E C O N O M I C S B U L L E T I N

Oil price and macroeconomy in Russia

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Abstract

In this note, using the VEC model we attempt to empirically investigate the effects of oil price and monetary shocks on the Russian economy covering the period between 1997:Q1 and 2007:Q4. The analysis leads to the finding that a 1% increase in oil prices contributes to real GDP growth by 0.25% over the next 12 quarters, whereas that to inflation by 0.36% over the corresponding periods. We also find that the monetary shock through interest rate channel immediately affects real GDP and inflation as predicted by theory.

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1. Introduction

Over the period of 1997 to 2007, crude oil prices have risen more than four-fold. Thanks to the oil price bonanza, Russia as the world's second largest oil exporter (and the largest natural gas exporter) has increased its net exports dramatically.

Of particular interest to us is the relationship between oil price and macroeconomic variables such as real gross domestic product (GDP) and inflation in Russia. Since the early 1980s a number of studies using a vector autoregressive (VAR) model have been made on the macroeconomic effects of oil price changes. Most studies, however, have focused on oil-importing countries (in particular, the United States), and concluded that oil price increases have a negative impact on economic activities (Hamilton 1983, Burbidge and Harrison 1984, Mork 1989, Ferderer 1996, and others). Yet, there is no consensus in these studies to what extent oil price shocks contribute to the U.S. economy. With regard to oil exporting countries, Mork, Olsen and Mysen (1994) and Bjørnland (2000) found that Norway was positively influenced by oil price fluctuations, whereas Abeysinghe (2001) demonstrated that Indonesia and Malaysia were negatively influenced in the long run. As far as Russia is concerned, using quarterly data for the period 1995:Q1 to 2001:Q3 Rautava (2002) studied the impact of oil prices on the economy, concluding that a 10% permanent increase in oil prices leads to a 2.2% GDP growth in the long run.

The purpose of this note is to empirically investigate the effect of oil prices on the level of real GDP and inflation for Russia using the VAR model with extended sample periods. Different from Rautava's approach, Ural oil prices are used and treated as an endogenous variable in our model. Also, in light of the financial crisis, dummy variables for 1998:Q3 and 1998:Q4 are used as exogenous variables. Another goal of this note is to examine the effect of monetary policy through the interest rate channel.

The remainder of this note is organized as follows. Section 2 presents the empirical framework, and section 3 reveals the empirical results. Finally, section 4 concludes this note.

2. Empirical Framework

Methodology

When the variables are stationary in levels, a VAR model is employed. The VAR model proposed by Sims (1980) can be written as follows:

$$Y_t = k + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t; \qquad u_t \sim i.i.d.(0, \Sigma)$$

where Y_t is an $(n \times 1)$ vector of variables, k is an $(n \times 1)$ vector of intercept terms, A is an $(n \times n)$ matrix of coefficients, p is the number of lags, u_t is an $(n \times 1)$ vector of error terms for $t = 1, 2, \cdots, T$. In addition, u_t is an independently and identically distributed ($i.i.d$) with zero mean, $i.e.\ E(u_t) = 0$ and an $(n \times n)$ symmetric variance-covariance matrix Σ, $i.e.\ E(u_t u_t') = \Sigma$.

However, if the variables are non-stationary, a vector error correction (VEC) model is generally employed. This is because the VAR in differences contains only information on short-run relationships between the variables. The VEC model developed by Johansen (1988) can be written as follows:

$$\Delta Y_t = k + \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-1} + u_t$$

where Δ is the difference operator, Γ denotes an $(n \times n)$ matrix of coefficients and contains information regarding the short-run relationships among the variables. Π is an $(n \times n)$ coefficient matrix decomposed as $\Pi = \alpha\beta'$, where α and β are $(n \times r)$ adjustment and co-integration matrices, respectively.

