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Do Oil Shocks Matter for Inflation Rate in Russia: An Empirical Study of Imported Inflation Hypothesis

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ABSTRACT

In this article we aim to assess the impact of world oil prices shocks on inflation dynamics in Russia. Based on the data for the period 2010-2017 for Russia we explore the relationship between world oil prices (Brent), exchange rate and Russian consumption price index using a VEC framework. For detecting the casual relationship, Granger causality test is applied. The results of the study show that oil prices, exchange rate and consumer inflation in Russia are cointegrated in the long-run. The results of the Wald test in the short run show that there is a statistically significant relationship between changes in world oil prices, exchange rate and CPI.

Keywords: Oil Prices, Inflation, Exchange Rate, Vector Error Correction
JEL Classifications: E31, F31, Q41

1. INTRODUCTION

One of the most important aims in achieving economic growth is maintaining price stability of the national economy. Maintaining stable and expected price volatility on various markets for goods and services enables to get stability in output and stock management. In case of high prices volatility rate, the continuity of reproduction process is at danger. National economies of developed and developing countries may be divided in two samples. In the first sample prevail national economies with demand inflation. In these cases, a positive shock of aggregate demand, due to a rise in households' income, consumer lending or to a shift in marginal propensity to consume gives birth to a rise in consumer prices. In most cases central and reserve banks, targeting inflation rate employ interest rate policy to affect real sector through different transmission channels of monetary policy. In some countries, most often developing ones or those being transitory, cost inflation prevails. In this case, multiple shocks affect consumer prices rate. Changes in budget spending, tax and fiscal policy, dependence on the imported goods and services, dependence on the currency rate, monopolistic or oligopolistic (including cartels) market structure make the national economy inelastic and at the same time sensitive to negative shocks in costs. Such inefficiency of the market economy may be even deepened, when the country largely depends on exports revenue.

In case of Russia more than sixty percent of the goods and service consumed are of imported nature, >40% of federal budget revenues come from exported oil rent, >70% of the national gross domestic product (GDP) is produced by government-owned enterprises. Given free float of the national currency, negative shocks of exchange rate have the potential to affect the consumer prices rate, thereby affecting inflation on markets for goods and services.

In this paper we aim to explore long- and short-run aspects of the relationship between oil prices dynamics (Brent) and consumer inflation in Russia as well as to provide evidence for or against the causal relationship between oil prices shocks and inflation rate

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on the example of Russia, testing the applicability of imported inflation hypothesis for the Russian case.

The remainder of the paper is organized as follows: Section 2 provides an overview of relevant literature; Section 3 describes econometric modeling techniques and data used; section 4 presents an analysis of empirical results; Section 5 presents the conclusion of the study.

2. LITERATURE REVIEW

To test the stated hypothesis, we refer to the relevant literature on the issue. As can be seen from Table 1, "inflation-economic growth" nexus is well tested on various examples, including both developed and developing countries, resources-rich and resources poor countries, transition economies and so on. A theoretical review of relationship between energy prices and macroeconomic variables is presented in a paper by Brown and Yüce (2002).

As can be seen form Table 1, relevant literature review show that for oil-importing countries the results are ambivalent. In case of the national exchange rate being dependent on the volatility of oil prices, a sharp decline in oil prices may lead to a rise in consumer prices.

3. MATERIALS AND METHODS

3.1. Research Methods

To test the hypothesis about relationship between shocks in world oil prices, exchange rate of the Russian ruble and consumer inflation in Russia, we use econometric techniques to analyze time series. The algorithm of the ongoing study is determined by several key stages. First and foremost, one should test sampled variables on stationarity or order of cointegration, since the time series must have the same order, as can be seen from equation (1). Secondly, it is necessary to determine presence/absence of correlation in long term between the variables in the equation. To check this assumption, we use a Johansen cointegration test. In a case of a long-term relationship on the one hand and condition of stationarity of sampled time series in the first order I (1) on the other, it is possible to use VEC model. In case of confirmation of cointegration presence between the variables of the sample, residuals of the equilibrium regression can be used to estimate error correction model. Also based on VEC model it is possible to identify short-term relationships between sampled variables. For this purpose, we would use the Wald test. The final stage of constructing a model is to conduct diagnostic tests to determine validity of the model. These include testing for heteroscedasticity and serial correlation, normality and stability of the model. Another tool for detecting presence or absence of the explored relationship is Pairwise Granger causality test.

