Bank of Russia

Spillover Effects of Russian Monetary Policy Shocks on the Eurasian Economic Union

WORKING PAPER SERIES

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Abstract

Russian monetary policy could translate on the countries of Eurasian Economic Union (EAEU) through different channels. However, there is still a lack of evidence of the significance of so called spillover effects of Russian monetary policy. This work investigates the influence of Russian monetary policy shocks, proxied by shocks of MIACR, on the EAEU countries. For that purpose, firstly, monetary policy shocks were identified via FAVAR model for the Russian economy, estimated on the monthly data of more than 50 indicators. Further, separately for each country of the union VAR models with previously extracted MP shocks were estimated and both impulse response functions (IRF) and forecast error variance decomposition (FEVD) were analysed. The main result of the work is that effects of shocks in MIACR on industrial production and inflation are not statistically significant. At the same time, such shocks have statistically significant effect on money supply, nominal exchange rates and money market rates in some union's countries. However, obtained effects are mostly small and heterogeneous.

Keywords: transmission effects, monetary policy, Eurasian economic union

JEL Classification: E52, E58, E59.

Introduction

It is known that the economies of Eurasian Economic Union (further, EAEU) are particularly sensitive to shocks arising in commodity markets (Polbin, Andreev, Zubarev (2018)), which largely determines the similarity of their business cycles. In addition, primarily due to the high trade integration, the Union countries are subject to the effects of shocks occurring in the ‘central’ Russian economy (Demidenko et al. (2017)). Therefore, when making decisions regarding national monetary policy, these countries should also be guided by the shocks that arise in the Russian economy and take into account their possible transmission effects. In this regard, it is necessary, in particular, to understand how the shocks of the Russian monetary policy will be transmitted to the small open economies of the Union, including what impact the shocks may have on the key macroeconomic indicators in these countries: industrial production, exchange rate, inflation and money supply etc. This work gives primary evidence of the transmission effects of the Russian monetary policy shocks on the economies of the EAEU countries, and allows understanding of how strong that effects in comparison with other external shocks.

Moreover, the contribution of this work to academic literature is that it provides additional evidence of the degree of economic integration of EAEU countries with Russia. In a number of works the authors check the degree of integration of the economies of the EAEU on the basis of a common reaction to some external shocks. For instance, Polbin, Andreev, Zubarev (2018) show the strong dependence of the EAEU economies on the prices for commodities – oil, gas and metals. The authors found that the output of all EAEU countries increases in the short run with the growth of the global factor, describing the dynamics of commodity prices. This provides us with an indirect evidence that the EAEU economies are connected to each other at least at the level of common business cycles dynamics. Also, Demidenko et al. (2017) analyse the integration of EAEU countries and in particular show that most of the trade flows within the union accounts to Russia, which results in significant effect of Russian GDP shock on the macro variables of the rest of the union. In contrast to the above mentioned studies, in this paper the degree of economic integration in the EAEU is considered in terms of the transmission effects of the Russian monetary policy. If the shocks of the Russian MP have a significant impact on industrial production, money supply, key rates or other key macro variables of the EAEU countries, this will add to the evidence of high level of integration of the Union’s countries with Russia.

The work uses monthly data for the period from May 2004 to November 2018 for 53 macro variables describing the Russian economy and external economic conditions. Within the framework of the constructed FAVAR model, the identification procedure was carried out and the shocks of the one-day Russian money market rate (MIACR) were obtained. After that, structural VAR models were estimated separately for each country of the Union. The impulse responses and forecast error variance decomposition were estimated, in order to analyse the reaction of industrial production, the money supply, money market rates, inflation and the exchange rate to the shock of the monetary conditions of Russia.

The results indicate that effects of Russian monetary policy shocks[1] on industrial production and inflation in EAEU-economies are not statistically significant, both in the short- and medium-term. However, statistically significant responses were observed from the money supply (M2), nominal exchange rates and money market rates in some countries in response to the monetary shock in Russia. For instance, in Kazakhstan, with a positive shock of the Russian MP (defined as unexpected rise in money market rates), the money supply decreases and the tenge strengthens against the rouble, which can be possibly explained by the Kazakh regulator’s intervention in the foreign exchange market under fixed exchange rate regime. In Armenia, in response to the positive shock in MIACR, a symmetric increase in the money market rate occurs, which may indirectly indicate that the country's central bank has to follow the Russian counterpart and therefore is not completely independent. For Belarus, the shock of Russia's MP also lead to a positive response from money market rates, but the increase is observed during only short-term period of 2-4 months. For Kyrgyzstan, there was no significant relationship between the shock of the Russian MP and the reaction of analysing variables. The transmission of monetary shock, if present, occurs rather quickly – over several quarters the cumulative response functions usually reach maximum values in absolute terms.

The results generally indicate a weak degree of integration of the economies of the union with Russia in the context of the transmission effects of monetary policy. The forecast error variance decomposition confirms the results of the impulse response functions and gives us reason to believe that the effects of Russian MP shocks on the EAEU economies are mostly small and insignificant. The only exception is that the monetary shock of Russia accounts for 20% of the variance of the forecast error for the interbank rate in Armenia. The robustness of the results was verified by comparing estimates of Russian money market shocks obtained from several models with different identification assumptions.

[1] Hereinafter, monetary shocks are understood as shocks of the one-day MIACR interbank rate.

The remainder of the paper is organised as follows. Section 1 describes main transmission channels of monetary policy, section 2 identifies the shocks of the Russian monetary policy, the third section characterises the procedure to obtain the effects of the Russian monetary policy on industrial production, money supply, exchange rates, inflation and money market rates in the EAEU and also provides the reader with expected results. The forth section contains short summary of the results and the fifth section concludes.

1 Transmission channels of monetary policy shocks on small-open economies

The analysis of the effects of the monetary policy of a ‘central’ or key economy on other economies (usually small-open neighbouring countries) was carried out for different countries in many of works, particularly in Kim (2001), Giovanni, Shambaugh (2008) and Georgiadis (2016), Aizenman, Chinn, Ito (2016). Thus, Kim (2001) found that US monetary policy tightening leads to a sizeable decrease in the growth rates of the rest G7 countries. Georgiadis (2016) come to similar conclusion and show that the magnitude of the transmission effects of US monetary policy is quite large and for some economies, US monetary policy has even greater influence than on its own, American economy. Analysing the influence of rates in the ‘central’ economies of the regions on the growth rate of real output in more than a hundred countries, Giovanni, Shambaugh (2008) find that the change in the key rate in the ‘central’ economy has an impact on the pace of real GDP growth only in countries with an exchange rate tied to the rate of the ‘central’ economy. Authors also show that pegged countries move their interest rates with the base country interest rates while floats do not. Among the main determinants of transmission effects, they consider not only the exchange rate regime, but also trade openness, economic structure, development financial market development, labour market rigidities and other factors.

However, as far as the author knows, the effects of Russian MP shocks on the neighbouring countries (CIS or EAEU) have not yet been studied. Unlike the USA or the EU, the identification of the effects of the impact of monetary shocks of Russia on EAEU countries is somewhat complicated due to the inaccessibility of long time series together with the presence of some structural shifts in the samples.

Monetary policy shocks can be transmitted to small open economies through various channels. Although an analysis of the monetary policy spillovers channels is not the primarily task of this study, it will be further useful to briefly outline the main ones of them.

1.1. Trade channel

The one of the main channel of spillover effects is the trade channel. According to the Mundell-Fleming-Dornbusch baseline model, monetary expansion could cause the deterioration of the terms of trade due to weakening of real exchange rate, which entails a strengthening of the balance of payments in the country (and therefore leads to a deterioration in the balance of payments and a drop in output in partner countries).[2] However, following the monetary expansion, the national income also increases and, accordingly, the demand for imported goods grows, which may worsen the trade balance in the national economy. This, in turn, can lead to an improvement in the balance of payments and an increase in output in the partner countries (see, for example, Adler, Buitron (2017)).

In the intertemporal choice models with forward-looking expectations lowering a key rate (and, accordingly, money market rates) could also affect current account in different ways. Current account in the national economy may either increase due to smoothing consumption (see ‘permanent income hypothesis’) or fall due to increased investment caused by lower real interest rates. At a lower real interest rate, agents in the economy begin to invest more actively, therefore current consumption and import could reduce. A reduction in imports in the national economy means a decrease in net exports (and, accordingly, output) of the trade partners. However, households can reduce their savings due to a reduction in deposit rates caused by the softening of monetary policy, which could negatively affect credit costs and investment and, conversely, increase consumption and imports. Different theories offer different explanations of the possible effects of the monetary policy impact on foreign countries, and there is no even a single consensus regarding the signs of such influences.

Anyway, the trade channel is probably the most important one for the transmission of MP shocks. According to the Georgiadis (2016), trade integration plays a crucial role in determination size of US monetary policy spillovers to the other countries. Since 2014, more than 90% of the commodity circulation within the EAEU has been accounted for Russia, and more than third of the foreign trade of each countries participating in the EAEU has been carried out within the Union. Therefore, it is expected that shocks occurring in Russia (incl. monetary policy shocks) can transmit to other EAEU countries through a trade channel.

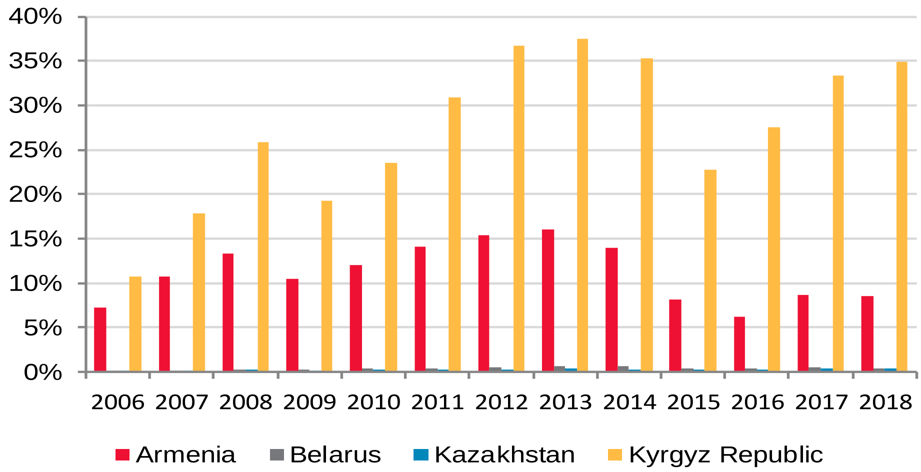
[2] Hereinafter, assuming that the Marshall-Lerner condition holds.

1.2. Remittances channel

Due to the specifics of the EAEU countries, the channel of remittances also acquires high importance. Remittance flows represent one of main channel of spillover effects from the world economy into developing countries. Developing countries that receive significant remittance inflows (like Mexico, Kyrgyz Republic or Tajikistan) tend to be more vulnerable to the external shocks than countries with low remittance inflows, Barajas et al. (2012). Countries with less trade and limited capital mobility could still be vulnerable to the shocks arising from the global economy because of their dependency on remittance flows.

This channel is the especially important for Armenia and Kyrgyzstan - the volume of money transfers from Russia to these countries was historically very large (Figure 1).

Figure 1. Dynamics of cross-border money transfers of individuals from Russia to other EAEU countries, in% of GDP.



Source: author's calculations.

As a result of decline in economic activity in Russia, remittances of migrants working in Russia also fall. Therefore, consumption and import in the partner countries of the Union, which are the main migration donors, may also decrease (short run, demand channel). In case of policy easing, reverse logic holds. At the same time, with a decrease in economic activity in Russia, an employment is also declining, while the least protected categories of workers (particularly migrants) are affected the most. Hence, significant share of migrants are forced to return home, which increases the supply of labour and reduces the costs of firms in their homeland, and, consequently, may leads to an increase in production and economic activity within the country (long run, supply channel). Therefore, the final effect on aggregate output in the medium term is also not obvious. Moreover, economic activity in Russia is determined largely by external shocks, and to a lesser extent, by the monetary policy. Thus, the initial reason of changes in remittances flows may be related to some global and external shocks and not with Russian monetary policy itself. One way or another, remittances from Russia play a huge role at least for the economies of Armenia and Kyrgyz Republic.

1.3. Financial channel

According to the monetary policy trilemma, countries with a fixed exchange rate and free capital mobility cannot have an independent monetary policy. In essence, this means that the monetary shock of the central economy (in our case, Russia) will be transmitted to integrated small open economies that adhere to a fixed (or any kind of controlled) exchange rate.

