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The role of oil prices and the real exchange rate in Russia's economy

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Jouko Rautava

The role of oil prices and the real exchange rate in Russia's economy

Bank of Finland
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All opinions expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

Jouko Rautava *

The role of oil prices and the real exchange rate in Russia‘s economy

Abstract

Most people seem to think that Russia’s economy and fiscal situation are still crucially tied up with international oil prices and the exchange rate of the rouble, although this view has recently been challenged by some analysts. Empirical research on this topic is, however, scanty. In this paper, the impact of international oil prices and the real exchange rate on Russia's economy and fiscal policy is analysed using VAR methodology and cointegration techniques. The research period covered is 1995:Q1 – 2001:Q3. The results indicate that in the long run a 10% permanent increase (decrease) in international oil prices is associated with a 2.2% growth (fall) in the level of Russian GDP. Respectively, a 10% real appreciation (depreciation) of the rouble is associated with a 2.4% decline (increase) in the level of output. These long-run equilibrium relationships also have a significant impact on short-run dynamics through an error-correction mechanism. The estimation results confirm also a strong dependence of fiscal revenues on output and oil price fluctuations. Estimated parameters and diagnostic statistics do not indicate that Russia’s dependence on oil and the real exchange rate would somehow have weakened in recent years.

Key words: Russian economy, fiscal policy, oil, real exchange rate, VAR, cointegration

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Jouko Rautava

The role of oil prices and the real exchange rate in Russia's economy

Tiivistelmä

Useimmat ihmiset näyttävät edelleen ajattelevan, että öljyn hintakehitys ja reaalinen valuuttakurssi vaikuttavat voimakkaasti Venäjän talouskehitykseen ja valtiontalouden tuloihin, joskin viime aikoina tämä näkemys on eräiden tarkkailijoiden toimesta kyseenalaistettu. Aiheen tärkeydestä huolimatta sitä on tutkittu empiirisesti vain hyvin vähän. Tässä tutkimuksessa öljyn hinnan ja reaalisen valuuttakurssin vaikutusta Venäjän talouteen ja finanssipolitiikkaan on analysoitu VAR-mallilla yhteisintegroituvuus-kehikossa. Tutkimusjakso on 1995:Q1 – 2001:Q3. Tulokset viittaavat siihen, että pysyvä 10 prosentin öljyn hintojen nousu (lasku) kasvattaa (vähentää) pitkällä aikavälillä Venäjän kokonaistuotannon (BKT) tasoa 2.2 prosentilla. Vastaavasti pysyvä ruplan reaalinen vahvistuminen (heikentyminen) 10 prosentilla johtaa pitkällä aikavälillä 2.4 prosentin kokonaistuotannon laskuun (kasvuun). Näillä pitkän aikavälin tasapainorelaatioilla on merkittävä vaikutus lyhyen aikavälin dynamiikkaan virheenkorjausmekanismin kautta. Estimointitulokset vahvistavat myös, että keskushallinnon tulot riippuvat voimakkaasti kokonaistuotannon ja öljyn hintojen vaihteluista. Tämän tutkimuksen mukaan Venäjän talouden riippuvuus energian hinnasta ja reaalisen valuuttakurssin tasosta ei ole vähentynyt viime vuosina.

Asiasanat: Venäjä, talouskehitys, öljy, valuuttakurssi, VAR, yhteisintegroituvuus

1 Introduction

Soon after the August 1998 crisis Russia's economy started to recover quickly, as the weakened rouble improved the price competitiveness of Russian firms and increased their profitability. Since the second quarter of 1999, in addition to the cheap rouble, Russia's trade surplus continued to strengthen due to an oil price-led export boom, which contributed to growth by easing liquidity constraints in the economy. The speed of the turnaround in the economy was surprisingly fast, given all the weaknesses regarding economic policy-making and the institutional environment in Russia in the aftermath of the 1998 crisis. While Russia's gross domestic product declined in 1998 by 5%, in the following year the growth rate exceeded 5%, and accelerated further to 8% in 2000. In 2001, the real growth of Russia's GDP decelerated back to 5%.

Strong export and growth performance helped to solve immediate fiscal problems, which were the ultimate reason for the 1998 collapse. Moreover, the overall situation improved dramatically after spring 2000, when President Putin's administration came into power. Compared to previous governments, the new government was much more serious regarding stabilisation policies and, in particular, in promoting reforms. Naturally, all these changes in policy-making were possible only due to better relations among the main political decision-making bodies – the president, the government, and the parliament – in post-Yeltsin Russia.

