The importance of external and internal shocks for real exchange rate and industrial production in Russia: SVARX approach

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February 14, 2016

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Abstract

This paper studies the main sources of macroeconomic fluctuations in Russia which is oil-exporting developing economy. We use SVARX approach with long run restrictions to identify oil price shock, nominal shock and two types of productivity shocks. Contrary to previous studies, we found that Balassa-Samuelson effect was not the main driver of industrial production and real exchange dynamics in Russia. Oil price dynamics is an important source of industrial production and real exchange rate fluctuations which speaks in favor of the fact that the Russian economy is poorly diversified.

Keywords: SVARX, long-run restrictions, oil price, Balassa-Samuelson effect.

JEL Codes: C32, F41, O47.

1 Introduction

We start with a brief description of the macroeconomic environment in Russia in the last two decades. It is well known that Russia substantially depends on oil revenues. Default in august 1998 led to severe drop in real exchange rate and GDP. Starting from 1999 there was a long period of recovery economic growth in

Russian economy which was followed by real exchange rate appreciation. Russia is net oil-exporting country so gradual increase in oil price which started in 2003 also positively influenced its real exchange rate. Continuing oil price growth led to overheating of the Russian economy right before the world financial crisis in 2008. That is why GDP and real exchange rate drop during the crisis were so severe. After 2010, economic growth in Russia slowed down. Decreasing oil price in 2014 and 2015 resulted in a huge drop in revenues, real exchange rate depreciation and even negative GDP growth rate.

It is often discussed in literature that Balassa-Samuelson effect (see Balassa (1964), Samuelson (1964)) is observed in developing countries. Specifically, productivity growth in tradable sector is a very important source of economic growth and real exchange rate appreciation. For the Russian economy there is also evidence in Gurvich *et al.* (2008) that a significant part of GDP growth and real exchange rate appreciation in last 15 years were due to Balassa-Samuelson effect. In our paper, we make an attempt to specify this shock separately from general productivity growth (in both tradable and nontradable sectors simultaneously) in order to check its importance for Russian economy.

In this paper, we use VARX approach to analyse the influence of inner and external macroeconomic shocks on major macroeconomic variables. We treat oil as exogenous variable as Russia is a small open economy and it is a price-taker on the global market. There are plenty of papers studying impacts of oil price shocks using VAR analysis mainly within developed economies which are usually net oil-importers. The papers by Blanchard and Gali (2007), Peersman (2005), Korhonen and Ledyaeva (2010), Tang *et al.* (2010), Huang and Feng (2007) and many other authors concern this issue.

In the last two decades, there were also quite many papers focused on studying the same issues for developing, oil-exporting countries. Bjørnland (1998) investigates the role of real and nominal shocks in explaining business cycles in Norway, which is an oil-exporting small open economy, using VAR model with long run restrictions. Authors of the paper Esfahani *et al.* (2013) use VECX model to estimate influence of oil revenues shock on main macroeconomic variables of Iranian economy. Farzanegan and Markwardt (2009) also attempted to examine the importance of oil price shocks for Iran but with the help of VAR model with short run restrictions. All the works and many others including Iwayemi and Fowowe (2011), Omojolaibi (2013), Sameti and Teimouri (2012) and Wang *et al.* (2013) are concentrated on the different types of oil price shocks. In our paper, we try to specify other external and internal macroeconomic shocks taking into account strong influence of oil price dynamics on the Russian economy postulating oil price being an exogenous variable.

Some papers specify macroeconomic shocks in the framework of VAR with long run restriction proposed by Blachard and Quah (1989) with the oil price in the variable list. Mehrara and Oskoui (2007) study macroeconomic fluctuations in four oil-exporting countries. They specify four type of shocks: real oil price shocks, aggregate supply shocks, real demand shocks and nominal shocks. They found that most output fluctuations in Iran and Saudi Arabia were caused by oil price shocks while aggregate supply shocks were the main source of output fluctuations in Kuwait and Indonesia.

Rafiq (2011) uses combination of short and long run restriction to find sources or macroeconomic fluctuation in several oil-exporting countries. His specification takes into account possible Balassa-Samuelson effect. Results of the coinetgrated VAR model for developed countries proposed by Alexius (2005) reveal a Balassa-Samuelson effect.

In this paper, we focus on external end internal shocks as the main sources of macroeconomic fluctuation in Russia, which a small open oil-exporting economy. We follow Mehrara and Oskoui (2007) using long run restrictions but we specify a different set of shocks and treat oil price as fully exogenous variable in our structural vector autoregression model.

The paper is structured as follows. Section 2 provides a brief description of the data set and unit root tests. In Section 3, we present model specifications and the structural VARX model. Section 4 provides detailed findings that characterize the macroeconomic fluctuations in Russia with the impulse response estimates and historical decomposition from the SVAR model. Section 5 concludes.

2 Description of data and Unit Root Analysis

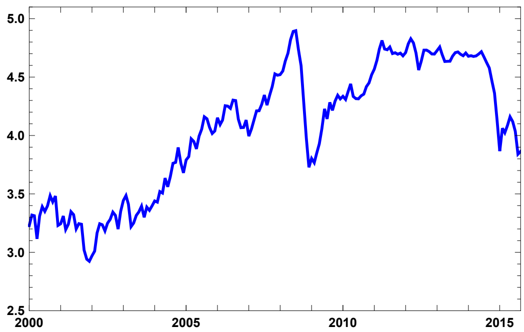
In this study, we use monthly data taken from IFS database for four variables: oil price, industrial production index, real effective exchange rate and consumer price index for Russia. All four variables that we consider are provided in the following figures (in logs). The industrial production index and cpi are seasonally adjusted (with x-13) while the other series are not. The period is from January 2000 to September 2015. All variables are depicted in Figure 1.