Data Sources

The variables used are as follows: inflation (IF) as measured by the percentage changes of consumer price index (CPI, 2005=100) obtained from United Nations Economic Commission for Europe (*http://w3.unece.org/pxweb/database/stat/Economics.stat.asp*); interest rate (IR) from the central bank of Russian Federation (http://www.cbr.ru/); real GDP (RGDP); and Ural oil price (UOP) from Energy Information Administration (*http://tonto.eia.doe.gov/dnav/pet/hist/wepcuralsw.htm*). RGDP is defined as the nominal GDP, taken from Federal State Statistics Service (*http://www.gks.ru/bgd/free/B00_25/IssWWW.exe/Stg/dvvp/i000180r.htm*), deflated by the CPI. BOP was converted from US dollars per barrel to the Russian roubles per barrel. The nominal exchange rates were collected from International Monetary Fund, *International Financial Statistics*. The time span covered by the series is from 1997:Q1 to 2007:Q4. Apart from the IR, the data were seasonally adjusted by means of CensusX12-ARIMA. All series were expressed in logarithmic form.

3. Empirical Results

Unit Root Test

In general, since many economic time series have non-stationary characteristics, the variables must be tested for stationary process. The problem with non-stationary data is that the Ordinary Least Squares (OLS) regression procedures can easily result in incorrect conclusions. Therefore, in order to avoid the spurious regression, the Augmented Dickey-Fuller (ADF) test proposed by Dickey and Fuller (1981), whose null hypothesis is that there is a unit root, is adopted. Table 1 shows results of unit root tests for four variables. The results indicate that the series without IF and IR are non-stationary when the variables are defined in levels. By first-differencing the series, in all cases, the null hypothesis of non-stationary process is rejected at the 1% significance level.

Co-integration test

Since the variables are integrated of order one, we proceed to test for co-integration. The co-integration test, formulised by Engle and Granger (1987), was further improved by Johansen (1988). The test is given by the following equation: $\lambda_{trace}(r \mid n) = -T \sum_{i=r+1}^{n} \log(1-\lambda_i)$ where r is the number of co-integrating relations, and n is the number of variables. The null hypothesis is that the number of co-integrating vectors is less than or equal to r against the alternative hypothesis of $r > 0$.

Prior to performing the co-integration tests, we need to estimate the VAR model in levels in order to determine the optimal lag length. It was then found that the lag length based on the Akaike information criteria (AIC) was 5 lags.

As a preliminary procedure, it is also necessary to select the optimal model for the deterministic components in the system. Therefore, following Johansen and Juselius (1992) we choose the model by testing the joint hypothesis of both the rank order and the deterministic components, applying the so-called Pantula's (1989) principle. The results of the co-integration tests based on trace statistics are presented in Table 2. The results suggest the choice of model 2 (with intercept (no trend) in co-integrating equation and no intercept in VAR) as the appropriate model. We found the existence of three co-integrating relations.

Since the unrestricted VAR model is a merely statistical presentation, we here assume that there are long-run equilibrium relationships between (i) UOP and RGDP, (ii) RGDP and IF and (iii) IF and IR (based on the well-known Fisher equation). In matrix notation, the restricted co-integration relations for Y_t = [UOP, RGDP, IF, IR] can be formulated as follows:

$$\beta' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 0 & 1 & * & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}.$$

Consequently, the hypothesis was accepted with a *p*-value of 0.43 (Chi-square(2)=1.66).

Lagrange Multiplier (LM) Test

In order to ascertain whether the model provides an appropriate representation, a test for misspecification should be performed. We thus employ the LM test for autocorrelation, whose null hypothesis is that there is no serial correlation at lag order *h*. Table 3 indicates the results of the LM test for VEC model residual serial correlation. The results suggest that there is no obvious residual autocorrelation problem for the model because all *p*-values are larger than the 0.05 level of significance.

Impulse-Response Functions

The impulse response functions trace the effect of a one-standard-deviation shock in a variable on current and future values of the variables. In our system, we use generalized impulse response functions (GIRFs) proposed by Pesaran and Shin (1998), not those based on a Cholesky decomposition which is sensitive to the ordering of the variables. Figure 1 and Table 4 indicate, respectively, the impulse responses and the accumulated responses of the co-integrated VAR model with 5 lags and the three restricted co-integrating vectors. We conducted estimations of the GIRFs 12 periods ahead. The results suggest that real GDP responds symmetrically to an oil price increase as expected. Additionally, the accumulated response for up to the 12^{th} quarter is estimated to be 0.25%, which is not so far to that obtained by Rautava (2002). Likewise, it is observed that the immediate response of inflation to the shock exhibits positive and statistically significant, but becomes negative in the 2^{nd} quarter. Nevertheless, the accumulated response over 12 quarters is positive and estimated to be 0.36%.