In spite of major reform initiatives, progress in legislation and changes in the business atmosphere, the core question remains: How vulnerable is Russia's economic and fiscal situation to changes in world market energy prices and the exchange rate of the rouble? While some people claim that due to political factors and economic reforms Russia's dependence on oil has declined, one can argue that such conclusions are perhaps premature, as only a few reforms have really been implemented in practice and in any case the core structure of the economy changes slowly.

This paper contributes to this discussion by analysing Russia's oil dependence using VAR modelling and cointegration techniques. The remainder of the paper is organised as follows. In the next section, recent discussion on the role of international oil prices is presented and commented on. Section 3 deals with data issues and unit root tests. In the fourth section, a VAR and cointegration framework is used to analyse long-run relationships among Russian GDP, fiscal revenues, the real exchange rate of the rouble and international oil prices. Based on this analysis, a parsimonious short-run error-correction model for the variables concerned is estimated in Section 5. The robustness of these results is checked in Section 6 by using an aggregate raw material price index instead of an oil variable. The paper concludes with discussion on the significance of the results.

2 A common view on the role of oil prices

As mentioned above, there is a common perception that oil prices and the real exchange rate have a major impact on Russia's GDP dynamics. This view is based on the fact that exports in relation to GDP in 2001 totalled about one-third, and roughly half of export revenues came from energy. Moreover, the federal budget is believed to be heavily dependent on both output developments and energy prices. According to several sources, revenues from the energy sector account for 30-40 % of central government total revenues.[1]

The attached graphs (Figure 1) on the development of output, real federal revenues, the real effective exchange rate and oil prices reinforce the view that there are strong links among the relevant variables. In particular, fiscal revenues seem to follow closely oil prices and GDP trends. The dependence of output on oil prices is perhaps not as obvious as in the case of fiscal revenues, although the graphs reveal co-movements of GDP and oil prices before the August 1998 crisis and again since 1999. The real exchange rate graph indicates that since the beginning of 1995 there has been a tendency for the real exchange rate to appreciate, except in 1998 when the rouble collapsed as a result of the August crisis. Incidentally, real exchange rate appreciation is a common feature in most transition economies (the Balassa-Samuelson effect). Nevertheless, the nature of the relationship between output and the real exchange rate is not evident from the figures alone. One should also notice the dramatic impact of the August 1998 crisis on Russian data series. The 1998 events raise questions about possible structural breaks in the series and, consequently, whether there have been some deep changes in the working and dynamics of the Russian economy after 1998.

Figure 1. Russian GDP, fiscal revenues, the real exchange rate and oil prices (raw series)

[1] For example, OECD (2002) reports that gas and electricity taxes alone covered some 30 % of all federal budgetary revenues in 2000.

Despite a general view that oil plays an important role in the Russian economy, there is surprisingly little research on how oil prices affect Russian macroeconomic dynamics. Most analyses are based on rather simple and straightforward calculations as to how much a one dollar-change in the price of crude oil will change Russia's export or fiscal revenues. Thus, typically assessments by the Russian government, international financial institutions or investment banks focus on Russia's external and fiscal vulnerability, i.e., Russia's ability to service its debts.

Given that Russia exports some 150 million tons of crude oil per year, it is easy to compute that a dollar change in the world market price of oil per barrel would result in a USD 1.1 billion change in Russia's annual export revenues. Based on oil price information, one can further try to assess how other energy exports react to oil price changes and, consequently, what the overall impact is on external and fiscal balances. Thus, for example, in autumn 2001 Russia's prime minister Kasyanov said – presumably based on calculations by the government's think tanks – that a one dollar change in the price of a barrel of oil will change the total income of the Russian economy by USD 2 billion and federal revenues by 1 billion.[2]

In its Country Report 2001 for Russia, the IMF offers a more sophisticated medium-term assessment of Russia's external vulnerability to oil price changes. In the report, two alternative oil price scenarios are presented. Under the baseline scenario, it is expected that international oil prices fall gradually to USD 19.5 per barrel between end-2001 and 2006, the real exchange rate of the rouble continues to strengthen, and that economic reforms proceed. Given these assumptions, Russia's external balance will weaken significantly, but the current account will continue to show a healthy surplus. On the other hand, according to the IMF low oil price scenario, in which oil prices fall to USD 15 per barrel at the end of 2001, the current account surplus will still remain positive, though in the first years almost 2% of GDP lower than under the baseline. Lower energy prices will also decrease foreign exchange reserves and weaken the fiscal situation so that over 2002-06, enlarged government revenues will be on average 1% of GDP lower than under the baseline. Nevertheless, the difference between the two scenarios does not seem to be particularly dramatic, which might lead one to think that Russia's dependence on oil is not particularly strong.