At first we would like to discuss strategy for unit root hypothesis testing. Let a process for y_t be generated as follows:

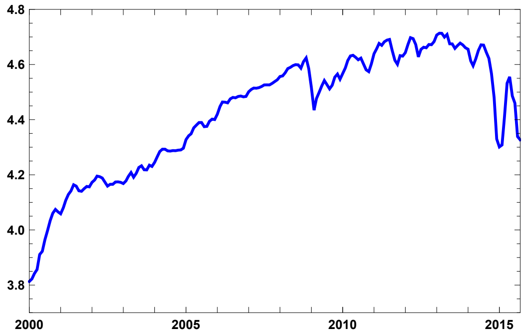
$$y_t = \mu + \beta t + u_t, \tag{1}$$

$$u_t = \rho u_{t-1} + e_t, \tag{2}$$

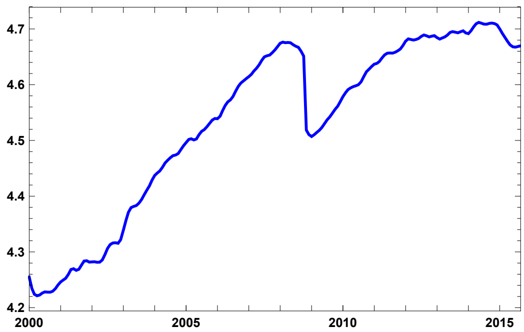
where e_t is a stationary process (satisfying, e.g., conditions of Phillips and Solo



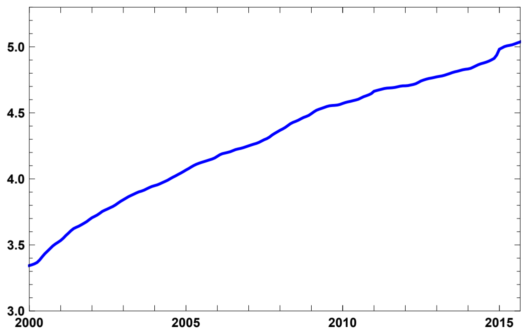
(a) oil price



(b) real effective exchange rate



(c) industrial production index



(d) consumer price index

Figure 1. Graphs for used variables.

(1992) for linear processes). We are interesting in testing for the null hypothesis $\rho = 1$. We consider four tests that are most popular in empirical applications:

1. $ADF\text{-}GLS^{\mu}$ is effective under small initial conditions and without trend in DGP;

2. $ADF\text{-}GLS^{\tau}$ is effective under small initial conditions and with trend in DGP;

3. $ADF\text{-}OLS^{\mu}$ is effective under large initial conditions and without trend in DGP;

4. $ADF\text{-}OLS^{\tau}$ is effective under large initial conditions and with trend in DGP;

The superscript μ denotes that only intercept is included in the ADF-regression, the superscript τ denotes that intercept and trend are included in the ADF-regression. The lag length is selected according to MAIC for OLS-detrended data (as in Perron and Qu (2007)). Thus, different tests are efficient for different magnitudes of nuisance parameter (magnitudes of trend and initial condition). The best and simplest solution for this problem is to reject the unit root null hypothesis if at least one of the tests rejects it. This strategy is proposed by Harvey *et al.* (2009) and Harvey *et al.* (2012) and refers as union of rejection testing strategy:

$$\begin{aligned}\text{Reject} H_0 \text{ if } ADF\text{-}GLS^{\mu} < m_{\xi} cv_{\xi}^{GLS,m} \text{ or } ADF\text{-}GLS^{\tau} < m_{\xi} cv_{\xi}^{GLS,t} \\ \text{or } ADF\text{-}OLS^{\mu} < m_{\xi} cv_{\xi}^{OLS,m} \text{ or } ADF\text{-}OLS^{\tau} < m_{\xi} cv_{\xi}^{OLS,t}, \quad (3)\end{aligned}$$

where m_{ξ} is the scaling constant to control the size of this strategy.

This strategy can be improved by additionally testing the trend significance and value of the initial condition. E.g., if the trend is clearly present in the data, then there is no need to use inefficient tests without trend, or if the initial condition is detected to be large, then GLS-tests should not be used. The trend significance could be detected by the tests proposed by Harvey *et al.* (2007), Perron and Yabu (2009) and Bunzel and Vogelsang (2005), that are robust to whether the series are I(0) or I(1). However, in our case there is no reason to perform pre-tests because all tests fail to reject the unit root null hypothesis at 5% significance level (see Table 1).

Table 1. Unit root tests

	$ADF\text{-}OLS^{\mu}$	$ADF\text{-}OLS^{\tau}$	$ADF\text{-}GLS^{\mu}$	$ADF\text{-}GLS^{\tau}$
rer	-1.59	-0.37	-0.14	-0.54
prod	-1.93	-1.19	0.45	-1.15
cpi	0.10	-3.21*	1.31	-0.59
oil	-1.40	-0.86	-0.49	-1.16

There is only one case of rejecting null hypothesis of the unit root for cpi series.

In addition, we report results from the bias-corrected version of the KPSS test, proposed in Kurozumi and Tanaka (2010). This modification use the finite sample bias term in the numerator of the test statistic and implement Sul *et al.* (2005) long-run variance estimator. The results are given in Table 2. For long-run variance estimation we use the BIC and boundary rule equal to 0.80, 0.90 and 0.95. If the boundary rule increases, then the power of the test decreases.

