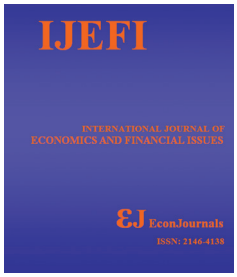

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Investigating the Impact of Monetary Policy using the Vector Autoregression Method

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ABSTRACT

Careful identification of the transmission channels of monetary policy is an important step in the global assessment of the major institutional changes. Research in this area should be constantly updated because of the strong structural dynamics. The goal of this paper is to study the monetary transmission in the Russian economy. The study was carried out using the vector autoregression (VAR) method. The analysis of impulse functions of interest rate shocks, corporate lending, volume of money supply, growth of prices and the exchange rate was carried out. An interpretation of the transmission channels of the Russian economy was given. The following channels were considered: Interest rate, bank lending, cash flows, unforeseen prices and the exchange rate channel. All channels under consideration are statistically confirmed, but they exist with varying degrees of effectiveness. The existence of weak channels of monetary transmission is associated with the depressive state of the economy, lack of its growth in recent years, and high inflation, as well as with the policy of shift from the ruble rate targeting to the inflation targeting policy. The outcomes of use of the standard VAR methods for the developing Russian economy can be used as a guideline for further theoretical and empirical analysis of the transmission mechanism.

Keywords: Monetary Policy, Vector Autoregression, Impulse Functions
JEL Classifications: E52, E58

1. INTRODUCTION

Stabilization of the economy remains a serious problem in developing countries, and, according to Mishra and Montiel (2012), the definition of means to improve the effectiveness of monetary policy in these countries is an important task. The vector autoregression models (VAR models) became one of the most important tools for analysis of mechanisms of monetary policy. This research technique can use a reduced number of theoretical limitations, which allows to easily use them and to identify structural shocks. According to Christiano (2012), the VAR models still play an important role today. It is important to note that according to the estimated impulse functions of response, the VAR models provide a natural way to select the parameters of the structural model and evaluation of the empirical validity of alternative models of Christiano (2006). As a rule, being able to obtain empirically plausible evaluations of the dynamic reactions of the major macroeconomic variables of the monetary policy, the VAR methods are widely used both in the evaluation of the empirical fit of structural models (for example, Boivin and Giannoni, 2003; Christiano et al., 2000) and in Bernanke policy applications (2004).

The basics of using VAR for the study of the macroeconomic impacts of unforeseen changes in policy were laid down in Sims paper (1980). Further papers of Bernanke and Blinder (1992) and Sims (1992), as well as another series of the studies of Christiano et al. (2000) revealed how the VAR method works in identification

and measuring the impact of the monetary policy of innovation on macroeconomic variables.

The core idea of this approach is that the identification of the impacts of monetary policy shocks requires only the establishment of some shocks (such as changes in the interest rate (Bernanke and Blinder, 1992) and does not require identification of the rest of the macroeconomic model.

Some criticism of the VAR approach to monetary identification of the policy revolves around a relatively small amount of information used by small dimension VARs. Standard VARs rarely use more than six or eight variables in order to save the degrees of freedom.

In the well-known paper of Leeper et al. (1996), the authors point out that the number of variables included in the model can be increased by applying Bayesian procedures, but even in this case the VAR systems still tend to contain <20 variables.

The goal of this paper is to study the monetary transmission in the Russian economy. A number of authors who have examined the monetary policy in the Russian economy used the VAR models (Drobyshevskiy et al., 2009; Granville and Mallick, 2010; Lomivorotov, 2013); due to limitations of the number of variables, the evaluations are not stable and are dependent on the choice of variables and timeframe; further difficulties were in determining the transmission channels, through which the external factors operate.

The sample data for the analysis of the monetary policy of the Russian economy is objectively short, which causes difficulties in econometric estimation. Furthermore, it is difficult to identify the targets and tools of the regulator. For example, before the 2008 crisis, the Central Bank of Russia adhered to several goals of the monetary policy simultaneously (stabilization of exchange rates, reduction of inflation and support of emission) and used a wide range of tools to achieve them, including interest rates, foreign exchange intervention, refinancing and liquidity absorption transactions, as well as reserve requirements (Lomivorotov, 2015).

Given the profound dynamic and structural changes in the Russian economy, the analysis of changes in monetary policy remains an important task.

2. METHODS

2.1. Specification of the VAR Model

Basic VAR model that we use to analyze the impacts of the monetary policy shock of the Russian economy is as follows:

$$Y_t=A(L)Y_{t-1}+B(L)X_t+\varepsilon_t \quad (1)$$

Where Y is a vector of endogenous variables and X_t is a vector of exogenous variables, and ε_t is an error vector for a normal distribution.

As a rule, the vector of endogenous variables (Y_t) consists of: Gross domestic product (GDP) growth rate (y_t); consumer price indices (CPI) (p_t), monetary nominal interest rate (i_t), exchange rate (r_t), money supply (m_t):

$$Y_t=[y_t\ p_t\ i_t\ r_t\ m_t] \quad (2)$$

In this paper, the vector of exogenous variables contains the prices of Urals crude oil (oil), FRS rate and a constant:

$$X_t=[c,\ oil,\ frs] \quad (3)$$

2.2. Research Design

In this paper, we make estimations using the VAR method on data from 2002 to 2015 to study the macroeconomic impacts of the shock of monetary policy in the Russian economy. With the help of several standard identification schemes, we suppose to analyze the impulse responses of the main macroeconomic variables to unexpected monetary policy tightening shocks.

The monthly indicators of the Russian economy from 01.02.2002 to 01.07.2015 are taken as data. Data source is the Bank of Russia website (www.cbr.ru) and the Rosstat data (www.gks.ru). Indicators are marked as follows:

IGDP - index of industrial production, % to the previous period of the last year; M2 - monetary aggregate, billion rub.; MO - Money supply, billion rub.; RM - Average weighted market exchange rate of the ruble to the dollar, RUB/USD; CPI - consumer price index for goods and services, month to the corresponding month of previous year, %; Loans - volume of corporate lending, IC - investment in fixed assets, current prices, billion ruble; NRES - international reserves, million USD; IREF - refinancing rate, %; OIL - price of Urals crude oil, USD per barrel; IRLnef - average weighted interest rate on ruble loans to non-financial institutions, up to 1 year; MIACR - MIACR interest rate, 1 day; MIBOR - MIBOR interest rate, 2-7 days; FRS - FRS interest rate.