3.1.1. Unit root test

For the analysis of long-term relationships between the variables, Johansen and Juselieus (1990) admit that this form of testing is only possible after fulfilling the requirements of stationarity of the time series. In other words, if two series are co-integrated in order d (i.e. $I[d]$) then each series has to be differenced d times to restore stationarity. For $d = 0$, each series would be stationary in levels, while for $d = 1$, first differencing is needed to obtain stationarity. A series is said to be non-stationary if it has non-constant mean, variance, and auto-covariance over time (Johansen and Juselius, 1990). It is important to cover non-stationary variables into stationary process. Otherwise, they do not drift toward a long-term equilibrium. There are two approaches to test the stationarity: Augmented Dickey and Fuller (ADF) test (1981) and the Phillips and Perron test (1988). Here, test is referred to as unit-root tests as they test for the presence of unit roots in the series. The use of these tests allows to eliminate serial correlation between the variables by adding the lagged changes in the residuals of regression. The equation for ADF test is presented below:

$$\Delta Y_t = \beta_1 + \beta_2 t + aY_{t-1} + \delta_3 \sum \Delta Y_{t-1} + \varepsilon_t \quad (1)$$

Where ε_t is an error term, β_1 is a drift term and $\beta_2 t$ is the time trend and Δ is the differencing operator. In ADF test, it tests whether $\alpha = 0$, therefore the null and alternative hypothesis of unit root tests can be written as follows:

H_o: A = 0 (Yt is non-stationary or there is a unit root).
H_1: A < 0 (Yt is stationary or there is no unit root).

The null hypothesis can be rejected if the calculated t value (ADF statistics) lies to the left of the relevant critical value. The alternate hypothesis is that a <0. This means that the variable to be estimated is stationary. Conversely, we cannot reject the null hypothesis if null hypothesis is that a = 0, and this means that the variables are non-stationary time series and have unit roots in level. However, normally after taking first differences, the variable will be stationary (Johansen and Juselius, 1990). On the other hand, the specification of P-P test is the same as ADF test, except that the P-P test uses nonparametric statistical method to take care of the serial correlation in the error terms without adding lagged differences (Gujarati, 2003). In this research, we use both ADF and P-P test to examine the stationarity of the sampled time series.

3.1.2. Johansen co-integration test

To test for presence of cointegration we apply the Johansen test using non-stationary time series (values in levels). If between variables does exist a cointegration, the first-best solution would be using Vector Error Correction methodology (VECM) model. An optimal number of lags according to Akaike information criterion for providing Johansen test is determined in VAR space. To conduct Johansen test, we estimate a VAR model of the following type:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \epsilon_t \quad (2)$$

in which each component of y_t is non-reposeful series and it is integrated of order 1. x_t is a fixed exogenous vector, indicating the constant term, trend term and other certain terms. ε_t is a disturbance vector of k dimension.

We can rewrite this model as:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} V_i \Delta y_{t-1} + Bx_t + \grave{o}_t \quad (3)$$