Several investment banks have also given similar assessments concerning the role of oil in the Russian economy and, in particular, Russia's vulnerability to a sudden oil price decline. Most country reports seem to conclude that due to an excellent fiscal and external situation as well as a pro-reform government, Russia is today much less vulnerable to oil price declines than before the 1998 crisis.

A salient shortcoming of the aforementioned assessments is that they are based on a predetermined GDP assumption rather than on a system in which the GDP is determined endogenously and which explicitly takes into account how output changes due to terms of trade shock caused by energy price changes. While some analyses present a macroeconomic model for the Russian economy, they do not cover the particular issue of Russia's oil price dependence.[3] Likewise, the impact of the real exchange rate on GDP has gained

[2] A similar "rule-of-thumb" estimate of the effects of a one dollar-change on Russia's exports and budget revenues is offered by, for example, SchroderSalmonSmithBarney of Citygroup ("*Why Russia is more than an "oil play": Reforms, growth and macroeconomic preparedness"*, 9 October 2001) and several other investment banks.

[3] See Basdevant (2000), and Gavrilenkov and Henry (1999).

only little attention in empirical research, although there is a broad consensus regarding the importance of this topic.[4]

Recently, however, discussion concerning Russia's oil dependence has become more interesting - and controversial. In several occasions during fall 2001, it was argued that decreases in oil prices have no negative impact on real GDP growth.[5] Because these views were based on a macroeconomic model developed for the Russian Ministry for Economic Development and Trade, they might have an influence on decision-makers. Hence, there is an additional motivation to examine and elaborate on the issue.

3 Data and unit root tests

In this paper, a vector autoregressive (VAR) model and a cointegration framework are used to examine the effect of oil price and real exchange rate changes on GDP and fiscal revenues. Thus, the idea is to test whether the data currently available allow construction of a reasonable econometric model for the Russian economy that would give some additional empirical evidence concerning long-run relations among the relevant variables.

For the time being, a natural reason for the lack of empirical work on the impact of oil prices and the real exchange rate on Russia's economy has been data problems. In particular, time series regarding output and fiscal operations are short, and frequent revisions of data make their use inconvenient. Moreover, due to the transition process, there have been various structural and institutional changes in Russia that complicate empirical analysis. Thus, while diagnostic tests should give us a hint of the magnitude of such data problems, a very short and exceptional research period inevitably means that all results will be tentative.

In this paper, quarterly data for 1995:Q1 – 2001:Q3 are used to estimate a VAR model for the Russian economy. The model includes Russian GDP, federal government revenue and the real exchange rate of the rouble as endogenous variables. International oil prices comprise an exogenous (non-modelled) variable. The GDP index (level) is computed using data from Goskomstat, while data for federal government revenues and oil prices[6] are taken from the IMF's International Financial Statistics (IFS). The real effective exchange rate data are from the IFS and the Russian Economic Trends (RECEP). The consumer price index is used as a deflator to compute real revenue figures. As Figure 1 indicates, there is strong seasonal variation in the GDP and revenue series and, consequently, seasonally adjusted data are used for these two variables. Moreover, as the lag between the spot oil price and actual contract prices is some 3-4 months, and between the oil price and gas prices 6-9 months, a four-quarter moving average is used for the oil price variable.

Consequently, the list of variables, all of which are in logarithmic form, and their abbreviations are as follows: Log of seasonally adjusted real GDP (gdp); log of seasonally adjusted real revenues of the central government (gov); log of the rouble's real effective exchange rate (rex); and log of the oil price (oil).

[4] Gavrilenkov and Henry (1999) use their macroeconomic model for Russia to examine the economic consequences of a nominal exchange rate devaluation of the rouble.

[5] For example, Rudiger Ahrend, "*Better Low Than High*" The Moscow Times, 16 October 2001.

[6] Russian Urals crude oil is expected to follow closely the price of North Sea Brent, a benchmark price used in this exercise.

Unit root tests regarding the order of integration of the series give somewhat contradicting results (see Table 1). While most tests indicate that real output, revenues and the exchange rate are I(1) variables, some of the tests conclude that the oil price is a stationary variable in this particular sample period. Nevertheless, the results show that all the variables are integrated of, at most, order one. Thus, given the earlier discussion, graphs, economic theory considerations and the properties of individual series, it seems acceptable to proceed to construct a formal econometric system in order to examine whether there are stationary long-run relationships among Russian GDP, federal budget revenues, the real exchange rate and international oil prices; i.e., we now proceed to analyse whether the variables are cointegrated.