Table 2. Bias-corrected KPSS test

	bound=0.8		bound=0.9		bound=0.95	
	$KPSS^{\mu}$	$KPSS^{\tau}$	$KPSS^{\mu}$	$KPSS^{\tau}$	$KPSS^{\mu}$	$KPSS^{\tau}$
rer	57.03***	3.02***	14.29***	0.77***	3.64***	0.24***
prod	145.36***	4.75***	36.37***	1.20***	9.15***	0.34***
cpi	12824.72***	47.88***	3206.21***	11.98***	801.58***	3.01***
oil	22.24***	0.92***	5.59***	0.25***	1.46***	0.11

For almost all series we reject the null hypothesis of stationarity even at 1% significance level. One exception is the oil price when the boundary rule is equal to 0.95. But this may be due to low power with this bound.

All in all, we could treat all the series as having unit root so the first differences or cointegration analysis should be used. But we tested for cointegration rank by the bootstrap test proposed by Cavaliere *et al.* (2010) and we didn't find any cointegration in the series.

3 Full VAR Analysis

In the previous section, we found that we could treat all four series as difference stationary (I(1)) without cointegration between them. Therefore, it makes sense to estimate structural VAR model for these series in first differences.

SVAR model is estimated with the help of special VAR toolbox in Matlab.[1] The lag length has been chosen according to the likelihood ratio test (see, e.g., Lüutkepohl (2005, Section 4.2.2)). Because the number of lags can be different for endogenous and exogenous variables, initially we test the null hypothesis that number of lags for endogenous variables equal to l against alternative that the number of lags is equal to $l+1$ sequentially for $l = 7, 6, \dots, 0$ and for each number of lags, saw, k, for exogenous variable, $k = 1, 2, \dots, 7$. The significance level is assumed to be 10%. If the null hypothesis is rejected, then the procedure stops. Table 3 shows that for all k the number of lags is chosen to be six.

Table 3. Likelihood ratio tests for lag lenght

k	1	2	3	4	5	6	7
LR(0|1)	239.7	236.1	234.3	233.2	233.7	232.6	234.1
LR(1|2)	16.7	19.4	22.3	21.5	21.9	22.7	22.4
LR(2|3)	21.7	23.1	23.6	27.3	28.9	28.6	27.7
LR(3|4)	18.8	18.0	15.2	12.6	15.7	15.6	15.8
LR(4|5)	9.5	9.7	9.7	9.7	9.0	11.8	10.8
LR(6|7)	20.3*	18.0*	18.2*	18.1*	19.1*	20.3*	18.4*
LR(7|8)	11.0	10.7	10.6	10.5	10.2	9.4	9.9
LR(8|9)	5.4	5.7	5.7	5.4	5.8	6.3	6.2

Next, we should choose the number of lags for exogenous variable conditional on six lags for endogenous variables. A similar sequence of procedure choose (see Table 4) two lags for exogenous variable.

[1] https://sites.google.com/site/ambropo/MatlabCodes

Table 4. Likelihood ratio tests for lag lenght

	LR(6,1|6,2)	LR(6,2|6,3)	LR(6,3|6,4)	LR(6,4|6,5)	LR(6,5|6,6)	LR(6,6|6,7)
6	8.3*	4.9	3.4	7.6	7.6	1.5

Therefore, we consider results of the estimated SVAR model with six lags of endogenous variables and two lags of exogenous variable.

Assumptions for this specification are based on economic theory and specific features of the Russian economy. Russia is an oil-exporting small open economy, so in our SVARX analysis, we follow Blanchard and Quah (1989) and Mehrara and Oskoui (2007) setting long run restrictions, but we treat oil price (Poil) as fully exogenous variable and use. The ordering of endogenous variables is as follows: log of real effective exchange rate of ruble (REER), log of industrial production index (IP) and log of consumer price index (CPI). We define structural shocks in the following manner: Balassa-Samuelson-type productivity shock, general productivity shock in the whole economy and nominal shock. As mentioned before, all the variables are included in the model in first differences, so the vector of stationary variables is $(\Delta REER, \Delta IP, \Delta CPI, \Delta Poil)$.

Long-run restrictions are based on economic theory. Oil price is included into the model as an absolutely exogenous variable. Nominal shock does not affect real variables such as real effective exchange rate and industrial production index in the long run (like in Clarida and Gali (1994), Mehrara and Oskoui (2007)). That is, exchange rate depreciates proportionally to price increase and the nominal shock is neutral in the long run. General productivity shock should not have any influence on the real effective exchange rate in the long run. In the last case, we assume that productivity increase in both sectors of the economy (tradable and non-tradable) leads to same increase in the whole economy leaving relative prices of goods unchanged. Specific Balassa-Samuelson-type productivity shock, contrary to general productivity shock, does influence real exchange rate in the long run (it could also have influence on industrial production and cpi). Unlike the cited articles, we identify these two types of productivity shocks that seems to be more relevant for the Russian Federation with a long period of recovery growth.

All estimation results are presented in figures below. In impulse response functions' graphs, the solid lines represent point estimates, while the dashed lines correspond to 68% the confidence interval. We use 68% confidence interval instead of 95% because it is shown in Sims and Zha (1999) that 68% confidence level provides a more accurate estimate of the probability of covering the true impulse response comparing to 95% confidence level.

Let's consider Balassa-Samuelson-type productivity shock in Figure 2 where accumulated impulse response functions are depicted. This specific shock stems from productivity growth in tradable goods production sector. Due to the increase in real wages in this sector and labor mobility in the whole economy real wages in non-tradable sector also rise. This leads to higher inflation and real exchange rate appreciation. This is exactly what we could see in the graphs: the shock leads to permanent increase in industrial production and appreciation of both real exchange rate and consumer price index in the long run. That is why we decided to define this shock as a Balassa-Samuelson-type one.