The shock of monetary policy is determined using a standard Cholesky factorization with the original assumption that the policies of the shocks do not simultaneously affect the data out, prices and money, but may affect the exchange rate immediately. However, the policy interest rate does not respond to the current changes in the effective exchange rate.

Charts of these indicators for the period 2002-2015 are shown in Figure 1.

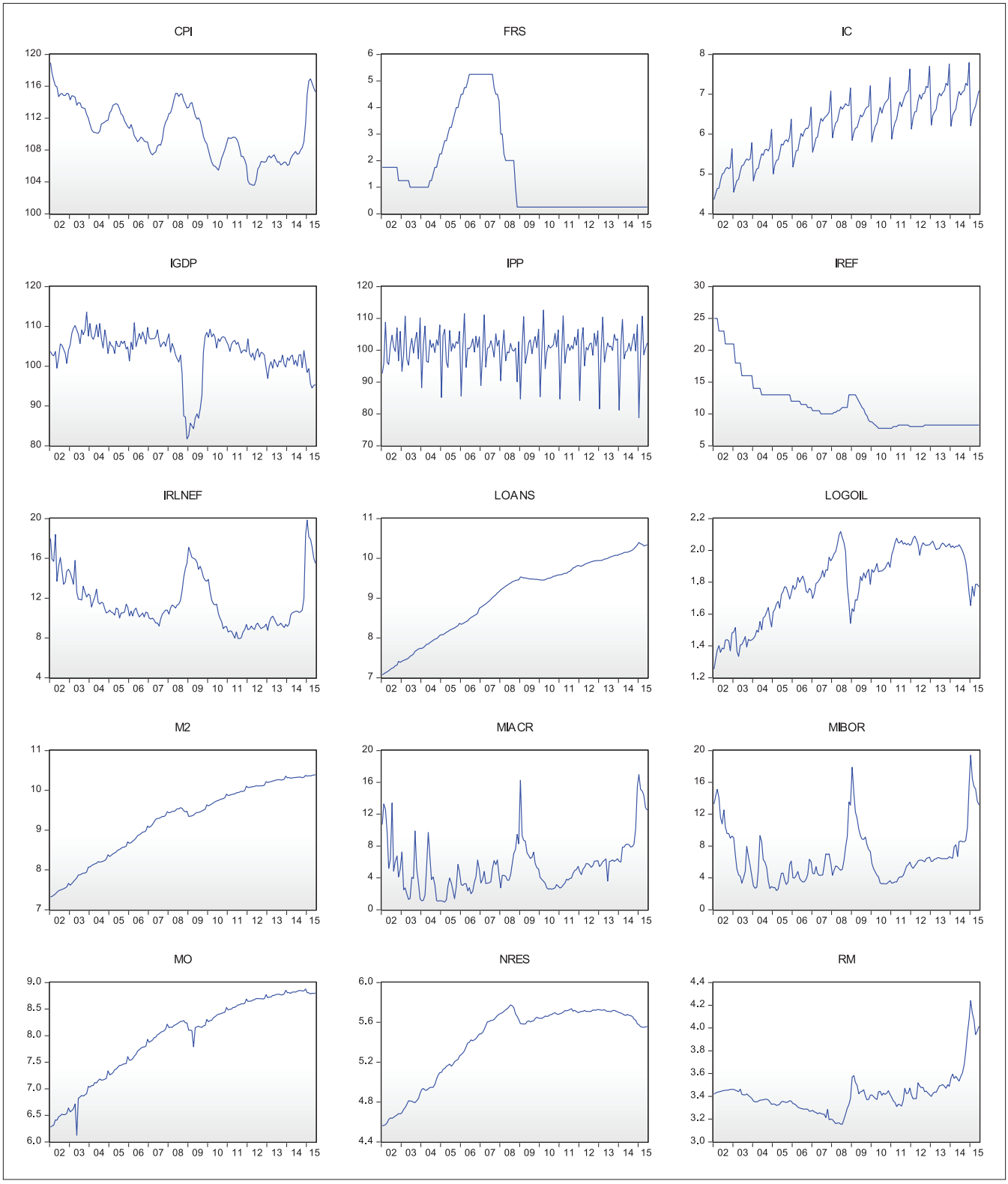
The logarithms of all figures, except those expressed as a percentage, were taken to receive a linear type of the relations between indicators.

All calculations using the VAR method were performed in EViews package.

The length of lagging has been selected using the Akaike and Schwarz criteria (1). A single test was made for this specification, and since it was found that all the inverse roots are less than one in absolute value and located inside the unit circle, this VAR model is stationary.

The Portmanteau test for residual serial correlation was made. The multidimensional Q-statistics of Box-Pierce/Ljung-Box

Figure 1: Charts of the basic indicators of the Russian economy in 2002-2015



were calculated up to the specified order. The absence of serial correlation was established.

Also, the Lagrange multiplier test for autocorrelation was made. It was established that the null hypothesis of absence of serial correlation is satisfied.

Let us assume that the following variables are responsible for certain channels of monetary transmission:

1. Average weighted rate on ruble loans to non-financial institutions for up to 1 year, (IRLnef) - for the interest rate channel (%).
2. Logarithm of the amount of corporate lending (loans) - for the bank lending channel.

3. Logarithm of the M2 money supply as an indicator of the total volume of ruble-denominated means of payment in the economy (M2) - for the cash flow channel (CF).
4. CPI - For the unforeseen price growth channel.
5. Logarithm of the average weighted market exchange rate of the ruble to the dollar (RM) - for the exchange rate channel.

3. EMPIRICAL RESULTS

Empirical analysis of the transmission mechanisms using the VAR method.