As far as monetary shock is concerned, we confirm that an increase in interest rates leads to a decrease in real GDP in the short run as predicted by theory. At the same time, the accumulated response over 12 quarters is -0.52%, which is almost double the impact of the oil price shock. Similarly, the initial response of inflation to the monetary shock exhibits asymmetry as expected. In the 2^{nd} quarter, however, we observe the inverse response, so-called price puzzle, reported by Sims (1992), that an increase in interest rates leads to an increase in inflation. Yet, given that the puzzle disappears in the 3rd quarter, this phenomenon may be partly explained by the cost channel that an increase in interest rates raises the marginal costs of suppliers as in Barth and Ramey (2001). It is observed that the accumulated response is -1.04%, suggesting the three-fold impact of the oil price shock.

4. Conclusions

In this note, using the VEC model we have empirically demonstrated the effects of oil price and monetary shocks on the Russian economy covering the period 1997:Q1-2007:Q4. The analysis leads to the finding that a 1% increase in oil prices contributes to real GDP growth by 0.25% over the next 12 quarters, whereas that to inflation by 0.36% over the corresponding periods. We also find that the monetary shock through interest rate channel immediately affects real GDP and inflation as predicted by theory. Overall, we see that the impact of the monetary shock on the economy is greater than that of the oil price shock. This finding is against that reported by Hamilton and Herrera (2004). Notwithstanding the small sample size, this note may offer some insight into the relationships between oil price and macroeconomic variables in Russia.

References

Abeysinghe, T. (2001) "Estimation of Direct and Indirect Impact of Oil Price on Growth" *Economic Letters*, **73**, 147-153.

Barth, M. J. and V. Ramey (2001) "The Cost Channel of Monetary Transmission" *NBER Macroeconomics Annual*, **16**, 199-240.

Bjørnland, H. C. (2000) "The Dynamic Effects of Aggregate Demand, Supply and Oil Price Shocks—A Comparative Study" *The Manchester School*, **68**, 578-607.

Burbidge, J. and A. Harrison (1984) "Testing for the Effects of Oil-Price Rises Using Vector Autoregressions" *International Economic Review*, **25**, 459-484.

Dickey, D. A. and W. A. Fuller (1981) "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root" *Econometrica*, **49**, 1057-1072.

Engle, R. F. and C. W. J. Granger (1987) "Co-integration and Error Correction: Representation, Estimation, and Testing" *Econometrica*, **55**, 251-276.

Ferderer, J. P. (1996) "Oil Price Volatility and the Macroeconomy: A Solution to the Asymmetry Puzzle" *Journal of Macroeconomics*, **18**, 1-26.

Hamilton, J. D. (1983) "Oil and the Macroeconomy Since World War II" *Journal of Political Economy*, **91**, 228-248.

Hamilton, J. D. and A. M. Herrera (2004) "Oil Shocks and Aggregate Macroeconomic Behaviour: the Role of Monetary Policy" *Journal of Money, Credit, and Banking*, **36**, 265-286.

Johansen, S. (1988) "Statistical Analysis of Cointegrating Vectors" *Journal of Economic Dynamics and Control*, **12**, 231-254.

Johansen, S. and K. Juselius (1992) "Testing Structural Hypotheses in a Multivariate Cointegration Analysis of the PPP and the UIP for UK" *Journal of Econometrics*, **53**, 211-244.

MacKinnon, J. G., M. A. Haug and L. Michelis (1999) "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration" *Journal of Applied Econometrics*, **14**, 563-577.

Mork, K. A. (1989) "Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results" *Journal of Political Economy*, **97**, 740-744.

Mork, K. A., Ø. Olsen and H. T. Mysen (1994) "Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries" *The Energy Journal*, **15**, 19-35.

Pantula, S. G. (1989) "Testing for Unit Roots in Time Series Data" *Econometric Theory*, **5**, 256-271.

