The Role of Oil Prices in Russia's Economy

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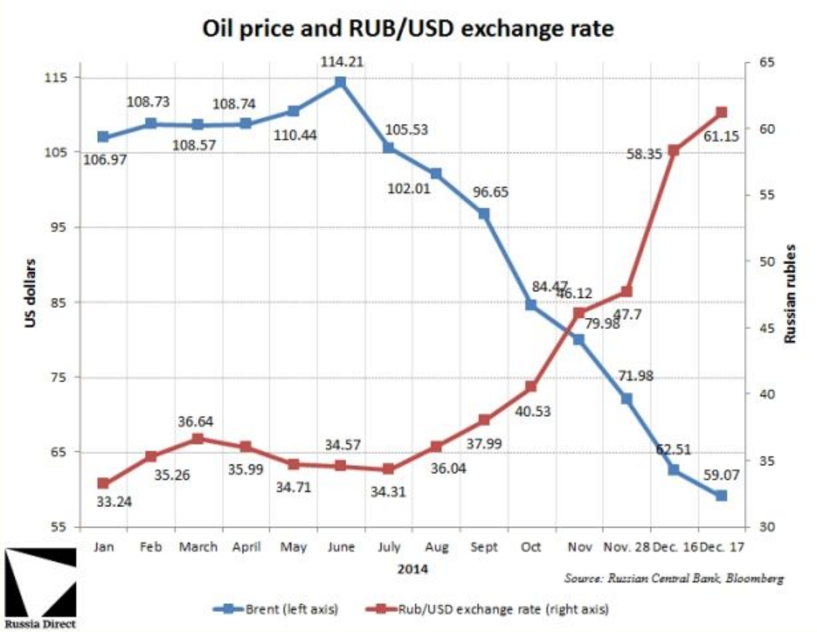
Introduction

- Economy is highly dependent
  - In 2013, oil and gas was 68% of Russian exports
- Oil and gas is nearly half of the Russian government’s budget
- Oil price directly impacts the Ruble price:
  - Cheap oil causes depreciation
  - Correlation strengthened as oil production increased
- Crucial factor in geopolitics
  - May impact military spending

Economic Impact of the Oil Price



- As cheap oil weakens the Russian economy, this causes the ruble to depreciate, leading to inflation.
- Causes high volatility in foreign exchange markets.
- Currency weakness accelerated inflation to a 13-year high of 16.9 percent in March 2015.
- Annual consumer-price growth eased to 12.9 percent in December 2015.