Table 1: Literature review

Author	Sample	Methodology	Results of the study
Alom et al. (2013)	Oil shocks-macroeconomic variables, Australia, New Zealand, South Korea, Singapore, Hong Kong, Taiwan, India and Thailand, 1980-2010	SVAR analysis	Resource poor countries that specialize in heavy manufacturing industries like Korea and Taiwan are highly affected by international oil price shocks. Oil price shocks negatively affect industrial output growth and exchange rate and positively affect inflation and interest rates. On the other hand, oil poor nations such as Australia and New Zealand with diverse mineral resources other than oil are not affected by oil price shocks. Only exchange rates are affected by oil price shocks in these countries. As a whole, the effects of external oil prices depend on the economic characteristics of the countries.
Aydin and Acar (2011)	Oil shocks - macroeconomic variables, Turkey	Dynamic CGE analysis	The simulation results show that these oil prices have very significant effects on macro indicators and carbon emissions in the Turkish economy
Baumeister and Kilian (2014)	Oil prices fluctuations – food prices, industrialized countries, 1974-2013	Regression analysis	There is no evidence that oil price shocks have been associated with more than a negligible increase in US retail food prices in recent years. Nor is there evidence for the prevailing wisdom that oil-price driven increases in the cost of food processing, packaging, transportation and distribution have been responsible for higher retail food prices. Similar results hold for other industrialized countries.
Berument et al. (2010)	Oil price shocks - inflation - real exchange rate, Tunisia, Morocco, Algeria, Bahrain, Saudi Arabia and Iran, 2000-2015	SVAR analysis	The impulse response functions reveal that, in the long run, oil price fluctuations have the major impact on real exchange rate of the oil-importing countries (Tunisia and Morocco) while the impact on inflation is smaller and absorbed by the rigidity of subsidized products prices. The variance decomposition results also assert that oil price shocks do not explain notably the variation in the two considered variables in Algeria and Iran. We further identify an impact on the two variables that is both statistically significant and economically large in the rest of countries.
Blanchard and Gali (2007)	Oil price shocks – GDP – CPI, 1970-2005, G7, Euro12, OECD	Regression analysis	The effects of oil price shocks have changed over time, with steadily smaller effects on prices and wages, as well as on output and employment.
Burakov (2017)	Oil prices shocks – growth – emigration, Russia, 1990-2015	Regression analysis	Author confirms the existence of a long-term relationship between oil prices, economic growth and emigration. In the short-run direct causality between oil prices and economic growth, as well as between economic growth and emigration is found. Thereby, existence of transmission in form of indirect channel of oil prices' shocks on migration decisions of households is confirmed.
Chang and Wong (2003)	Oil prices – GDP – inflation, Singapore	Regression analysis	Results show that Iran's military and security expenditures significantly respond to a shock in oil revenues (or oil prices), while social spending components do not show significant reactions to such shocks.
Cuñado and Pérez de Gracia (2004)	Oil prices – macroeconomy relationship, Asian countries, 1975-2002	Regression analysis	Results suggest that oil prices have a significant effect on both economic activity and price indexes, although the impact is limited to the short run and more significant when oil price shocks are defined in local currencies.
Du et al. (2010)	World oil price – macroeconomy, China, 1995-2008	Regression analysis	The results show that the world oil price affects the economic growth and inflation of China significantly, and the impact is non-linear.
Farzanegan (2010)	Oil shocks and government spending, Iran, 1959-2007	Regression anaylis	Results show that Iran's military and security expenditures significantly respond to a shock in oil revenues (or oil prices), while social spending components do not show significant reactions to such shocks.

(Contd...)

