2)}{m+n}} \frac{\overline{B_i} - \overline{B\_acc_i}}{\sqrt{nS^2(B_i) + mS^2(B\_acc_i)}} ,$$

where $\overline{B_i}$ and $\overline{B\_acc_i}$ are the sample means of two distributions, $S^2(B_i)$ and $S^2(B\_scc_i)$ are the standard deviation of two distributions, n =*1000* and m =*5000* are the distribu-

[4] We use the mean and standard deviation of the distribution of 1,000 initially drawn parameters to standardize the respective parameters of accepted models.

tion sizes. We use the quantiles of normal distribution *N ~ (0,1)* to test the hypothesis, which is acceptable for large samples.

Second, we test for the homogeneity of distributions using the Mann-Whitney-Wilcoxon rank test (Mann and Whitney, 1947). This test implies the hypothesis H_0: $P(B_i < B\_acc_i) = 1/2$ and the following test statistic:

$$U = \min(U1, U2)$$

$$U1 = \sum_{i=1}^{n}\sum_{j=1}^{m} I(B_i < B\_acc_j)$$

$$U2 = \sum_{i=1}^{n}\sum_{j=1}^{m} I(B_i > B\_acc_i)$$

Which is approximately normally distributed $U \sim N(\frac{nm}{2}, \frac{nm(n+m+1)}{12})$ for large *n* and *m*.

The results are summarized in Table 3.

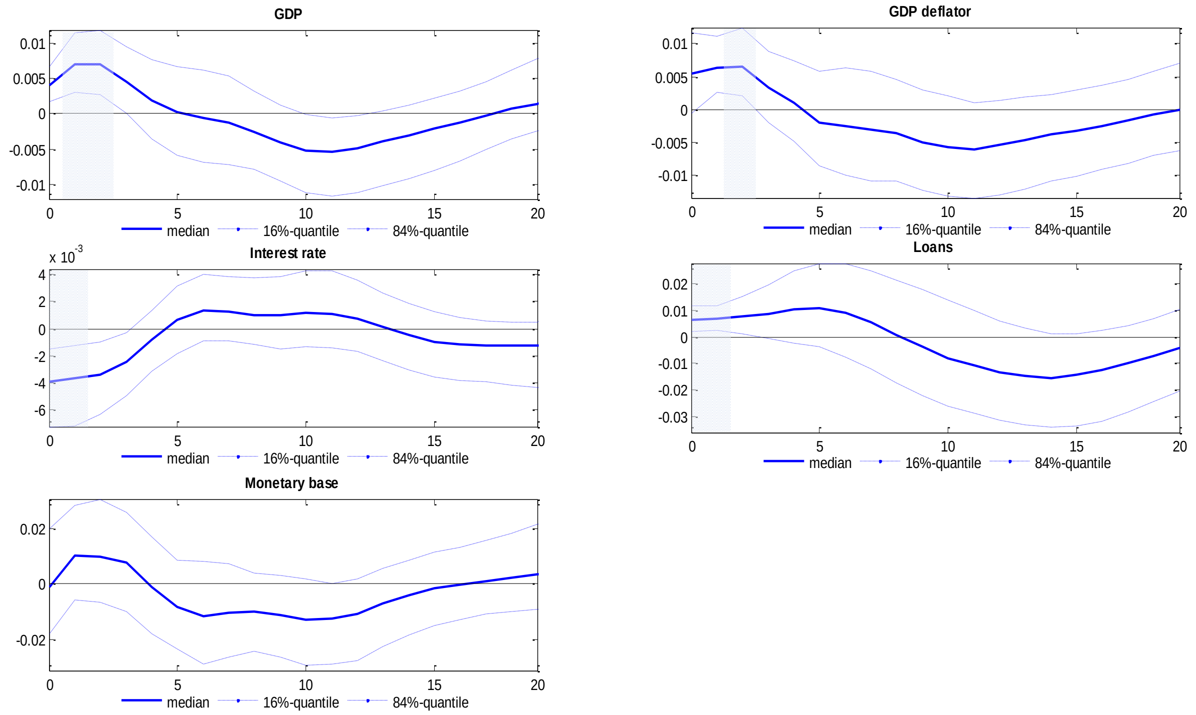
Table 3 Results of sign restriction validity tests

	Number of parameters (Full time sample)		Number of parameters (Pre-crisis time sample)	
	H_0: Means equal	H_0: Distributions homogenous	H_0: Means equal	H_0: Distributions homogenous
p-value>0.1	80	80	18	15
0.05<p-value<0.1	0	0	4	5
0.01<p-value<0.05	0	0	6	7
p-value<0.01	0	0	52	53
Aggregate distributions comparison (test statistic)	*-0.13*	*0.06*	*3.1*	*2.29*

