How factors of real exchange rate dynamics affect real GDP in Russia: SVARX approach

Andrey Polbin[a,b], Anton Skrobotov[a] and Andrey Zubarev[a]

[a] Russian Presidential Academy of National Economy and Public Administration

[b] Gaidar Institute for Economic Policy

February 10, 2017

CONFERENCE DRAFT PAPER – PLEASE DO NOT CITE OR CIRCULATE WITHOUT THE AUTHORS' PERMISSION

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. In our framework specific Balassa-Samuelson-type productivity shock differs from general productivity shock in its ability to affect real exchange rate in the long run. We found that significant part of real exchange rate movements was due to Balassa-Samuelson shock which also affected real GDP dynamics. Oil price dynamics was the most important source of real GDP and real exchange rate fluctuations which speaks in favour 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.

In recent years there is an active debate about the influence of real exchange rate dynamics on output. In Russian economic literature this issue along with determinants of real exchange rate dynamics were discussed in Gurvich et al. (2008), Zubarev and Trunin (2014), Polterovich et al. (2016) and Sosunov and Ushakon (2009). Real exchange rate movements may arise due to Balassa-Samuelson effect (see Balassa (1964), Samuelson (1964)) that is often observed in developing countries. Specifically, productivity growth in tradable sector is a very important source of economic growth and real exchange rate appreciation. In particular, there is also evidence for the Russian economy 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. The drawback of this result is that authors didn't take into account multicollinearity that stems from high correlation between productivity differential (used as a proxy for Balassa-Samuelson effect) and terms of trade. This makes coefficient estimates to be biased and invalid. In our paper, we make an attempt to specify this Balassa-Samuelson-type productivity shock separately from general productivity growth (in both tradable and nontradable sectors simultaneously) taking into account terms of trade in order to check its importance for Russian economy.

In this paper, we use SVARX approach to analyse the influence of factors that determine real exchange rate dynamics on output in Russian economy. 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. Polbin and Skrobotov (2016) considered cointegration between oil price dynamics and GDP. 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.

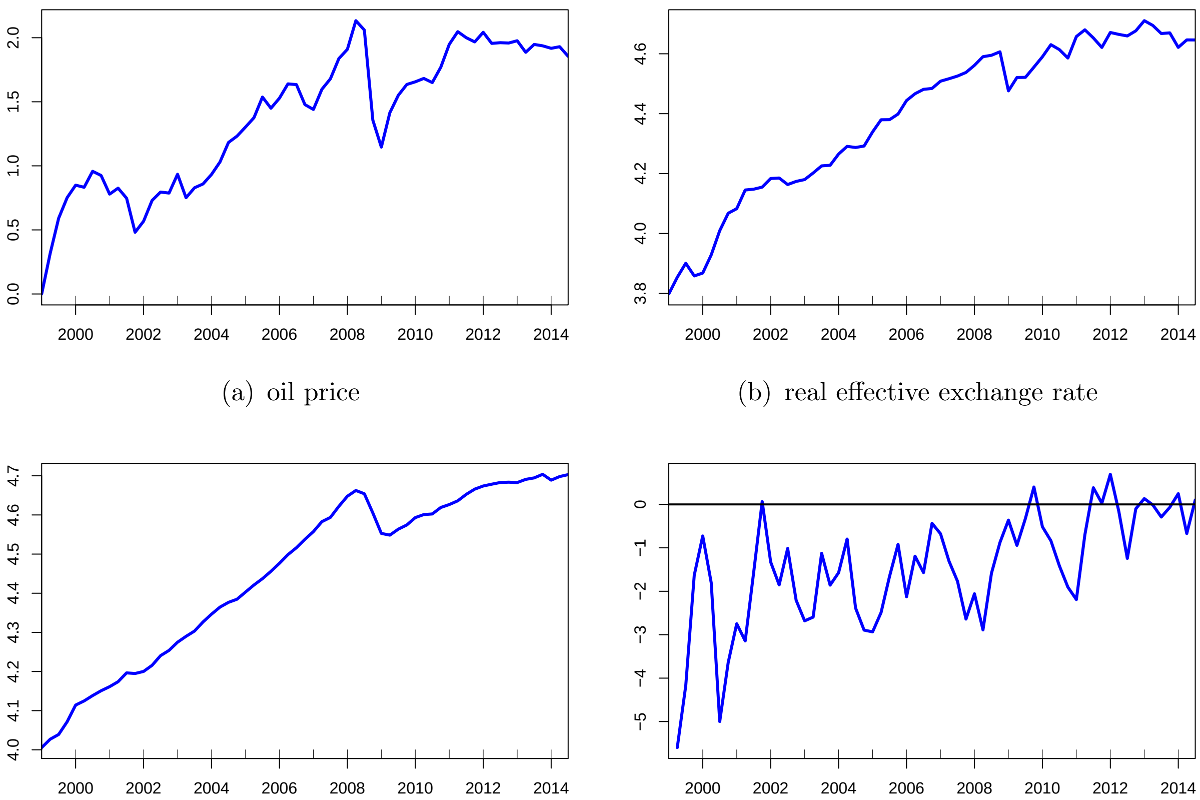
Rafiq (2011) uses combination of short and long run restriction to find sources or macroeconomic fluctuation in several oil-exporting countries. His specification takes into account possible Balassa-Samuelson effect. Results of the coinetgrated VAR model for developed countries proposed by Alexius (2005) 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. Specifically, we put most attention on shocks that affect real exchange rate dynamics and lead to real GDP movements. 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 estimation results that describe macroeconomic fluctuations in Russia with the impulse response estimates and historical decomposition from the SVARX model. Section 4 concludes.