An empirical analysis provided in Rey (2015) shows that the monetary policy of a ‘central’ economy will be transmitted into small open economies even without regard to the exchange rate regime through changes in investor risk appetite and changes in cross-border capital flows. Monetary shock in the central economy leads to an increase in the global factor which describes the dynamics of capital flows between countries. Therefore, with the free capital mobility, the global financial cycle (which in the case of the EAEU can be caused by the Russian monetary policy shocks) limits the national monetary policy regardless of the exchange rate regime. In this regard, a financial channel potentially may be important. With a decrease in the policy rate in the central economy, there is an outflow of investments in countries with higher rates and yields. As a result, capital flows comes to such economies, which strengthens their exchange rates, worsening the terms of trade. However, the financial channel may be less important than trade channel and even ineffective, since the financial markets in the Union countries are mostly underdeveloped and illiquid, Alturki, Espinosa-Bowen, Ilahi (2009), Rukavishnikov (2016).

In the next chapter, we will proceed with the identification of Russian MP shocks.

2 Monetary policy shock identification

In order to identify Russian monetary policy shocks, a factor-augmented vector autoregression (FAVAR) model was estimated. FAVAR was first introduced in Bernanke, Boivin, Eliasz (2005) and is widely used to trace out the effect of monetary policy innovations on the economy in many academic works (see, for example, Wu, Xia (2016), Boivin, Giannoni, Mihov (2009), Bianchi, Mumtaz, Surico (2009), Stock, Watson (2005), etc.). The model can comprise large data arrays, which potentially helps avoid the missing variables problem often arising in small-dimensional VAR models. To build the model, 53 macroeconomic indicators were used that describe the Russian economy and foreign economic conditions. The data used have a monthly frequency (05.2004 - 11.2018) and are presented in table 1 in Appendix A.

It is necessary to note several transformations that were made with these time series. Firstly, all variables in which seasonality was observed were cleared from it using the ARIMA X-13 SEATS procedure (for such variables the corresponding values in the '*SA'* column in table 1 in Appendix A equal 1). Secondly, all the series that turned out to be non-stationary in levels were transformed to be approximately stationary by taking the first difference of logarithms or the first differences of raw data. The data sources were Rosstat, Bloomberg Finance L.P. and the official website of the Central Bank of the Russian Federation.

The value of money in the economy is understood as an instrument of monetary policy in the work, and the MIACR interbank lending rate of 1 day was chosen as its proxy. The choice of this rate is primarily dictated by the fact that it better approximates the real value of money in the interval before the introduction of the key rate in comparison with other alternatives like the repo auction rate, main refinancing rate, etc.).[3] Other potential alternative to MIACR also includes the RUONIA rate, which stands for Ruble Overnight Index Average rate. However, historical statistics for RUONIA rate exists only since September 2010, which substantially reduces the possibilities of our analysis. However, historical statistics for RUONIA rate exists only since September 2010, which substantially reduces the possibilities of our analysis. We also argue that the short-term interbank rate can correctly and effectively reflect the general current stance of monetary policy. Note, however, that changes in unconventional and macroprudential policies may be better reflected through long-term rather than short-term rates, given the long-run orientation of such policies.

In order to build the model, initial variables were 'folded' into the first few principal components. From the variables of the external sector, the first principal component (*EXO*) was generated, explaining 42% of the variation in the initial set of external factors. Also, from the variables of commodities prices the first principal component (*CMDTY*) was generated. Further, from the 'slow' variables, which cannot change in the same month in response to a monetary shock, the first principal component was generated, which reflects the common

[3] Note that until 2014, the Central Bank of the Russian Federation mainly targeted the exchange rate rather than inflation (through the regulation of money market rates), and the choice of MIACR as a monetary tool for the regulator may lead to some bias in the results.

dynamics of slowly changing variables. Namely, ‘slow’ variables include industrial production, the CPI, commissioning of houses and other variables indicated by the green colour in Table 1 in Appendix A. ‘Slow variables’ are variables that, for various reasons, do not change in the same month in response to other shocks, including monetary policy shocks. In a similar way, the first principal component of the ‘fast’, mainly financial variables, was found using such variables that could change in response to any internal or external shocks in the same month. As a result, the original data set was collapsed into the following:

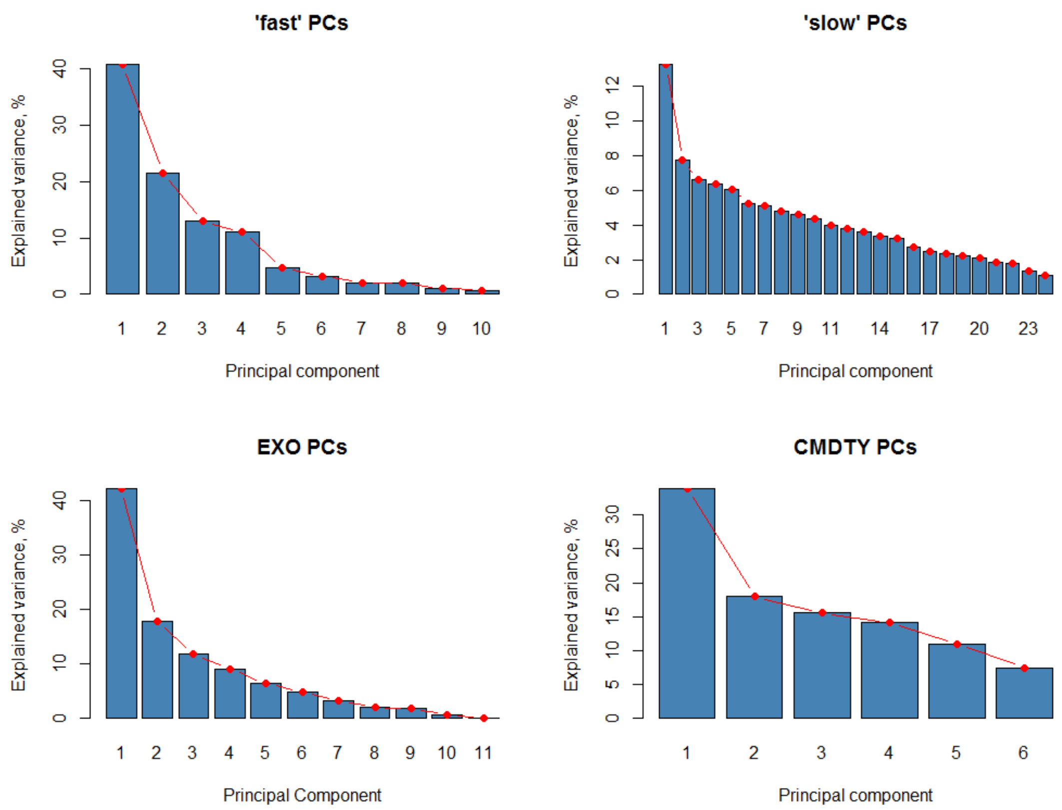
Table 1. Shares of explained variance of each factor

	Share of explained variance	*Number of used variables to construct factor*
Key_rate*	*100%*	*1*
EXO	*42%*	*11*
CMDTY	*34%*	*6*
PC1_slow	*14%*	*24*
PC1_fast	*41%*	*10*

** One-day MIACR*

According to Figures 2-5, the couple of first principal components (with the exception of *PC1_slow*) explain a significant proportion of the variation in the dynamics of the variables.

Figures 2-5. The explained variance shares for each principal component



Source: author’s calculations.

External factors were folded into the first two principal components (*EXO* and *CMDTY*). The shock of any of the principal components will be the shock of some linear combination of the factors which form it. Now let's see which variables correlate the most with each of the external factors. Table 2 gives the correlation coefficients of the principal components with the underlying variables that form them.

Table 2. Correlation coefficients of external principal components with variables

Variable	***EXO***	***Variable***	***CMDTY***
MOVE	0.17*	*Oil price*	0.75*
Libor	0.97*	*Gas spot price*	0.06
Treasury 10Y	0.86*	*Aluminium_Pr*	0.55*
EMBI	-0.51*	*Gold price*	0.32*
FedRate	0.96*	*Copper*	0.82*
VIX	0.18*	*Ore*	0.62*
Unem_US	-0.54*		
Nikkei	-0.07		
ECB rate	0.81*		
S&P500	-0.17*		
Unem_euro	-0.83*		

** - coefficient is statistically significant at 5% level*

From Table 2 we can conclude that the first principal component of EXO is statistically more strongly related to the value of money and unemployment levels in Europe and America and less strongly to stock indices, as well as with the volatility of the stock and bond markets. This first principal component EXO can be interpreted as a proxy for the global Philips curve, or as a proxy for global economic growth. The second principal component (CMDTY) is more strongly correlated with oil and copper prices.

At the first stage, using the previously extracted factors, a FAVAR model was estimated in which the first two principal components, reflecting external factors for the Russian economy (EXO and CMDTY), were exogenous, and the remaining variables (‘slow’ and ‘fast’ factors and MIACR) were endogenous. The inclusion of only the first principal components is due to the fact that they explain a significant proportion of variance, and the results do not change significantly when estimating models with 2 and 3 factors as well.

In order to identify the shocks of Russian monetary policy (MIACR shocks), an identification procedure is necessary. The identification procedure was based on the Cholesky decomposition, with the following order of variables in the model: ‘slow’ principal component, MIACR, ‘fast’ principal component. Although Cholesky decomposition is a standard identification strategy, its appropriateness can be reasonably questioned, see Christiano, Eichenbaum, Evans (2005). However, we argue that our distinction between ‘slow’ and ‘fast’ variables, following the idea of Bernanke, Boivin, Eliasz (2005), makes the identification strategy appropriate and supports this choice.

Often, researchers resort to VAR estimates on the assumption that the monetary authority can only respond to shocks of slow variables in the same period, while shocks of fast variables do not affect the policy of the regulator, see, for example, Bernanke, Blinder (1992), Christiano, Eichenbaum, Evans (1999). Therefore, the baseline specification in work assumes that any shocks of slow variables (including inflationary and production shocks) lead to a Central Bank response. In other words, the monetary authority is assumed to see the dynamics of slow-moving variables when choosing key rate. However, monetary shocks can affect only fast-moving variables in the same month, without changing the slow, due to the some policy transmission lags.

As a result, the FAVAR model and the matrix of structural coefficients (A) have the following form[4]:

$$A * \begin{bmatrix} PC_{slow} \\ Key_{rate} \\ PC_{fast} \end{bmatrix}_t = \Phi(L) * \begin{bmatrix} PC_{slow} \\ Key_{rate} \\ PC_{fast} \end{bmatrix}_{t-1} + D(L) * \begin{bmatrix} EXO \\ CMDTY \end{bmatrix}_t + e_t$$

$$A = \begin{matrix} PC_{slow} \\ Key_{rate} \\ PC_{fast} \end{matrix} \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix}$$

Where, $\Phi(L), D(L)$ – second order lag polynomials[5], e_t – error term.