Table 1. Unit root tests for sample period 1995 Q1 – 2001 Q3

	Augmented Dickey-Fuller test			Phillips-Perron test		
	None	Constant	Con. + Trend	None	Constant	Con. + Trend
gdp	0.54	-0.70	-0.93	0.36	-0.81	-0.77
Dgdp	-2.84**	-2.83	-3.75*	-3.58**	-3.55*	-4.29*
gov	0.18	-1.23	-1.09	0.03	-1.71	-1.47
Dgov	-3.23**	-3.18*	-3.31	-5.95**	-5.86**	-6.17**
rex	-0.12	-2.15	-2.20	0.10	-1.79	-1.87
Drex	-3.62**	-3.54*	-3.51	-3.62**	-3.54*	-3.47
oil	0.05	-4.72**	-4.96**	0.61	-1.22	-1.61
Doil	-2.77**	-2.73	-2.65	-2.08*	-2.11	-2.01

Notes: Due to seasonally adjusted data, only one lag is used for calculations. * and ** denote significance at the 5% and 1% levels, respectively.

4 Long-run analysis: VAR and cointegration

In the previous section it was found that GDP, fiscal revenues and the real exchange rate are in levels non-stationary I(1) variables, while the results for the oil price variable were somewhat mixed. Nevertheless, the results allow for the possibility that there is a stationary long-run relationship among the variables concerned. Given the focus of this paper, we would particularly like to know how the level of GDP on the one hand, and the level of fiscal revenues on the other hand, react in the long run to changes in the level of oil prices and the real exchange rate. A VAR model and cointegration techniques are used to get new insights into these relationships.

Given the small number of observations, there is a need to keep the system as small as possible in order to allow for the estimation of parameters. Thus, a VAR system including GDP (gdp), fiscal revenues (gov) and the real exchange rate (rex) is constructed to illustrate the functioning of the Russian economy.[7] The oil price variable (oil) is treated as a non-modelled exogenous variable, because international oil prices are believed to be determined outside the system. Indeed, the basic idea is to enrich possible long-run cointe-

[7] One should notice that the system represents Russia's economy perhaps more broadly than one would first expect since, besides output and the fiscal sector, the real exchange rate captures both nominal exchange rate and inflation effects.

gration relationships among system variables by allowing the oil price variable in the cointegration space.

Starting with four lags, the system was finally reduced to a second-order VAR. Reduction was based on information on the significance of estimated parameters in the system and single equations, as well as an F-test related to system reduction. Quite surprisingly, it was found that no dummies were needed, in spite of the dramatic events of the August 1998 crisis and some other exceptional periods. There were no particular problems with diagnostics of the system or single equations (see Appendix 1).[8]

The cointegration results are reported in Tables 2a and 2b. The maximum-eigenvalue test and the trace test both allow for two cointegration vectors. Given the test results shown in Table 2a, it seems plausible to assume two cointegration vectors.

Table 2a. Cointegration results

```
SYS Cointegration analysis 1995 (1) to 2001 (3)

    eigenvalue     loglik for rank
                     232.886   0
      0.623528       246.074   1
      0.422493       253.486   2
     0.0525691       254.215   3

           Maximum eigenvalue test                  Trace test
Ho:rank=p  -Tlog(1-\mu)   using T-nm   95%  -T\Sum log(.)  using T-nm   95%
 p ==  0        26.38**      20.52    21.0      42.66**      33.18*   29.7
 p <=  1        14.82*       11.53    14.1      16.28*       12.66    15.4
 p <=  2        1.458        1.134     3.8      1.458        1.134     3.8

standardized \beta' eigenvectors
          gdp         gov         rex         oil
       1.0000    -0.35338    0.010273    0.095701
      -8.9008      1.0000     -1.4731      1.0480
      -393.47      15.416      1.0000      42.089

standardized \alpha coefficients
 gdp             0.15556    0.053233  0.00018777
 gov              2.3051     0.23814  -0.0018117
 rex             -1.0806     0.17247  -0.0010223
```

Table 2b. Restricted cointegration results

```
SYS General cointegration test 1995 (1) to 2001 (3)

\beta'
          gdp         gov         rex         oil
      -2.7076      1.0000     0.00000    -0.29737
       1.0000     0.00000     0.23785    -0.21723

\alpha
 gdp          -0.0017383    -0.32296
 gov            -0.57641     -1.3753
 rex             0.55433     -1.1148
```

[8] PcGive (PcFiml) versions 9.21 and 10.0 were used for estimation.