Pesaran, H. H. and Y. Shin (1998) "Generalized Impulse Response Analysis in Linear Multivariate Models" *Economic Letters*, **58**, 17-29.

Rautava, J. (2002) "The Role of Oil Prices and the Real Exchange Rate on Russia's Economy" *BOFIT Discussion Papers*, http://ideas.repec.org/p/hhs/bofitp/2002_003.html.

Sims, C. A. (1980) "Macroeconomics and Reality" *Econometrica*, **48**, 1-48.

Sims, C. A. (1992) "Interpreting the Macroeconomic Time Series Facts" *European Economic Review*, **36**, 975-1011.

Table 1: Augmented Dickey-Fuller test results

Variables	Intercept	Intercept and Trend
UOP (log)	−1.293	−2.287
⊿UOP (log)	−4.231***	−4.303***
IF (log)	−1.277	−4.900***
⊿IF (log)	−6.478***	−6.131***
IR (log)	−2.264	−3.196*
⊿IR (log)	−6.794***	−6.742***
RGDP (log)	1.846	−0.589
⊿RGDP (log)	−4.186***	−6.512***

Notes: (1) ⊿ means 1st difference. (2) *, ** and *** refer to the rejection of the null hypothesis of the presence of a unit root at 10%, 5% and 1% levels, respectively. (3) Sample periods (adjusted) are from 1997:Q2 to 2007:Q4.

Table 2: Co-integration test results

No. of CE(s)		Model 2	Model 3	Model 4
H_0	H_1			
r=0	r>0	106.238*	87.202*	120.582*
		(54.079)	(47.856)	(63.876)
r≤1	r>1	50.854*	38.559*	71.890*
		(35.192)	(29.797)	(42.915)
r≤2	r>2	24.668*	14.704	29.792*
		(20.261)	(15.494)	(25.872)
r≤3	r>3	5.876	5.876*	8.753
		(9.164)	(3.841)	(12.517)