Figures 2-6 show the impulse functions of the response to the variables of monetary policy included in the VAR, a shock in which causes the growth of the indicator for one standard deviation. Two dotted lines in each panel represent the 95% confidence bands. Impulse responses are displayed for the 20-month period.

3.1. Interest Rate Channel

Impulse functions from the interest rate are shown in Figure 2. According to the monetary theory, after the shock of monetary policy, it is expected that the output data, prices and demand for money will all fall, while the exchange rate and interest rates will rise. Money and the exchange rate should react more quickly to the shock, while the prices tend to respond more slowly.

This mechanism is based on the assumption that the monetary authorities use the amount of liquidity in the economy to control interest rates and, consequently, to stimulate investment and other components of aggregate demand.

In case of the limiting shock that affects the interest rates, prices react slowly: For the first 4 periods they grow a little and then fall. To some extent, we can say that this contradicts the theory and is a "price puzzle." Investments fall sharply during 2 periods. The output grows steadily, and this reaction is prolonged. Money supply, loans and interest rates fall. Exchange rate grows for a short period and then falls. These responses are significant and enduring.

In the case of the output reaction, we see the growth against theoretical expectations, often found in empirical studies using the VAR model and called the "output puzzle." Additional studies with the specification of MIBOR and MIACR rate (Figure 3) showed that the response from MIACR rate is a small growth and then drop. The response from the MIBOR rate is an immediate small drop, but the prolonged reaction, which is more comparable with the latest ideas about the output response (Ahmadi and Uhlig, 2015).

Bernanke and Gertler (1995) found in the study of the economy responses to monetary policy shocks that although the unexpected tightening of monetary policy usually has a temporary effect on

Figure 2: Impulse function of the interest rate response

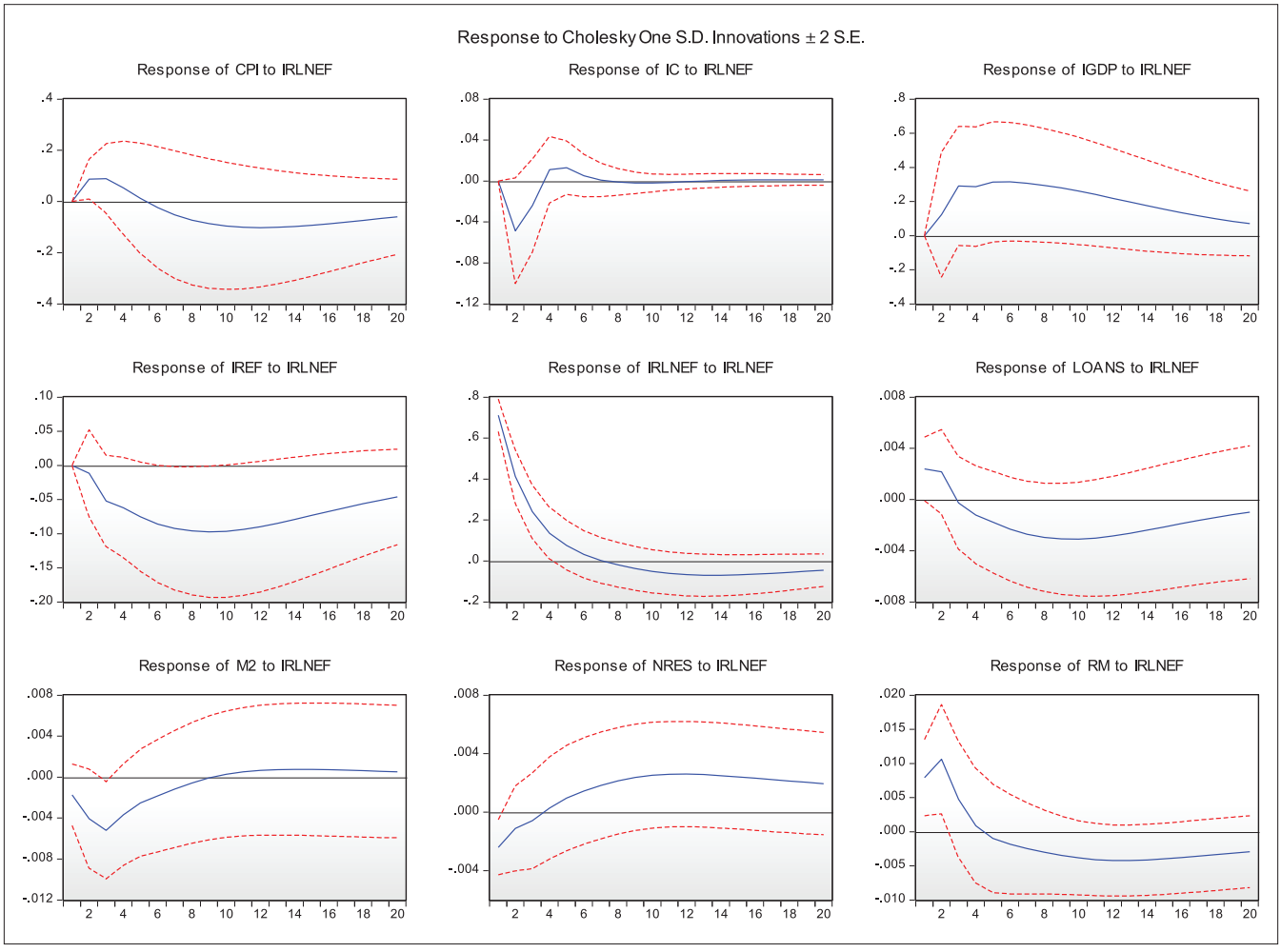


Figure 3: Impulse function of the response of output from IRL_{nef}, MIACR, MIBOR interest rates