Data set

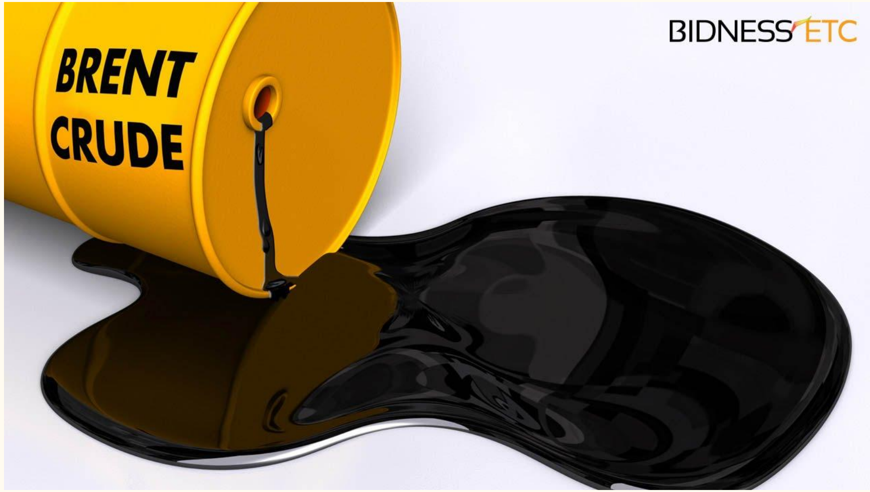
2003 Q1 - 2016 Q3

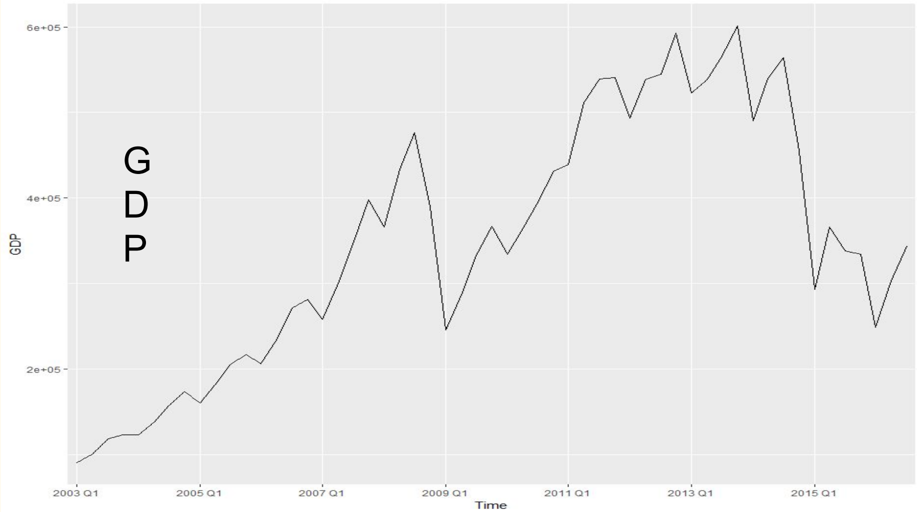
Gross Domestic Product (GDP)

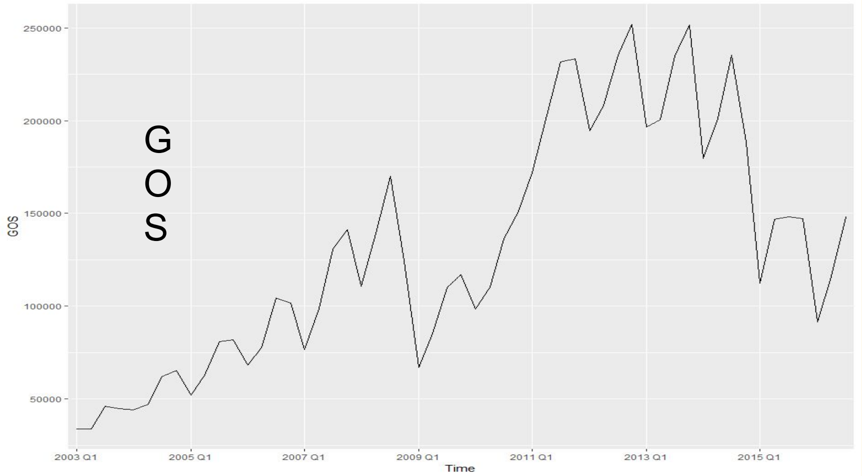
Gross Operating Surplus (GOS)

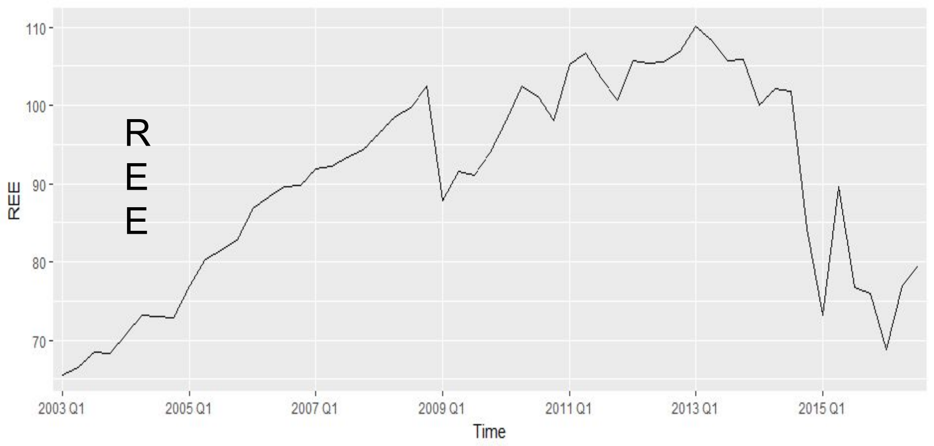
Real Effective Exchange Rates (REE)