Table 1: ***(Continued)***

Author	Sample	Methodology	Results of the study
Galesi and Lombardi (2009)	Oil and food price shocks - inflation, 33 countries, 1999-2007	Regression analysis	Impulse response analysis reveals that oil and food price shocks have different inflationary effects. During the period 1999-2007, the inflationary effects of an oil price shock mostly affected developed regions, while food price increases hit particularly emerging economies. No significant relationship between oil shocks and core inflation for the United States and the euro area is observed. This result suggests that the presence of significant second-round effects on inflation depends on the country-specific reaction function of the monetary authorities
Gómez-Loscos et al. (2011)	Oil price shocks – GDP – inflation, Spain, 1970-2008	Regression analysis	The influence of oil price shocks on the GDP progressively disappears while the impact on inflation decreases from 1986 onwards but becomes significant again ten years later. The most outstanding result is that oil price movements explain at least some of the recent inflation
Hooker (2002)	Oil price changes – inflation, USA, 1957-1999	Regression analysis	Since around 1980, oil price changes seem to affect inflation only through their direct share in a price index, with little or no pass-through into core measures, while before 1980 oil shocks contributed substantially to core inflation
Kilian (2005)	Oil prices – output – inflation, G7 countries, 1971-2004	Regression analysis	An exogenous disruption of global oil production typically causes a temporary reduction in real GDP growth that is concentrated in the second year after the shock. The median CPI inflation response peaks three to four quarters after the shock. There is clear evidence that exogenous oil supply disruptions need not generate sustained consumer price inflation. Evidence of sustained inflation (as in the case of Germany) therefore must reflect a favorable institutional environment
Lamazoshvili (2014)	Oil price shocks – inflation, Georgia, Armenia	Regression analysis	The identified responses of key macroeconomic variables suggest that demand channel may be an important transmission factor. Given the high share of food items in the CPI of the developing economies under study, increased world real activity is likely to translate into increased food prices directly as well as indirectly through higher oil prices. The structure of energy flows and the politics of natural gas matter for the transmission of oil shocks
Omojolaibi (2013)	Oil price changes - economic activity Nigeria, 1985-2010	SVAR analysis	The IRFs and the FEVDs results suggest that domestic policies, instead of oil-boom should be blamed for inflation. Also, oil price variations are driven mostly by oil shocks, however, domestic shocks are responsible for a reasonable portion of oil price variations

GDP: Gross domestic product, IRFs: Impulse response functions, FEVDs: Forecast error variance decompositions

Where

$$\prod = \sum_{i=1}^{p} A_i - I,\ V_i = -\sum_{j=i+1}^{p} A_j \qquad (4)$$

if the coefficient matrix $\prod$ has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\prod = \alpha\beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VEC model. Johansen's method is to estimate $\prod$ matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of $\prod$ (Johansen, 1991).

3.1.3. Vector error correction model

Granger (1988) suggested the application of VECM in case if the variables are cointegrated in order to find short-run causal relationships. VECM, therefore, enables to discriminate between long-run equilibrium and short-run dynamics. In this sense, we employ following VECMs to estimate causal linkages among the variables:

$$\Delta ln l = a_0 + \sum_{i=1}^{k} a_1 \Delta ln l_{t-i} + \sum_{i=1}^{n} a_2 \Delta lnm_{t-i} + \sum_{i=1}^{m} a_3 \Delta lnr_{t-i} + \lambda ECT_{t-1} + v_1$$

$$\Delta ln\, m = \beta_0 + \sum_{i=1}^{k}\beta_1 \Delta\, lnm_{t-i} + \sum_{i=1}^{n}\beta_2 \Delta lnl_{t-i} + \sum_{i=1}^{m}\beta_3 \Delta lnr_{t-i} + \partial ECT_{t-1} + v_2$$

$$\Delta ln\, r = \eta_0 + \sum_{i=1}^{k}\eta_1 \Delta\, lnr_{t-i} + \sum_{i=1}^{n}\eta_2 \Delta lnl_{t-i} + \sum_{i=1}^{m}\eta_3 \Delta lnm_{t-i} + \chi ECT_{t-1} + v_3$$

Where l – international oil prices (Brent), m – consumer price index, r – exchange rate of Russian ruble to US dollar (RUB/USD). (Granger, 1988).

Providing regression analysis of the sampled variables by modeling VECM allows us to determine the existence of substantial and statistically significant dependence not only on the values of other variables in the sample, but also dependence on previous values of the variable.

However, VEC model must meet the requirements of serial correlation's absence, homoscedasticity of the residuals and to meet the requirement of stability and normality. Only in this case the results can be considered valid.

