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**IMPACT OF WORLD OIL PRICES ON
AN ENERGY EXPORTING ECONOMY
INCLUDING MONETARY POLICY**

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Abstract

This research investigates the interrelationship between the main macroeconomic indicators of an oil exporting country and world oil prices using a vector autoregressive (VAR) approach. We focus on an economy, which is a non-OPEC oil exporter and its oil revenues account for a significant proportion of the country's total export and budget revenues. We explain the oil price transition mechanisms to this economy from the export side and through the fiscal channel taking into account the monetary policy factor. The results suggest that oil price fluctuations have a significant impact on the oil exporting country's real GDP, CPI inflation rate, interest rate, and exchange rate. Moreover, to estimate monetary policy rule for this energy exporter, we test the Taylor equation and associated Taylor rule, including the oil prices gap, since the latter may have a significant impact on the key policy rate. The evidence suggests that the Taylor rule describes the post-financial crisis monetary policy of this economy relatively well. Finally, we discuss future research and lessons from this economy for monetary policy makers.

Contents

1. INTRODUCTION

Following the first oil price shock of 1973, energy prices volatility and its impact on the macro-economy have become an important area of research in the field of economics. The second oil shock of 1979 caused by the cut in oil supply highlighted once again the significance of immediate energy price change. Hamilton (1983) was one of the first scholars, who showed the importance of the energy price changes to the U.S. economy when he concluded that oil price increases had contributed to some of the U.S. recessions during the period 1948-1972. The interest in oil price fluctuations and their role in the macro-economy was renewed again due to a sharp increase in oil price in early 2000 and immediate drop in 2008 caused by the Lehman crisis (Hamilton 2009; Yoshino and Taghizadeh-Hesary 2014a). Research done by Peersman and Van Robays (2012) and Taghizadeh-Hesary et al. (2016) identified economies that benefited and lost after the recent oil price shock. Aydoğan et al. (2017) assess the relationship between oil prices and stock markets and show that the correlation between these varies according to whether the country is an oil-exporter or an oil-importer.

Generally, oil price fluctuations significantly affect oil importers' production costs and, therefore, price levels, while in energy exporting countries oil price movements mainly affect energy export revenues and government budget revenues. Nevertheless, it was widely accepted that energy price volatility is not only an important cause of macro-economic fluctuations, but also affects the fiscal and monetary policy of different economies. In this paper, we are going to estimate the effects of oil price changes on the economy of an energy exporting country.

This paper aims to estimate the impact of oil price volatility on one of the largest oil exporting countries, complementing the existing literature in several ways. First, we provide a brief overview of oil price transition mechanisms to the economy of an oil exporting country, secondly, we explain about the world oil market. As a next stage, we develop a macro-economic model for an energy exporting country and estimate it using a VAR approach. We also have conducted a breakpoint test, in order to check the stability of our time series. Finally, the data sample was divided into two sub-samples and estimated for both periods separately. It provides us with an insight on how the impact of oil price fluctuations has changed in the long run. Moreover, we incorporated a monetary variable into the model, since we believe that the macro-economy of the energy exporting country is affected by oil prices through the monetary policy channel. At the end of this paper, we analyze the monetary policy rule for an energy exporting country. In conclusion, we discuss the lessons that can be drawn from this energy exporting country. The analysis we conducted could be further applied to other non-OPEC[1] oil exporting countries, as well as gas exporting economies (such as Azerbaijan, Kazakhstan, Indonesia, and others).

The rest of this paper is structured as follows: in the next section, we provide an explanation of the oil price transition mechanisms and a brief overview of the world oil market. In the third section, we provide a VAR methodology and data description. In the fourth section, we provide the Impulse Response Functions (IRF), variance decomposition and monetary policy rule analysis. In the last section, we summarize our results and conclude the paper.

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[1] Organization of the Petroleum Exporting Countries, an inter-governmental organization of 14 members: Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela as in October, 2017.

2. RESEARCH BACKGROUND

2.1 Oil Price Transition Mechanisms

Generally, oil prices transmit to the economy of an energy exporting country through the fiscal channel and export channel, as is shown in the figure below. Whenever oil prices experience an increase, an oil exporting country enjoys larger capital inflows in the form of foreign currency, which leads to domestic exchange rate appreciation. Domestic exchange rate appreciation causes a decline in the price of imported goods, which usually make up a large part of the total consumer goods of energy exporting countries. Therefore, with an oil price increase the general price level declines (deflation) and as monetary policy reaction, the interest rate declines as well (according to the Taylor rule).

The second channel is the fiscal or government budget channel. Since the export of energy resources is highly taxed, with an oil price increase the energy exporting country will have a fiscal surplus and increase in government spending, which eventually lead to an increase in GDP.

Figure 1: Transition Channels of Oil Prices to Oil Exporting Economy
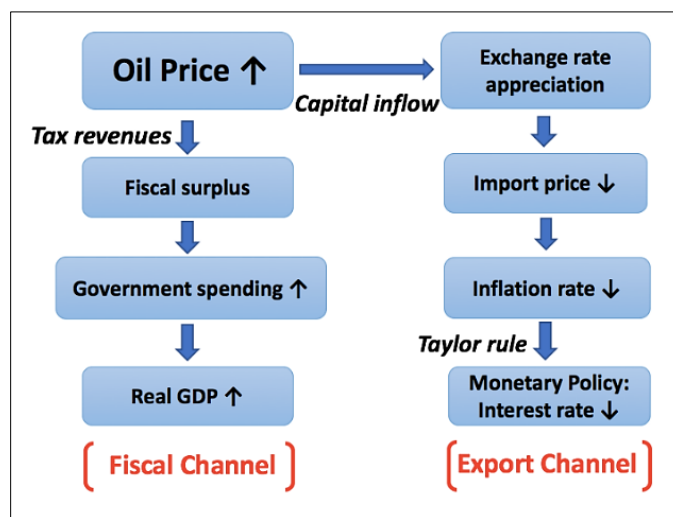
Source: Authors.

