The Impact of Oil Price Volatility on Macroeconomic Activity in Russia

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Abstract

Since the beginning of the 1980s a large number of studies using a vector autoregressive (VAR) model have been made on the macroeconomic effects of oil price changes. However, surprisingly few studies have so far focused on Russia, the world's second largest oil exporter. The purpose of this paper is to empirically examine the impact of oil prices on the macroeconomic variables in Russia using the VAR model. The time span covered by the series is from 1994:Q1 to 2009:Q3, giving 63 observations. The analysis leads to the finding that a 1% increase (decrease) in oil prices contributes to the depreciation (appreciation) of the exchange rate by 0.17% in the long run, whereas it leads to a 0.46% GDP growth (decline). Likewise, we find that in the short run (8 quarters) rising oil prices cause not only the GDP growth and the exchange rate depreciation, but also a marginal increase in inflation rate.

Resumen

Desde comienzos de la década de 1980 se han llevado a cabo numerosos estudios que utilizan un modelo de vectores autorregresivos (VAR) para analizar los efectos económicos de los cambios en los precios del petróleo. No obstante, sorprendentemente son escasos los estudios realizados hasta ahora que se centran en Rusia, el segundo exportador mundial de petróleo. La finalidad de este documento es examinar empíricamente el impacto de los precios del petróleo sobre las variables macroeconómicas en Rusia utilizando el modelo VAR. El análisis lleva a la conclusión de que un aumento (descenso) del 1% en los precios del petróleo contribuye a la depreciación (apreciación) del tipo de cambio en un 0,17% a largo plazo, al mismo tiempo que supone un crecimiento (descenso) del PIB de un 0,46%. Asimismo, observamos que a corto plazo (8 trimestres) el incremento de los precios del petróleo no sólo provoca un crecimiento del PIB y la depreciación del tipo de cambio, sino también un incremento marginal en el ritmo de inflación.

Keywords: co-integration test; impulse response functions; oil prices; Russia

JEL codes: Q4

1. Introduction

Since the beginning of the 1980s a large number of studies using a vector autoregressive (VAR) model have been made on the macroeconomic effects of oil price changes. Empirical and theoretical studies generally find that oil price increases negatively affect the macroeconomic activities in net oil-importing countries through the supply-side (: production cost) and demand-side (: income transfer) channels (Hamilton 1983, 1996, 2003; Burbidge and Harrison 1984; Mork 1989; Mork *et al*. 1994; Ferderer 1996; Rotemberg and Woodford 1996; Finn 2000; Jimenez-Rodríguez and Sanchez 2005, 2009). With regard to net oil-exporting countries, Mork *et al*. (1994) and Bjornland (2000) demonstrated that oil price volatility has a positive impact on the Norwegian economy, whereas Abeysinghe (2001) found that Indonesia and Malaysia were negatively influenced in the long run. However, surprisingly few studies have so far focused on Russia, the world's second largest oil exporter. Using quarterly data for the period 1995:Q1 to 2002:Q4 Rautava (2004) 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 paper is to empirically examine the impact of oil prices on the macroeconomic variables such as inflation, real effective exchange rate and real GDP for Russia using the VAR model. The analysis is different from the previous studies in that real instead of nominal oil prices are used in the model.

The remainder of the paper is organized as follows. Section 2 provides the empirical framework, and section 3 presents the empirical results. Section 4 concludes.

2. Empirical Framework

2.1. Methodology

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

$$Z_t = \mu + \sum_{i=1}^{p-1} A_i Z_{t-i} + \varepsilon_t,; \qquad \varepsilon_t \sim i.i.d.(0,\Omega)$$

where Z_t is an ($n \times 1$) vector of variables, μ is an ($n \times 1$) vector of intercept terms, A_i is an ($n \times n$) matrix of coefficients, p is the number of lags, ε_t is an ($n \times 1$) vector of error terms for $t = 1,2,\cdots,T$. In addition, ε_t is an independently and identically distributed ($i.i.d$) with zero mean, *i.e.* $E(\varepsilon_t) = 0$ and an ($n \times n$) symmetric variance-covariance matrix Ω, *i.e.* $E(\varepsilon_t \varepsilon_t') = \Omega$.