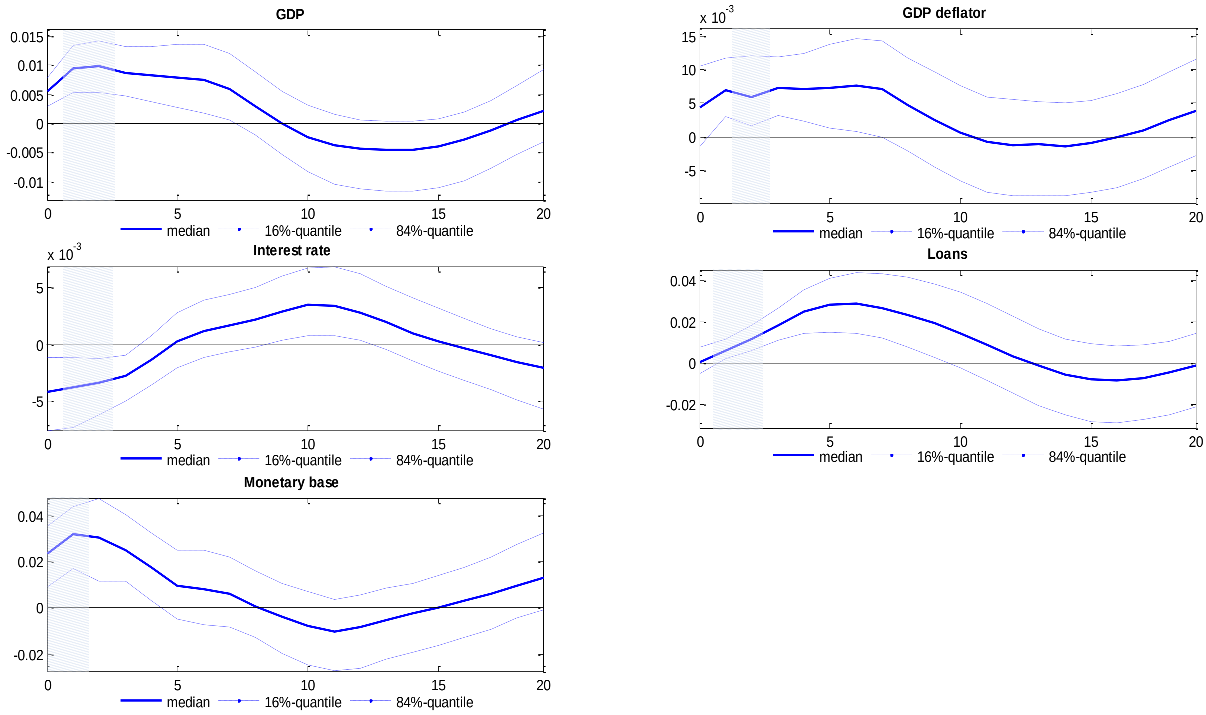
The results indicate that, for the benchmark model, none of the VAR parameters of the initially drawn and eventually accepted models were significantly different. For the models estimated on the pre-crisis sample, the VAR parameters of accepted models had to be noticeably different from our initially estimates to fulfill the sign restrictions.

Annex III: Alternative model estimates with monetary base used as monetary stance variable