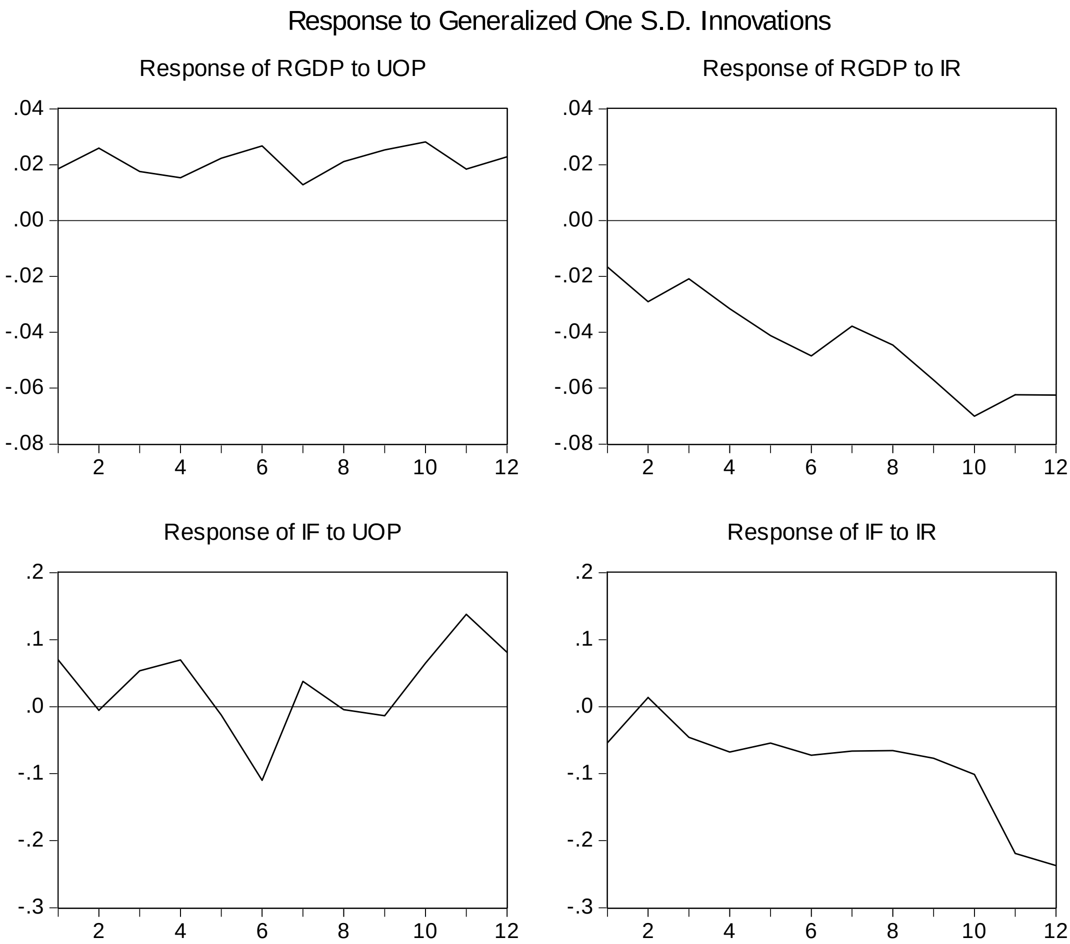
Notes: (1) CE(s) refers to the co-integrating equation(s). (2) * denotes rejection of the hypothesis at the 5% level. (3) The lag length, which was determined by AIC, was 7 lags. (4) Sample periods (adjusted) are from 1997:Q3 to 2007:Q4. (5) The values of brackets refer to critical values based on MacKinnon-Haug-Michelis (1999). (6) Model 1: No intercept or trend in the co-integrating equation (CE) or VAR, H_2 (r)= $\alpha\ \beta' Y_{t-1}$. Model 2: Intercept (no trend) in CE, and no intercept or trend in VAR, H_1^*(r)= $\alpha(\beta' Y_{t-1}+P_0)$. Model 3: Intercept (no trend) in CE and VAR, H_1 (r)= $\alpha(\beta' Y_{t-1}+P_0) + \alpha_\perp \gamma_0$. Model 4: Intercept and trend in CE, and no trend in VAR, H^* (r)= $\alpha(\beta' Y_{t-1}+P_0+P_1 t) + \alpha_\perp \gamma_0$. Model 5: Intercept and trend in CE, and linear trend in VAR, H (r)= $\alpha(\beta' Y_{t-1}+P_0+P_1 t) + \alpha_\perp(\gamma_0+\gamma_1 t)$. $\alpha_\perp$ is the n x (n-r) matrix such as $\alpha' \alpha_\perp$=0 and rank ($|\alpha|\alpha_\perp|$)=0. In general, the model 1 and model 5 are considered as rare cases.

Table 3: Autocorrelation LM test

Lags	1	2	3	4	5
P–value	0.77	0.15	0.95	0.07	0.95

Notes: (1) Sample periods are from 1997:Q1 to 2007:Q4. (2) Probabilities are from Chi-square with 16 degrees of freedom.

Figure 1: GIRFs for the Co-integrated VAR Model



Notes: (1) Sample periods are from 1997:Q1 to 2007:Q4 with 5 lags and the three restricted co-integrating vectors. (2) Impulse responses for up to 12 quarters are displayed.

Table 4: Accumulated GIRFs for the Co-integrated VAR Model

Period	Accumulated Response of RGDP		Accumulated Response of IF	
	Oil shock	Monetary shock	Oil shock	Monetary shock
1	0.019	−0.017	0.070	−0.054
2	0.044	−0.046	0.064	−0.040
3	0.062	−0.066	0.118	−0.086
4	0.077	−0.098	0.188	−0.154
5	0.100	−0.139	0.175	−0.208
6	0.126	−0.188	0.065	−0.280
7	0.139	−0.225	0.103	−0.346
8	0.160	−0.270	0.099	−0.412
9	0.186	−0.327	0.085	−0.488
10	0.214	−0.397	0.150	−0.590
11	0.232	−0.459	0.288	−0.808
12	0.255	−0.522	0.369	−1.046

Notes: (1) Sample periods are from 1997:Q1 to 2007:Q4 with 5 lags and the three restricted co-integrating vectors. (2) Accumulated impulse responses for up to 12 quarters are displayed.