Due to the small number of variables in the VAR system and rather strong and straightforward assumptions concerning possible links among the variables, it was relatively easy to identify the two cointegration vectors (ß-vectors).[9] Thus, after restricting the real exchange rate to zero in the first β-vector in Table 2a, an exactly identified equation for fiscal revenues was obtained (the first β-vector in Table 2b). In a similar manner, restricting fiscal revenues to zero in the second β-vector led to a reasonable vector for GDP. It was found that no additional zero-restrictions are allowed. Moreover, restrictions on α-parameters show that none of the three variables in the VAR is weakly exogenous.[10]

As regards Russia's GDP, the cointegration vector (see Figure 2) demonstrates that there is a stationary long-run relationship so that the level of GDP depends on the level of the real exchange rate and oil prices. For example, a permanent 10% appreciation of the real exchange rate is associated with a 2.4 % drop in GDP. Respectively, a 10% permanent increase in the level of international oil prices would cause the level of GDP to increase by 2.2%. While our framework does not allow for testing whether, in general, the rouble's real appreciation is associated with oil price increases, as one would expect, this question is touched upon in the next section, which focuses on short-run issues.

The cointegration vector of fiscal revenues, for its part, indicates that a permanent 1% change in the level of GDP is associated with a 2.7% change in the level of the central government real revenues. However, the output elasticity of revenues seems to be more sensitive to the estimation period than the other parameters of the system. In particular, dropping out 1995 observations from the estimation period would cause the ß-coefficient of output to decline to 1.6. A corresponding instability at the beginning of the sample period is seen in the graph of the cointegration vector of government revenues in Figure 2. This instability in the revenue equation demonstrates perhaps that a heavy transition-related output and revenue decline continued until the latter part of 1995 and, hence, caused the overshoot of the output elasticity.[11] Regarding oil prices, the long-run error-correction mechanism suggests that a 10% change in the level of oil prices would in the long run cause a 3.0% change in federal real revenues. Given the high volatility of oil prices, this result seem to confirm the general belief that Russia's fiscal revenues are heavily affected by energy prices.

Figure 3 displays how the parameter estimates of cointegration vectors have developed over time. While one can notice a certain instability in the parameters, they nevertheless are perhaps more stable than one would expect. In particular, there are no clear trends of change and, consequently, the parameter estimates do not support the views that the role of oil or the real exchange rate in output determination have declined since the 1998 crisis. Rather, it seems that oil and the exchange rate developments have recently become even more important than they used to be, although it is difficult to see why this would have happened. Given frequent revisions of output data, naturally one cannot exclude the possibility that there are some problems with the currently available data for 2001.[12]

---

[9] At every stage, restrictions were tested before proceeding to next step.

[10] Neither of the two cointegration vectors could be identified as a reasonable long-run equilibrium condition for the real exchange rate.

[11] Cointegration estimation results for the sample period 1996:Q1 – 2001:Q3:

gdp = -0.30*rex + 0.20*oil

gov = 1.61*gdp + 0.52*oil

[12] Parameter constancy tests (one-step residuals and Chow tests) of the initial VAR-model did not either indicate particular problems, except in the GDP equation in 2001:2 and 2001:3. However,

Figure 2. Restricted cointegration vectors*

* Variables are scaled by means to fit the same picture.

Figure 3. Recursive estimates of the coefficients*

* Note that the signs refer to the initial cointegration vectors.

like "unexpected" changes of some coefficient parameters in Figure 3, it is difficult to interpret this possible instability in the GDP equation at the end of the research period.

5 Short-run analysis: An error-correction model (ECM)

Although the focus of this paper is on the long-run impact of oil prices and the real exchange rate on Russia's output, also a short run error-correction model was estimated to check the robustness of results. Thus, the VAR that forms the basis of the two error-correction relationships above is mapped into a stationary I(0) system, and the reformulated system is estimated using OLS. Corresponding to two lags in model of the levels of the variables, the lag length in the system of variables in differences is one. After getting a parsimonious VECM, the process of model reduction was continued by imposing zero restrictions on insignificant regressors in each equation. A FIML method was used to estimate the system. The estimation results are in Table 3 and diagnostic statistics are presented in Table 4.