2.2 The World Oil Market

Crude oil is still the major energy source world-wide due to its high energy density and relatively easy extraction, transportation, and refining. In the modern history of energy prices, up until the mid-1990s, OPEC has played a significant role in oil pricing, therefore the market was affected purely by supply factors. However, since then, the power has moved to non-OPEC oil suppliers and notably oil-consumers. This mostly happened because of the rapid economic growth in Asia, especially in India and the People's Republic of China (PRC), which is associated with an increase in energy consumption, especially oil. Increased demand caused diversification of the supply side, and from the late-1990s OPEC was no longer the main oil exporter (Figure 2)[2].

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[2]   See more details on oil prices in Hamilton (2013) and Yoshino and Taghizadeh-Hesary (2016).

Figure 2: World Crude Oil Export, 1970–2012
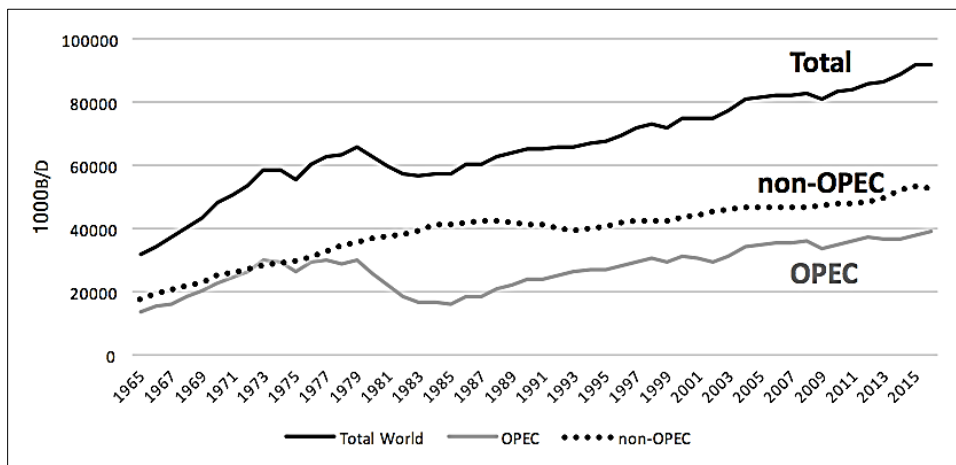
Data Source: Energy Statistics Yearbook (UN) & Institute of Energy Economics, Japan (IEEJ).

As discussed in Yoshino and Alekhina (2016), for those energy exporting countries where oil accounts for a significant share of total export and crucially contributes to the government budget, there arises a risk of oil price volatility. The oil market is highly volatile compared to other commodities due to the fact that oil supply and demand have a low price elasticity, which makes the price of oil fluctuate widely. It therefore has a direct impact on the oil exporters' economies, as these depend on oil export revenues. The example in Figure 3 shows the relations between the nominal GDP of an energy exporting country and Brent crude oil prices.

Figure 3: Nominal GDP and Brent Crude Oil Price, 1993–2016
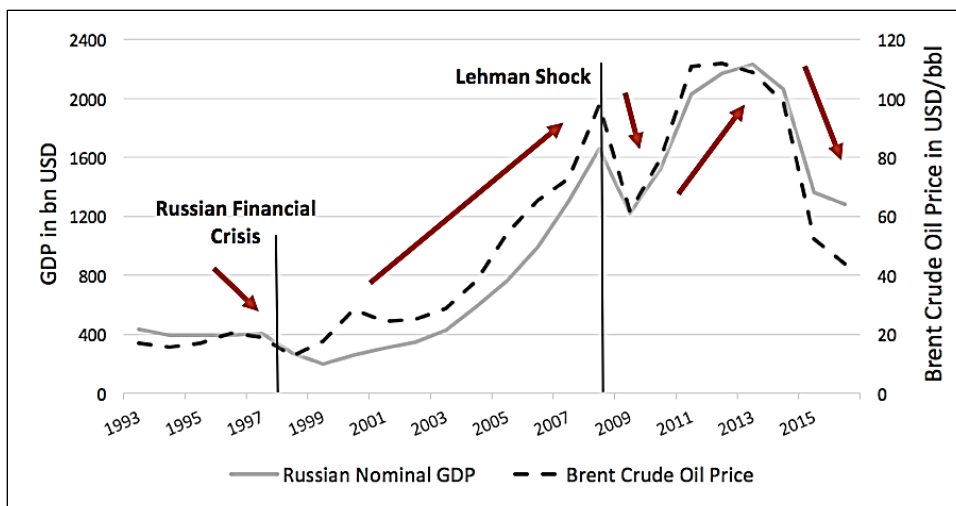
Data Source: Federal Reserve Economic Data (FRED).

Figure 4 shows major oil price trends and world main events associated with oil price fluctuations. We can see that the prices of three different oil grades are highly correlated and basically follow the same path.