Table 2: Results of individual unit root test

Variables in	ADF		PP	
	Statistic	Prob.**	Statistic	Prob.**
Levels				
Intercept	9.569	0.528	7.462	0.3984
Intercept and trend	12.178	0.317	14.073	01.983
First-difference				
Intercept	42.903	0.0000**	58.382	0.0000**
Intercept and trend	31.114	0.0010**	64.201	0.0000**

**denotes statistical significance at the 5% level of significance

Table 3: Results of unrestricted VAR model diagnostic testing

Type of test	Results		
VAR residual serial correlation LM test	Lags	LM-stat	P-value
	1	8.9024	0.7902
	2	4.1942	0.4821
Stability condition test	All roots lie within the circle. VAR satisfies stability condition		
Heteroscedasticity (white test)	0.9742*		
VAR residual cross correlation test	No autocorrelation in the residuals		

**denotes acceptance of null hypothesis (Ho: There is no serial correlation), *denotes acceptance of null hypothesis of homoscedasticity

3.2. Materials and Data Processing

We test a hypothesis of relationship between oil prices shocks, exchange rate of the Russian ruble and consumer price index on example of the Russian data for the period 2000 to 2017. The base period is 1 month. Using VECM, we set ourselves a task to determine sensitivity of domestic consumer inflation in Russia to shocks in international oil prices and exchange rate volatility.

To conduct time-series analysis, all variables are transformed into logarithms and detrended where necessary. To study sensitivity and causal linkages between the variables in the sample in short- and long-run, we turn to regression analysis, which involves the construction of VEC model of certain type based on stationary time series, testing the model for heteroscedasticity of the residuals, autocorrelation. To test casual linkages between the sampled variables we use pairwise Granger causality test.

4. RESULTS AND DISCUSSION

The first step in testing hypotheses is to test variables for the presence of unit root. For this purpose, we use standard tests - ADF and P-P test. Results of unit root testing are presented in Table 2.

As can be seen from the test results of the variables for the presence of unit root in their differentiation to the first order, we can reject the null hypothesis of unit root in each of the variables. Thus, the condition of stationarity at I (1) is performed, which gives us reason to test variables for cointegration. However, it is necessary to determine the optimal time lag.

Building a VAR model involves determining the optimal number of lags. In our case, the Akaike information criterion equals (2). Consequently, we built a model based using time lag of 1 month to determine the relationship in the short run. The results of the diagnostic testing of VAR model for heteroscedasticity of residuals, autocorrelation, serial cross-correlation, and stability are presented in Table 3. As can be seen from Table 3, the model is stable, heteroscedasticity and serial correlation of residuals in the model are absent.

The model is used to determine the level of sensitivity of control variables to shocks in oil prices and exchange rate in the short run and we use it to test for stable long-run relationship, applying Johansen cointegration test. Results of Johansen co-integration test are presented in Table 4.

Johansen test results show the presence of cointegration between a number of equations, which allows presuming the existence of a

Table 4: Results of Johansen co-integration test

Hypothesized number of CE(s)	Eigenvalue	Trace statistics	0.05 critical value	Prob.*
None*	0.7045	44.2336	29.7907	0.0000*
At most 1	0.3562	15.9725	17.4021	0.1801
At most 2	0.0667	1.6583	3.8416	0.2345

Trace statistics indicate 1 cointegrating equation at the 0.05 level. *denotes statistical significance at the 5% level of significance

Table 5: Results of vector error correction model

Coefficient number	Coefficient meaning	Standard error	t-statistic	P-value
C (1)	−0.1483	0.231	5.5892	0.0001*
C (2)	0.1759	0.825	4.7408	0.4509
C (3)	0. 0121	0.152	2.5533	0.0167*
C (4)	0.0315	0.394	4.0732	0.0004*
C (5)	85.5197	24.168	3.9643	0.0018

*denotes statistical significance

Table 6: Wald test results for short run relationship

Test statistic	Value	Probability	Test statistic	Value	Probability
t-statistic	−1.3516	0.0005*	t-statistic	1.2348	0.0103*
F-statistic	1.7853	0.0005*	F-statistic	1.4528	0.0103*
Chi-square	1.7853	0.0008*	Chi-square	1.4528	0.0074*
Null hypothesis: C (3)=0 (world oil prices)			Null hypothesis: C (4)=0 (exchange rate)		

*denotes statistical significance and rejection of Ho: No short-run relationship

long-term relationship between them. Starting from the results of the cointegration test, we can proceed to the construction of VEC model to reveal presence or absence of long-term and short-term relations between variables.