2 Description of data and Unit Root Analysis

In this study, we use quarterly data taken from IFS and Rosstat for the following variables: real price of oil, real GDP, real effective exchange rate and real interest rate.[1] All variables that we consider are provided in Figure 1 (all variables are in logs except for real interest rate). Real GDP was seasonally adjusted (with x-13) while the other series were not. The considered period is from 1999Q1 to 2014Q3. It starts after the default of 1998 and ends right before the monetary regime change that has potentially great influence in cross-correlation properties of macroeconomic variables. According to Lucas critique (Lucas, 1976) parameters of our VAR model will change due to structural change of monetary policy.



(a) oil price

(b) real effective exchange rate

(c) real GDP

(d) real interest rate

Figure 1: Variables used for model estimation.

At first we would like to discuss the strategy for unit root hypothesis testing. We consider four tests that are most popular in empirical applications: $ADF\text{-}GLS^{\mu}$, $ADF\text{-}GLS^{\tau}$, $ADF\text{-}OLS^{\mu}$ and $ADF\text{-}OLS^{\tau}$. OLS-based tests are effective under large initial condition, while GLS-based tests are effective under small initial conditions (see Harvey et al. (2009)). The superscript μ denotes that only intercept is included in the ADF-regression, the superscript τ denotes that intercept and

[1] Real price of oil derived from nominal price of oil and US CPI, real interest rate derived from Moscow interbank interest rate and CPI. US and Russian CPI were seasonally adjusted.

trend are included in the ADF-regression. The lag length is selected according to BIC.

The results are presented in Table 1. For real effective exchange rate and GDP all tests fail to reject the unit root null hypothesis even at 10% significance level. The unit root null hypothesis is rejected for real interest rate at 1% significance level by $ADF\text{-}OLS^{\mu}$ and at 5% significance level by $ADF\text{-}GLS^{\mu}$. We also present test statistics $ADF\text{-}GLS^{\tau}$ and $ADF\text{-}OLS^{\tau}$ for completeness but there is no reason to assume the presence of a trend in real interest rate dynamics. As far as real oil price is concerned we can treat it as a random walk following Alquist et al. (2013).

Table 1: Unit root tests

	$ADF\text{-}OLS^{\mu}$	$ADF\text{-}OLS^{\tau}$	$ADF\text{-}GLS^{\mu}$	$ADF\text{-}GLS^{\tau}$
reer	-2.55	0.48	-1.58	-1.10
gdp	-2.11	0.18	-1.92	-1.60
rate	-4.26***	-1.47	-5.38**	-3.67***

We also tested for cointegration rank between three non-stationary series by the bootstrap test proposed by Cavaliere et al. (2010) and we didn't find any evidence of cointegration amongst these series.

3 Full VAR Analysis

In the previous section, we showed that we can treat three series as difference stationary (I(1)) without cointegration between them and real interest rate should be treated as a stationary process. Therefore, it makes sense to include three non-stationary variables in structural VAR model in first differences.

SVARX model is estimated with the help of special VAR toolbox in Matlab.[2] AIC chooses the specification with three lags of considered variables while BIC chooses one lag only. The overestimation of the lag order is not a serious problem comparing to underestimation therefore we consider results of the estimated SVARX model with three lags of endogenous and exogenous variables.

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 Blachard and Quah (1989) and Mehrara and Oskoui (2007) setting long run restrictions, but we treat oil price (Poil) as fully exogenous variable. The ordering of endogenous variables is as follows: log

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

of real effective exchange rate of rouble (REER), log of real GDP (GDP) and real interest rate (RATE). 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 above, all the variables except for real interest rate are included in the model in first differences, so the vector of stationary variables is $(\Delta REER, \Delta GDP, RATE, \Delta Poil)$.

The logic for definition of the shocks is as follows. Nominal shock does not affect real variables such as real effective exchange rate and output 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 the 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 output and real interest rate). Unlike the cited articles, we identify these two types of productivity shocks what 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.

To make results more transparent, hereinafter we use accumulated impulse response functions for real exchange rate and real GDP. Let's consider Balassa-Samuelson-type productivity shock in Figure 2 where 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 output and appreciation of real exchange rate in the long run. That is why we decided to define this shock as a Balassa-Samuelson-type one. Fall of real interest rate in the shot run stems from inflation increase mentioned above.

We treat general productivity shock as an equal productivity shock in tradable and non-tradable production sectors which leads to same productivity shock for the whole economy. Impulse response functions to this shock are presented in