Table 3. A parsimonious short-run model

```
MOD Estimating the model by FIML (using Oil04.in7)
        The estimation sample is: 1995 (1) to 2001 (3)

Equation for: Dgdp
                  Coefficient  Std.Error  t-value  t-prob
Constant              1.97062     0.4074     4.84   0.000
emgdp_1             -0.396811    0.08218    -4.83   0.000
Dgov_1              0.0340297    0.01923     1.77   0.092

Equation for: Dgov
                  Coefficient  Std.Error  t-value  t-prob
Constant             -5.84886      1.650    -3.55   0.002
Doil                 0.549042     0.2363     2.32   0.031
emgov_1             -0.653168     0.1843    -3.54   0.002

Equation for: Drex
                  Coefficient  Std.Error  t-value  t-prob
Constant              2.85905      1.168     2.45   0.024
Dgdp_1                2.97370     0.6367     4.67   0.000
emgov_1              0.319423     0.1305     2.45   0.024
Drex_1               0.216113     0.1345     1.61   0.124
```

While the significance of each right-hand side variable greatly depends on the order in which restrictions are imposed, there seem to be no major problems in ending up with quite reasonable results, at least in qualitative terms. No major problems with the diagnostics of the system or with the equations were found (see Table 4).[13]

Thus, given the fact that the purpose is merely to check whether the long-run error-correction variables really work in the short-run model, rather than build a realistic short-run model, the most important findings are the following. First, the signs of the error-correction parameters in the respective equations (i.e., –0.397 for *emgdp_1* in the GDP equation and –0.653 for *emgov_1* in the government revenue equation) are correct and they both are statistically significant. Second, while the short-run effects of the oil price change on output and the real exchange rate seem to be insignificant[14], the direct impact of the oil

[13] Besides tests reported in Table 4, one-step residuals and Chow tests were conducted and no problems with parameter constancy were found.

[14] This might reflect the fact that smoothed data for oil prices are used.

price change (*Doil*) on fiscal revenues is statistically significant. Thus, oil prices influence fiscal revenues both directly and through the long-run equilibrium condition (error-correction mechanism). Third, changes in output (*Dgdp_1*), contrary to oil prices, have a major impact on short-run real exchange rate developments. Fourth, besides long-run effects through the error-correction mechanism, GDP could be influenced by oil price changes via the public sector, as indicated by the parameter of the revenue variable (*Dgov_1*) in the short-run GDP equation. Thus, in the short-run, higher oil prices increase government revenues, which possibly cause more public spending and, hence, output growth.[15]

An important result of the short-run exercise is also that the recursive estimation results do not reveal any major changes in the system during the sample period ending 2001:Q3. Thus, the impact of the outstanding reform initiatives by Putin's administration does not yet show up in a manner that would allow one to conclude that Russia's dependence on oil price developments has significantly weakened.

Table 4. Diagnostic statistics for the short-run model

```
correlation of structural residuals (standard deviations on diagonal)
               Dgdp         Dgov         Drex
Dgdp       0.015037      0.26572     0.080551
Dgov        0.26572      0.11733      0.48879
Drex       0.080551      0.48879     0.075999

Dgdp        : Portmanteau( 4): 4.16834
Dgov        : Portmanteau( 4): 2.06791
Drex        : Portmanteau( 4): 3.31222
Dgdp        : AR 1-3 test:      F(3,17)  =   2.4394 [0.0998]
Dgov        : AR 1-3 test:      F(3,17)  =   1.2448 [0.3245]
Drex        : AR 1-3 test:      F(3,17)  =   3.1756 [0.0509]
Dgdp        : Normality test:   Chi^2(2) =   2.4374 [0.2956]
Dgov        : Normality test:   Chi^2(2) =   2.2297 [0.3280]
Drex        : Normality test:   Chi^2(2) =   3.8192 [0.1481]
Dgdp        : ARCH 1-3 test:    F(3,18)  =  0.31686 [0.8130]
Dgov        : ARCH 1-3 test:    F(3,18)  =   1.2468 [0.3222]
Drex        : ARCH 1-3 test:    F(3,18)  =  0.45480 [0.7171]
Dgdp        : hetero test:      F(12,11) =  0.62223 [0.7864]
Dgov        : hetero test:      F(12,11) =   1.2985 [0.3362]
Drex        : hetero test:      F(12,11) =   1.1276 [0.4246]

Vector Portmanteau( 4): 30.8271
Vector EGE-AR 1-3 test:  F(27,38) =  0.94608 [0.5533]
Vector Normality test:   Chi^2(6) =   7.1536 [0.3069]
Vector hetero test:      F(72,38) =  0.76807 [0.8332]
```

[15] However, one should recognise that statistical evidence concerning the impact of oil prices on the GDP through budgetary sector is relatively weak. Nevertheless, leaving out the revenue variable from the output equation would cause diagnostic problems.

6 Robustness test: The role of raw materials

Due to the fact that crude oil exports account for only 20-25% of the total value of Russia's exports, a natural extension, or test, of the previous set-up is to replace the oil price variable with a raw material price index. In this exercise a HWWA index for raw materials (including energy) is used, which means that the price developments of some 70-80% of Russian exports is now taken into account.