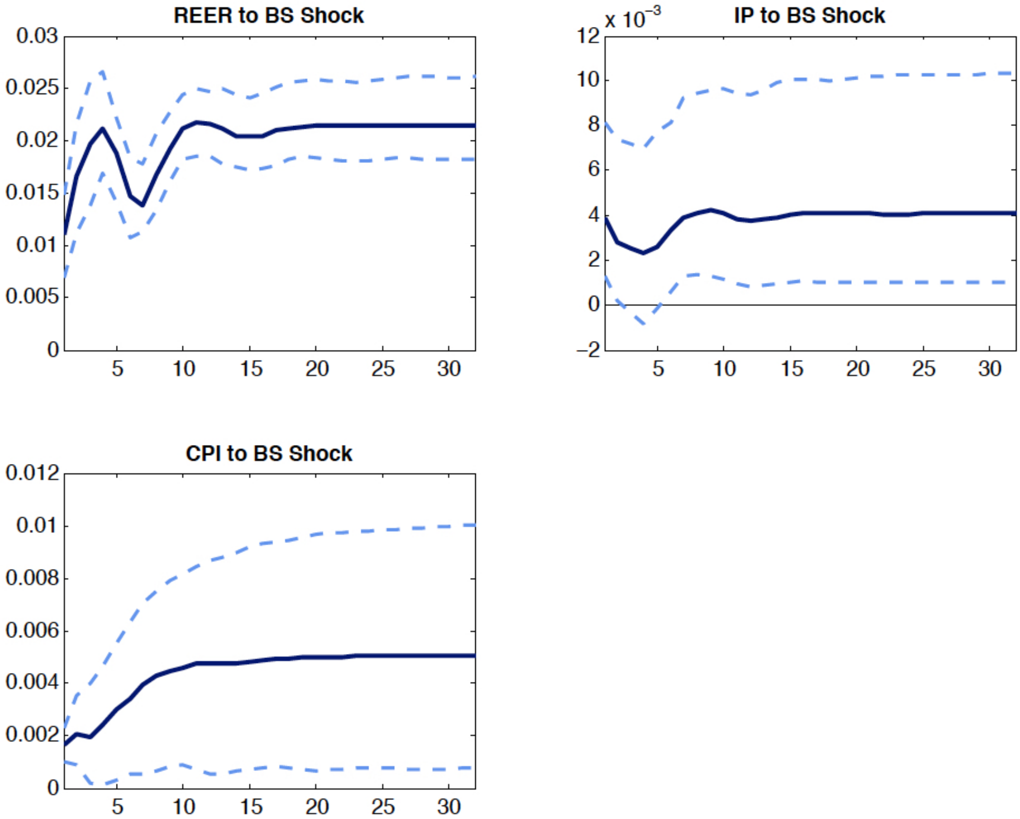


Figure 2. Balassa-Samuelson-type shock

We treat productivity shock as an equal productivity shock in tradable and non-tradable production sectors which leads to same productivity shock for the whole economy. Accumulated impulse response functions to this shock are presented in Figure 3. According to the plot, this shock leads to permanent increase in industrial production and short-run decline in real exchange rate. The logic for the output increase is quite simple and discussed above. Due to productivity growth and wage rigidities, marginal costs go down. This leads to price drop and real exchange rate depreciation. Further increase (adjustment) in wages causes prices to return to their previous level and real exchange rate to appreciate back (so no long run effect according to our specification). The sign of price level reaction to the productivity shock goes in line with our expectations, but this response is statistically insignificant after the very first period what may be caused by too short time span.