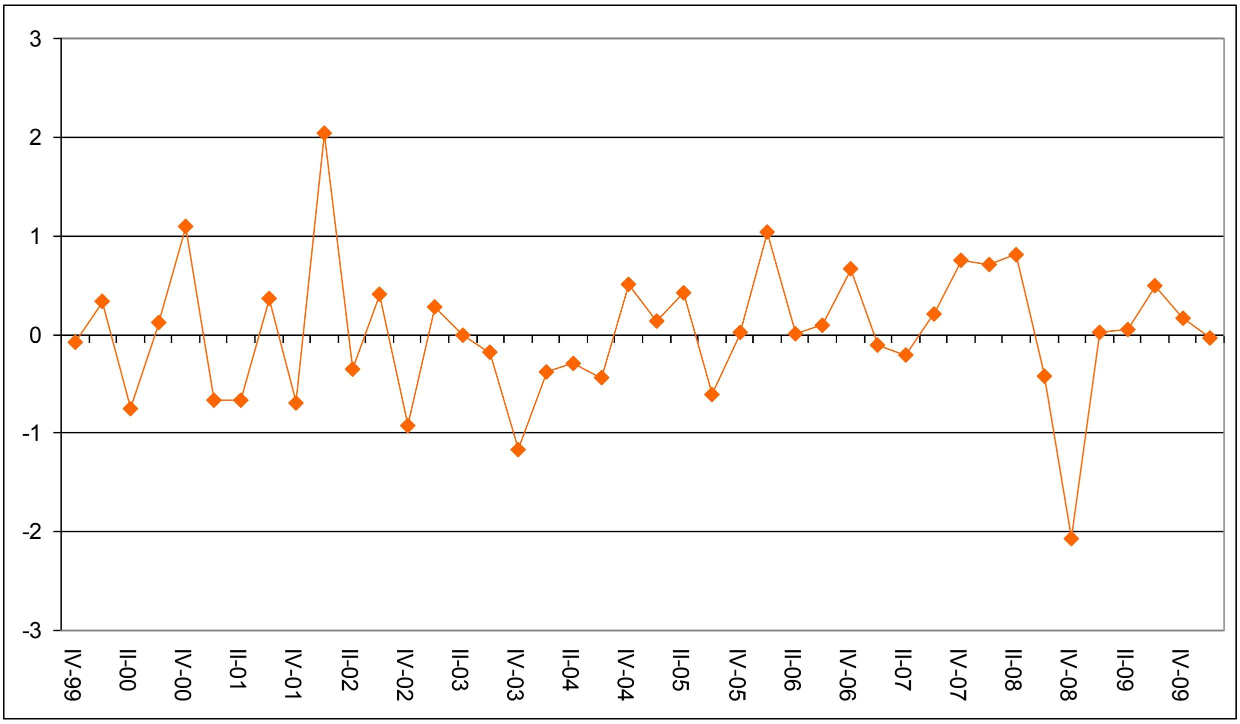
Impulse responses to expansionary loan supply shock (shaded area = sign restriction period)



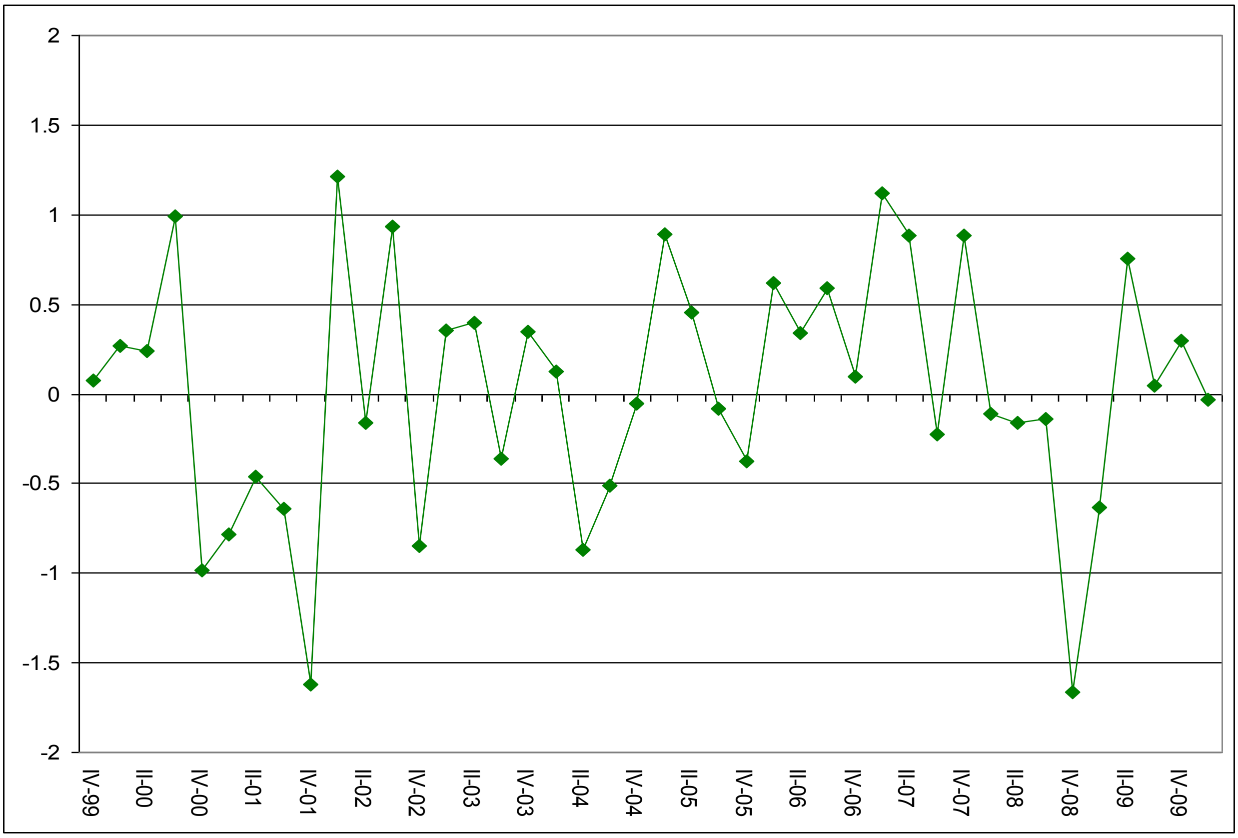
Impulse responses to expansionary monetary stance shock (shaded area = sign restriction period)