Replacing oil prices with the aggregate raw material price index seems to reinforce the previous results. The results support the previous assumption concerning the existence of two cointegration vectors (see Table 5). Moreover, Table 6 shows that the restricted cointegration estimation results are very similar to the previous system, except that the effect of the aggregate raw material price index (hwwa) is clearly stronger than that of the oil price alone. Thus, for example, while the oil price elasticity for GDP in the previous set-up was 0.22, the raw material price elasticity of output is 0.49. Replacing the oil price variable with the HWWA index does not change the results concerning the role of the real exchange rate.

In addition to long-run estimation results, also a short-run model based on the HWWA index was found to be very similar to the one with the oil price variable. The error-correction terms for GDP and federal revenues were both significant in the respective equations, and the coefficient of the price variable was significant only in the equation for fiscal revenues. Moreover, in this set-up fiscal revenues had clearly a statistically significant positive impact on output growth.

Table 5. Cointegration results based on raw material prices (HWWA-index)

```
SYS Cointegration analysis 1995 (1) to 2001 (3)

    eigenvalue     loglik for rank
                     232.886   0
      0.632749       246.409   1
      0.474274       255.089   2
     0.0177708       255.331   3

           Maximum eigenvalue test                  Trace test
Ho:rank=p  -Tlog(1-\mu)   using T-nm   95%  -T\Sum log(.)  using T-nm   95%
 p ==  0        27.05**      21.04*   21.0      44.89**      34.91*   29.7
 p <=  1        17.36*        13.5    14.1      17.84*       13.88    15.4
 p <=  2       0.4841       0.3765     3.8     0.4841       0.3765     3.8

standardized \beta' eigenvectors
          gdp         gov         rex        hwwa
       1.0000    -0.36838   -0.015776     0.24248
      -13.111      1.0000     -2.7270      4.4280
       11.165    -0.28206      1.0000    0.060921

standardized \alpha coefficients
 gdp             0.18727    0.021642  -0.0040968
 gov              3.0490     0.13145    0.012588
 rex            -0.89446     0.12378    0.010037
```

Table 6. Restricted cointegration results based on raw material prices (HWWA-index)

```
SYS General cointegration test 1995 (1) to 2001 (3)

\beta'
          gdp         gov         rex        hwwa
      -2.8753      1.0000     0.00000    -0.57960
       1.0000     0.00000     0.26642    -0.48923
\alpha
 gdp           -0.047347    -0.23260
 gov            -0.99175     -1.5260
 rex             0.45328     -1.2140
```

7 Conclusions

This paper examined how sensitive Russia's output and fiscal policy are to changes in international oil prices and the real exchange rate of the rouble. The findings support the prevailing common view that both of these factors play a major role in the Russian economy. More precisely, it was found that in the long run a 10% permanent increase (decrease) in international oil prices is associated with a 2.2% growth (fall) in the level of Russian GDP. On the other hand, a 10% real appreciation (depreciation) of the rouble is associated with a 2.4% decline (increase) in the level of GDP in the longer run. Correspondingly, a 10% increase (decline) in oil prices is associated with a 3.0% increase (fall) in federal government real revenues. The results confirm also the strong dependence of revenues on GDP developments (output elasticity is 2.7), although the estimated coefficient is heavily influenced by particular factors for 1995. The estimated short-run model for the Russian economy confirms that the long-run equilibrium conditions significantly affect the short-run dynamics of real GDP and real budget revenues through an error-correction mechanism. These results seem robust in the sense that similar effects – although stronger as one might expect – are achieved by replacing oil prices with an index of a broad range of raw material and energy prices.

The results of this study indicate that the impact of the oil price changes on output could be balanced by respective changes in the real exchange rate. However, this counterbalancing effect is not necessarily mechanical. Rather, from the economic policy perspective, Russia should continue to be prepared to tackle with the possible short-run problems triggered by oil prices, while, at the same time, continue to decrease its dependency on energy prices in the longer run through reform policies. In particular, given the important role of real exchange rate, the findings presented here give support to anti-inflation policies, through which Russian policy makers could restrain the real appreciation of the rouble and, hence, support output growth. In addition, while this study does not say much about the determination of the real exchange rate itself, it does indicate that, in the short-run, output developments seem to play an important role in the determination of the real exchange rate (rather than, for example, oil prices). Regarding future work, it would be interesting to see whether it would be possible to model the real exchange rate to take into account also long-run dependencies. Moreover, when longer time series become available, it will be possible to add some more variables to the VAR, in order to enrich the model and analysis and to take into account other factors affecting economic growth.

An interesting question naturally is whether Russia's economic reforms have started to yield results that would decrease its dependence on oil prices. The estimation results of this study do not reveal any indication of such tendencies.