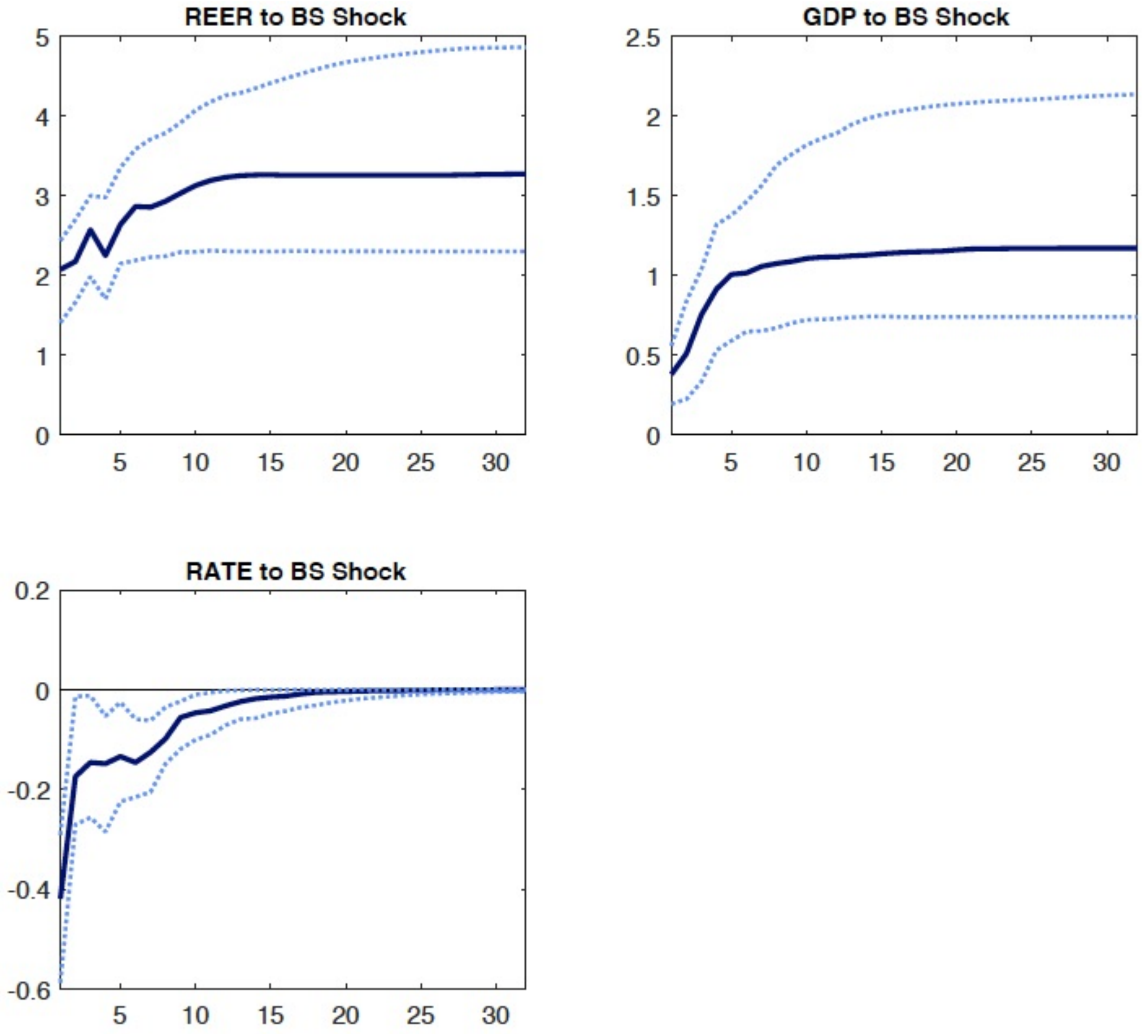


Figure 2: Balassa-Samuelson-type shock

Figure 3. According to the plot, this shock leads to permanent increase in output 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). Real interest rate increase in the short run is in line with inflation decline. The following temporary negative reaction may stem from inertia in wage adjustment which put some pressure on prices.

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. Tightening of the monetary policy results in