Further, after the model estimation, estimates of the structural shocks of monetary policy in Russia were recovered, as $u_t = A^{-1}e_t$. Figure 6 displays the combined dynamics of MIACR and recovered rate shocks from the given model. The graph shows that at the times of significant changes in the interbank rate (especially during the crisis of 2008-2009 and the

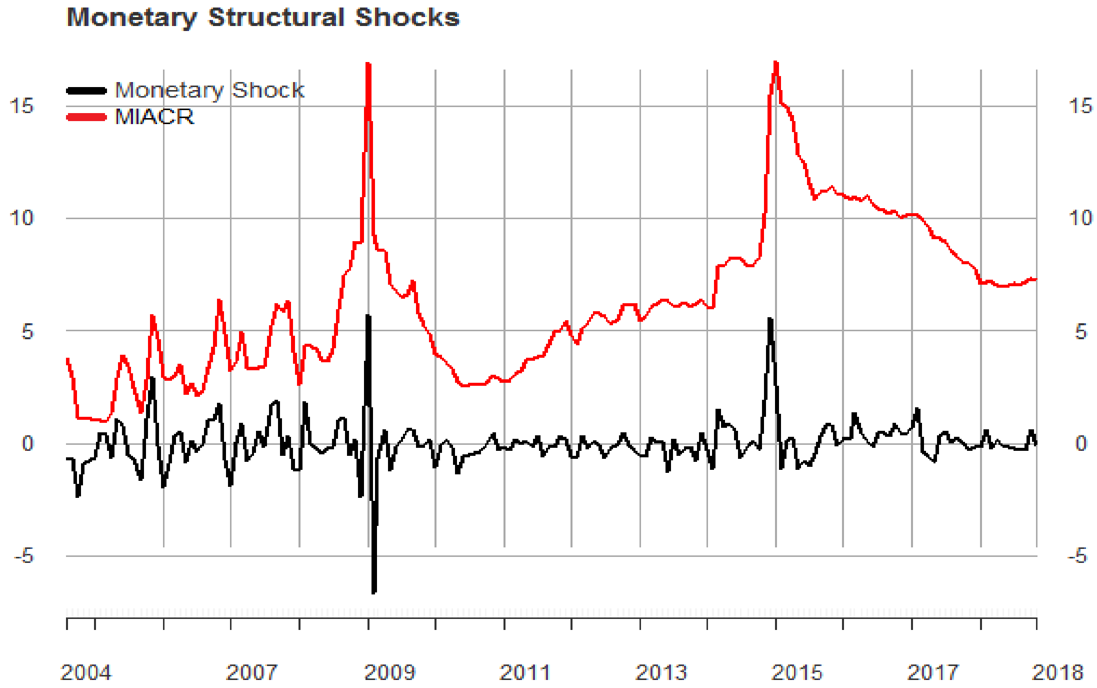
[4] A similar identification in the framework of a two-step FAVAR procedure was proposed in Bernanke, Boivin, Eliasz (2005). Of course, due to possible lags in the implementation of monetary policy and delays in the release of statistical data, sometimes exceeding one month, monetary policy may not have time to respond to current shocks, because monetary authority simply does not see these shocks in the available statistics. To check the robustness of the selected scheme, the Appendix B presents the results of the evaluation of several competing models, in particular, the model with the assumption that the interbank rate is included in the first VAR and the model where MIACR is the last. The results indicate visual and statistical similarity of the obtained monetary shocks under various identification assumptions.

[5] The optimal number of lags, according to the information criteria AIC, BIC and HQ equals 2. However, the robustness of our results with respect to lag length was made: we checked specifications with lag length from 3 to 4 and also with separately included 12th lag. All those models gave us essentially similar results but not presented in the work to save space.

end of 2014), the shocks in absolute terms were maximum and significantly differed from shocks that occurred in calm times.

Note that Figure 6 underlines the fact that there may be potential structural breaks in the sample in 2009, due to the World Financial Crisis, and in 2015, due to the change in monetary policy stance and the transition from the fixed exchange rate regime to inflation targeting. Potentially it could lead to biased results, given the fact that we use one fixed coefficient model to identify the shock on the whole sample. In order to check whether our results hold in a more flexible model, we provide a comparison of these results with whose from a rolling window exercise in Appendix B.

Figure 6. The dynamics of the MIACR shock and its actual values from FAVAR model.



Source: author's calculations.

The resulting monetary shocks will be used in the next part as exogenous variables in VAR models for each individual country of the Union.

3 Effects of the monetary policy of Russia on the small open economies of the EAEU

It has been argued that financial conditions and growth worldwide are driven by a global financial cycle, which appears to be determined to a large extent by monetary policy in a few centres or dominant countries. But, the reverse influence of small economies on the centre one is usually found to be negligible. For instance, there may be substantial spillover effects of US monetary policy on a variety of both advanced and developing countries, but the reverse influence is not significant, Kim (2001), Mackowiak (2007). Due to the distinctly big size and importance of the Russian economy in the Union, Russian monetary policy shocks are also assumed to be exogenous to the dynamics of the macro variables of the other Union countries. To this extent, we can use earlier identified shock in further separate VAR models for each of the other economies.

In order to analyse the effect of monetary policy shocks on neighbouring economies, for each country the following simple VAR models were estimated[6]:

$$Y_t = F + W_1 Y_{t-1} + W_2 Y_{t-2} + \cdots + L(p) Z_t + W_3 MS_t + W_4 MS_{t-1} + W_5 MS_{t-2} + e_t$$

Where, Y_t – the vector of endogenous variables $\{IP$ – *industrial production, CPI – consumer price index, IR – weighted money market rate, M2 – monetary aggregate M2, ER – nominal exchange rate*$\}$, F – vector of constants, Z_t – vector of exogenous variables $\{EXO, CMDTY\}$. Variables were transformed, if necessary, to stationary by taking the first differences of logarithms or the first differences of raw data (for the MIACR rate) and cleared from seasonality with ARIMA X-13 SEATS procedure.

Then the multipliers of the MS variable (in our case, this is the exogenous shock of the Russian money market) can be found from the corresponding elements of the following vectors:

- $M_0 = W_3 = (m_1^0 \quad m_2^0 \quad m_3^0 \quad m_4^0 \quad m_5^0)'$
- $M_1 = W_4 + W_1 * W_3 = (m_1^1 \quad m_2^1 \quad m_3^1 \quad m_4^1 \quad m_5^1)'$
- *Etc.*

The cumulative multiplier for the period will be the sum of the dynamic multipliers M_i presented above, and will reflect the magnitude of the change in the endogenous variable in the country when an exogenous monetary shock occurs in Russia. The impulse response function (IRF) in the work is defined by the trajectory of cumulative multipliers in time. Before evaluating the multipliers, it is necessary to check the results of evaluations of VAR models for stability and make sure that there is no autocorrelation in the residuals. To fulfil the stability

[6] The number of lags of endogenous variables in each model was determined using the information criteria AIC, BIC, and HQ. In case then criteria were not unanimous, the biggest one was chosen. If autocorrelation was observed in the residuals, then additional lag was included into model. Given the relatively small number of data points, the maximum number of lags was set as 4.

condition, it is necessary and sufficient that the moduli of all the eigenvalues of matrix A in the VAR (1,0) representation are less than unity (see Lutkepohl (2005) and Hamilton (1994)). In our case, for all models estimated in this work, the eigenvalue moduli do not exceed unity. The results of the LM tests for the presence of autocorrelation in errors indicate that at 5% significance level there is no autocorrelation in the errors.

Now we will briefly describe what results can be expected and why. It is assumed that, since the EAEU countries are small open economies with respect to Russia, Russian monetary shocks should have some influence on the economies of the EAEU countries, that is, the multipliers (reactions) of some variables may possibly be significantly different from zero. At the same time, it is assumed that industrial production should not change rapidly in the same period in response to a monetary shock from the Central Bank of the Russian Federation (i.e. m_1^0 should not be statistically different from zero), since the production sector may not immediately feel the effect of foreign monetary policy due to transmission lags. Also, due to price rigidity, it is also assumed that inflation, if it even responds to a Russian monetary shock, changes only with some lag.

In addition, a combination of the rouble depreciation and a positive shock of Russian monetary policy (an increase in MIACR) that accompanied it may exacerbate depreciation pressures on currencies in economies with fixed exchange rates which are integrated with the Russian economy. To prevent currency depreciation following the rouble suit, central banks of such economies can conduct foreign exchange interventions by selling US dollars. This prompts a decline in money supply and an increase in the cost of borrowing.

Note that periods in which the Union countries had managed or fixed exchange rates prevail in the time sample. For example, Kazakhstan had a fixed rate until August 2015; as a result, when evaluating the model for the period 2004-2018, the estimated model for Kazakhstan captures a long period of a fixed rate and may show multipliers that are overestimated in absolute terms. Moreover, although the Kyrgyz Republic has a *de jure* floating exchange rate, the regulator often enters the market with currency interventions, and Belarus for a long time had a fixed rate pegged to a basket of the euro, dollar and Russian ruble. Therefore, it is also expected that the exchange rate will either not change statistically (due to foreign exchange interventions) or will slightly depreciate in response to a positive monetary shock in Russia. Although formally all countries of the union at the current moment have switched to inflation targeting and have floating exchange rates, regulators often carry out foreign exchange interventions in order to reduce volatility in the foreign exchange markets.

An increase in interest rates in Russia is accompanied by an increase in investments in Russian assets from countries with any exchange rate regimes, since Russian assets, *ceteris paribus*, will yield higher income. At the same time, a growth slowdown in Russia may lead to a decrease in remittance flows to any of the EAEU countries. In order to prevent a significant depreciation in the value of a national currency at a fixed exchange rate as a result of the above-mentioned facts, central banks can not only carry out foreign exchange interventions, but also change their policy rates symmetrically. As a result, in this case, we should observe a drop in the money supply in circulation and/or an increase in key rates. Adler, Buitron (2017) showed that it would be beneficial for US trading partners (relatively small open economies) to lower rates in response to US monetary policy easing (what is usually called ‘competitive devaluation’). This allows the prevention of an inflow of funds into the economy with the higher return on assets, as well as weakening net exports and the corresponding deterioration of the balance of payments. Numerous statements in the press in 2018-2019 about a possible easing of monetary policy in the future against the backdrop of trade wars between the United States and China indirectly confirm this logic.

It is also assumed that in countries that are net exporters of natural resources, a positive shock in the commodity price index (CMDTY) can lead to higher incomes, including an increase in industrial production in the short term, as well as an increase in M2 due to currency interventions by regulators.

The EXO shock is more strongly associated with key rates and unemployment rates in Europe and America and can lead to an increase in the cost of foreign funding and a limitation of the budget sets of many commercial banks, which can lead to higher costs for all borrowers (‘income effect’), a decline in lending and hence M2. At the same time, commercial banks, faced with an increase in the cost of foreign borrowing from Europe and America and a corresponding increase in costs, can also increase lending to domestic companies in the national currency (‘substitution effect’), which may have a positive effect on the country's money supply, however, this is unlikely to have a significant impact on the real sector of the economy in the short term.

After a brief discussion of the methodology and expected effects, the following chapter summarises the main results of the analysis.

4 Results

The key results of the work are presented in Tables 3-4. Table 3 summarises information on the impulse response functions for each of the EAEU partner countries. Most of the considered variables in the countries do not significantly respond to Russian monetary shock (rise in MIACR by 1 pp), and the responses of the variables are quite heterogeneous. When markets determine exchange rates, it should be expected that with a monetary shock in Russia, the national currency of a partner country will weaken. However, this does not occur in all the countries of the Union and may indirectly indicate the use of foreign exchange interventions during Russian monetary policy shocks. While conducting currency interventions, a central bank must sell US dollars to the market and buy national currency, thereby decreasing money supply. Indeed, this is what was actually happening in Kazakhstan during the Russian monetary policy shocks in both 2008 and 2014. The Russian monetary policy shocks reinforced depreciation pressures on the Kazakh tenge that stemmed from global shocks at those times. Eventually, the tenge devalued in both occasions but it took some time.

In addition, the shock of MIACR leads to an increase in interbank rates of Armenia and Belarus, which may be a way to prevent a strong depreciation of the national currency. This may be indirect evidence of the integration of these economies with the Russian economy in the context of the implementation of monetary policy and the fact that monetary policy in these countries is not completely independent from Russian policy. For the Kyrgyz Republic, no significant effects of Russian MP shocks on macro variables were found.

Table 3. Macro variable reactions in response to a positive shock of MIACR

	Armenia	Belarus	Kazakhstan	Kyrgyz Republic
IP	**n/s**	**n/s**	**n/s**	**n/s**
CPI	**n/s**	**n/s**	**n/s**	**n/s**
IR	**+**	**+**	**n/s**	**n/s**
M2	**+**	**n/s**	**-**	**n/s**
ER	**n/s**	**depreciation**	**appreciation**	**n/s**

***** *n/s – IRF is statistically non-significant, given the 90% CI bands*

Table 4 presents the forecast error variance decomposition (FEVD) for all variables and countries. The fractions of variance which statistically differ from zero are highlighted in bold. As can be seen from the table, among all three external shocks, commodity price shock usually has the greatest impact on the macroeconomic variables, which confirms the conclusions of the work of Polbin, Zubarev, Andreev (2018). At the same time, the share of Russian monetary shock is usually small and does not exceed 5-10%. The only exception is the share of monetary shock in the FEVD for the Armenian money market rate, which equals about 21%. A likely explanation for this is that the regulator tried to stabilise the exchange rate for a large period of the sample and, due to the lack of reserves, in particular, in the period of the year 2009 and at the end of 2014, was forced to symmetrically control money market rates and not conduct direct currency interventions.