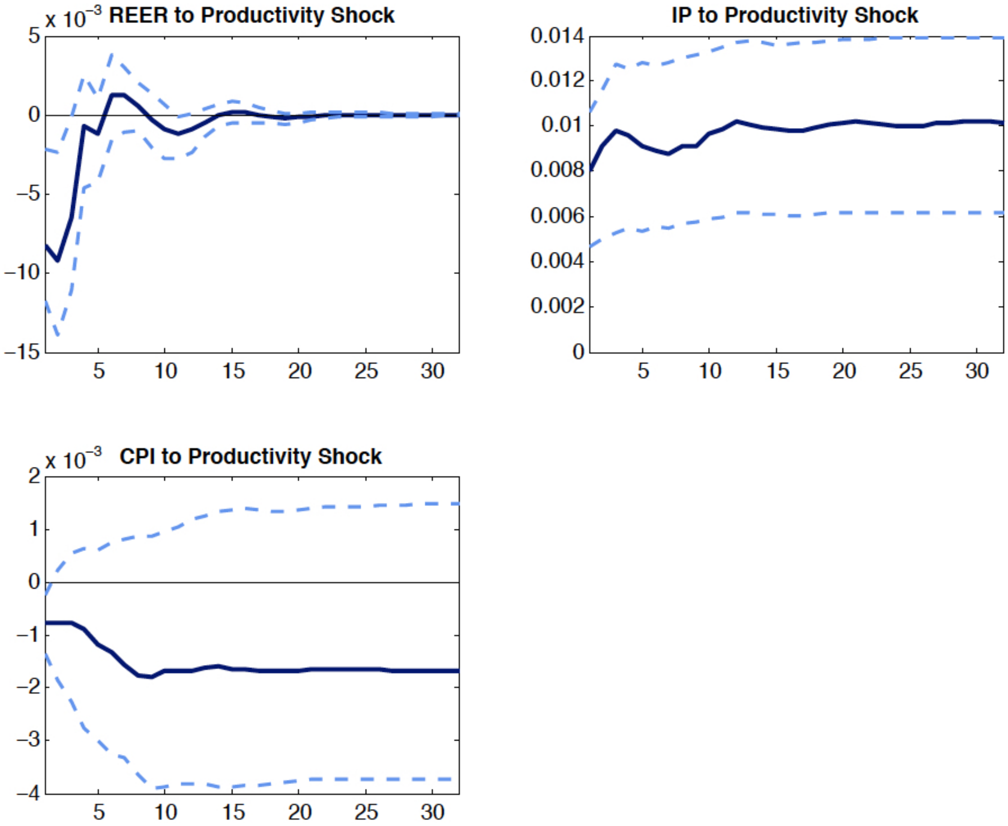


Figure 3. Productivity shock

As far as nominal shock is concerned, impulse responses are depicted in Figure 4. It is worth noting that we have imposed only long run restrictions on the impulse response functions. However, this identification provides us with economically consistent responses in the short run. Loosening of the monetary policy results in simultaneous real exchange rate depreciation and increase in consumer price index. This stems from the depreciation of the nominal exchange rate, which translates into an increase in the price of imported goods. Considered impulse response functions are statistically significant.

In response to the shock of monetary expansion we also observe a temporary increase in output due to the depreciation of the ruble and increase of the competitiveness of Russian goods, which also goes in line with our expectations. But this response is statistically insignificant what may be caused by too short time span.

Impulse response functions for the oil price shock are depicted in Figure 5. Reaction of all three variables is quite anticipated. Positive oil price shock is a

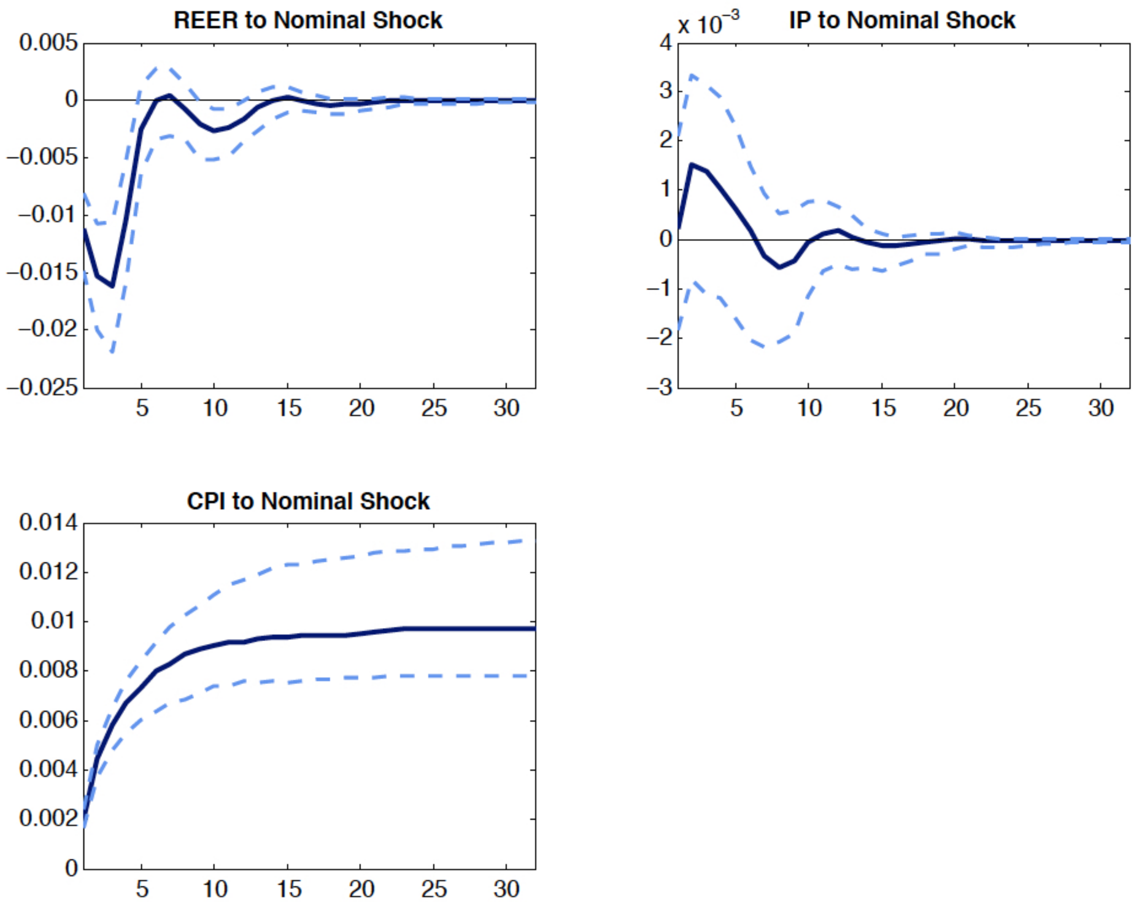


Figure 4. Nominal shock

wealth transfer and dollar inflow to Russian economy which leads real exchange appreciation through nominal exchange rate appreciation. It is more convenient and clear to describe logic for CPI reaction to negative oil price shock: significant oil price negative shock as we observed in crises could have positive influence on price level through nominal exchange rate depreciation and equalising of prices of foreign and domestic tradable goods.