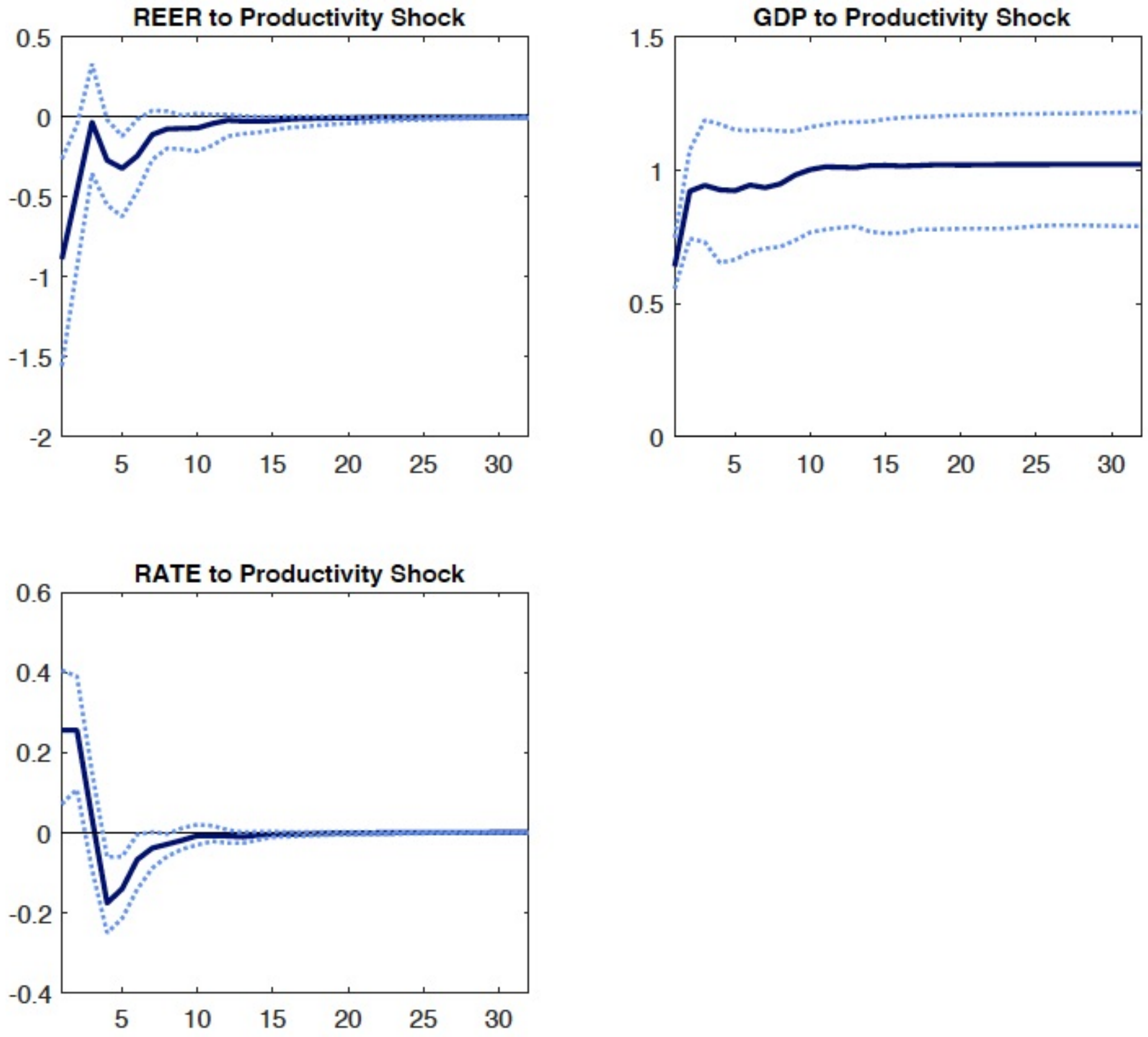


Figure 3: Productivity shock

simultaneous real exchange rate appreciation and decline in consumer price index which leads to increase of real interest rate. This stems from the appreciation of the nominal exchange rate, which translates into an decrease in the price of imported goods. Real GDP reaction to nominal shock is statistically insignificant.

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 wealth transfer and dollar inflow to Russian economy which leads to real exchange appreciation and decline in real interest rate through price level appreciation. During the long period of quasi-fixed exchange rate regime in Russia positive wealth transfer led to shift of aggregate demand which put some pressure on price level.