Figure 4: OPEC Basket, Brent Crude, and Urals Oil Prices, 2000–2014
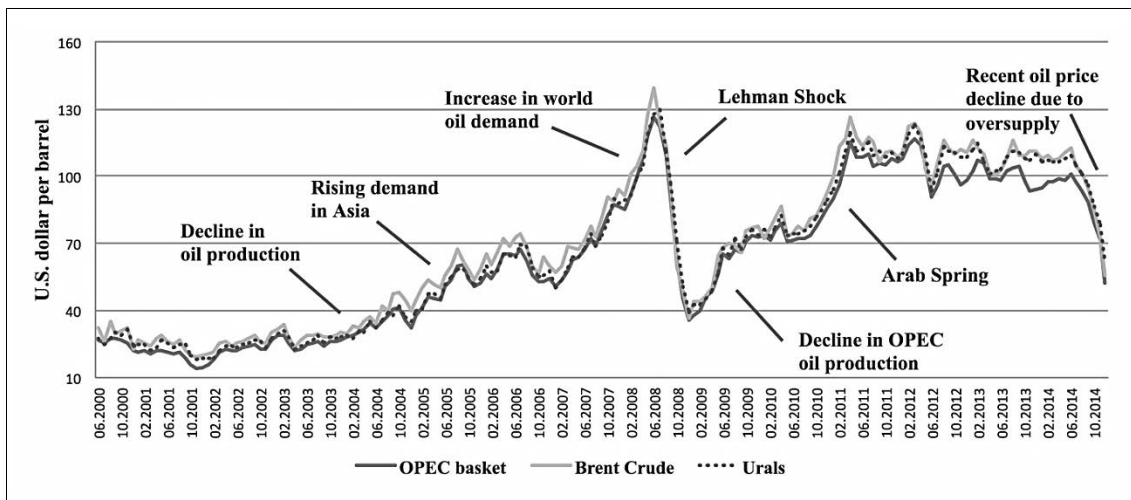
Data Source: US Energy Information Administration and Institute of Energy Economics, Japan (IEEJ).

As we mentioned in the previous section, one of the channels of oil price transition to the economy is the government budget. The extraction and export of natural resources is highly taxed; therefore, oil and gas revenues account for a significant part of the budget revenues. Figure 5 shows the general account budget revenues of an oil exporting country for the year 2015. Oil and gas extraction tax and export duties on oil and gas sum up to 45% of total revenues, making the share of income from natural resources the biggest in total budget revenues. Therefore, a decline in oil prices (Figure 4) may put severe pressure on the government budget and macro-economy of an energy exporting country.

Figure 5: General Account Budget Revenues for FY 2015
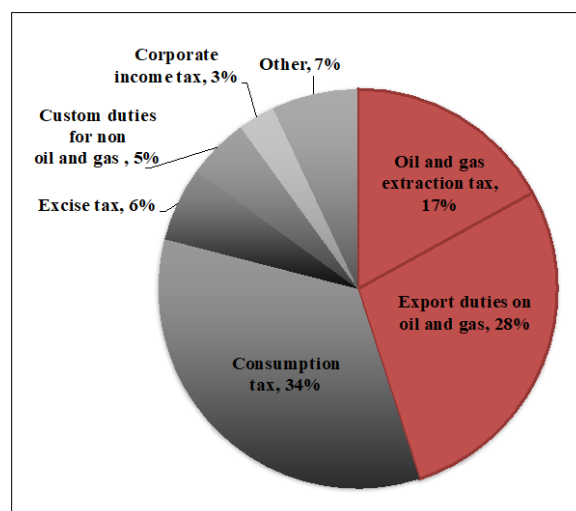
Data Source: Ministry of Finance of RF.

3. METHODOLOGY

3.1 VAR Model

In this section, we develop an econometric model to estimate the interrelationship between Brent Crude oil prices and the macroeconomic fundamentals such as real GDP growth rate, CPI inflation rate, exchange rate (against the U.S. dollar) and interest rate of the energy exporting country. To capture the goals of our research a structural VAR model was developed. Since the VAR model was introduced by Sims in 1980, it has become one of the most useful models in estimating the interrelationship and causality between variables. A number of studies have estimated the macroeconomic impacts of oil prices using a VAR approach pioneered by Hamilton (1983). More recent research has used this approach in order to investigate the determinants of real world oil prices (such as Kilian 2009). Ratti and Vespignani (2014) have estimated the interrelationships between oil price volatility and OPEC and non-OPEC oil production behavior using the VAR approach. Du et al. (2010) analyzed the impact of world oil prices on the PRC's economy using the method of multivariate vector auto regression. However, there are only a few studies that have estimated the relationship between oil price change and the macro-economy of non-OPEC oil exporting countries (for example Ito 2012; Mehrara and Mohaghegh 2011). In order to assess the abovementioned interrelationship between the world oil price volatility and the macroeconomic fundamentals of an economy, we consider a structural VAR model as follows:

$$B_o X_t = \beta + \sum_{i=1}^{j} B_i X_{t-i} + u_t \tag{1}$$

where $X_t = (X_{1t}, X_{2t} \dots X_{nt})$ is a $n \times 1$ vector of endogenous variables of the model, $\beta = (\beta_1, \beta_2 \dots \beta_n)$ is a $n \times 1$ vector of intercepts, B_i is a $n \times n$ coefficient matrix, X_{t-i} is the lag operator. j is the number of lags. And $u_t = (u_{1t}, u_{2t} \dots u_{nt})$ is a $n \times 1$ vector of uncorrelated structural innovations. In our empirical work, we will analyze a monthly structural VAR model. Our main objective is to estimate the impact of oil price shock on two main macroeconomic indicators, which are real GDP growth rate and CPI inflation rate. We also include the short-term interest rate and exchange rate in order to capture the indirect effect of oil price volatility on two main macroeconomic indicators through the monetary policy channel and trade channel respectively. Therefore, the vector X_t can be expressed as the following:

$$X_t = [\Delta \log(y_t), \pi_t, i_t, \Delta \log\left(e_t^{\overline{\frac{rub}{usd}}}\right), \Delta \log(p_t^{oil})] \tag{2}$$

where y_t, π_t, i_t, $e_t^{\overline{\frac{rub}{usd}}}$ and p_t^{oil} are for real GDP, CPI inflation rate, short term interest rate, Ruble to U.S. dollar exchange rate, and Brent Crude oil prices respectively (See Table 1).