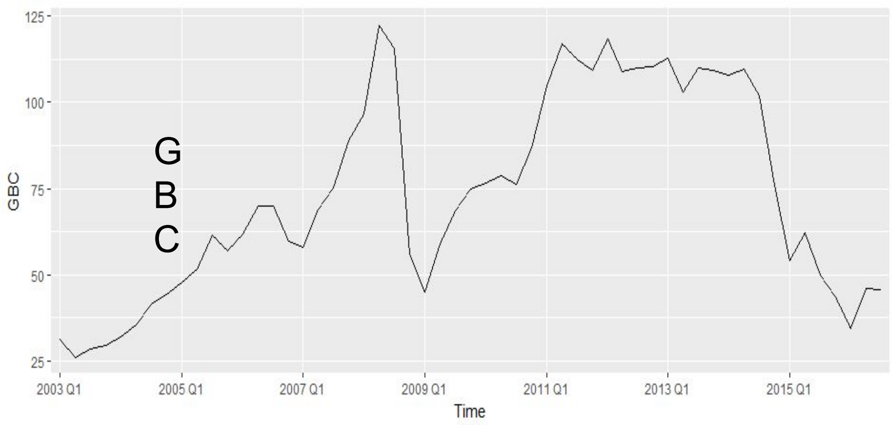
Global Price of Brent Crude (GBC)




G
D
P
GDP
6e+05
4e+05
2e+05
2003 Q1
2005 Q1
2007 Q1
2009 Q1
2011 Q1
2013 Q1
2015 Q1
Time