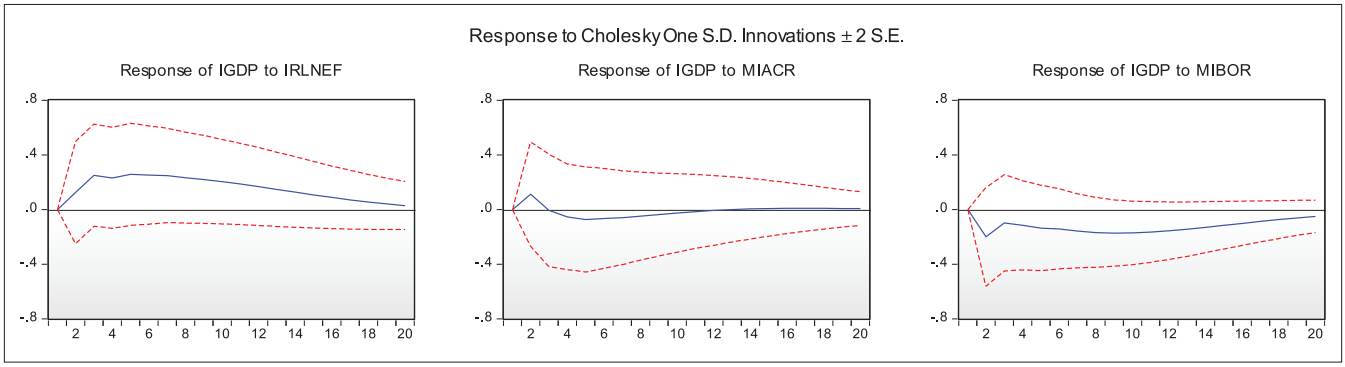
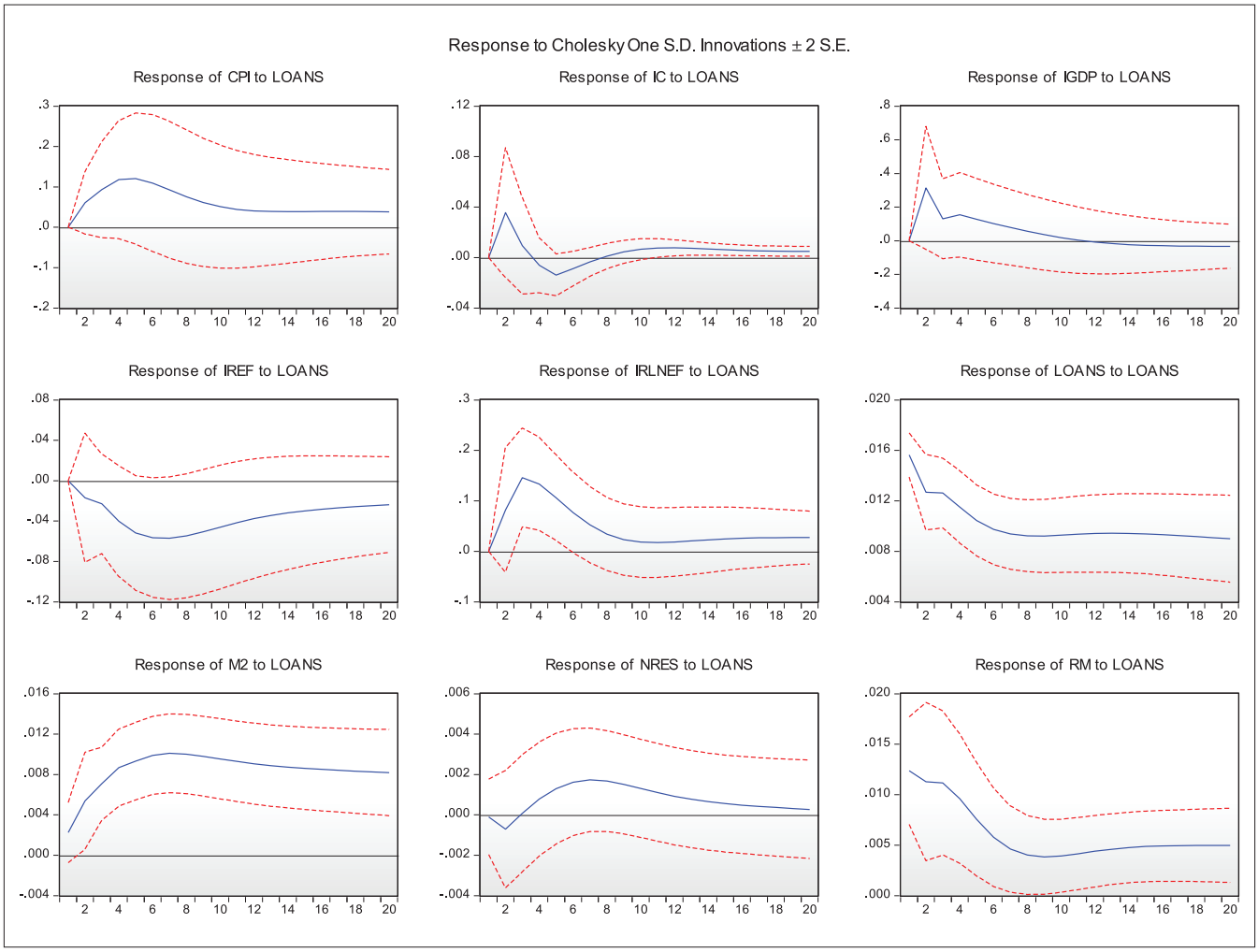


Figure 4: Impulse functions of the response of the corporate lending volume (LOANS)



interest rates, it nevertheless leads to a steady fall in real output and the price level. The final demand is falling quickly enough after the limiting shock of monetary policy. The output also falls, but with a delay, which means that there is the growth of commodity stocks in the short term. Gradually, the commodity stocks are reduced, which leads to a significant portion of GDP decline. The fastest and most significant drop is observed in such components of final demand as investment and consumption.

Wong (2000) analyzes the behavior of the functions of the output and price response to the shocks of monetary policy. The values of responses at different time intervals (3-60 months) allow to describe both a long-term and short-term behavior of variables. Growth in the output after a negative shock has been found in the short term, which contradicts the views that the output should fall. The output falls in most cases at intervals of the average length, but in the long term the shock effect converges to zero.