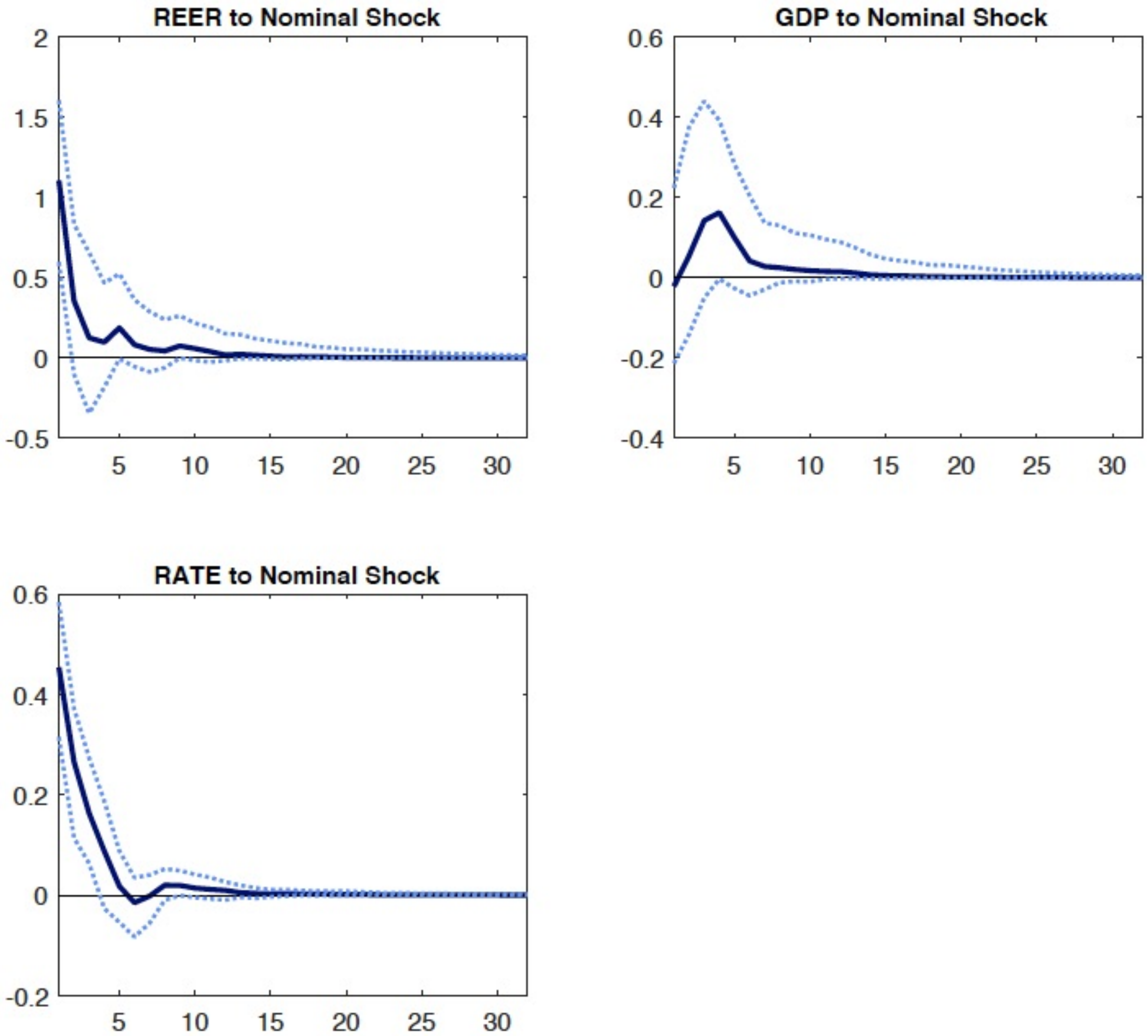


Figure 4: Nominal shock

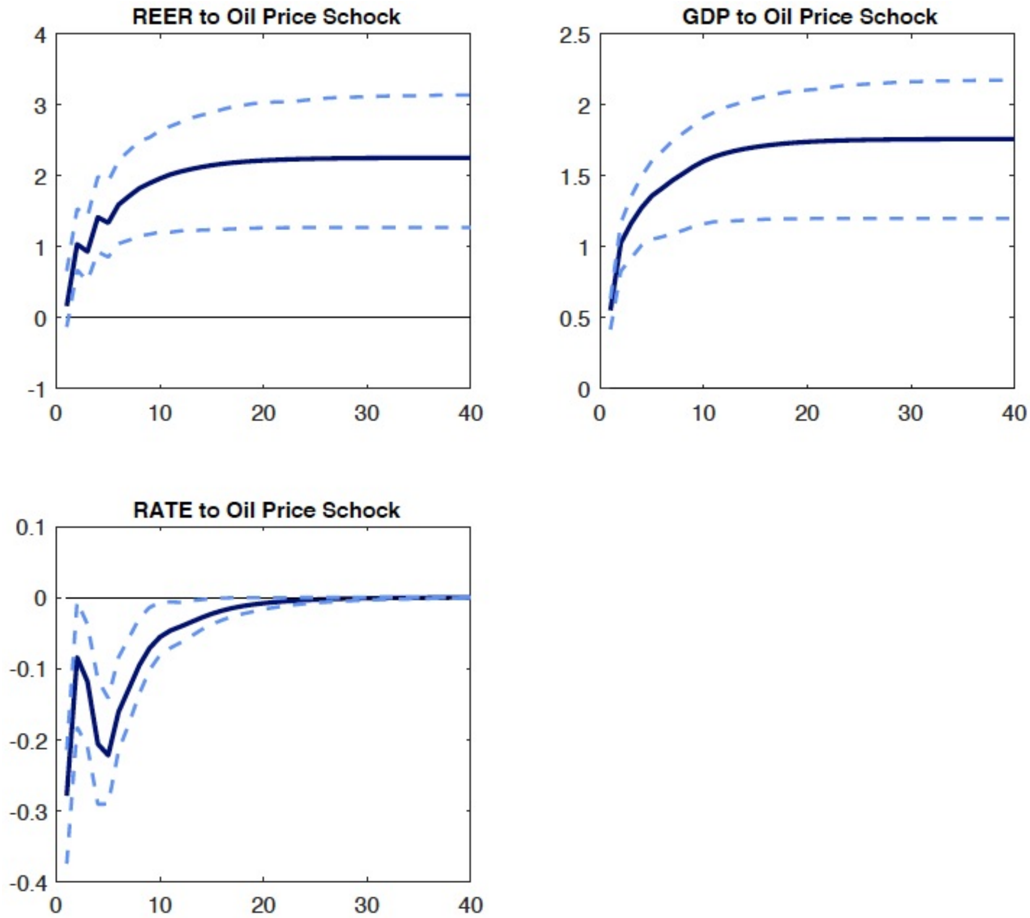


Figure 5: Oil price shock

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 to check the quality of the model comparing decomposition of each variable with the situation in the macroeconomic environment in Russia in the considered period. To be more clear and precise in interpreting the results we employ accumulated historical decomposition for output and real similar 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 of the considered 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 not only to non-tradable sector but also to world economy growth rate. Then from 2004 to 2008 we can see substantial contribution of growing oil price to real exchange rate appreciation in Russia. This led to overheating of the economy right before the world financial crisis of 2008–2009. We can observe not only strong negative contribution of oil price shock, which is quite intuitive, but also negative influence of Balassa-Samuelson shock during that crisis. This could happen due to temporal decline in world demand that led to production slowdown with constant employment in Russia (which artificially translated into decline in productivity). Then, after 2010 we can observe gradual decrease of accumulated contribution of Balassa-Samuelson-type shock. This corresponds to slowdown of Russian economy growth rate (this rate was also small comparing to the world economy growth rate). Starting from the beginning of 2014, Russia has been suffering from economic sanctions so strong negative Balassa-Samuelson effect happened due to the lack of technology and imported intermediate goods used as an input for production.