3.2 Variables and Data Description

For our empirical analysis, we use a monthly data set, starting from January 1993 to December 2016, which gives us 288 observations for each variable. As we stated earlier, the economy became an independent country at the end of 1991 and most of the data is available from the year of 1993. A description of the variables is provided in

Table 1 below. Data for GDP is available on a monthly basis and is obtained from the Ministry of Finance and deflated to 2010. For the inflation rate, CPI inflation was used with the base year of 2010. For the monetary variable, the interest rate (Central Bank key rate) was used, data is obtained from the Central Bank. For the exchange rate, we considered the Ruble per U.S. dollar exchange rate, since oil trading operates mostly in U.S. dollars. Finally, for the world oil prices, we used Brent crude prices in U.S. dollars per barrel, FOB.

Table 1: Variables Description

Notation	Variable	Data
y_t	Real GDP	Real GDP in 2010 Rubles
π_t	Inflation rate	CPI inflation rate, base year is 2010
i_t	Short-term interest rate	Nominal short-term interest rate
$e_t^{\frac{rub}{usd}}$	Exchange rate	Ruble to U.S. dollar exchange rate
p_t^{oil}	Oil price	Price of Brent Crude Oil, FOB, USD/barrel

Note: Data for real GDP, CPI inflation rate, and oil prices are seasonally adjusted using the technique Census X-13.

Data Source: Central Bank, US Energy Information Administration, IMF International Financial Statistics, Ministry of Finance of RF.

The data used for all variables except the interest rate is in logarithmic growth rates, since we found that some variables in levels contain unit root (non-stationary). However, if we convert them to the first differences they become stationary at 1% level of significance.[3]

3.3 Structural Stability Test

In this section, we are going to identify a structural break in the data sample. As discussed in Yoshino and Alekhina (2016), from the early 2000s, the new government enacted a number of pro-growth reforms. The economy finally started to recover after the financial crisis of 1998. Moreover, world oil prices were tripling by the end of 1999 compared to previous years, which helped to achieve a significant export surplus and to raise government budget revenues. Until the end of 1999, oil prices were comparatively low, therefore the contribution of oil exports to GDP was relatively small. Since oil prices started to rapidly increase in the late 1990s, the reliance on energy export revenues and, therefore, vulnerability to oil price changes increased as well. The relationship between oil prices and the economy may have changed at the time of the sharp oil price increase, therefore we assume a structural break in 2000:1. To find whether the data sample contains any breakpoints, we have to carry out a structural stability test. We used the standard Chow test, proposed by Chow (1960), to check for structural breaks in variables between 1993:1 and 2016:12. The formula is as follows:

$$Chow = \frac{\left(RSS_p - (RSS_1 + RSS_2)\right)/k}{(RSS_1 + RSS_2)/(N_1 + N_2 - 2k)} \qquad (3)$$

Where RSS_p is a combined regression line, RSS_1 and RSS_2 are regression lines before and after the break respectively, N_1 and N_2 are respectively the number of observations before and after the break, k is the number of parameters in the equation.

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[3] Statistical tests results are available upon request.

Table 2: Chow Test for Structural Break in 2000:1

F-statistic	200.3758	Prob. F (5, 278)	0.0000
Log likelihood ratio	439.7471	Prob. Chi-Square (5)	0.0000
Wald Statistic	1001.879	Prob. Chi-Square (5)	0.0000

Source: Authors.

The results of the Chow test are presented in Table 2 and suggest that our data contains a structural break in 2000:1 with a significance level of 1%. Therefore, we could reject a null hypothesis that the data set we use is stable. Hence, we break our sample into two sub-samples: 1993:1–1999:12, which is a period of low oil prices, and 2000:1–2016:12, which is a period of relatively high oil prices.

4. EMPIRICAL RESULTS

4.1 Impulse Response Analysis

In this sub-section, we provide the results of the Impulse Response Functions (IRF) analysis, which was conducted to capture the dynamics of the structural VAR model. IRF provide us with the evidence of dynamic responses to the one-standard-deviation shock to the variable and its lagged value. The Cholesky decomposition technique was used for solving the system of linear equations of the model. To fulfill the dynamic impact of the shock, we estimated the responses of each variable to the structural innovation for the 20 months ahead.

We are going to focus on the results of the sub-period of 2000:1–2016:12, since we have found insignificant relationships between oil prices and macro variables in 1993:1–1999:12.[4] As we assumed, the economy was not affected by oil prices before 2000, since they were relatively low, and the economy was unresponsive to oil price changes. With the increase in oil prices from late 1999, the dependence and vulnerability to oil price movements increased, so the variables have showed significant responses to the oil price shock from 2000. The results of IRF analysis are presented in Figure 4, which shows the responses on real GDP growth rate, CPI inflation rate, interest rate, and exchange rate to one standard shock to Brent crude oil prices with two standard error bands.

The results of IRF analysis are in accordance with our assumptions and suggest that real GDP growth is positively affected by oil prices immediately after the shock and later, after 5 months. As we mentioned, oil accounts for a large part of exports, moreover, energy export revenues crucially contribute to the government budget. Therefore, total output is tightly and positively linked with oil prices. When oil prices experience a positive shock, the budget revenues and therefore investment opportunities increase which consequently stimulates output growth. On the other hand, the CPI inflation rate, interest rate, and exchange rate negatively respond to positive oil price shock as is clear in Figure 4. The mechanism for this can be explained by the trade channel through which the exchange rate is directly and immediately affected by oil prices. Since the price of oil on the international market is determined in U.S. dollars, an increase in oil prices positively affects foreign reserves, which then results in the appreciation of the domestic currency.

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[4]   All supplementary materials are available upon request.