Table 4. The share of each of the shocks in the decomposition of the variance of forecast errors for the EAEU countries

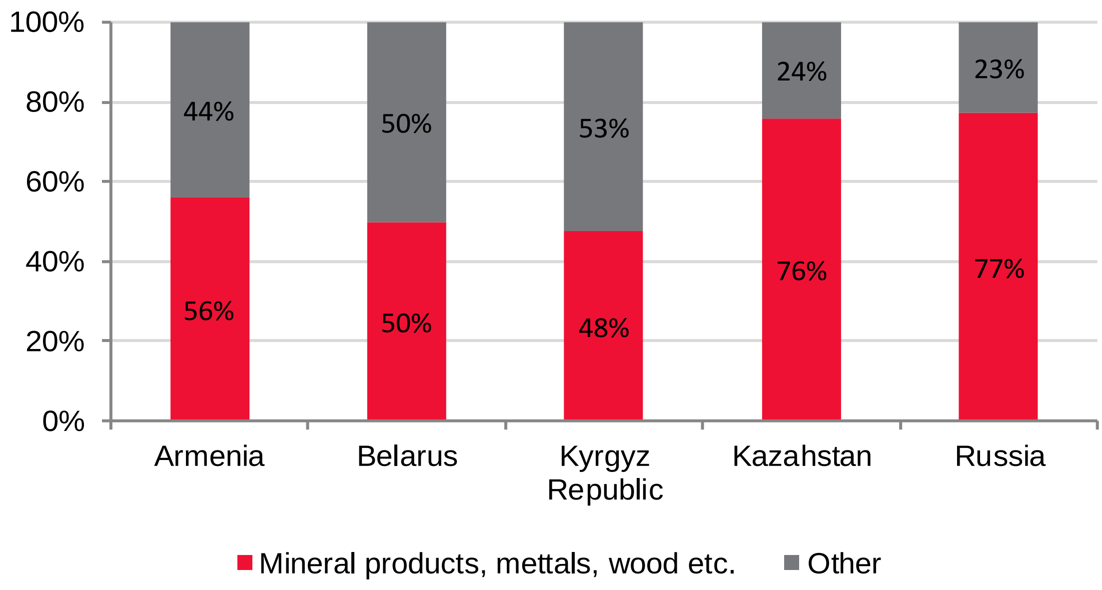
	Variable				
	IP	**CPI**	**IR**	**M2**	**ER**
	Belarus				
External shocks. incl.:	6.2%	3%	14.8%	21%	15%
Russian monetary shock (MS)	2.2%	1.3%	6.2%	6.3%	3.4%
Commodity price shock (CMDTY)	3%	1.2%	6.8%	**12.8%**	7.5%
Other external factors shock (EXO)	1%	0.5%	1.8%	1.9%	4.1%
Domestic shocks	93.8%	97%	85.2%	79%	85%
	Armenia				
External shocks. incl.:	10.2%	19%	22.7%	35.2%	21.5%
Russian monetary shock (MS)	1.1%	2.2%	**20.8%**	7.9%	**9.5%**
Commodity price shock (CMDTY)	4.9%	**14.3%**	1%	**24.3%**	8.6%
Other external factors shock (EXO)	4.2%	2.4%	0.9%	2.9%	3.4%
Domestic shocks	89.8%	81%	77.3%	64.8%	78.5%
	Kazakhstan				
External shocks. incl.:	10%	15.4%	14.9%	17%	32.7%
Russian monetary shock (MS)	1.4%	2.5%	4.9%	6.2%	**10%**
Commodity price shock (CMDTY)	7.8%	7.4%	5.1%	2.8%	**19.4%**
Other external factors shock (EXO)	0.8%	5.5%	4.9%	8%	3.3%
Domestic shocks	90%	84.6%	85.1%	83%	67.3%
	Kyrgyz Republic				

External shocks. incl.:	14%	8.8%	31%	22.4%	40%
Russian monetary shock (MS)	2.4%	2.1%	1.9%	4.9%	5.5%
Commodity price shock (CMDTY)	8.8%	2.8%	**14.4%**	**15.4%**	**27%**
Other external factors shock (EXO)	2.8%	3.9%	**14.4%**	2.1%	7.5%
Domestic shocks	86%	91.2%	69%	77.6%	60%

Note: *Entries are the percentage of the variance of the forecasted variable accounted for by variation in the column variable on a 12—month horizon. Estimates are based on vector autoregressions with 3-4 monthly lags of each variable depending on the information criteria. The ordering of the variables in the variance decomposition is the same as the ordering (left to right) of the columns.*

The reader can learn more about impulse response functions, as well as forecast error variance decomposition estimates in Appendix C (Figures 5-8). When comparing the magnitude of the responses of variables to all external shocks (including EXO and CMDTY shocks), it can be seen that the reaction of inflation, M2, and exchange rates is often stronger for commodity price shocks compared to the reaction to Russian monetary shock. This is probably an outcome of the significant share of commodities in the export flows of the EAEU countries (Figure 7).

Figure 7. Shares of commodities in exports in the Union countries in 2017



Sources: Bloomberg Finance L.P., author's calculations.

5 Conclusion

The impact of Russian monetary shocks on the EAEU economies was analysed in this work. Russian monetary policy shocks were identified as MIACR interbank rate shocks under the FAVAR model based on 53 variables describing the Russian economy and foreign economic conditions. To analyse the effect of monetary shocks, the impulse response functions and forecast error variance decompositions were estimated based on individual SVAR models for each of the EAEU countries.

Firstly, it was found that that Russian monetary policy shock does not have a significant impact on industrial production and inflation in the Union countries. At the same time, statistically and economically significant effects of Russian MP shocks were observed for the money supply, money market rates and exchange rates for some of the countries. However, the detected reaction is usually heterogeneous. Thus, given a positive monetary shock in Russia (rise in MIACR), the money supply significantly decreases in Kazakhstan and significantly increases in Armenia and does not statistically respond in Belarus or the Kyrgyz Republic. In the first case, this may be due to the fact that Kazakhstan for most of the considered period *de facto* had a controlled exchange rate, and the key rate growth (and therefore MIACR) in Russia led to Tenge depreciation and meant the need for currency interventions (purchases the national currency and the sale of Russian rubles in the foreign exchange market), which leads to a drop in the money supply. In the case of Armenia, the reaction of the monetary aggregate is possibly opposite because the regulator, for various reasons, is less likely to intervene in exchange rate formation on the foreign exchange market, preferring the regulation of money market rates. This is confirmed by the statistically significant at 5% level response of the Armenian money market rate, while the reaction of the monetary aggregate is statistically indistinguishable from zero. Probably, given the small amount of the country's foreign exchange reserves, it is rather difficult for the regulator to stabilise the Armenian dram over a long period of time.

The macro variables of the Kyrgyz Republic do not change significantly in response to monetary shocks in Russia, which at first sight seems strange, given the high degree of trade openness and the many economic ties between the country and Russia.

Secondly, it was found that a positive Russian monetary shock leads to a positive and significant reaction of money market rates in Armenia and Belarus (somewhat less pronounced). An increase in the money market rates may be a way to avoid strong depreciation of the national currencies. A symmetric increase in the rates may indicate a strong connection between these economies and the Russian economy, suggesting a lack of independence of the regulators in these countries.

The forecast error variance decompositions mainly repeat the results of the impulse response functions and show that a significant portion of the variance of variables is explained by external factors: the shock of commodity prices (CMDTY) and the shock of foreign economic conditions (EXO). At the same time, the contribution of the monetary shock of Russia is usually quite small for all countries and macro variables. Only for the interbank rate of Armenia does the contribution of the monetary shock of Russia (21%) exceed the total contribution of the remaining external shocks (2%). For monetary aggregates and exchange rates, the contribution of monetary shock is significant (but still small) only for Armenia and Kazakhstan. For other variables and countries, the contribution estimate is even non-significant. The heterogeneity of the results for different countries can be explained by the mixture of exchange rate regimes in the sample and the poor quality of statistics in the EAEU countries. The latter is illustrated, in particular, by the fact that the Repo rate was used as a proxy variable for the value of money for the Kyrgyz Republic, rather than the short-term money market rate, due to the inaccessibility of the complete time series of the latter.

On the one hand, cooperation between central banks and the pursuit of a coherent monetary policy will prevent the monetary authorities of the EAEU countries from reacting incorrectly to shocks in the Russian economy. On the other hand, the obtained results do not provide clear evidence of the presence of strong secondary effects of the impact of Russian monetary policy shocks on the rest of the economies of the Union.

The results were tested for robustness using several alternative specifications and identification assumptions. The obtained results are qualitatively similar for different specifications and resistant to the choice of lags in models for the EAEU countries. However, the main significant limitation of the analysis is the use of time sampling that captures different exchange rate regimes in different countries and, accordingly, different objectives of the regulators. Due to a change in exchange rate regime, not only could the magnitude of the influence of shocks change, but also the channels of monetary transmission itself. Also, recently all EAEU countries have switched to various types of floating exchange rates, which may make it somewhat more difficult to extend the analysis results obtained from retrospective data to the current situation. Even so, as floating exchange rates may help EAEU economies mitigate the spillover effects of Russian monetary policy, for now the influence could be even less pronounced. Nevertheless, accounting for structural changes (for example, using models with time-varying parameters or/and policy regime switches) as well as better accounting of second-order spillover effects (for instance, with help of global VAR models, introduced in Pesaran (2004)) may constitute an important direction for further research of the transmission effects of Russian monetary policy on the EAEU countries.

Literature

Adler, G. & Buitron, C. O. (2017). "Tipping the Scale? The Workings of Monetary Policy through Trade." *Review of International Economics*.

Aizenman, J., Chinn, M. D., & Ito, H. (2016). "Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions." *Journal of International Money and Finance*, 68, 298-330.

Alturki, F., Espinosa-Bowen, J., & Ilahi, N. (2009). "How Russia affects the neighbourhood: Trade, financial, and remittance channels" (No. 2009-2277). *International Monetary Fund.*

Barajas, M. A., Chami, M. R., Ebeke, M. C., & Tapsoba, M. S. J. A. (2012). "Workers' Remittances: An Overlooked Channel of International Business Cycle Transmission?" (No. 12-251). *International Monetary Fund.*

Bernanke, B., & Blinder, A. S. (1992). "The federal funds rate and the transmission of monetary policy." *American Economic Review*, 82(4), 901-21.

Bernanke, B., Boivin, J., & Eliasz, P. (2005). "Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach." *The Quarterly journal of economics*, 120(1), 387-422.

Bianchi, F., Mumtaz H. & Surico P. (2009). "The great moderation of the term structure of UK interest rates." *Journal of Monetary Economics* 56.6: 856-871.

Boivin, J., Giannoni M. & Mihov I. (2009). "Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data." *American Economic Review*, 99 (1): 350-84.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). "Monetary policy shocks: What have we learned and to what end?" *Handbook of macroeconomics*, 1, 65-148.

Demidenko, M., Korshunov, D., Karachun, O., Miksjuk, A., Pelipas, I., Tochitskaya, I., & Shymanovich, G. (2017). "Monetary Policy of EAEU Member States: Current Status and Coordination Prospects." *Joint Report by the Eurasian Economic Commission and the EDB*.

Di Giovanni, J., & Shambaugh, J. C. (2008). "The impact of foreign interest rates on the economy: The role of the exchange rate regime." *Journal of International economics*, 74(2), 341-361.

Georgiadis, G. (2016). "Determinants of global spillovers from US monetary policy." *Journal of International Money and Finance*, 67, 41-61.

Hamilton, J. D. (1994). "Time series analysis (Vol. 2, pp. 690-696)." *New Jersey: Princeton*.

Stock, J. H., & Watson, M. W. (2005). "Implications of dynamic factor models for VAR analysis (No. w11467)." *National Bureau of Economic Research*.

Kim, S. (2001). “International transmission of US monetary policy shocks: Evidence from VAR's.” *Journal of Monetary Economics*, 48(2), 339-372.

Lutkepohl, H. (1993). “Introduction to Multiple Time Series Analysis. 2nd ed.” *New York: Springer*

Maćkowiak, B. (2007). “External shocks, US monetary policy and macroeconomic fluctuations in emerging markets.” *Journal of monetary economics*, 54(8), 2512-2520.

Pesaran, M. H., Schuermann, T., & Weiner, S. M. (2004). “Modeling regional interdependencies using a global error-correcting macroeconometric model.” *Journal of Business & Economic Statistics*, 22(2), 129-162.