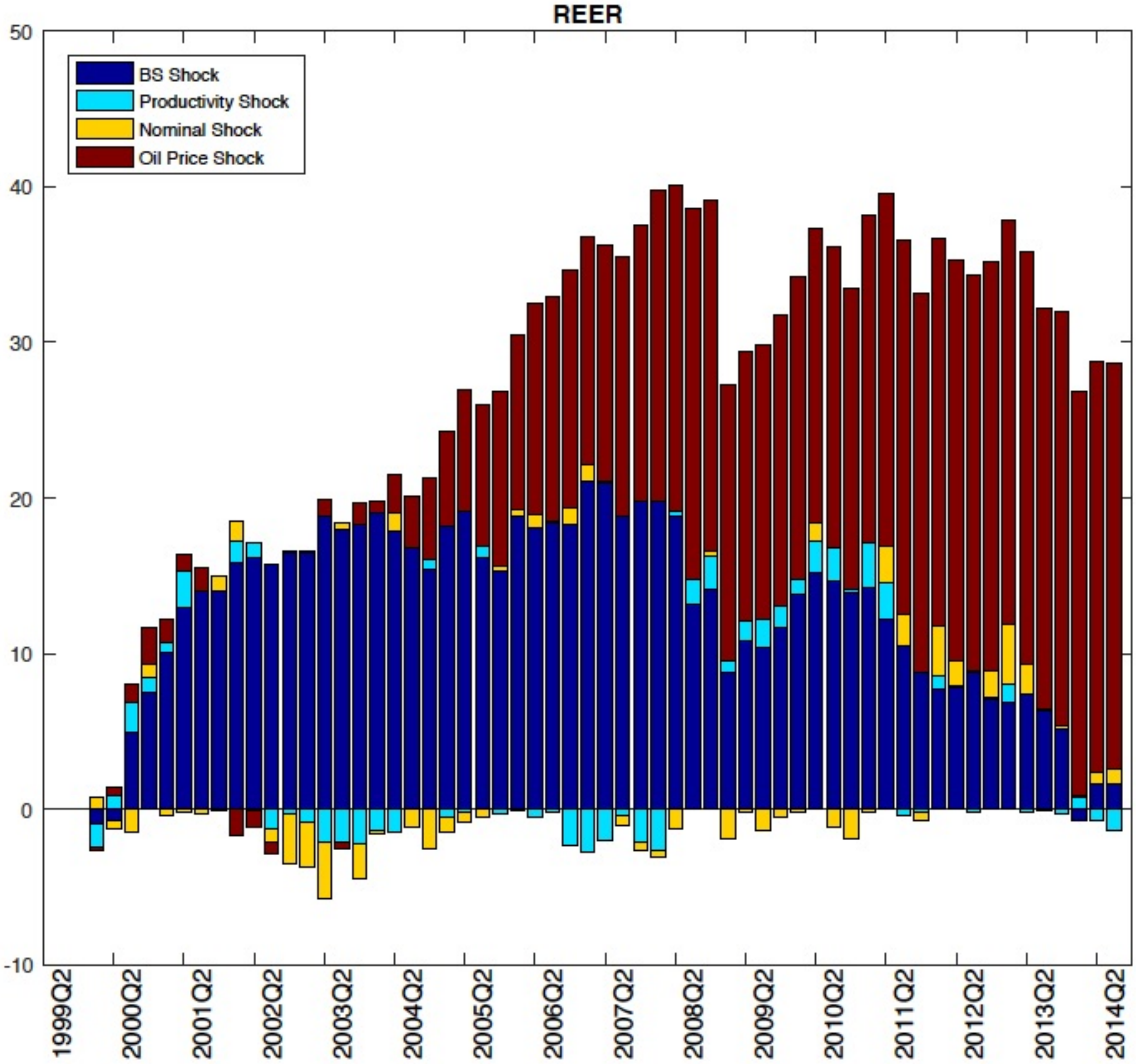


Figure 6: Real exchange rate decomposition

In the Figure 7 that presents historical decomposition of real GDP, we can see that the pattern of shocks' contribution is similar to that of real exchange rate. Balassa-Samuelson-type shock had the strongest influence in the beginning and in the end of the considered period (the latter one corresponds to introduction of economic sanctions against Russia). Oil price shocks were mostly important for output dynamics in Russian economy. The main difference with real exchange decomposition is the substantial contribution of general productivity growth to output dynamics during the overheating period right before the world financial crisis of 2008. Finally, we can say that significant part of real GDP variation (and real exchange rate variation) accounts for Balassa-Samuelson effect which is in line with Gurvich et al. (2008).