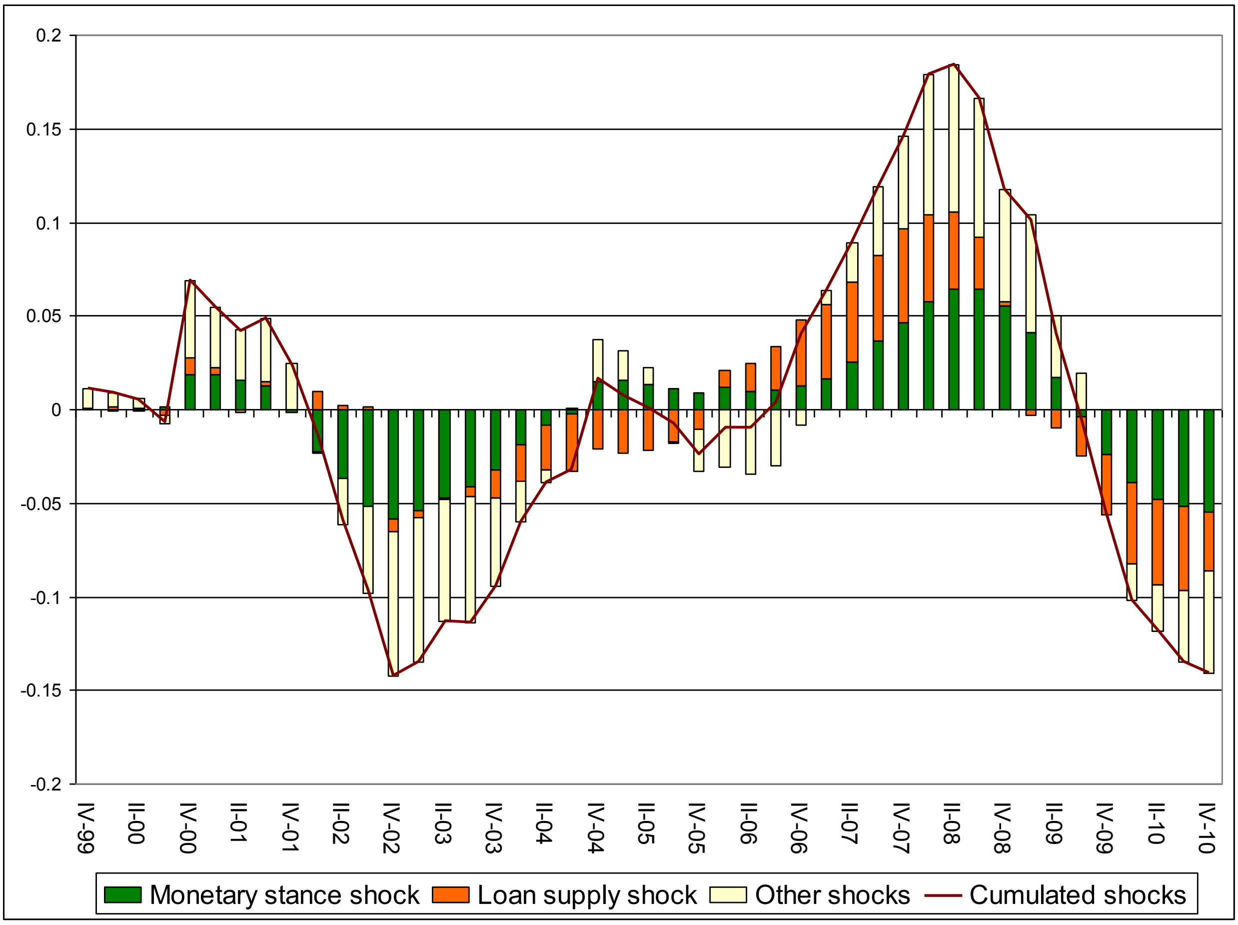
Identified loan supply shock innovations



Identified monetary stance shock innovations



Historical decomposition of loans into loan supply, monetary stance, and other shocks



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