**Figure 6: Responses of Macroeconomic Indicators to Positive Innovation
to Brent Crude Oil Price**
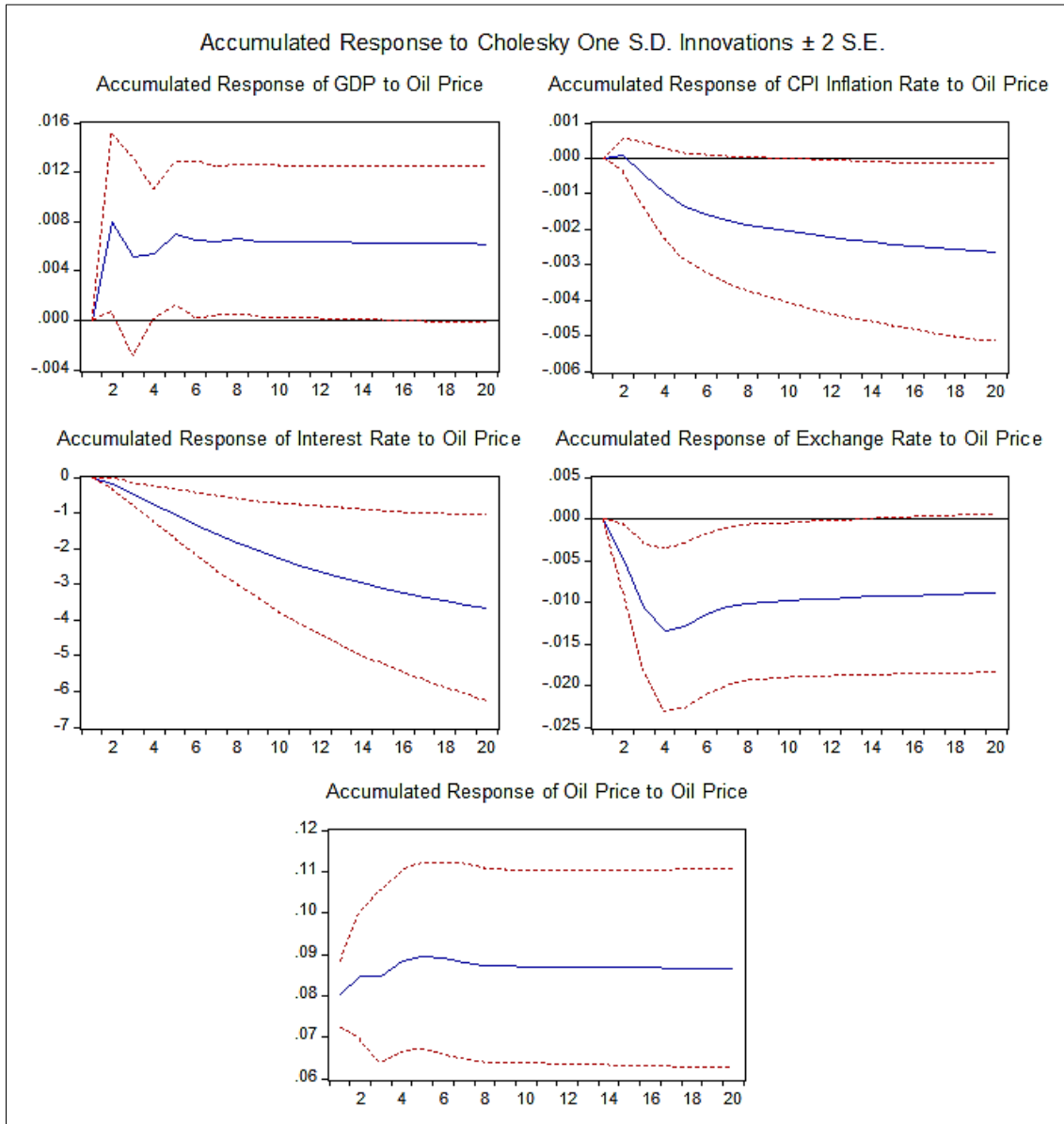
Note: Data is for the period of 2000:1 to 2016:12 in first differences of logarithmic form. Impulses for 20 months are presented.
Source: Authors' calculation.

For a large final goods importer, the exchange rate is crucial as it directly affects the economy through inflation and the interest rate channel. An improved exchange rate makes the import of consumer goods cheaper, therefore domestic inflation decreases. A large part of consumer goods of an oil exporting country is generally imported goods, therefore an increase in oil prices may negatively affect the inflation rate (Figure 10).

Figure 7: Oil Prices, Exchange Rate, and Import Price 1997–2014
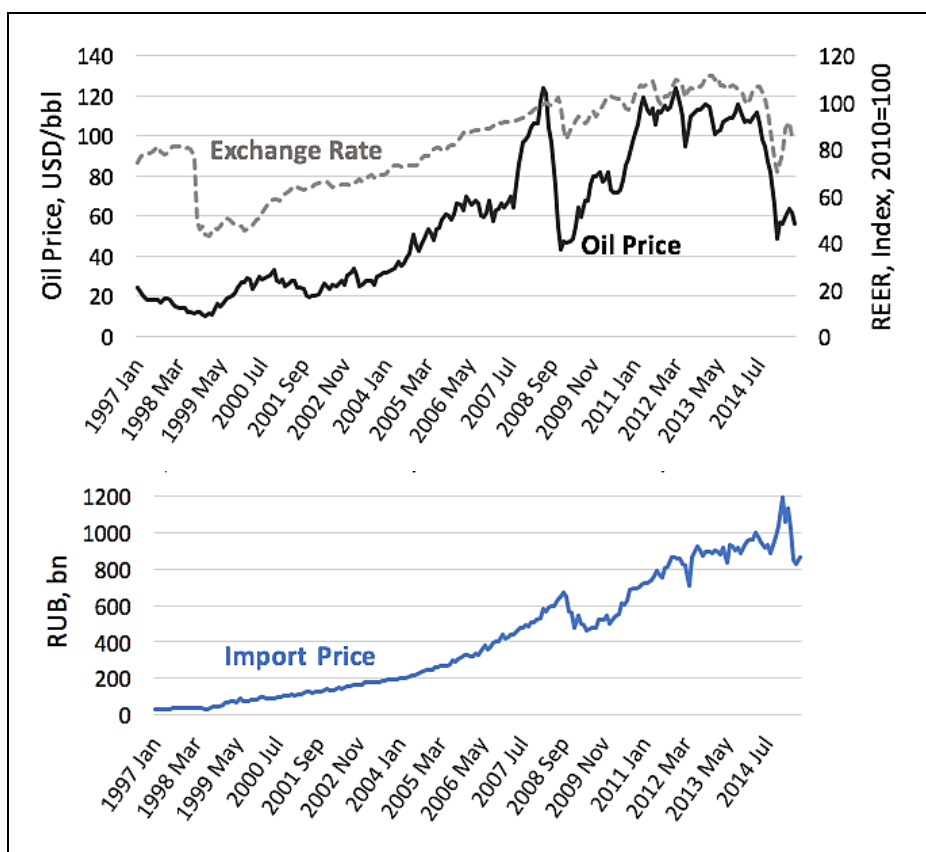
Finally, the volatility of the inflation rate affects monetary policy. Therefore, the increase in oil prices, which leads to appreciation of the exchange rate (Figure 7) and a lower inflation rate, negatively affects interest rate. We observe this after a positive oil shock in Figure 6.