Polbin A.V., Andreev M. Y. & Zubarev A. V. (2018). “The Dependence of member countries of the EAEU from commodity prices.” *Economics of the region*, No. 14. P. 623-637

Rey, H. (2015). “Dilemma not trilemma: the global financial cycle and monetary policy independence (No. w21162).” *National Bureau of Economic Research*.

Rukavishnikov, M. A. (2016). “Problems of Eurasian Economic Integration in the Sphere of Financial Services.” *Economic Sciences*. - 2016. - No. 136.- S. 96-100.

Wu, J. C., Xia, F. D. (2016). “Measuring the macroeconomic impact of monetary policy at the zero lower bound.” *Journal of Money, Credit and Banking*, *48*(2-3), 253-291.

Appendix A

Table 1. Variables used to construct FAVAR to identify monetary shocks in Russia.

Description	*SA*	*Logdiff or 1st diff*	*slow_PC*	*fast_PC*	*EXO*	*CMDTY*
MIACR	0	0	0	0	0	0
Monetary aggregate M2	1	1	0	1	0	0
Monetary aggregate M0	1	1	0	1	0	0
Nominal exchange rate of €	0	1	0	1	0	0
Nominal exchange rate of $	0	1	0	1	0	0
MOEX Russia Index	0	1	0	1	0	0
1-year OFZ yield	0	0	0	1	0	0
10-year OFZ yield	0	0	0	1	0	0
International reserves of BoR	0	1	0	1	0	0
Non-financial enterprises credit rate, up to 1 year	0	0	0	1	0	0
Non-financial enterprises credit rate, beyond 1year	0	0	0	1	0	0
Construction price index	1	1	1	0	0	0
Overall Exports	1	1	1	0	0	0
Overall Imports	1	1	1	0	0	0
Government revenue	1	1	1	0	0	0
Government expenditure	1	1	1	0	0	0
Real wage index	1	1	1	0	0	0
Housing commissioning index	1	1	1	0	0	0
Construction output index	1	1	1	0	0	0
PMI in manufacturing	0	1	1	0	0	0
Unemployment rate	1	1	1	0	0	0
Declared need for employees	1	1	1	0	0	0
Retail turnover	1	1	1	0	0	0
Freight turnover	1	1	1	0	0	0
Volume of paid services to the population	1	1	1	0	0	0
Real Disposable Income	1	1	1	0	0	0
Industrial Production: Mining and Quarrying	1	1	1	0	0	0
Industrial Production: Manufacturing	1	1	1	0	0	0
Industrial production: electric power, natural gas, and steam; air conditioning	1	1	1	0	0	0
Total loans, up to 1 year	0	1	1	0	0	0
Total loans, beyond 1 year	0	1	1	0	0	0
Freight transport Price Index	1	1	1	0	0	0
Producer price index: Mining and Quarrying	1	1	1	0	0	0
Producer price index: Manufacturing	1	1	1	0	0	0
Producer price index: electric power, natural gas, and steam; air conditioning	1	1	1	0	0	0

Emerging Markets Bond Index	0	0	0	0	1	0
FED rate	0	0	0	0	1	0
VIX index	0	1	0	0	1	0
Unemployment in USA	1	0	0	0	1	0
Nikkei index	0	1	0	0	1	0
Standard & Poor's 500 Index	0	1	0	0	1	0
Gold price	1	1	0	0	0	1
ECB deposit rate	0	0	0	0	1	0
Gas Price, Henry Hub	1	1	0	0	0	1
Aluminium price	1	1	0	0	0	1
Unemployment in Eurozone	1	0	0	0	1	0
Merrill Lynch Option Volatility Estimate index	0	1	0	0	1	0
Oil price. WTI	0	1	0	0	0	1
LIBOR	0	0	0	0	1	0
10-year FedFund rate	0	0	0	0	1	0
Copper price	0	1	0	0	0	1
Ore price	0	1	0	0	0	1

Appendix B

1.1. Robustness of identification scheme

To test the robustness of the obtained monetary shocks to changes in the methodology, several alternative specifications were estimated, in particular:

1) FAVAR models in which the MIACR rate is located first/last.
2) Standard SVAR model with the following variables: IP, CPI, MIACR, M2, exchange rate. The results of the model estimation, also identified using the Cholesky decomposition and the mentioned above ordering.
3) FAVAR model on a rolling window. Estimation the model on the rolling window makes it possible to better take into account the structural changes taking place in the Russian economy in comparison with the models evaluated on the full sample. The selected window width is 90 observations.

Table 1 indicates rather high pairwise correlation coefficients between shocks obtained from different models/identification assumptions (Table 1). Further, we will discuss the alternative models in greater details.

Table 1. Correlation matrix of structural shocks of the Russia money market rate (MIACR) from various models

	FAVAR (IR 1st)	FAVAR (IR 2nd)	FAVAR (IR 3rd)	SVAR	FAVAR (rolling window, T=90)
FAVAR (IR 1st)	1.00				
FAVAR (IR 2nd)	0.98*	1.00			
FAVAR (IR 3rd)	0.95*	0.95*	1.00		
SVAR	0.85*	0.81*	0.82*	1.00	
FAVAR (rolling window, T=90)	0.90*	0.91*	0.85*	0.75*	1.00

Note: (*) means that the correlation coefficient does not equal zero at 1% significance level.

1.2. Different ordering in FAVAR

While identifying the Russian monetary shocks, the explicit assumption was used that monetary authorities could respond to shocks of slow variables (IP, CPI, etc.) in the same month. However, due to possible lags in statistical publication (sometimes reaching more than a month), the Bank of Russia may not have enough time to respond to the shocks that actually occur in the economy, simply not clearly observing them from statistics available on the date. Accordingly, if the regulator does not have time to respond to these shocks, then money market rates, usually strongly associated with the current monetary stance, should also not change much. Therefore, to check the stability of the results, we also evaluated a model with an alternative ordering of variables in the model. It assumes that in the same time period:

1) Shocks in the Russian economy (both the shocks of the ‘slow’ PC and the shocks of the ‘fast’ PC) do not affect decision-making on changing the key rate and therefore do not also affect MIACR[7];
2) Shocks of ‘fast’ PC do not affect the slow principal component[8];

[7] Assumption No. 1 implies that in order to decide on a change in the key rate in response to some shock in the national economy, it is necessary to first carefully analyze the current and future economic conditions and only then convene a Board of Directors, which may be enough time consuming and take more than a month. At the same time, reacting later than necessary, the Central Bank may introduce unwanted distortions into the markets, only further worsening the situation. Therefore, in order to not to harm, the Central Bank of Russia usually does not respond to short-term shocks (shocks of fast PC), concentrating on more persistent and significant shocks. In addition, as is known, a substantial part of the most important statistics for the monetary policy implementation is collected either quarterly (GDP) or with a significant delay of several weeks, or even months (CPI and IP). As a result, monetary authorities simply cannot instantly, in the same month, respond to internal shocks.

[8] Assumption No. 2 is based on the fact that in order to change the ‘slow’ PC, it is necessary to change its components, for example, the industrial production index. But change of industrial production usually requires a change of business processes (increasing capacity utilisation, changing the level of investment, and so on). Do it in the same month when the shock of the ‘fast’ PC occurs is almost impossible.

3) The ‘fast’ PC depends both on the shocks of the interbank rate and on the shocks of the ‘slow’ PC[9].

As far we interested in the identification of monetary shocks, the key assumption of this identification scheme is assumption No. 1. The introduction of this assumption is due to the belief that, for a number of reasons, monetary policy may be relatively behind to the main dynamics of short-term economic indicators. As a result, the matrix of structural coefficients for such identification scheme has the form:

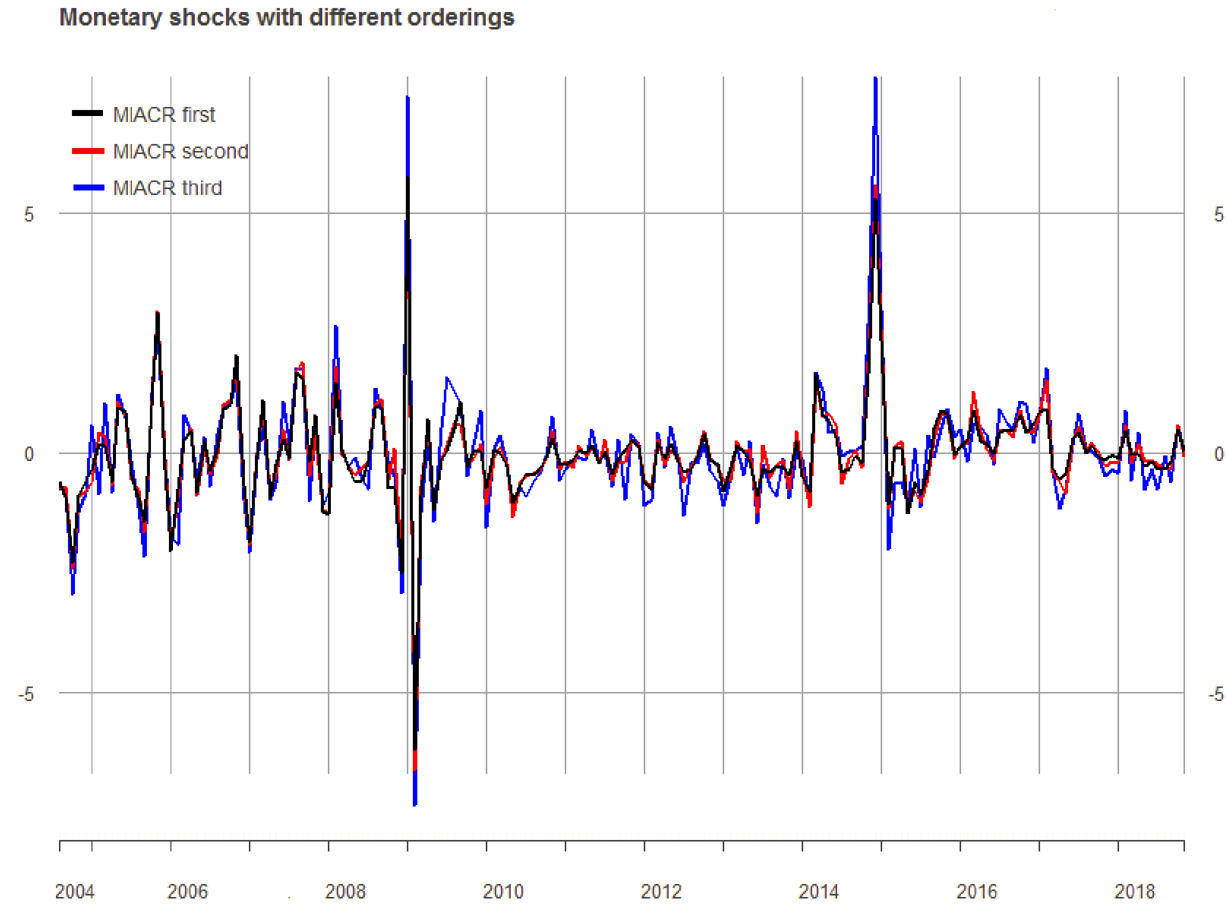
$$\begin{matrix} Key\_rate \\ PC1\_slow \\ PC1\_fast \end{matrix} \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix}$$

In addition, a model was considered in which the rate is included as the last variable. This specification in a some sense is inverse to the previous one and allows to reflect the fact that the interbank market rate can respond to shocks of all variables during the month in which these shocks occur. This ordering may be also justified because that the division of variables into ‘fast’ and ‘slow’ can be reasonably questioned.

Note, that it is not obvious *a priori* which ordering out of these 3 provides more veracious results. Also note that the only information used further from the model for Russia is the shock of the interbank market rate. Therefore, the main criterion for the robustness of the identification scheme will be the presence of a high correlation between the obtained estimates and the visual similarity of MIACR shocks with different order of variables in the FAVAR model. The correlation of monetary shocks obtained in FAVAR with different ordering of variables in the model ranges in 0.95-0.98 (Table 1). Therefore, since the correlation coefficient turned out to be quite high, we can conclude that the results are robust to the choice of the money market rate order in the model. Figure 1 also shows that the differences in the magnitude of shocks are small for both normal and crisis periods; therefore, the order in which the interbank rate is included in the model in our case may has only a marginal effect on the results.

[9] Assumption No. 3 is based on the fact that a fast PC contains mainly financial time series (MOEX index, euro and dollar exchange rates, etc.), which change quite quickly (usually within one to two days or even couple of hours) in response to any, both internal and external shocks.