According to (Ahmadi and Uhlig, 2015), the output has a negative reaction, but modest in size after the limiting shock of monetary policy.

Figure 5: Impulse functions of response of the money supply

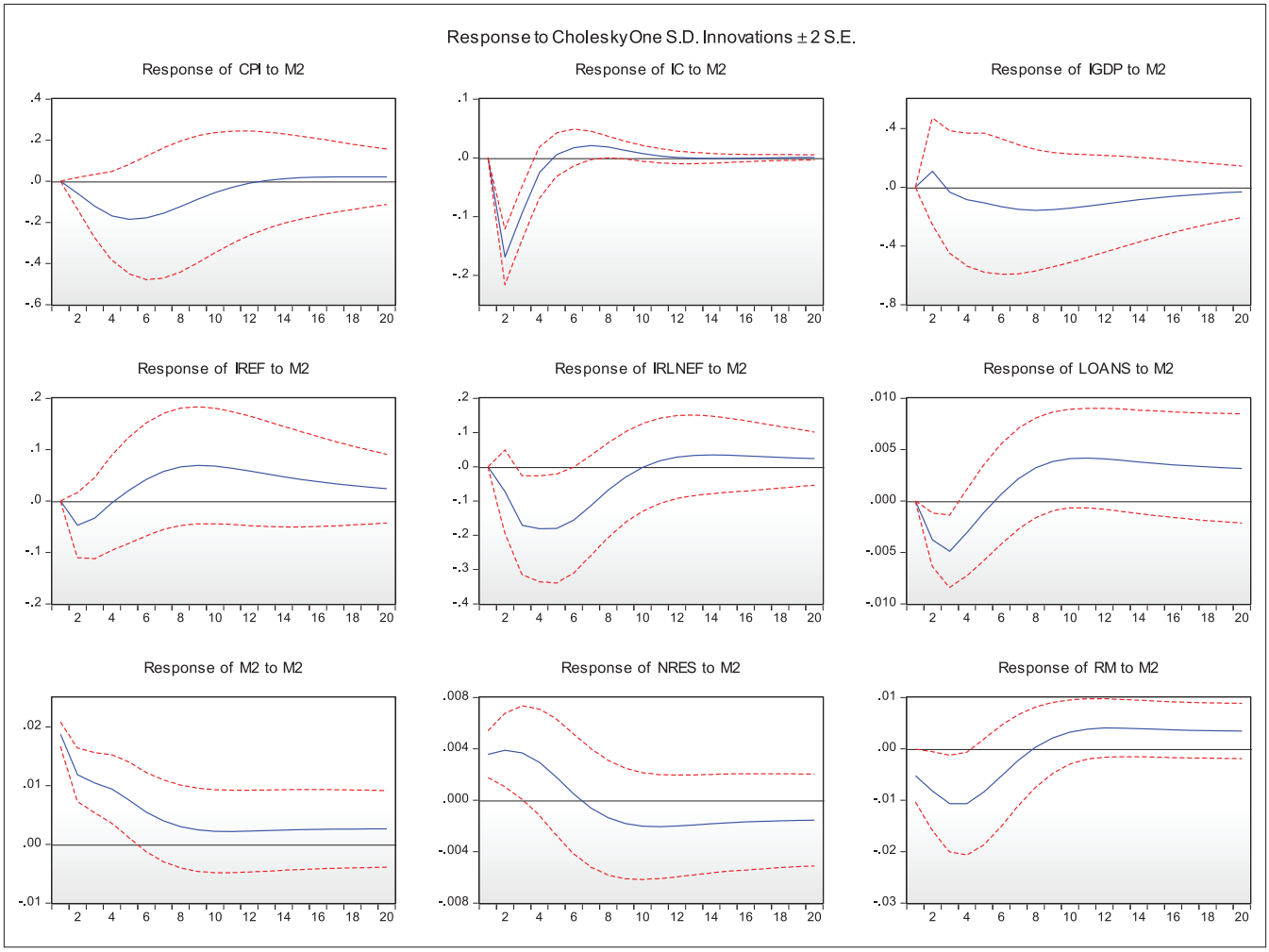
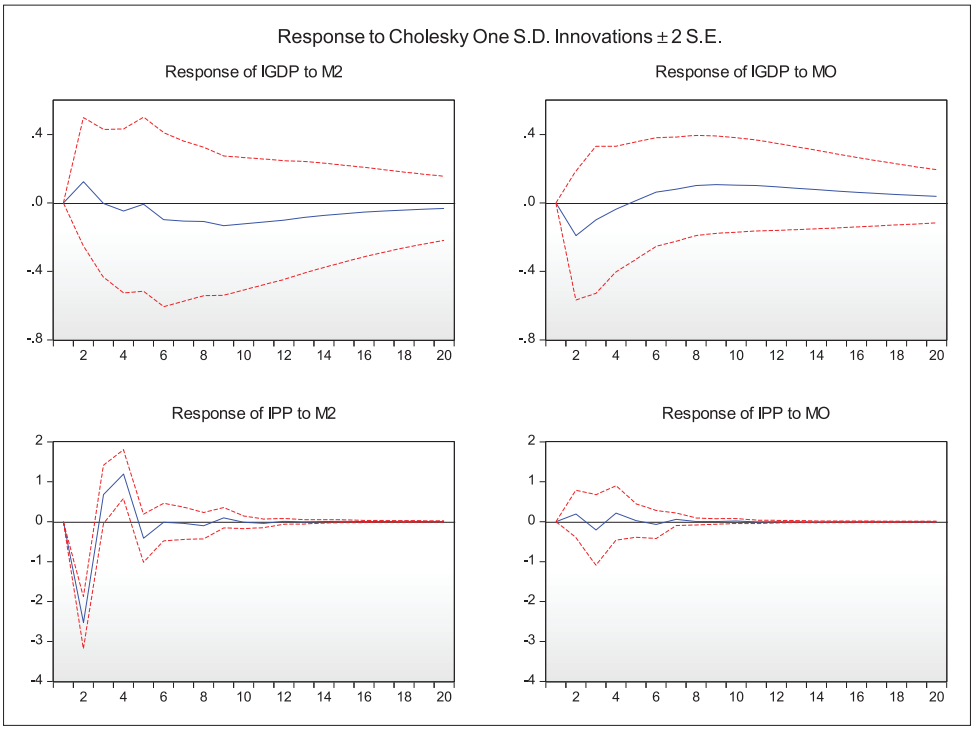


Figure 6: Impulse functions of response from the M2 money supply, MO to IGDP, IPP



3.2. Bank Lending Channel

Figure 4 shows the impulse functions of the bank lending response.