However, if the variables are non-stationary, we need to apply co-integration tests. If there is no co-integration, the VAR model in differences is conducted. Otherwise, a vector error correction (VEC) model is generally employed. The model developed by Johansen (1988) can be written as follows:

$$\Delta Z_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-1} + \varepsilon_t$$

where Δ is the difference operator, Γ_i 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.

2.2. Data sources

The variables used are as follows: inflation rate (*ifr*) as measured by the percentage changes of consumer price index (CPI, 2005=100); real effective exchange rate (*reer*, 2005=100); real GDP (*rgdp*) defined as the nominal GDP deflated by the CPI; and real oil price (*rop*) defined as Brent oil price in U.S. dollars converted (by the period average exchange rate) to Russian roubles per barrel deflated by the CPI. The data for oil prices are taken from Energy Information Administration (http://www.eia.doe.gov/) and the rest are obtained from International Monetary Fund, *International Financial Statistics*. The time span covered by the series is from 1994:Q1 to 2009:Q3, giving 63 observations. Apart from the *ifr* and *reer*, the data were seasonally adjusted by means of CensusX12-ARIMA. All series were expressed in logarithmic form. In addition, dummy variables for 1998:Q3 and 1998:Q4 are used as exogenous variables in light of the Russian financial crisis.

3. Empirical Results

3.1. Unit root tests

Macroeconomic time series are often non-stationary and therefore the variables must be tested for stationary process. Considering the small sample size, the Dickey-Fuller Generalized Least Squares (DF-GLS) test developed by Elliot *et al.* (1996), assuming the null hypothesis of a unit root, is adopted. Table 1 shows results of unit root tests for four variables. The results of the DF-GLS test indicate that the series 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.

Table 1. DF-GLS tests

Variable	Intercept	Intercept and Trend
ifr (log)	-1.147	-2.807
⊿*ifr* (log)	-4.566*	-4.787*
reer (log)	-0.124	-2.632
⊿*reer* (log)	-4.727*	-5.304*
rgdp (log)	-0.668	-2.069
⊿*rgdp* (log)	-3.354*	-4.218*
rop (log)	-1.885	-2.845
⊿*rop* (log)	-4.977*	-5.466*

Notes: (1) ⊿ means 1st difference. (2) * refers to the rejection of the null hypothesis at the 1% significant level. (3) The number in parenthesis denotes the lag intervals.

3.2. Co-integration tests

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 $r > 0$.

Following Johansen and Juselius (1992) we choose the optimal 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. By comparing *p*-values we select the model 2 (with intercept (no trend) in the long-run and no intercept in the short-run models) as the appropriate model. Consequently, it was found that there are at least two co-integrating relations among the four variables.

Table 2. Co-integration tests

No. of CE(s)		Model 2	Model 3	Model 4
H_0	H_1			
r=0	r>0	82.015*	69.594*	91.512*
		(54.079)	(47.856)	(63.876)
		[0.000]	[0.000]	[0.000]
r≤1	r>1	37.988*	25.586	47.463*
		(35.192)	(29.797)	(42.915)
		[0.024]	[0.141]	[0.016]
r≤2	r>2	19.511	10.345	18.785
		(20.261)	(15.494)	(25.872)
		[0.063]	[0.255]	[0.293]
r≤3	r>3	4.562	4.102*	5.401
		(9.164)	(3.841)	(12.517)
		[0.334]	[0.042]	[0.539]

Notes: (1) CE(s) refers to the co-integrating equation(s). (2) * denotes rejection of the hypothesis at the 5% significance level. (3) The lag length, which was determined by SIC, was 2 lags with maximum lag order 7. (4) Sample periods (adjusted) are from 1994:Q4 to 2009:Q3. (5) The values of round brackets and square brackets refer to critical values and p-values, respectively, based on MacKinnon-Haug-Michelis (1999). (6) Model 1: No intercept or trend in the co-integrating equation (CE) or VAR; Model 2: Intercept (no trend) in CE, and no intercept in VAR; Model 3: Intercept (no trend) in CE and VAR; Model 4: Intercept and trend in CE, and no trend in VAR; Model 5: Intercept and trend in CE, and linear trend in VAR. In general, the model 1 and model 5 are considered as rare cases.