Figure 1. Comparison of three shocks obtained from the FAVAR model with all possible identification assumptions under Cholesky decomposition.

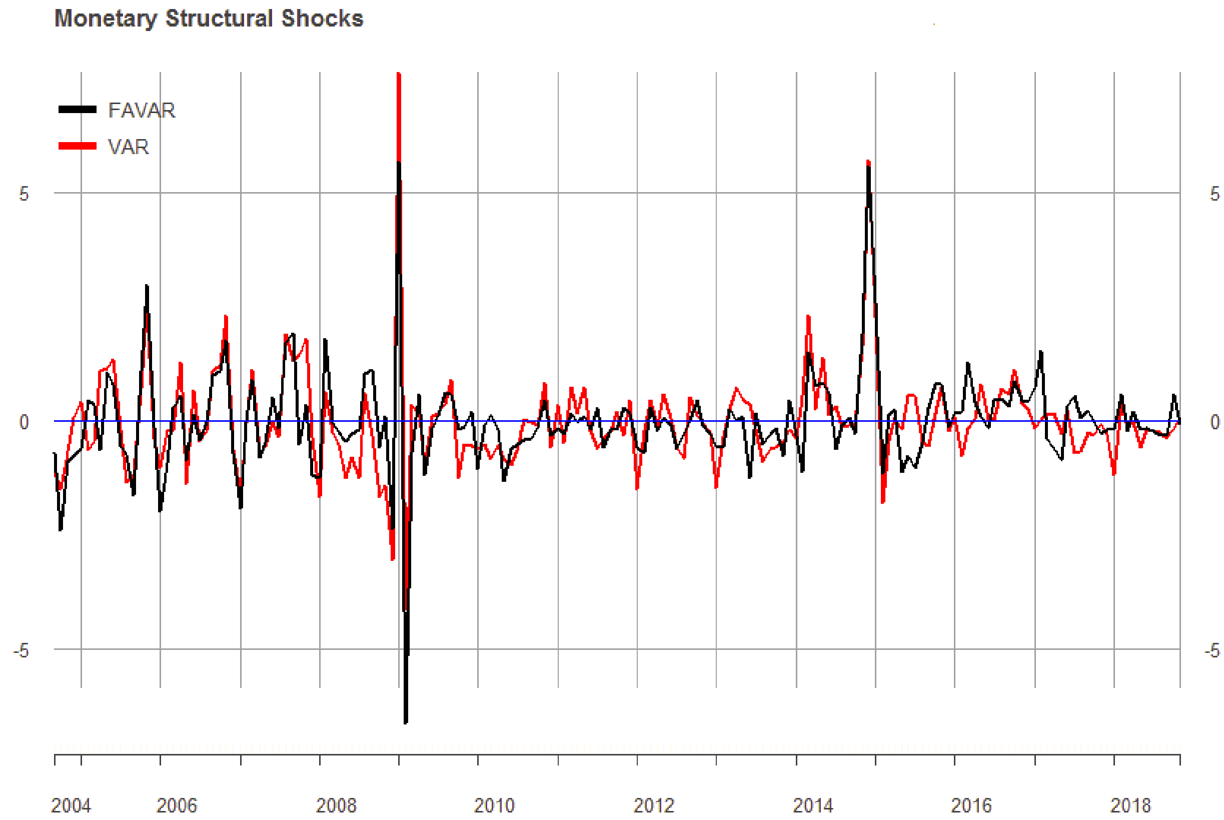


1.3. Alternative VAR model for receiving monetary shocks

It is possible that in the constructed FAVAR factors are not quite correctly identified because there are enormous number of ways how justifiable split variables onto 'slow' and 'fast'. In order to verify this, the simplest and one of the most often used VAR model for identifying monetary policy shocks was estimated. The endogenous variables were IP, CPI, MIACR, M2, the exchange rate, and the exogenous factors were also the first principal components made up of the corresponding 'external' factors EXO and CMDTY. The estimated structural shocks for such VAR model do not differ much from the results of the basic FAVAR specification (in which the rate is included as second). Note that in identifying such a VAR model, the Cholesky decomposition was also used, and the order of the variables coincides with the mentioned above.

The shocks obtained by FAVAR and VAR are fairly similar visually (Figure 2), and are also statistically close to each other (the correlation coefficient depending on the order of variables in FAVAR is 0.82-0.86), which again confirms the robustness of the results .

Figure 2. Comparison of two shocks obtained from baseline FAVAR and simple VAR.



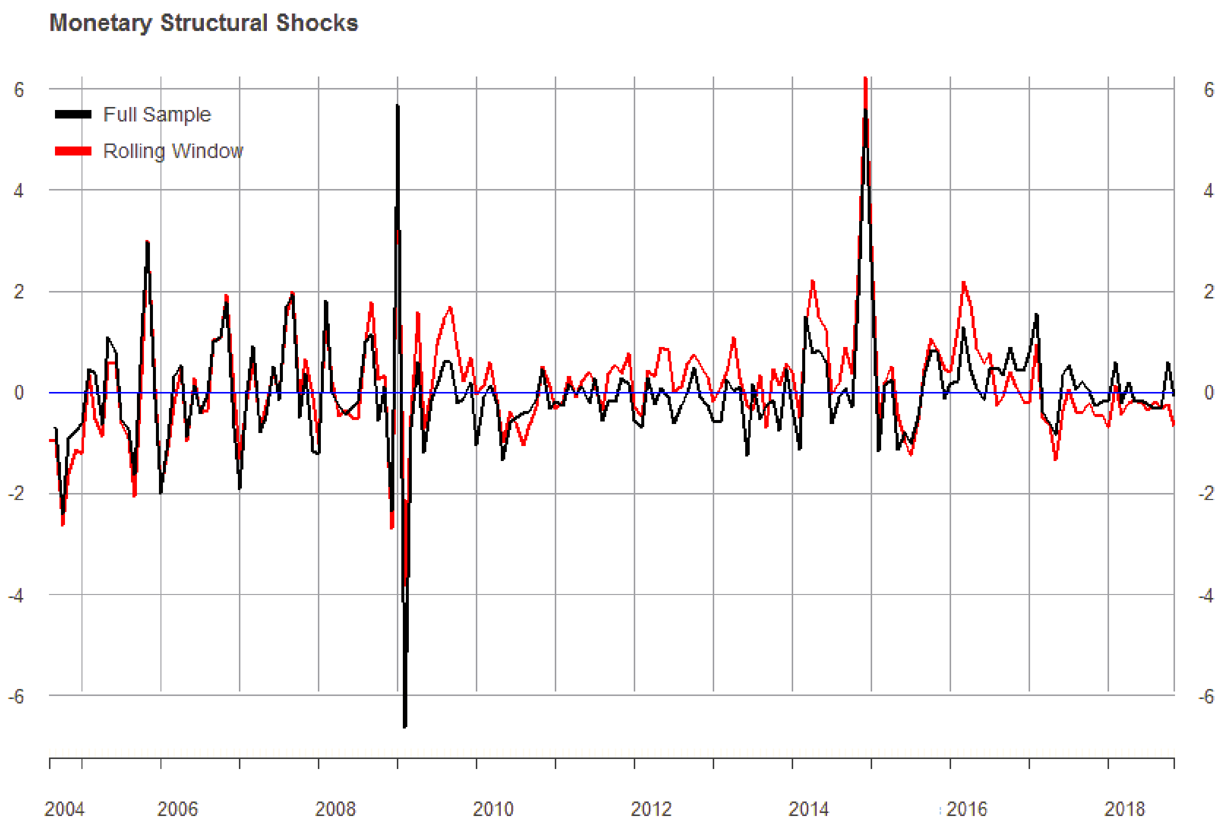
1.4. Rolling window FAVAR estimation

When evaluating the model for identifying monetary shocks in Russia, the assumption that the coefficients of the model do not change over time was used. This assumption itself is quite restrictive. In particular, during the considered time period, Russia experienced two economic crises (2008-2009, 2014-2015), the monetary and fiscal policy stances have changed significantly (transition to inflation targeting, introduction of the budget rule etc.), the country faced economic sanctions. In addition, the structure of the economy itself is gradually changing and ignoring this can lead to a bias in the estimates of the coefficients. Also, when evaluating the model for identifying current shocks, we should ideally use only information about past values of variables and ignore information from the future periods. When evaluating the model over the entire interval, information from the future 'leaks' into estimates of current shocks, which potentially could also add some bias in the results.

In order to take into account these arguments, the baseline FAVAR model was evaluated on a rolling window of 90 data points. The choice of window width is dictated by two considerations: with fewer points for estimation, the VAR models will be unstable, and when evaluated on a wider window, the model will reflect worse the actual changes in the structure of the economy. The evaluation procedure was the following: using the first 90 observations, the model was evaluated and monetary shocks were obtained for a given period, then the 'window' was shifted by one period into the 'future', and the model was reestimated, which allowed finding a monetary shock in the last period, etc.

As a result, it was found that the monetary shocks estimated on the full sample do not differ much from the shocks obtained when evaluating the model on the rolling window (Figure 3).

Figure 3. Comparison of two shocks obtained from the FAVAR model on a full sample and on a rolling window



Appendix C

Figure 1. Impulse response functions for **Armenia** in response to: monetary policy shock (**MS ≈ +1pp.**), global factor shock (**EXO**) and commodity price shock (**CMDTY**)

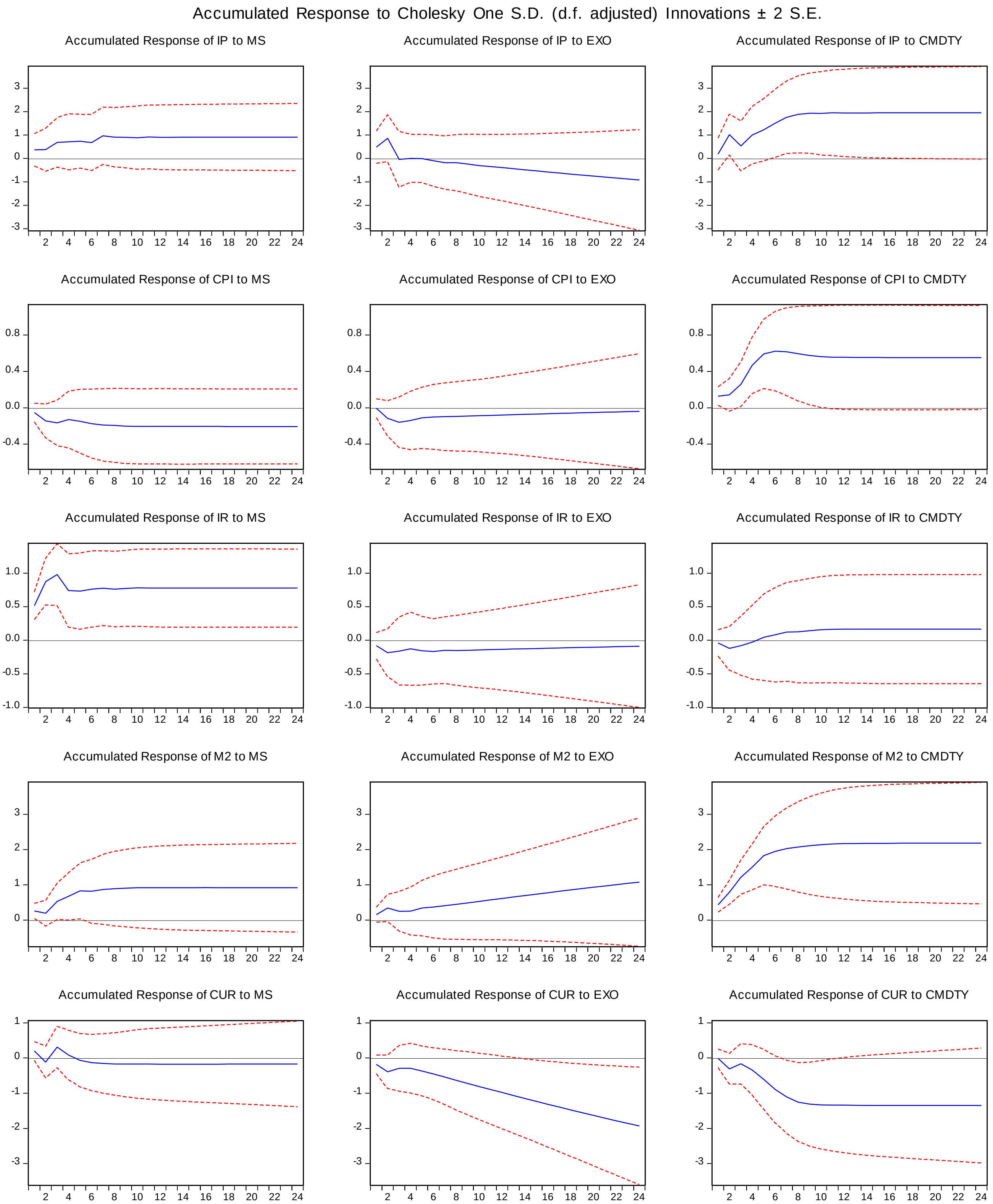


Figure 2. Impulse response functions for **Kyrgyz Republic** in response to: monetary policy shock (**MS ≈ +1pp.**), global factor shock (**EXO**) and commodity price shock (**CMDTY**)