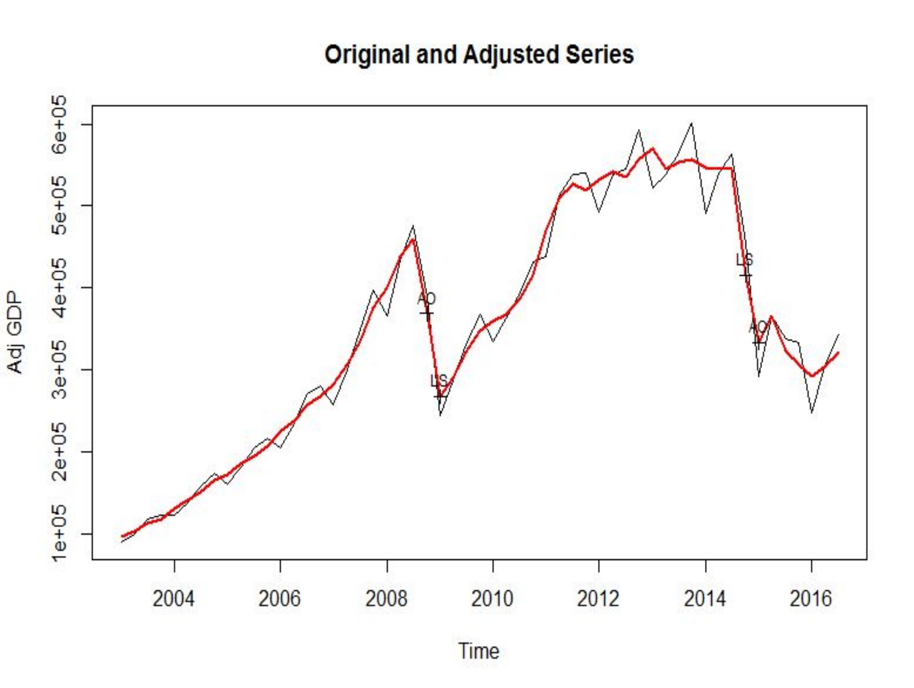

G
O
S
GOS
250000
200000
150000
100000
50000
2003 Q1
2005 Q1
2007 Q1
2009 Q1
2011 Q1
2013 Q1
2015 Q1
Time

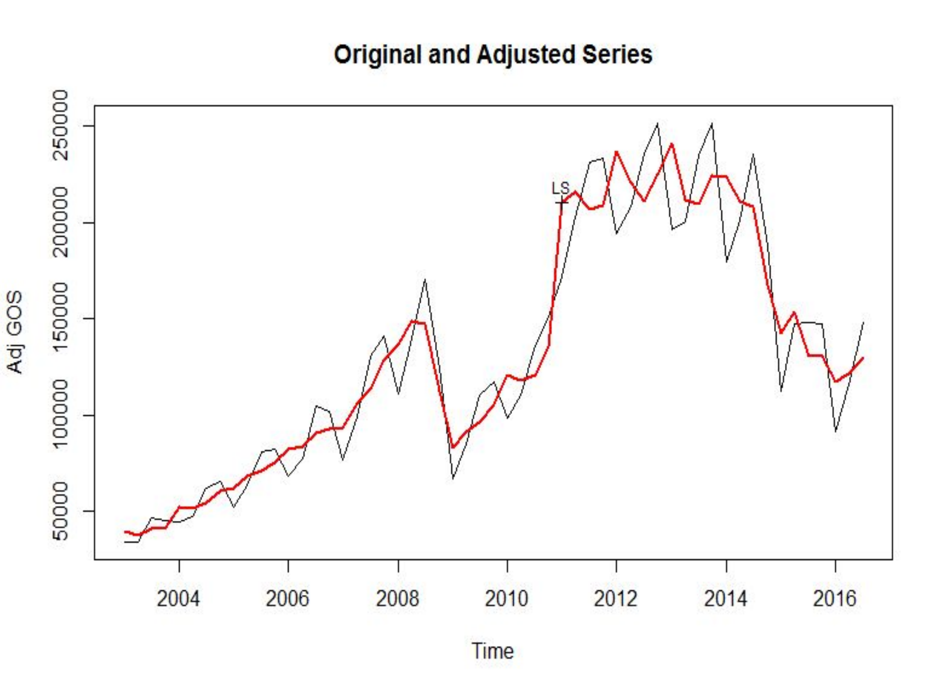

R
E
E
REE
110
100
90
80
70
2003 Q1
2005 Q1
2007 Q1
2009 Q1
2011 Q1
2013 Q1
2015 Q1
Time


G
B
C
GBC
125
100
75
50
25
2003 Q1
2005 Q1
2007 Q1
2009 Q1
2011 Q1
2013 Q1
2015 Q1
Time

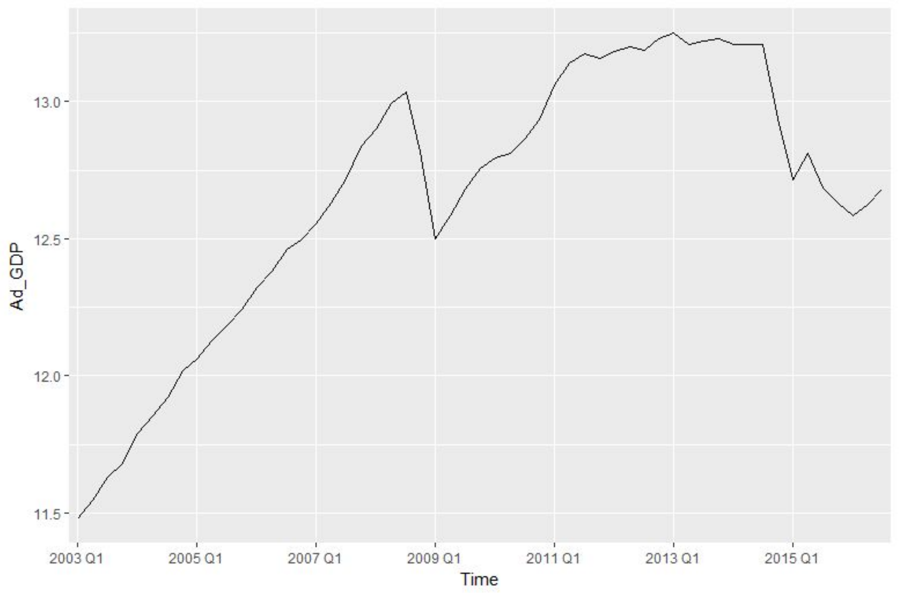
Seasonal adjustment

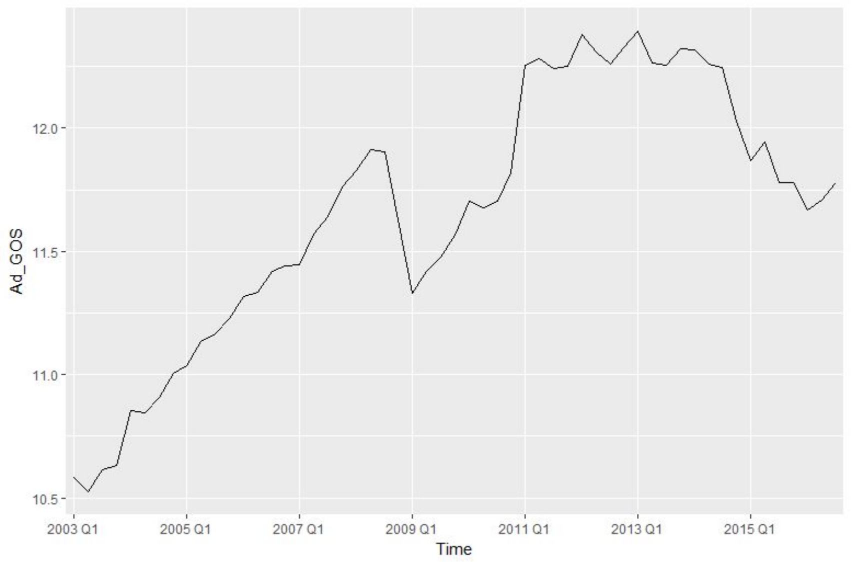
- by using X-13ARIMA-Seats





Log Transformation on GDP and GOS





Unit root tests

Augmented Dickey-Fuller test: All series are I(1)