Since the unrestricted VEC model is merely a statistical presentation, we here assume that there are linear combinations between (i) *ifr* and *rgdp*, (ii) *rgdp* and *rop*, and (iii) *reer* and *rop*. As a consequence, the hypothesis was accepted with a *p*-value of 0.743 (Chi-square(1)=0.106), and the estimate of β' for Z_t = [*ifr*, *reer*, *rgdp*, *rop*] is given by $\beta' = \begin{bmatrix} \underset{(0.044)}{0.277} & 0 & 1 & \underset{(0.186)}{-0.462} \\ 0 & 1 & 0 & \underset{(0.282)}{0.175} \end{bmatrix}$, where the figures in brackets denote standard errors. The estimated coefficients are statistically significant. The first co-integrating vector implies that a 1% rise (fall) in inflation rate is negatively (positively) associated with real GDP growth by 0.27% in the long run, whereas that of real oil prices contributes to the GDP growth (decline) by 0.46%. The former relationship is empirically supported by Gylfason and Herbertsson (2001) and Gillman *et al*. (2004). The second vector represents that a 1% increase (decrease) in real oil prices leads to the depreciation (appreciation) of real effective exchange rate by 0.17% in the long run. This can be explained by the fact that the price level in Russia is relatively lower than that of its trading partners.

In order to check whether the model provides an appropriate representation, a test for misspecification should be performed. We thus employ the Lagrange Multiplier (LM) test for autocorrelation proposed by Breusch and Godfrey (1981), whose null hypothesis is that there is no serial correlation at lag order *h*. The results of Table 3 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.

Table 3. LM test

Autocorrelation LM test	Lags	P-value
	1	0.14
	2	0.64

Notes: (1) Sample periods are from 1994:Q1 to 2009:Q3. (2) Probabilities are from chi-square with 16 degrees of freedom.

3.3. Impulse-response functions

In order to capture the short-run dynamics of the model, we use impulse response functions, which trace the effect of a one-standard-deviation shock in a variable on current and future values of the variables. In our model, we assume that oil prices do not react to disturbances in other macroeconomic variables. The shock can be identified through a standard Cholesky decomposition with the variables ordered as follows: [*rop*, *rgdp*, *ifr* and *reer*].

Table 4 shows the accumulated response to a positive oil price shock. These results suggest that rising oil price has positive effects on real GDP by 0.39% over the next 8 quarters as expected, whereas it leads to a decrease in real effective exchange rate by 0.20% over the preceding period. At the same time, for inflation rate, the response to the shock is marginally negative and becomes positive in the 7th quarter (but still insignificant). This may be mainly attributed to the increased aggregate demand driven by oil export income.

Table 4. Accumulated response to a positive oil price shock

Period	*rgdp*	*ifr*	*reer*
1	0.019	-0.016	-0.019
2	0.059	-0.019	-0.034
3	0.110	-0.008	-0.056
4	0.163	-0.020	-0.083
5	0.217	-0.027	-0.115
6	0.273	-0.006	-0.146
7	0.333	0.032	-0.177
8	0.395	0.077	-0.208

Notes: The ordering is as follows: [*rop*, *rgdp*, *ifr* and *reer*]. Sample periods are from 1994:Q1 to 2009:Q3 with 2 lags and two restricted co-integrating vectors. Accumulated impulse responses for up to 8 quarter are presented.

4. Conclusion

In this paper, using co-integration analysis and impulse response functions, we have attempted empirically to assess to what extent oil price increases affect real effective exchange rate and real GDP in Russia. The analysis leads to the finding that a 1% increase (decrease) in oil prices contributes to the depreciation (appreciation) of the exchange rate by 0.17% in the long run, whereas it leads to a 0.46% GDP growth (decline). Likewise, we find that in the short run (8 quarters) rising oil prices cause not only the GDP growth and the exchange rate depreciation, but also a marginal increase in inflation rate.

Overall, these results lead to the conclusion that the Russian economy is greatly vulnerable to oil price volatility. Given the economic damage in case of falling oil price, it seems reasonable to suppose that the country needs to diversify its key industries and enhance the competitiveness of non-energy sectors by increasing foreign direct investment (FDI) from the rest of the world, driven by the improvement of investment environment through the World Trade Organization (WTO) accession.

Notwithstanding the data limitations, this study may provide some insight into the relationship between oil price and macroeconomic variables in Russia.

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