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

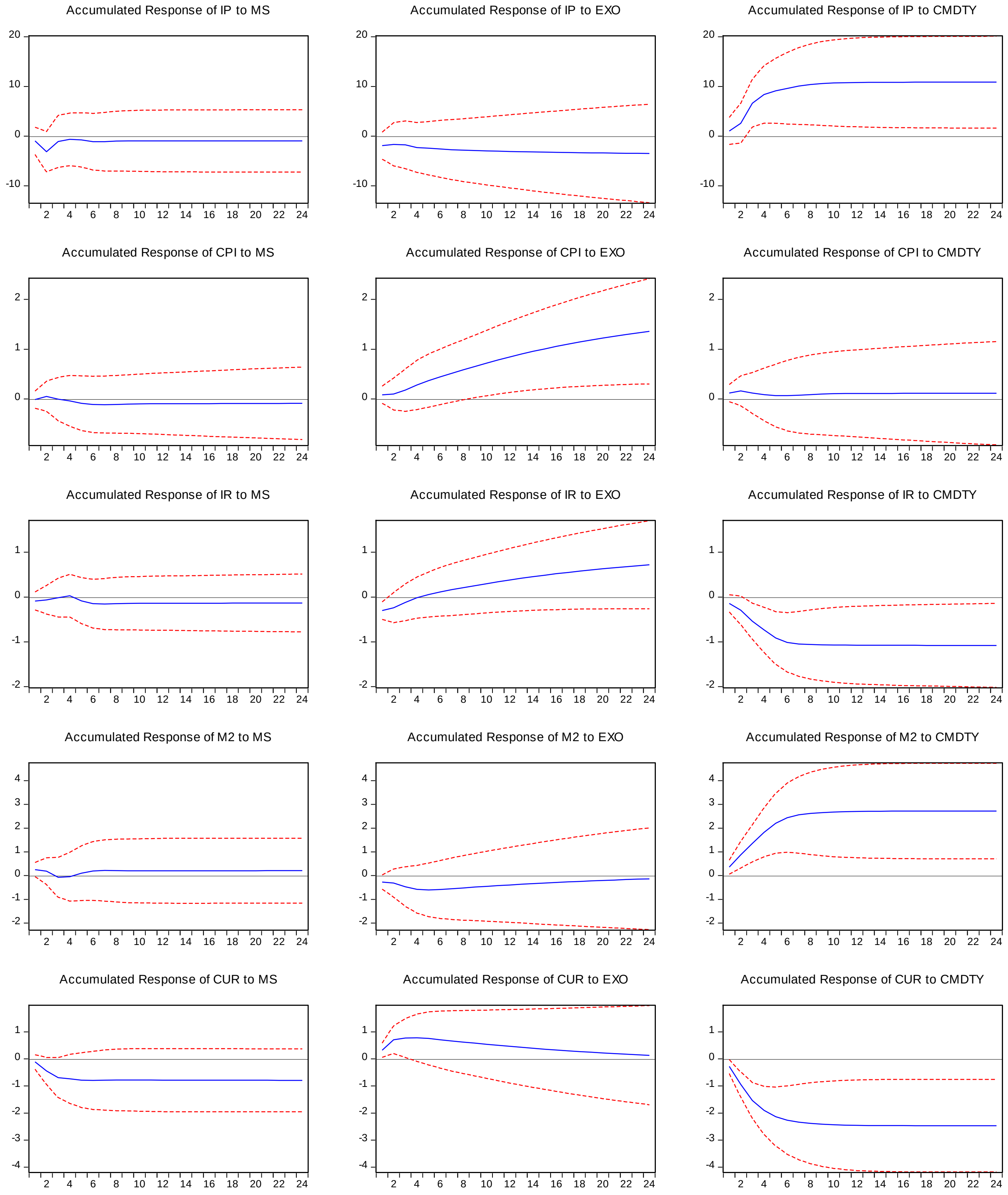


Figure 3. Impulse response functions for **Kazakhstan** in response to: monetary policy shock (**MS ≈ +1pp.**), global factor shock (**EXO**) and commodity price shock (**CMDTY**)

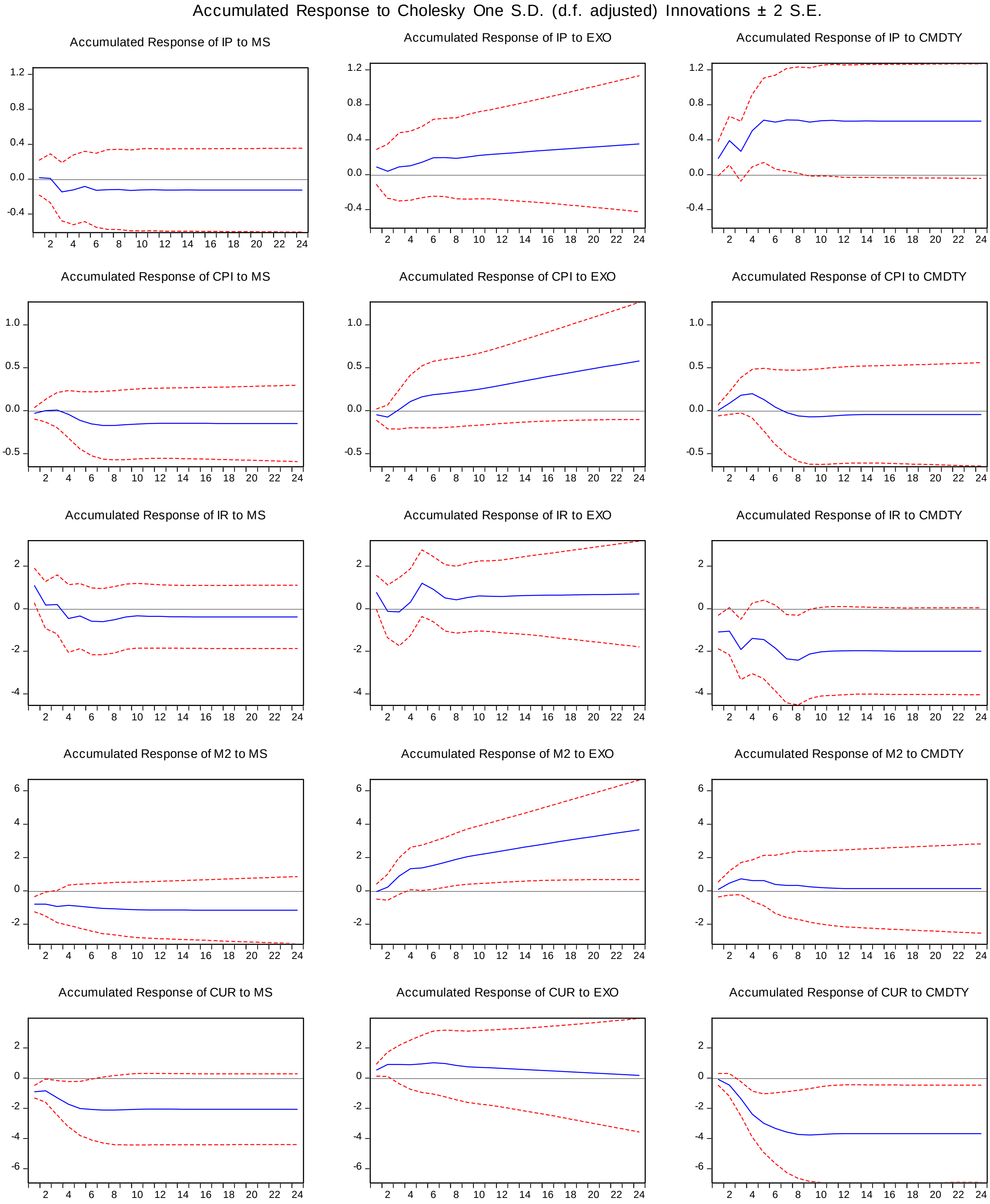


Figure 4. Impulse response functions for **Belarus** in response to: monetary policy shock (**MS ≈ +1pp.**), global factor shock (**EXO**) and commodity price shock (**CMDTY**)