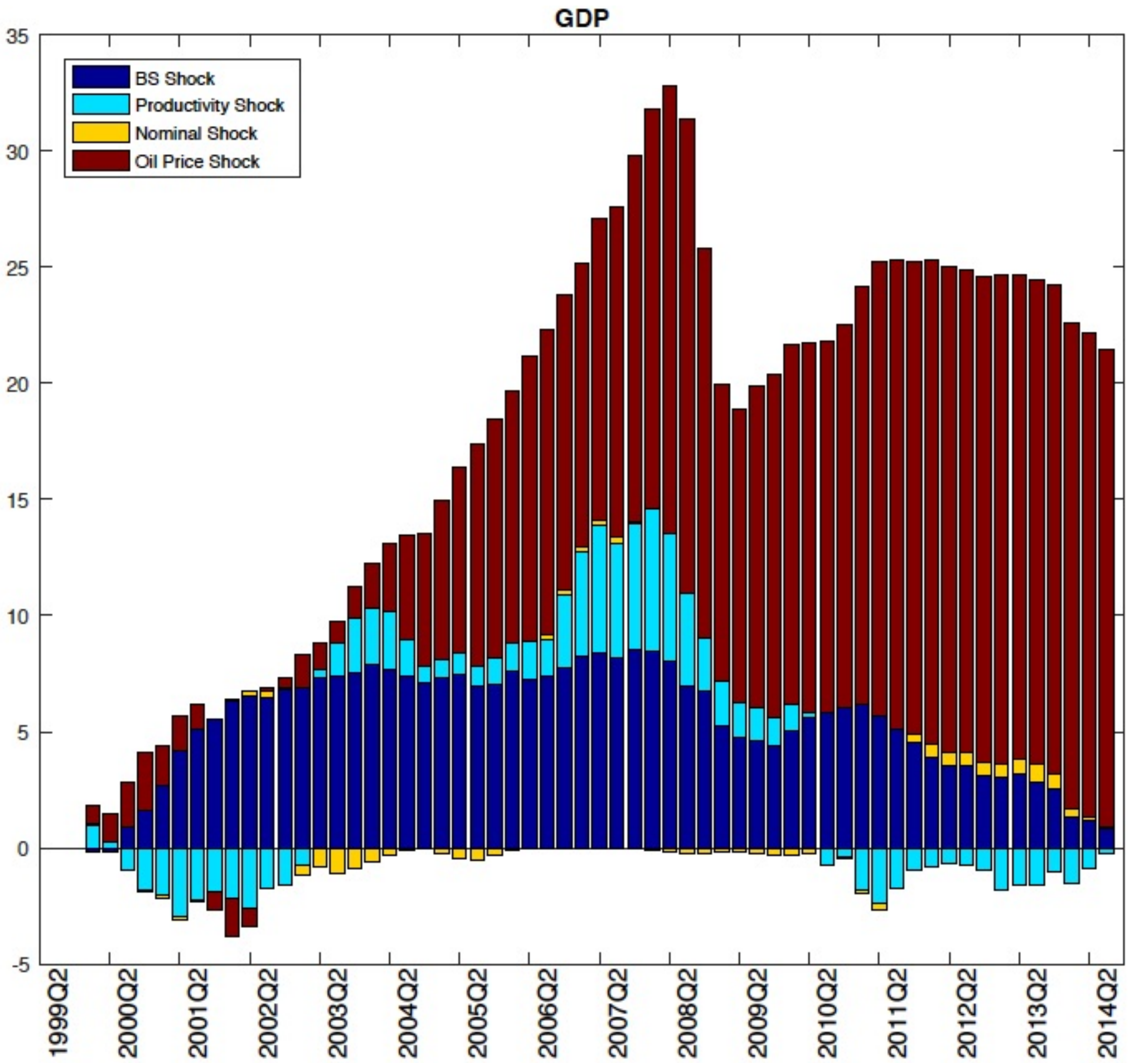


Figure 7: Industrial production decomposition

As far as real interest rate is concerned, we could conclude that its dynamics was mainly defined by nominal shocks and oil price shocks (see Figure 8 where non-accumulated historical decomposition is depicted). Oil price growth during the period 2004–2008 increased aggregate demand and hence put some escalating pressure on inflation which led to negative impact of oil price shocks on real interest rate. Balassa-Samuelson-type shocks also increased inflation during recovery growth in 2000-2003 which led to lowering of real interest rate.

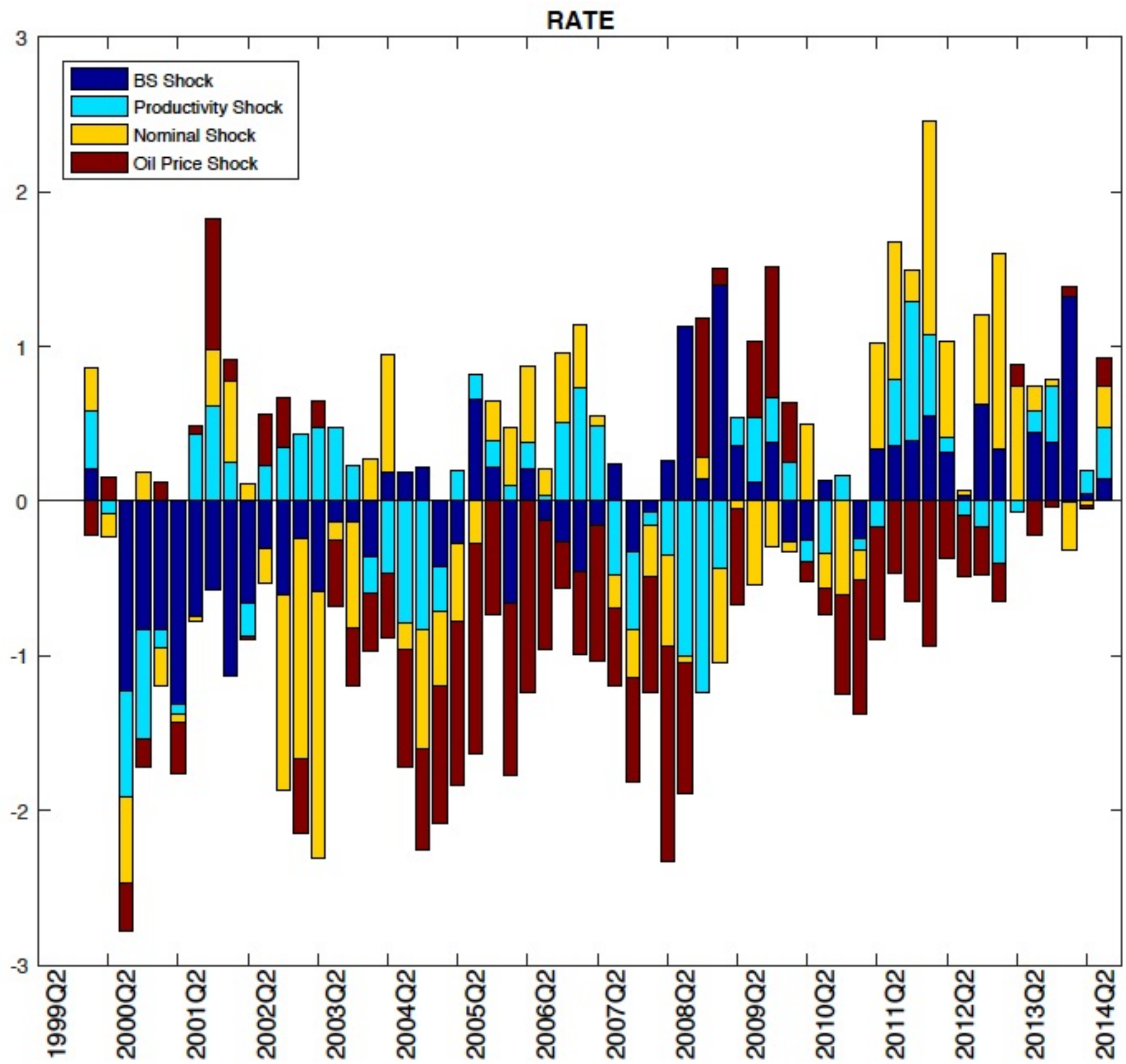


Figure 8: CPI decomposition

4 Conclusion

This study is on the influence of factors that determine real exchange rate dynamics on output 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.