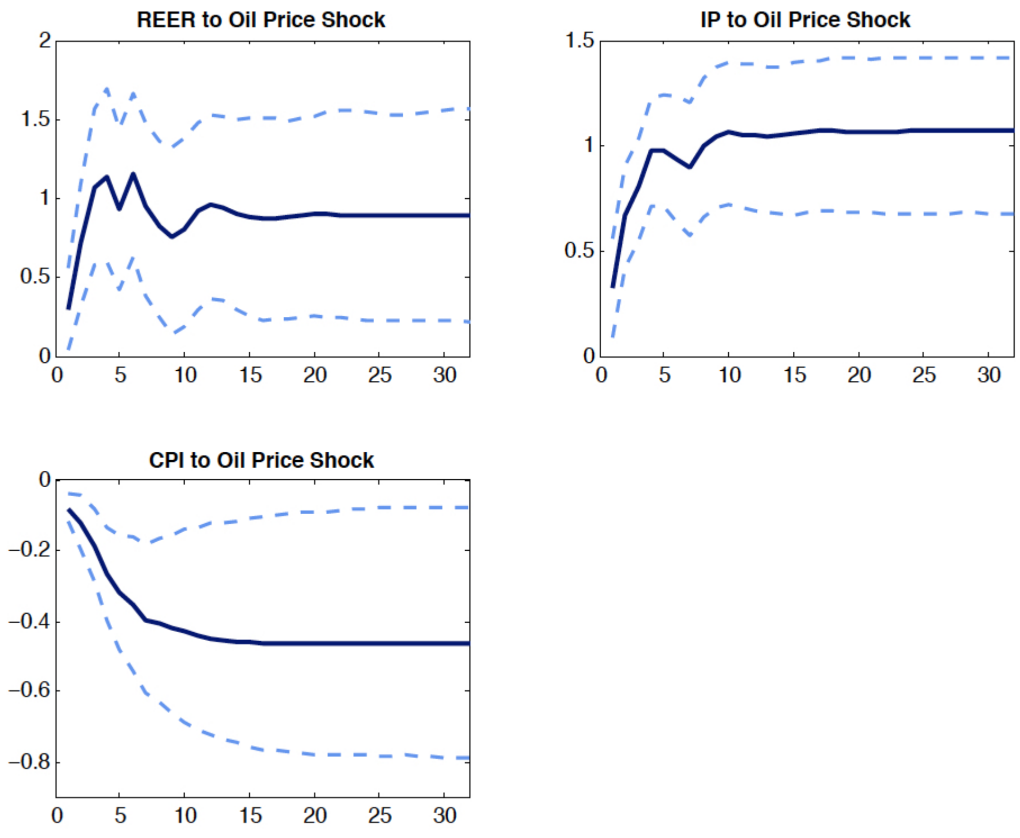


Figure 5. Oil price shock

It is also very interesting to look at historical decomposition of contribution of the shocks to the dynamics of each variable. Historical decomposition of shocks' contribution helps us check the quality of the model comparing decomposition of each variable with the situation in the macroeconomic environment in Russia in the last 15 years. To be more clear and precise in interpreting the results we employ not accumulated historical decomposition opposite to the way as we did with the impulse response functions.

Let's first look at the historical decomposition of the real exchange rate dynamics depicted in Figure 6. We could see from the picture that Balassa-Samuelson-type shock had the strongest influence in the beginning and in the end of the considering period. The period of 2000 and 2001 is characterised by substantial recovery growth after crisis of 1998 so it is quite natural that productivity of tradable sector had been growing during that period with faster rate comparing to non-tradable sector. Starting from the beginning of 2014, Russia has been suffering from economic sanctions so negative Balassa-Samuelson effect happened due to the lack of technology and imported intermediate goods used as input for production. During the financial crisis of 2008 we could see strong negative influence by oil price dynamic.

The most interesting point in discussion of shocks' contribution to the real exchange rate dynamics is strong negative effect followed by substantial positive influence of nominal shock in 2014. There were a substantial depreciation of the domestic currency in the second half of 2014, and dollar became a very good financial active that time comparing to ruble. This situation required tightening of monetary policy by Central Bank so its inaction(Central Bank increased interest rate only slightly) could be treated as a negative nominal shock. Later, Central Bank of Russia increased his key interest rate (monetary policy rate) dramatically – from 9% to 17%. This led to lowering currency risks and easing the pressure on the ruble which could be treated as a positive nominal shock influence on real exchange rate. In addition it is worth mentioning that during the crisis in 2008 and starting from 2014, we could strong negative effect from oil price drop.