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Appendix 1. Diagnostic statistics for the long-run VAR

```
SYS Estimating the unrestricted reduced form by OLS
The present sample is:  1995 (1) to 2001 (3)

URF Equation 1 for gdp
Variable     Coefficient    Std.Error  t-value  t-prob
gdp_1            0.69553      0.24555    2.833  0.0106
gdp_2          -0.087664      0.21204   -0.413  0.6839
gov_1           0.019707     0.030961    0.637  0.5320
gov_2          -0.018551     0.032534   -0.570  0.5752
rex_1          -0.087580     0.038663   -2.265  0.0354
rex_2           0.010950     0.042427    0.258  0.7991
oil             0.078578     0.027996    2.807  0.0113
Constant          1.8874      0.96530    1.955  0.0654

\sigma = 0.0169725   RSS = 0.005473259946

URF Equation 2 for gov
Variable     Coefficient    Std.Error  t-value  t-prob
gdp_1          -0.062942       1.8412   -0.034  0.9731
gdp_2            0.96121       1.5899    0.605  0.5526
gov_1            0.26350      0.23215    1.135  0.2705
gov_2            0.13216      0.24395    0.542  0.5943
rex_1           -0.23759      0.28990   -0.820  0.4226
rex_2          -0.091336      0.31813   -0.287  0.7771
oil              0.39391      0.20992    1.876  0.0760
Constant         -1.2335       7.2381   -0.170  0.8665

\sigma = 0.127264   RSS = 0.3077273729

URF Equation 3 for rex
Variable     Coefficient    Std.Error  t-value  t-prob
gdp_1            0.91051       1.0632    0.856  0.4025
gdp_2            -3.1240      0.91811   -3.403  0.0030
gov_1            0.22953      0.13406    1.712  0.1031
gov_2            0.30904      0.14087    2.194  0.0409
rex_1             1.0427      0.16741    6.229  0.0000
rex_2           -0.30889      0.18371   -1.681  0.1090
oil             0.034304      0.12122    0.283  0.7802
Constant          8.8557       4.1797    2.119  0.0475

\sigma = 0.0734903   RSS = 0.1026157433

correlation of URF residuals
                     gdp         gov         rex
 gdp              1.0000
 gov             0.21780      1.0000
 rex            0.020036     0.44758      1.0000

standard deviations of URF residuals
          gdp         gov         rex
     0.016973     0.12726    0.073490

loglik = 254.21528  log|\Omega| = -18.8308  |\Omega| = 6.63597e-009  T = 27
log|Y'Y/T| = -13.3865
R^2(LR) = 0.995679  R^2(LM) = 0.684502
```

```
F-test on all regressors except unrestricted, F(21,49) = 13.303 [0.0000] **
variables entered unrestricted:
  Constant

F-tests on retained regressors, F(3, 17)
      gdp_1     2.98259 [0.0605]         gdp_2     5.39736 [0.0086] **
      gov_1     1.00581 [0.4143]         gov_2     1.58624 [0.2295]
      rex_1     17.0853 [0.0000] **      rex_2    0.933135 [0.4462]
        oil     2.89999 [0.0652]

correlation of actual and fitted
          gdp         gov         rex
      0.96647     0.89830     0.94885

gdp     :Portmanteau  4 lags=   4.2898
gov     :Portmanteau  4 lags=   2.0671
rex     :Portmanteau  4 lags=   2.4351
gdp     :AR 1- 3 F( 3, 16) =      0.796 [0.5139]
gov     :AR 1- 3 F( 3, 16) =    0.48353 [0.6984]
rex     :AR 1- 3 F( 3, 16) =    0.71474 [0.5574]
gdp     :Normality Chi^2(2)=    0.84731 [0.6547]
gov     :Normality Chi^2(2)=     2.4846 [0.2887]
rex     :Normality Chi^2(2)=     3.1318 [0.2089]
gdp     :ARCH 3  F( 3, 13) =     0.2327 [0.8720]
gov     :ARCH 3  F( 3, 13) =    0.53099 [0.6689]
rex     :ARCH 3  F( 3, 13) =    0.22786 [0.8753]
gdp     :Xi^2    F(14,  4) =    0.29792 [0.9600]
gov     :Xi^2    F(14,  4) =    0.19965 [0.9898]
rex     :Xi^2    F(14,  4) =    0.73514 [0.7028]
Vector portmanteau  4 lags=   33.408
Vector AR 1-3  F(27, 24) =     1.0277 [0.4759]
Vector normality Chi^2( 6)=    5.8694 [0.4380]
Vector  Xi^2  Chi^2( 84) =      85.59 [0.4312]
```

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