The growth in domestic lending causes an immediate inflationary effect, which lasts more than a year. The growth in corporate lending also causes a sharp but short-term growth in investment. The positive shock of domestic lending causes the growth of industrial production for 10 months, strong growth in the interest rate and its stabilization after 10 months. The money supply grows rapidly and has a significant response. Eventually, the domestic lending growth leads to a significant depreciation of the exchange rate during the first year.

3.3. Cash Flow Channel

Figure 5 shows the impulse function in response to money supply shocks.

The supply of lending resources expands. CPI falls but begins to rise after 6 periods. Investments fall sharply, and then grow and stabilize during 3 periods. GDP declines slowly with a 2-quarter lag and stabilizes after 18 periods. The interest rate falls for 4 periods, and then stabilizes after 6 periods. The exchange rate first falls and then grows to a new level. These data allow to conclude that money has virtually no impact on output. A conclusion can be made about the low efficiency of the channel. However, such a result can also be received because of incorrect specification. Figure 6 shows the impulse functions of response not only from M2 money supply, but also from MO, and the output is presented not only by the index of industrial production to the corresponding period of the past year (IGDP), but also by the index to the previous period of the current year (IPP). The reaction of this index (IPP) is a sharp and confident decline in output from the M2 shock. The reaction of the IGDP impulse function from the MO money supply shock is decline for 2 periods with the reaction up to 5 periods. This result allows to speak about a certain efficiency of the cash flow channel.

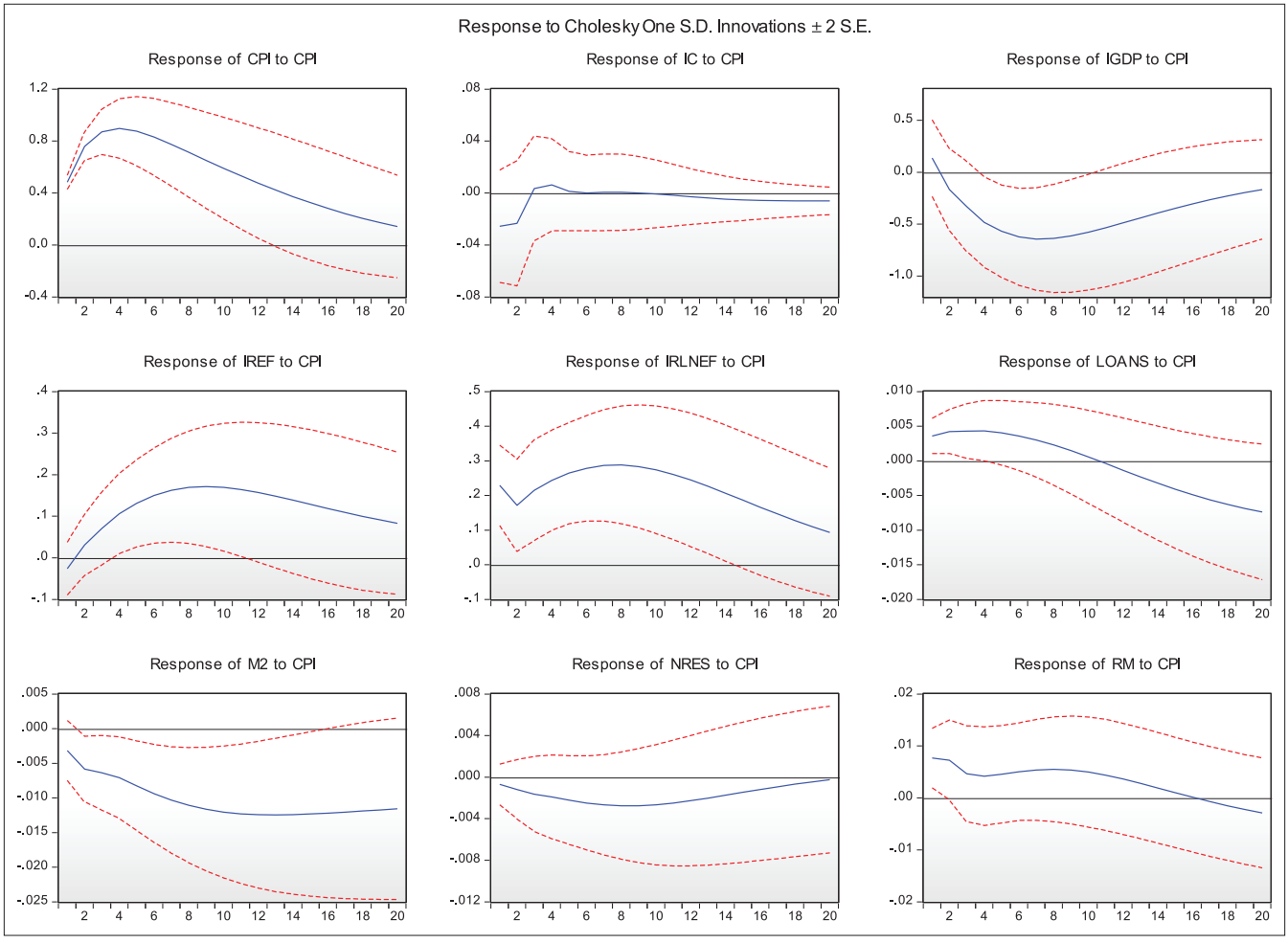
3.4. Channel of Unforeseen Price Growth

Figure 7, which shows the impulse functions of response of the price growth, demonstrates that the investments stabilize at the same level after 2 periods, output falls considerably and the reaction lasts for more than 20 periods, the interest rate grows significantly, and this reaction is resistant, lending volumes decline, money supply becomes smaller and the exchange rate falls.