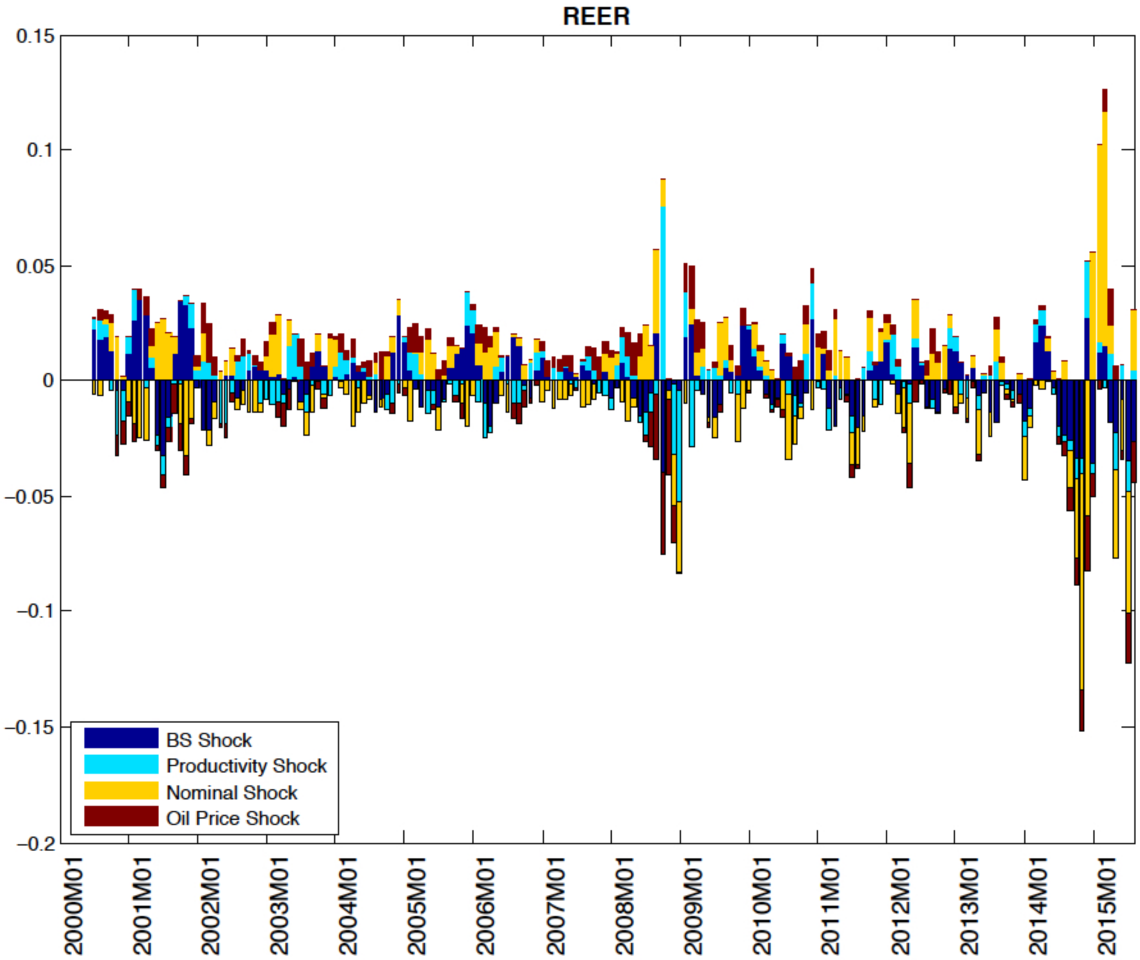


Figure 6. Real exchange rate decomposition

In the Figure 7 that presents historical decomposition of industrial production, we can see that oil price shock and productivity shock were mostly important for its dynamics. These two shocks influence industrial production in predictable way: before the financial crisis of 2008, positive impact had been prevailing while during the crisis, strong negative impact took place. Oil price drop in 2013-2014 also negatively affected industrial production which coincided with productivity drop in tradable sector discussed above.

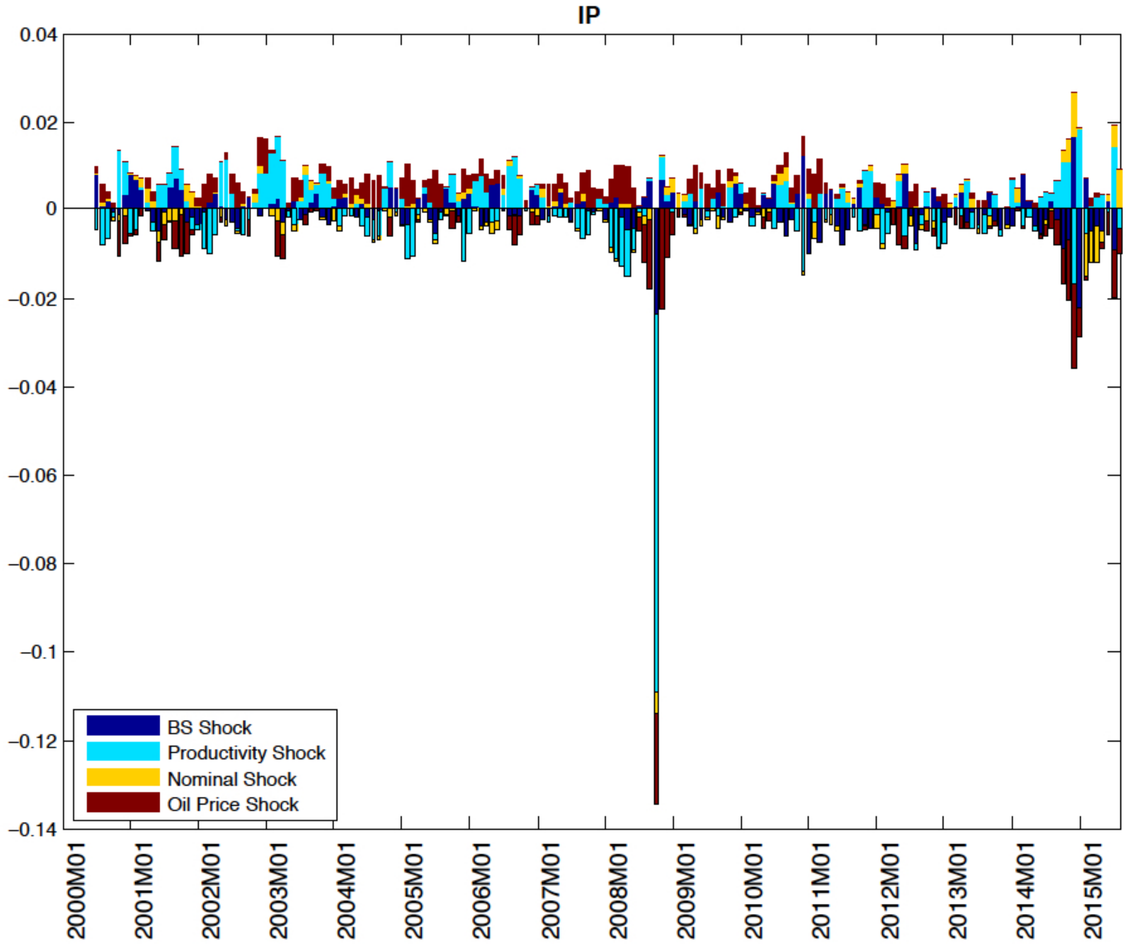


Figure 7. Industrial production decomposition

As far as cpi is concerned, we could conclude that its dynamics was mainly defined by nominal shocks (Figure 8). Especially interesting is substantial escalating impact in 2014. Not tight enough monetary policy resulted into not only ruble inflation in foreign goods' prices but also in domestic products inflation due to having exchange rate under its equilibrium level.