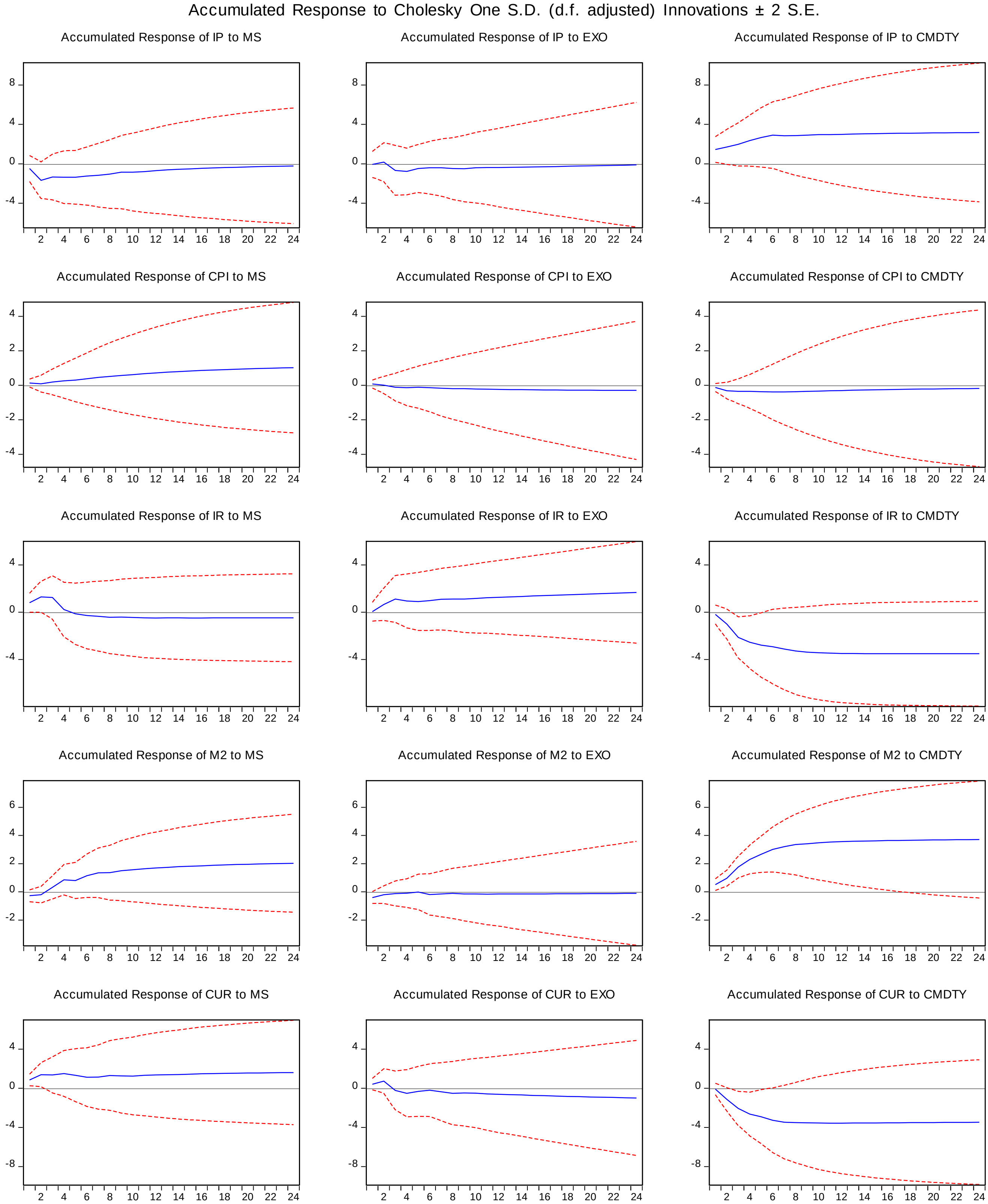


Figure 5. Forecast error variance decomposition for **Armenia**

Variance Decomposition using Cholesky (d.f. adjusted) Factors

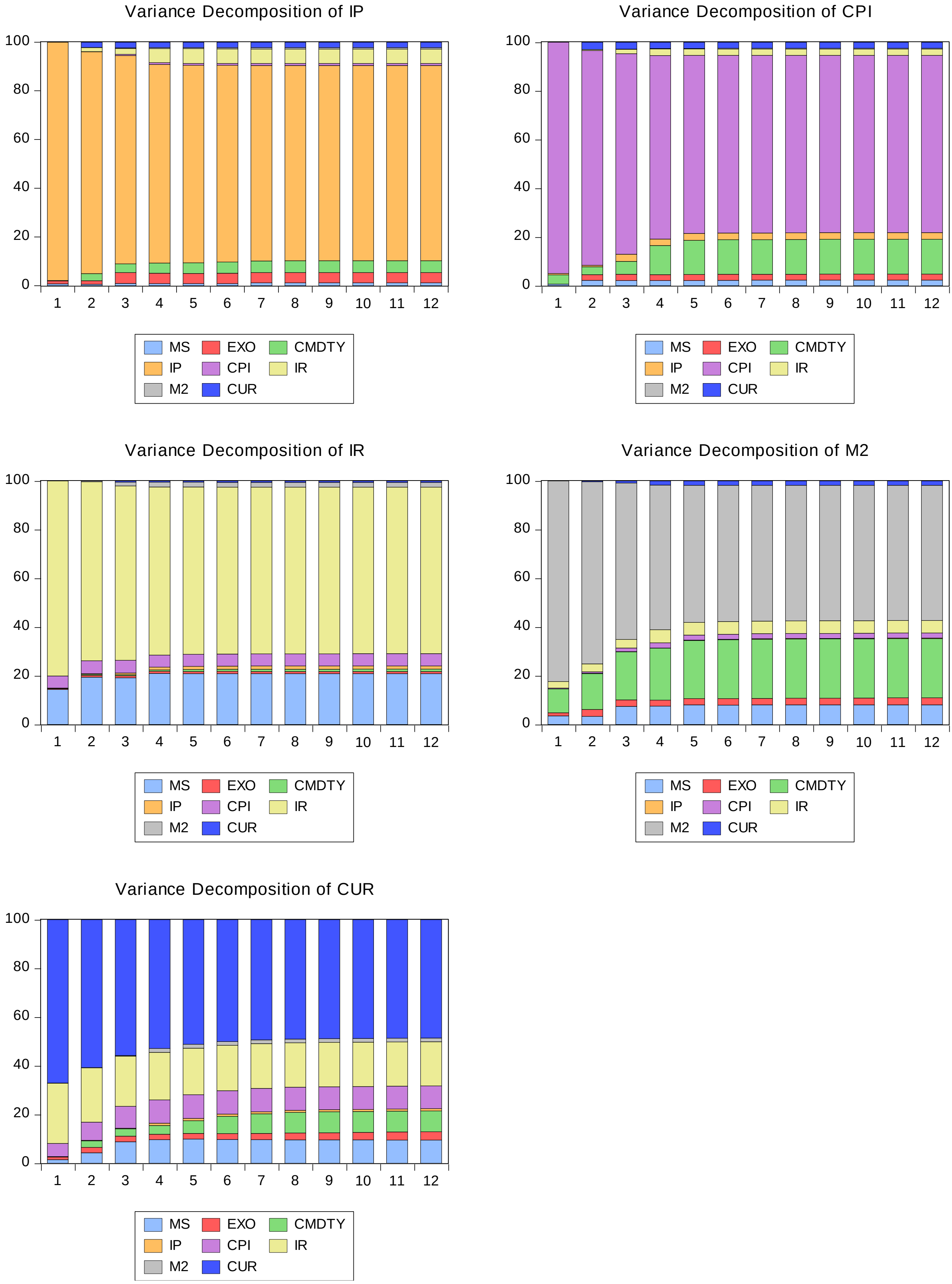


Figure 6. Forecast error variance decomposition for **Belarus**

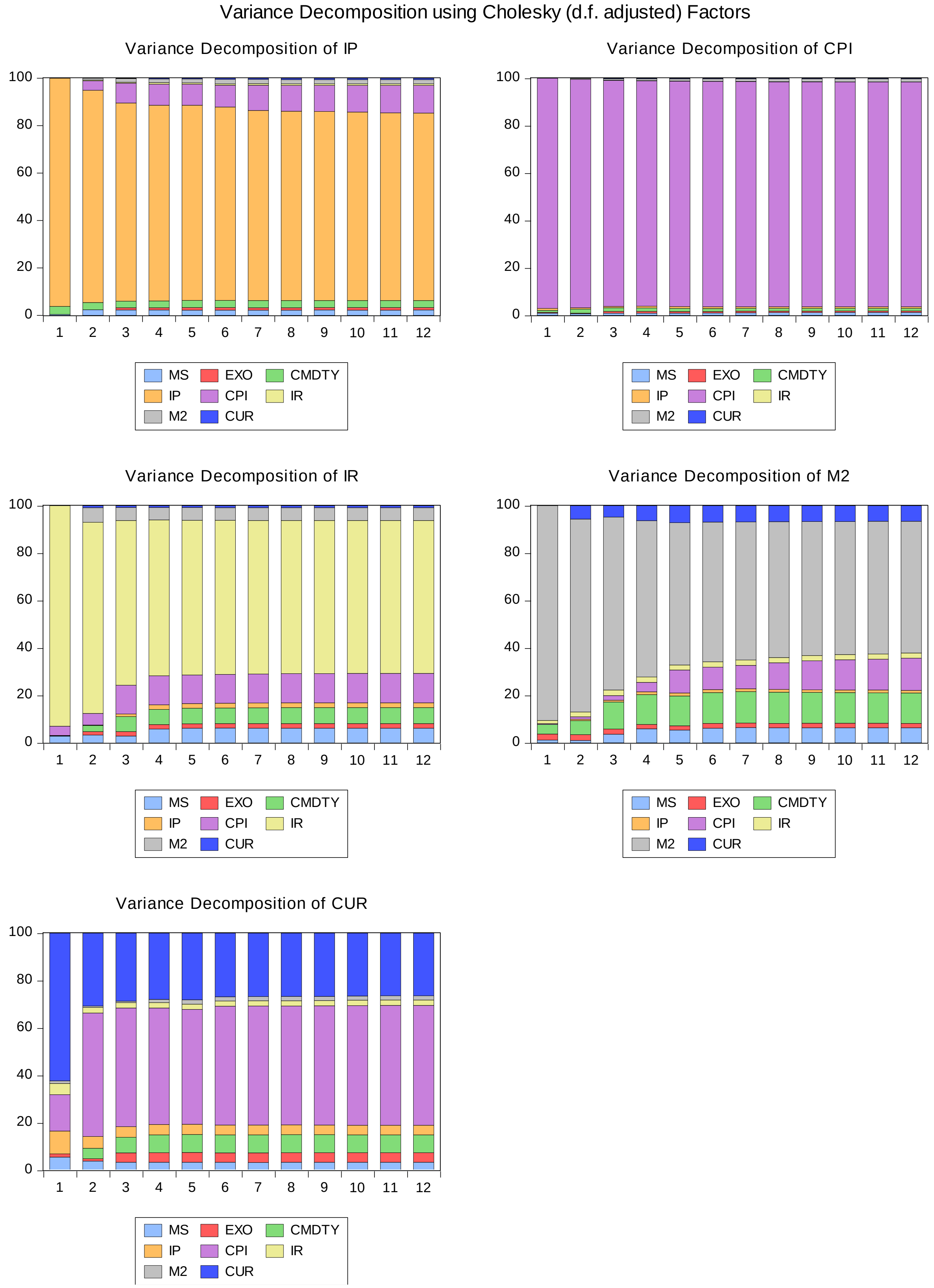


Figure 7. Forecast error variance decomposition for **Kazakhstan**

Variance Decomposition using Cholesky (d.f. adjusted) Factors

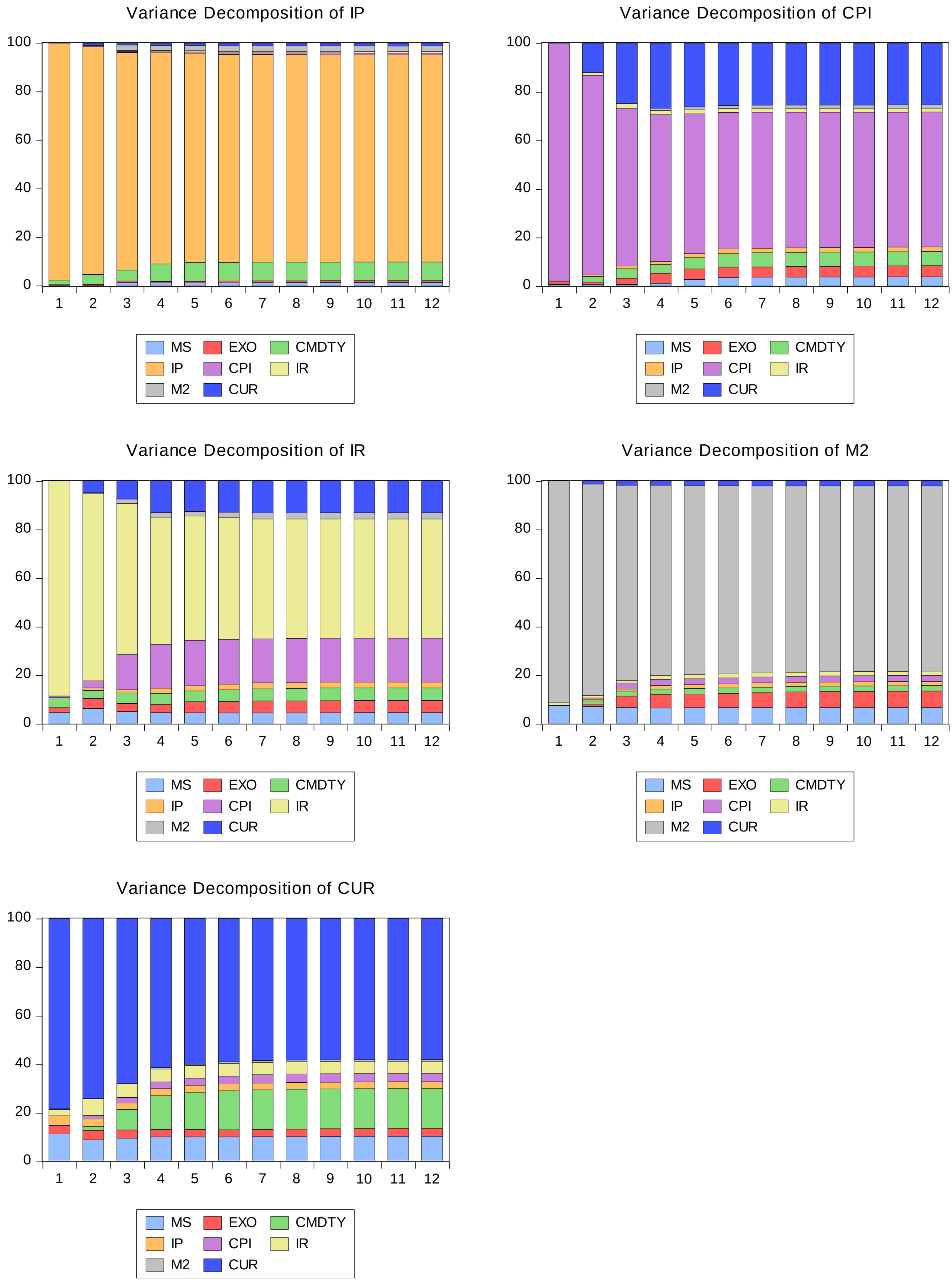


Figure 8. Forecast error variance decomposition for **Kyrgyz Republic**

Variance Decomposition using Cholesky (d.f. adjusted) Factors