3.5. Exchange Rate Channel

Let's consider the reaction of impulse functions from the use of the effective exchange rate as a monetary policy tool. The shock of monetary policy leads to a higher effective exchange rate, and the output, prices, money, and interest rate will decline after the

Figure 7: Impulse functions of response of the price growth



shock. Buying rubles and selling currency to increase the effective exchange rate leads to a shortage of rubles, which will push the interest rate up. However, in the process of effective sterilization, the impact on the interest rate must be neutralized. In the event that the expected trend of the rate appreciation is credible, the condition of the parity in the interest rate between the Russian Federation and its major trading partners should contribute to the reduction in the local interest rates.

Figure 8 shows the impulse responses on the exchange rate shock.

The reaction of the interest rate is theoretically correct. It first grows for 3 periods, then declines for 5 periods. As a result of the depreciation of the exchange rate, we notice an immediate and statistically significant growth in the industrial production. Money responds 2 months after the shock, grows and stabilizes after 10 periods. Prices grow as a result of a positive shock affecting the exchange rate. The exchange rate remains above the trend for a considerable period of time, then shows a positive deviation of the exchange rate from its trend. The decline in the exchange rate causes an increase in the interest rate, the effect of which lasts for about six months. The corporate lending responds to the exchange rate shock with a slight growth for 2 months and then decline for 10 months. Given that the exchange rate from the M2 money supply shock grows (Figure 5), we can talk about the effectiveness of the exchange rate channel.

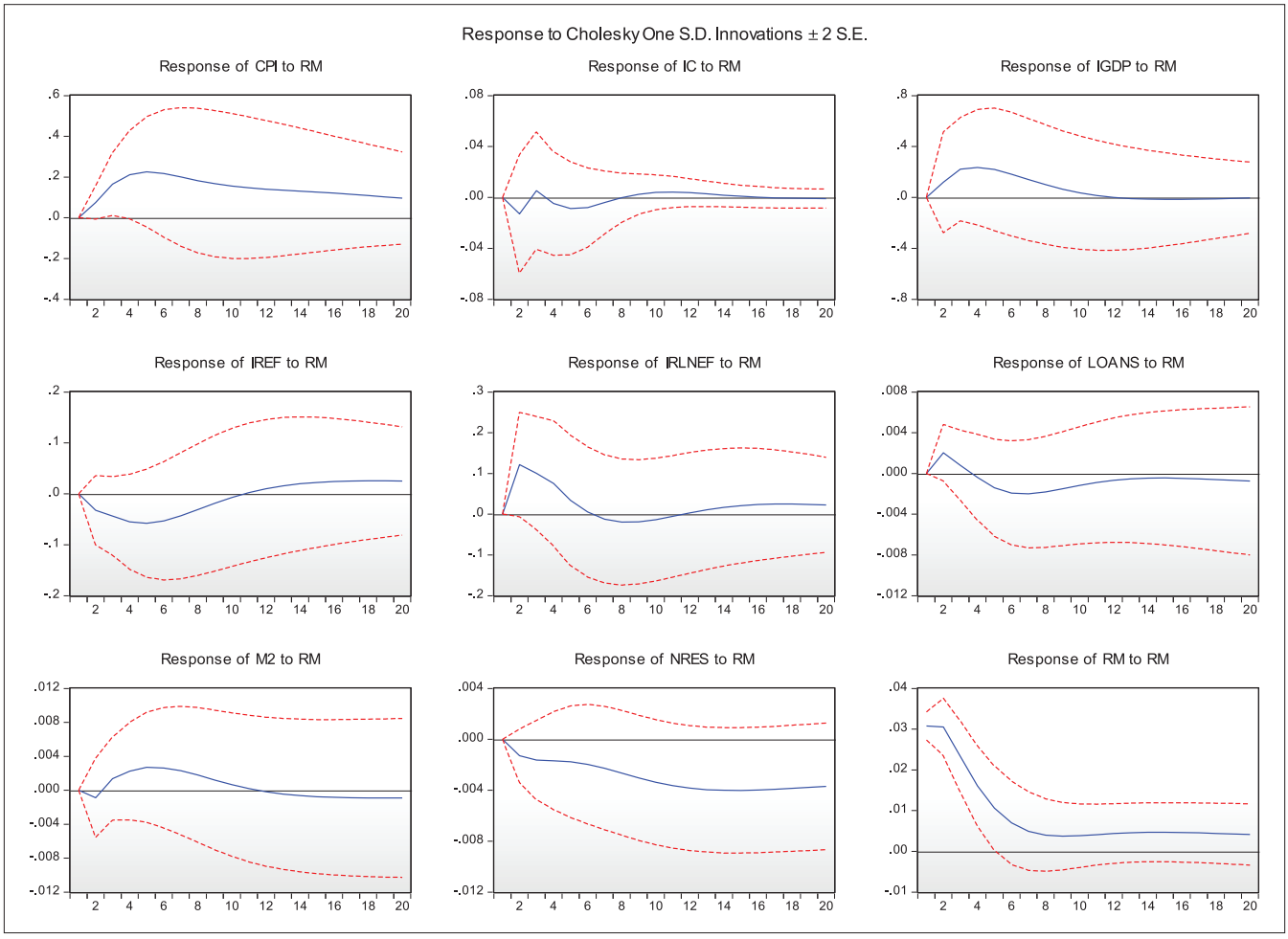
4. DISCUSSION

The following general conclusions can be made. The limiting shock of monetary policy affecting the interest rate causes decline in investments, money supply, domestic lending, interest rate and exchange rate. These responses are significant and enduring. Reaction of prices and output contradicts the theory. Interest rate channel requires further study to improve the reliability of the results.