The results of the model, showing the relationship between the sampled variables are presented in Table 5.

As can be seen from the Table 5, the value of error correction term C(1) is negative in sign and statistically significant. This suggests the existence of long-run relationship between the variables of the sample. In other words, we obtained evidence that Brent oil prices, exchange rate and CPI in Russia are cointegrated, so that they have similar trends of movement in the long term.

The C (1) shows speed of long run adjustment. In other words, this coefficient shows how fast the system of interrelated variables would be restored back to equilibrium in the long run or the disequilibrium would be corrected. Given statistical significance at 5% level (P-value being <5%) and negative meaning, the system of variables corrects its previous period disequilibrium at a speed of 14.83% in one year (given optimal lag meaning of 2 months for ECM). It implies that the model identifies the sizeable speed of adjustment by 25.19% of disequilibrium correction in 1 year for reaching long-run equilibrium steady state position.

As can be seen from the results of the Wald test (Table 6) in the short term there is a relationship between changes in world oil prices, exchange rate and CPI. Moreover, this relationship is opposite. Based on the results of the Wald test, we can detect statistically significant effects running from changes in oil prices to the inflation rate with rate of adjustment towards equilibrium of 1.21% in t−1. In other words, a rise in oil prices leads to a rise in inflation rate. For example, a 1% increase in oil price will lead to a 1.21% rise in domestic inflation.

The second result shows presence of causality running from exchange rate volatility to inflation rate with the speed of adjustment towards equilibrium at 3.15%. So, the results of Wald test show that exchange rate in the short term has the potential to affect inflation rate. Thus, a 1% increase in the exchange rate leads to a 3.15% increase in inflation rate, measured by CPI.

The final stage of the analysis of the model is to determine the extent of its validity. For this, it is necessary to conduct some diagnostic tests, including tests for heteroscedasticity of the residuals and serial correlation in the model. The results of these tests show that residuals are homoscedastic and serial correlation is absent.

5. CONCLUSION

In this paper we aim to explore long- and short-run aspects of the relationship between exchange rate, oil prices dynamics (Brent) and inflation rate in Russia as well as to provide evidence for or against the causal relationship between the sampled variables on the example of Russia.

To test the hypothesis about relationship between shocks in world oil prices, exchange rate and inflation level in Russia, we use econometric techniques to analyze time series. The algorithm of the ongoing study is determined by several key stages. First and foremost, one should test sampled variables on stationarity or order of cointegration, since the time series must have the same order, as can be seen from equation (1). Secondly, it is necessary to determine presence/absence of correlation in long term between the variables in the equation. To check this assumption, we use a Johansen cointegration test. In a case of a long-term relationship on the one hand and condition of stationarity of sampled time series in the first order I (1) on the other, it is possible to use VEC model. In case of confirmation of cointegration presence between the variables of the sample, residuals of the equilibrium regression can be used to estimate error correction model. Also based on VEC model it is possible to identify short-term relationships between sampled variables. For this purpose, we would use the Wald test. The final stage of constructing a model is to conduct diagnostic tests to determine validity of the model. These include testing for heteroscedasticity and serial correlation, normality and stability of the model.

Based on these results we construct a VEC model, where the value of error correction term C(1) is negative in sign and statistically significant. This suggests the existence of long-run relationship between the variables of the sample. In other words, we obtained evidence that Brent oil prices, exchange rate volatility and inflation rate in Russia are cointegrated, so that they have similar trends of movement in the long term.

The results of the Wald test in the short term show that there is a relationship between changes in world oil prices, exchange rate and CPI. Based on the results of the Wald test, we can detect statistically significant effects running from changes in oil prices to the inflation rate with rate of adjustment towards equilibrium of 1.21% in t−1. In other words, a rise in oil prices leads to a rise in inflation rate. For example, a 1% increase in oil price will lead to a 1.21% rise in domestic inflation.

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