4.2 Variance Decomposition Analysis

We have also conducted variance decomposition analysis in order to decompose and estimate the scale of the variation in each endogenous variable due to the positive shock in the exogenous variable (oil prices). This analysis will help us in understanding the size of the impacts of exogenous innovations to the model. In our case, we are going to decompose the variance of real GDP growth rate, CPI inflation rate, interest rate, and exchange rate with respect to oil prices. The period estimated is 2000:1–2016:12, as we have found that the impacts of oil prices are significant only during this period. The results are presented in Figure 8.

The evidence obtained from conducting variance decomposition analysis suggests that oil price movements significantly contribute to the volatility in macro-economic indicators. More precisely, the contribution of one unit shock to oil prices explains up to 2%, 4%, 8%, and 6% of variability in real GDP growth, CPI inflation rate, interest rate, and exchange rate respectively. It highlights once again the importance of the oil sector to the economy and its vulnerability to exogenous shocks in oil prices on the world market.

Overall, the results we obtained suggest that the economy is highly vulnerable to innovations in oil prices. Since the energy sector and export of natural resources play a crucial role in this country's economy, a decline in oil prices on the world market leads to significant deterioration of the macroeconomic performance. On the other hand, when oil prices experience growth, it is beneficial for the macro economy. Thus, we have empirically found that when oil prices increase, the country experiences (i) an increase in foreign currency inflows, which makes it easier to maintain the stability of the exchange rate, therefore imported goods become cheaper and inflation falls; and (ii) the government budget enjoys a surplus, which makes real GDP grow more rapidly.

**Figure 8: Variance Decomposition**
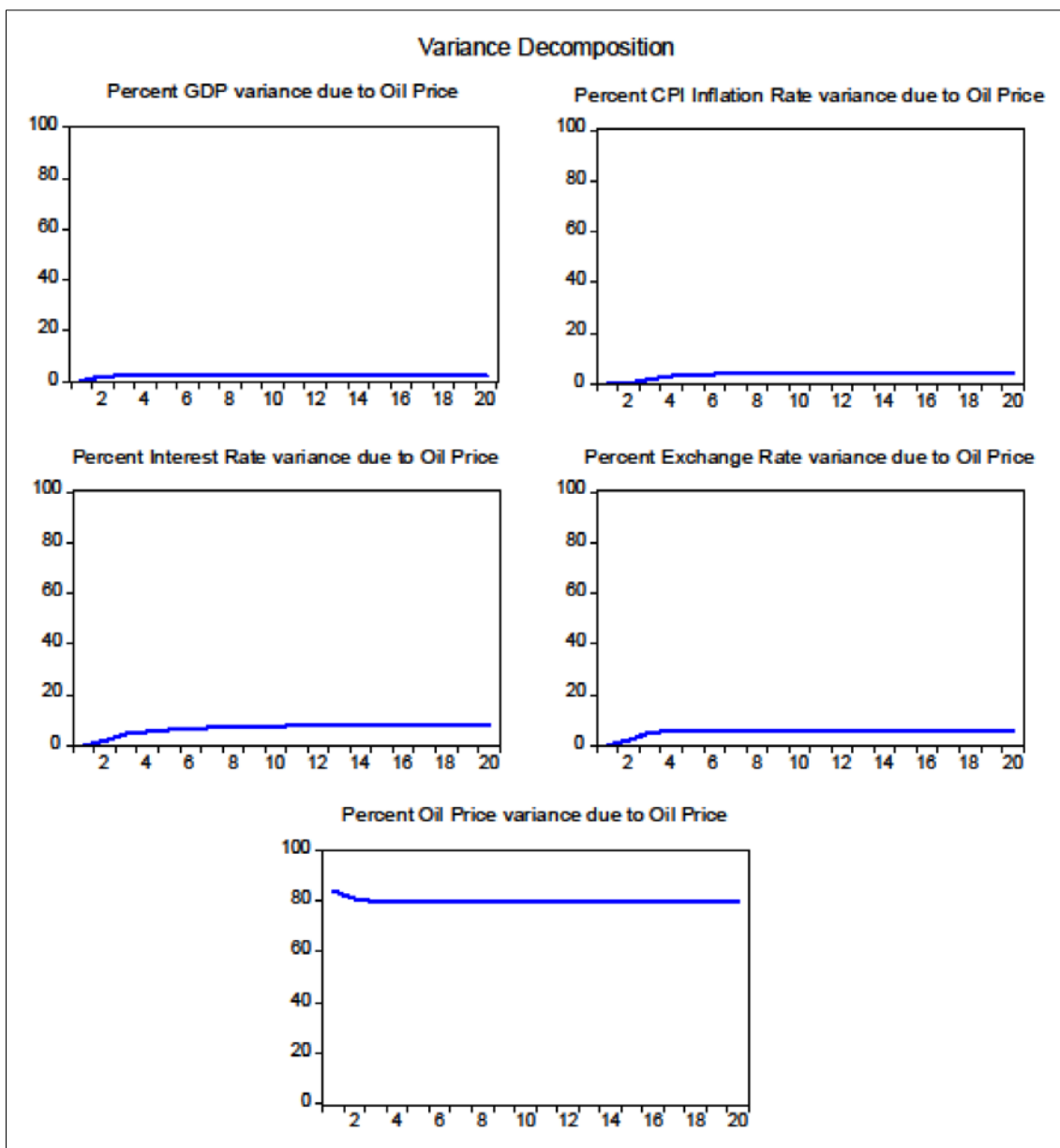
Note: Data is for the period of 2000:1 to 2016:12 in first differences of logarithmic form. Decomposition for 20 months is presented.
Source: Authors.