We found that output movements were mainly due to oil price shocks. We found that significant part of output and real exchange rate dynamics in Russia in the period 1999—2014 accounts for Balassa-Samuelson effect but this effect was crucial only during the recovery growth in 2000—2003 and slowdown after 2010. General productivity shocks were also important for output dynamics. Real interest rate dynamics accounts for nominal shocks but substantial oil price shocks along with Balassa-Samuelson-type shocks also affected it.

References

Alexius, A. (2005). Productivity shocks and real exchange rates. *Journal of Monetary Economics*, 52(3):555–566.

Alquist, R., Kilian, L., and Vigfusson, R. J. (2013). Forecasting the price of oil. *Handbook of economic forecasting*, 2:427–507.

Balassa, B. (1964). The purchasing-power parity doctrine: a reappraisal. *The Journal of Political Economy*, pages 584–596.

Bjørnland, H. C. (1998). Economic fluctuations in a small open economy–real versus nominal shocks.

Blachard, O. and Quah, D. (1989). The dynamic effects of aggregate supply and demand shocks. *American Economic Review*, 79(4):655–673.

Blanchard, O. J. and Gali, J. (2007). The macroeconomic effects of oil shocks: Why are the 2000s so different from the 1970s? Technical report, National Bureau of Economic Research.

Cavaliere, G., Rahbek, A., and Taylor, A. M. R. (2010). Testing for co-integration in vector autoregressions with non-stationary volatility. *Journal of Econometrics*, 158:7–24.

Clarida, R. and Gali, J. (1994). Sources of real exchange-rate fluctuations: How important are nominal shocks? In *Carnegie-Rochester conference series on public policy*, volume 41, pages 1–56. Elsevier.

Esfahani, H. S., Mohaddes, K., and Pesaran, M. H. (2013). Oil exports and the iranian economy. *The quarterly review of economics and finance*, 53(3):221–237.

Farzanegan, M. R. and Markwardt, G. (2009). The effects of oil price shocks on the iranian economy. *Energy Economics*, 31(1):134–151.

Gurvich, E., Sokolov, V., and Ulukaev, A. (2008). Estimate of balassa-samuelson effect contribution to the real exchange rate dynamics. *Voprosy Ekonomiki*, 7:12–30.

Harvey, D., Leybourne, S., and Taylor, A. (2009). Unit Root Testing in Practice: Dealing with Uncertainty over the Trend and Initial Condition (with Commentaries and Rejoinder). *Econometric Theory*, 25:587–667.

Huang, Y. and Feng, G. (2007). The role of oil price shocks on china's real exchange rate. *China Economic Review*, 18(4):403–416.

Iwayemi, A. and Fowowe, B. (2011). Impact of oil price shocks on selected macroeconomic variables in nigeria. *Energy policy*, 39(2):603–612.

Korhonen, I. and Ledyaeva, S. (2010). Trade linkages and macroeconomic effects of the price of oil. *Energy Economics*, 32(4):848–856.

Lucas, R. E. (1976). Econometric policy evaluation: A critique. In *Carnegie-Rochester conference series on public policy*, volume 1, pages 19–46. Elsevier.

Mehrara, M. and Oskoui, K. N. (2007). The sources of macroeconomic fluctuations in oil exporting countries: A comparative study. *Economic Modelling*, 24(3):365–379.

Omojolaibi, J. A. (2013). Does volatility in crude oil price precipitate macroeconomic performance in nigeria? *International Journal of Energy Economics and Policy*, 3(2):143–152.

Peersman, G. (2005). What caused the early millennium slowdown? evidence based on vector autoregressions. *Journal of Applied Econometrics*, 20(2):185–207.

Polbin, A. and Skrobotov, A. (2016). Testing for structural breaks in the long-run growth rate of the russian economy. *HSE Economic Journal*, 20(4):588—623.

Polterovich, V., Popov, V., et al. (2016). Exchange rate, inflation and industrial policy. *Journal of the New Economic Association*, 29(1):192–198.

Rafiq, M. S. (2011). Sources of economic fluctuations in oil-exporting economies: implications for choice of exchange rate regimes. *International Journal of Finance & Economics*, 16(1):70–91.

Sameti, M. and Teimouri, B. (2012). A long run structural macroeconometric model for iran. *Iranian Journal of Economic Research*, 17(50):99–137.

Samuelson, P. A. (1964). Theoretical notes on trade problems. *The Review of Economics and Statistics*, pages 145–154.

Sims, C. A. and Zha, T. (1999). Error bands for impulse responses. *Econometrica*, 67(5):1113–1155.

Sosunov, K. and Ushakon, N. (2009). Determination of the real exchange rate of the ruble and assessment of long run policy of real exchange rate targeting. *Journal of New Economic Association*, (3-4):97–122.

Tang, W., Wu, L., and Zhang, Z. (2010). Oil price shocks and their short-and long-term effects on the chinese economy. *Energy Economics*, 32:S3–S14.

Wang, Y., Wu, C., and Yang, L. (2013). Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. *Journal of Comparative Economics*, 41(4):1220–1239.

Zubarev, A. and Trunin, P. (2014). Effect of the ruble exchange rate on russia's economic activity. *Studies on Russian Economic Development*, 25(2):176–183.