The study of the bank lending channel showed that a growth in domestic lending causes the growth in prices, which lasts more than a year, and a short-term investment growth. The positive shock of domestic lending leads to the growth of industrial production for 10 months, a steady growth of the interest rate and the money supply. Domestic lending growth leads to a significant depreciation of the exchange rate during the first year. Overall, the bank lending channel is available.

Study of the cash flow channel showed that the shock affecting the money supply causes decline in prices, investment, slowly reduces GDP with a 2-quarter lag and stabilizes after 18 periods.

Figure 8: Impulse functions of the response of the exchange rate



The interest rate falls for 4 periods, and then stabilizes after 6 periods. The exchange rate first falls and then grows to a new level. These data allow to conclude that money has virtually no impact on output. Additional analysis found that the reaction of the index (IPP) is a sharp and confident decline in output from the M2 shock. The reaction of the IGDP impulse function from the MO money supply shock is decline for 2 periods with the reaction up to 5 periods. A general conclusion can be made about the low efficiency of the cash flow channel.

The unforeseen price channel is characterized by a slight fall in output from the PCI and the money supply, while at the same time the PCI from the money supply shock falls steadily.

The unforeseen price growth channel is characterized by a significant drop in output, decline in the money supply, lending volumes and exchange rates. The interest rate increases significantly, and this reaction is resistant. This suggests a theoretically correct response of the factors and channel availability.

The rate channel is characterized by a slight change in output from the money supply shock, steady growth of output from the exchange rate, and a growth in the exchange rate from the money supply shock.

The study of the exchange rate channel leads to a conclusion that the reaction of the interest rate is theoretically correct. It first grows for 3 periods, then declines for 5 periods. A significant growth in industrial production is observed in result of the exchange rate depreciation. Money and prices grow after the shock as a result of a positive shock affecting the exchange rate. The exchange rate remains above the trend for a considerable period of time. Reduction in the exchange rate causes an increase in the interest rate, the effect of which lasts for about six months. The corporate lending responds to the exchange rate shock with a slight growth for 2 months, and then declines for 10 months. Given that the exchange rate from the M2 money supply shock grows (Figure 5), we can talk about the effectiveness of the exchange rate channel.

Summarizing, we can conclude that all the relevant channels - the interest rate channel, bank lending channel, cash flow channel, unforeseen price growth channel and exchange rate channel exist but have varying degrees of effectiveness. The exchange rate channel is the most effective; the bank lending channel and the unforeseen price growth channel are also effective. Considering the interest rate channel and the cash flow channel, we can tell that they are ineffective, but it should be noted that their analysis is not easy.

This characteristic of the monetary policy channels is apparently related to the depressive state of the economy, the lack of its growth in recent years, and high inflation. This characteristic is also obviously influenced by the policy of the Bank of Russia, which was aimed at maintaining stability in the economy and support of the ruble rate. Several publications explore these aspects: Rautava (2004; 2013), Beck et al. (2007), Granville and Mallick (2010), De Grauwe and Storti (2004).

Rautava (2004) analyzes the impact of international oil prices and the real exchange rate on the economy and fiscal policy of Russia using the VAR methodology and cointegration method. The results show that a permanent 10% increase (decrease) in world oil prices in the long term is connected with an increase (drop) in the level of Russia's GDP by 2.2%. Accordingly, 10% of the real exchange rate (depreciation) of the ruble is connected with the fall (increase) in the capacity level by 2.4%.

In the article, Rautava (2013) considers using a structural error correction model built for the purposes of forecasting, the assessment of which indicates that the Russian economy is still heavily dependent on the world oil prices and that there are no major differences in this respect before and after the crisis of 2008-2009.

Granville and Mallick (2010) investigate the possible transmission channel between the real interest rate, inflation pace, growth of the exchange rate, growth of production volumes and foreign exchange reserves in the Russian economy, and believe that the inability of monetary authorities to reduce inflation is explained by the policy of exchange rate targeting.

De Grauwe and Storti (2004) confirmed that the rate of inflation affects the effectiveness of monetary policy.

It should be noted that in order to improve the reliability of results when using the VAR method, we can increase the number of variables; to avoid the well-known theoretical "curse of dimensionality," more complex models than the standard VAR model can be used - factor-augmented VAR (FAVAR) (Bernanke et al., 2004), Bayesian VAR model (Banbura et al., 2010, Deryugina and Ponomarenko, 2015), as well as imposition of sign restrictions directly on the impulse characteristics of a large set of variables in the Bayesian VAR (FAVAR), and in this case, as the authors showed, each additional sign restriction may have the improvement in the structural identification (Ahmadi and Uhlig, 2015), as well as models of dynamic stochastic general equilibrium (DSGE).

5. CONCLUSIONS

The recent changes in monetary policy in the Russian economy in the period from 2002 to 2015 were studied in this paper, and the interpretation of the transmission channels was given. The study was conducted using the VAR method.

The Bank of Russia declared the transition to inflation targeting as a long-term goal, and thus understanding of the instruments used and the extent to which the banking sector responds to changes in monetary policy is very important.

A stationary solution was found for the 12 main variables, and the existence of 5 transmission channels that exist with varying degrees of effectiveness was statistically confirmed.

The high efficiency of the exchange rate channel, bank lending channel and the unforeseen price growth channel was confirmed.

Low efficiency of the interest rate channel and the cash flow channel can be associated with both the methodology of the study - specification, small sample, small number of variables and changes in central bank policy - the shift from the ruble targeting policy to the inflation targeting policy, as well as macroeconomic indicators: The decline in the Russian economy growth, high inflation, dependence on the world oil prices.

Overall, the results show that the use of the standard VAR methods for the data of the Russian economy as a developing one can be used as a guideline for further theoretical and empirical analysis of the transmission mechanism.

Events in the Russian economy in 2015-2016, the sharp fall in oil prices and a corresponding weakening of the ruble lead to a change in the economy structure. These events and the introduction of crisis response budgeting measures create a new monetary policy regime. It is important to monitor how these results have changed as the data from the new regime of a single monetary policy, and evaluate the effectiveness of the monetary policy tools.

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