4.3 Monetary Policy

In the final section, the monetary policy instrument and monetary policy rule will be estimated and discussed. According to the Central Bank of this energy exporting country, currently the main monetary policy instrument is the key rate or short-term interest rate. Moreover, the Central Bank conducts its monetary policy in the framework of inflation targeting and since late 2014 in a free float exchange rate regime. However, the true nature of the post-soviet monetary policy since the 1990s is unclear, therefore we are going to test whether the monetary policy was conducted using the Taylor rule, which is a setting formula for central banks' policy rates. There have been some studies on the experience, covering different time spans and providing different results.[5] We are going to focus on the longest data set available to date and cover the period from 1993 to 2016 using monthly data in order to identify the monetary policy rule for the energy exporting country.

Figure 9: Annual Inflation Rate and Inflation Target Range, 2000–2016
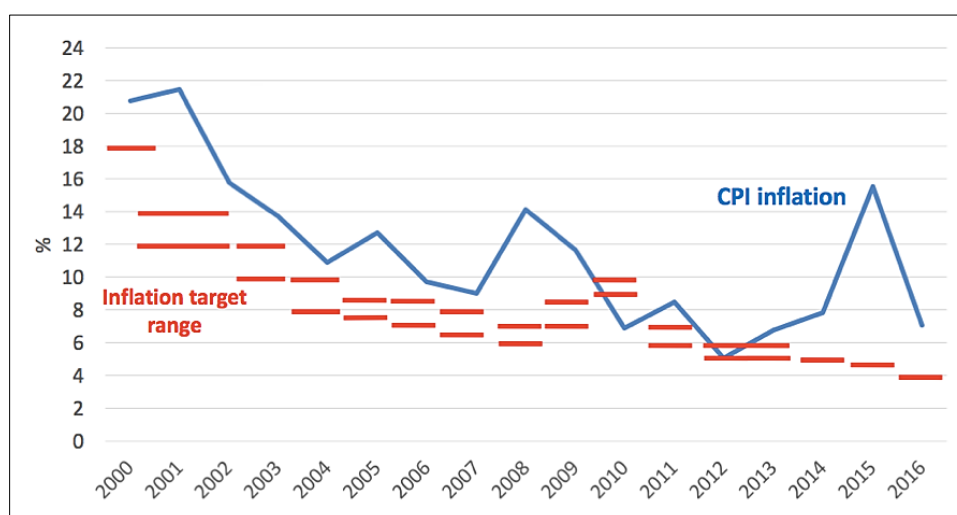
Data sources: World Bank and CBR.

In order to describe the monetary policy behavior of the Central Bank, we will adopt the Taylor rule framework, which requires central banks to adjust nominal policy rates in response to movements of inflation and GDP gaps.[6] We will, however, modify the original Taylor equation[7] in order to account for the impact of (i) the exchange rate, since the country is considered as an open economy (Figure 5); and (ii) oil prices, since they have been proven to play a significant role in the economy and may affect monetary policy as well (Figure 10).

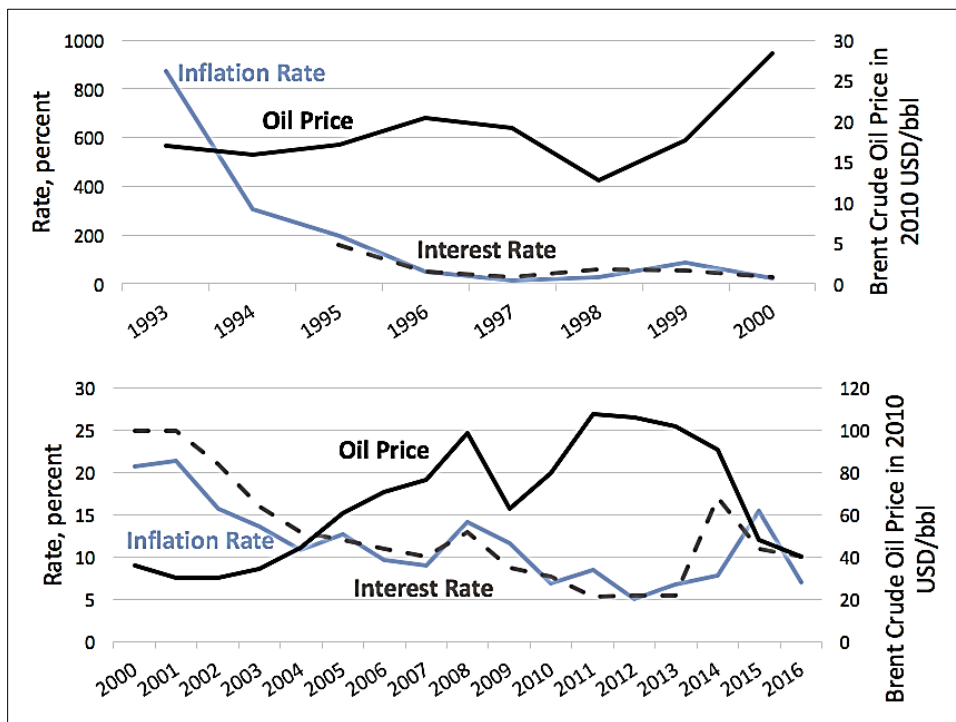Therefore, the Taylor rule equation we are going to estimate will take the following form:

$$i_t = \alpha_0 + \alpha_1(\pi_t - \pi_t^*) + \alpha_2(y_t - y_t^*) + \alpha_3(e_t - e_t^*) + \alpha_4(oil_t - oil_t^*) + \varepsilon_t \qquad (4)$$

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[5] See for example Vdovichenko and Voronina (2006), Esanov et al. (2005).

[6] For more details refer to Yoshino and Taghizadeh-Hesary (2017).

[7] As described in Taylor (1993, 2001).

Figure 10: Oil Prices, Inflation Rate, and Interest Rate, 1993–2016

Data Source: FRED, Central Bank, Ministry of Finance. Interest rate is the short term nominal rate in %; inflation rate is the annual price change in %; oil price is the price of Brent Crude, in USD adjusted for US CPI base year 2010.

where i_t is policy rate, π_t is inflation rate, π_t^* target inflation rate, y_t is real GDP growth rate, y_t^* is potential GDP growth rate, e_t is effective exchange rate, e_t^* is potential exchange rate, oil_t is price of Brent crude oil, oil_t^* is potential oil prices. To calculate the inflation gap, the CPI inflation rate less the inflation target was used. For the period 1993–1999 for target, we used the average inflation rate over the period, and from 2000 the official Central Bank inflation target was used. The GDP growth gap was calculated by removing the HP-trend from monthly real GDP growth. Exchange rate gap and oil prices gap were calculated by subtracting HP-trend values from the effective Ruble exchange rate and from the nominal Brent crude oil prices. As for the policy rate, we used the short-term interest rate. We estimated the Taylor rule equation for three periods: 1993–1999, the period right after the abolishing of the USSR and when the monetary mechanism was still unclear, 2000–2016, when the Central Bank had an official target for the inflation rate with a break in 2008 in order to account for the financial crisis.

Table 3 shows the results of the Taylor rule regression estimation, comparing three different periods and using monthly data. We can see from the table that only for the latest period of 2008 to 2016 there is supporting evidence for the Taylor rule specification. For the first and second periods, the explanatory power of the models is very weak and almost all the variables are insignificant. The third model has the higher R-squared and all variables have correct signs. The interpretation of the results is as follows, the higher inflation rate gap leads to an increase in the policy rate, which shows a clear focus on inflation targeting. The GDP gap has not shown any significant effect on policy rate, on the other hand, the appreciation of the exchange rate had a negative impact on the nominal interest rate, as well as the oil price increase, the mechanism is provided in the previous section.

Table 3: Taylor Rule Regression Results by Period, Monthly Data

	1993–1999 Policy Rate	2000–2008 Policy Rate	2008–2016 Policy Rate
Inflation gap	0.107***	0.219	0.398***
GDP growth gap	−10.234	−2.243	−2.117
Ruble effective exchange rate gap	131.56	36.536	−9.28**
Oil prices gap	17.875	−4.896	−3.724*
Constant	97.729***	16.655***	8.02***
R^2	0.25	0.017	0.57
Number of observations	82	106	87

Note: *** represent significance at 1%, ** represent significance at 5%, * represent significant at 10% levels.

We can conclude that after the global financial crisis the monetary authority was basically following the Taylor monetary policy rule with a strong focus on inflation targeting.

5. CONCLUDING REMARKS

In this paper, we have analyzed oil price movement effects on the macro-economic indicators of one of the oil exporting countries. Although the overwhelming majority of previous studies have focused on the impacts of oil shocks on the advanced economies, with a special focus on oil-importers, we selected a non-OPEC oil exporter. Despite their crucial dependence on oil exports and important role on the international energy market, non-OPEC countries were generally neglected in the economic literature, mostly because of a lack of long-term time series data. For this study, we analyzed the monthly data sample, which covers the period from 1993:1 to 2016:12 using a structural VAR model. This model can therefore be applied to other energy exporters if a data sample is obtained.

The novelty of this study is that a monetary variable was incorporated into the model, since we believe that the macro-economy of the energy exporting country is affected by oil prices especially through the monetary policy channel, which we have explained in our paper by estimating the VAR model and Taylor rule equation. Therefore, this research is complementary to the literature on the impact of oil price changes on this oil-supplying economy in various directions. We believe that monetary policy authorities have to be aware of possible unexpected oil price movements when determining monetary policies. Macro-economic indicators of energy exporters are highly vulnerable to oil price changes, as this research shows, an increase in oil prices may continuously and positively affect the real GDP growth, decrease CPI inflation and interest rate, and lead to domestic exchange rate appreciation.

This research can be further developed and extended. It will be left for future studies to assess how the macro fundamentals of other non-OPEC energy exporters (such as Azerbaijan, Kazakhstan, Indonesia, and others) are responding to oil price fluctuations. It will also be interesting to identify macro-economic responses not only on aggregate, but also on sectoral level (such as industrial, transportation, and others). Comparing the impacts of oil price shocks on this group of economies and finding patterns will eventually contribute to the development of policy implications that can possibly help these economies to strategically deal with unexpected oil price changes.

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