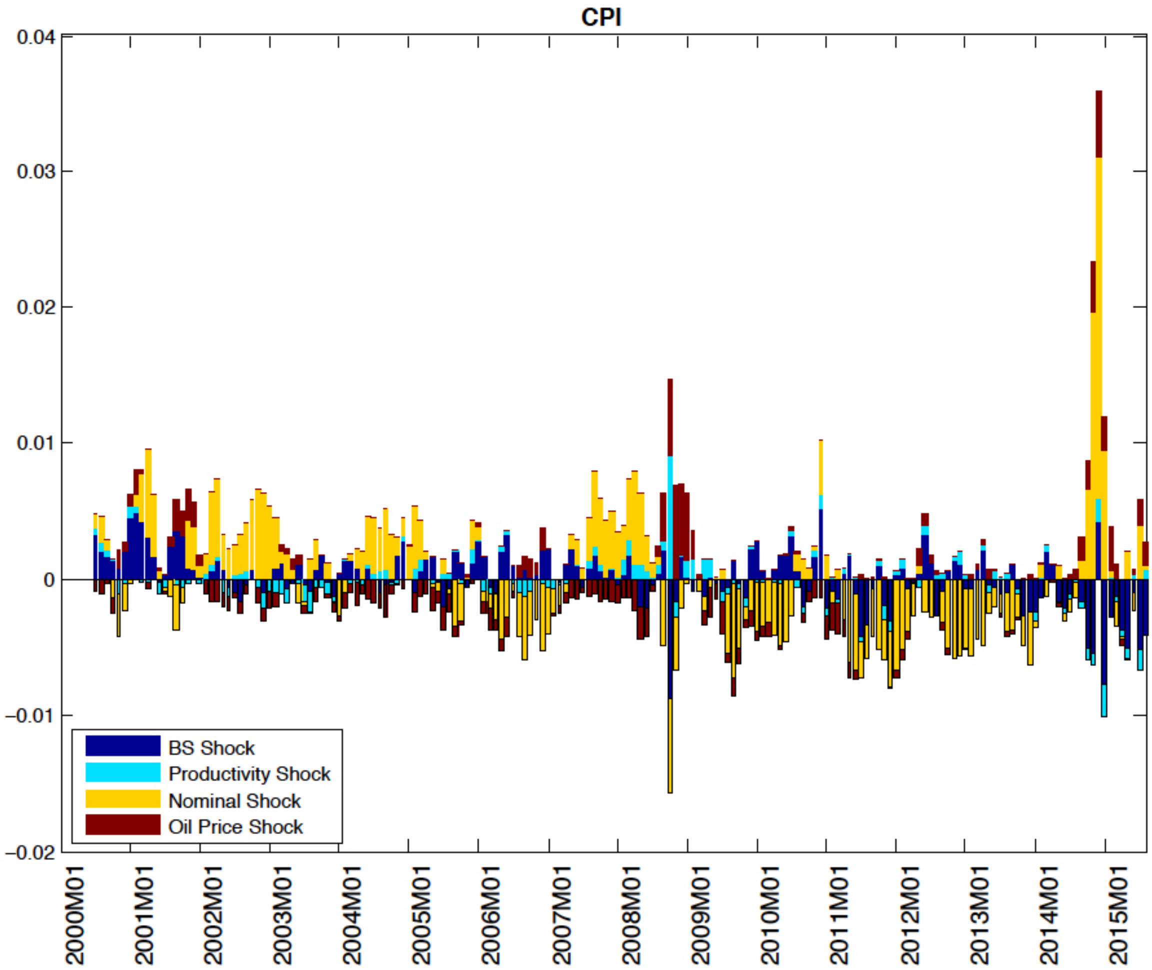


Figure 8. CPI decomposition

4 Conclusion

This study is on the influence of external and internal shocks on main macroeconomic variables in Russia which is a small open oil-exporting economy. We use the scheme with long run restriction and exogenous oil price to identify two types of productivity shocks, nominal shock and oil price shock. The distinguishing feature of this article is the separation of Balassa-Samuelson type productivity shock in tradable sector only from general productivity shock. Contrary to some other studies, we found that Balassa-Samuelson effect was not the main source of economic growth in an oil-exporting small open developing economy as Russia in the last fifteen years. This effect was crucial only during the last two years due to economic sanctions against Russia.

We also found some evidence that not tightening monetary policy in time in the second half of 2014 led to a nominal shock that negatively affected the dynamics of real exchange rate. We also found that permanent industrial production movements were mainly due to productivity and oil price shocks. Nominal shocks were the main driver of consumer price index dynamics but substantial oil price shocks also affected it.

Based on these findings, we could conclude that Russian economy is highly vulnerable to external shocks but after switching to floating exchange rate regime in 2014, nominal shock also became an important source of macroeconomic dynamics.

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