	GDP	Diff_GDP	GOS	Diff_GOS	REE	Diff_REE	GBC	Diff_GBC
None	-1.832	-4.726***	-1.618	-4.445***	-1.565	-5.959***	-2.116	-5.490***
Constant	1.886	7.494***	1.445	6.627***	1.680	11.990***	1.889	10.07***
Con. + Trend	2.729	11.240***	2.038	9.940***	2.512	17.980***	2.825	15.098***

Both X_{it} & Y_t are $I(1)$

$$\Big\downarrow \, ?$$

$$Y_t - \beta_i X_{it} = \varepsilon_t \sim \boldsymbol{I}(0)$$

Cointegration-Johansen test

Lag Selection: Varselect( )

AIC(n)	HQ(n)	SC(n)	FPE(n)
2	2	1	2

Johansen Test: find one cointegration relationship

	test	10pct	5pct	1pct
r <= 3 |	3.61	7.52	9.24	12.97
r <= 2 |	10.57	17.85	19.96	24.60
r <= 1 |	21.17	32.00	34.91	41.07
r = 0 |	58.16	49.65	53.12	60.16

Vector Error Correction Model

Vector Error Correction Model

$$\Delta y_t = \prod y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Delta y_{t-p+1} + \varepsilon_t$$

Only have one cointegration relationship, then,

$$\Delta y_t = \alpha \beta^T y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Delta y_{t-p+1} + \varepsilon_t$$

where α is 4×1 and β^T is 1×4

Vector Error Correction Model

Then

$$\Delta Y_t = \begin{bmatrix} -0.260 \\ -0.259 \\ 0.020 \\ -0.572 \end{bmatrix} \begin{bmatrix} 1.000 & -0.757 & -2.983 & 0.892 \end{bmatrix} Y_{t-1} + \begin{bmatrix} 0.402 & -0.019 & -1.085 & 0.383 \\ 0.607 & -0.132 & -1.488 & 0.406 \\ 0.191 & 0.082 & -0.552 & 0.047 \\ 0.261 & -0.004 & -1.696 & 0.519 \end{bmatrix} \Delta Y_{t-1}$$

Test residuals,

	GDP	GOS	REE	GBC
ADF Test	-4.7003***	-4.2066***	-4.1282***	-5.2647***
Normality Test	0.1631***	0.6431***	0.0041	0.0002
Ljung-Box Test	0.8729	0.9267	0.5577	0.971

Cointegration- Engle and Granger test

1. Test if there is Unit root in each component series individually by using ADF.
2. Test cointegration among the components, i.e., to test whether $\alpha' Y_t$ is I(0).

- If Yt =(Y1t,Y2t,...,Ymt) is cointegrated, $\alpha' Y_t$ is I(0) where =(1, 2,..., m). Then, $(1/\alpha_1)\alpha$ is also a cointegrated vector where $\alpha_1 \neq 0$

Cointegration- Engle and Granger test

- EG consider the regression model for Y1t

$$Y_{1t} = \delta D_t + \phi_1 Y_{2t} + \cdots + \phi_{m-1} Y_{mt} + \varepsilon_t$$

where D_t: deterministic terms.

- Check whether residual term is I(1) or I(1)
  - If I(1), then Yt is not cointegrated.
  - If I(0), then Yt is cointegrated with a normalized cointegrating vector

$$\alpha' = (1, \varphi_1, \dots, \varphi_{m-1})$$

- Steps:
  - Run OLS. Get estimate $\widehat{\alpha} = (1, \widehat{\varphi_1}, \dots, \widehat{\varphi_{m-1}})$
  - Use residual for unit root testing.

Cointegration- Engle and Granger test

Is cointegrated?

	GDP	GOS	REE	GBC
GDP		No	No	Yes
GOS	No		No	No
REE	No	No		Yes
GBC	Yes	No	Yes	

Causality test of GDP and GBC

Granger Causality Null Hypothesis	P-value
GDP do not Granger-cause GBC	0.7794***
GBC do not Granger cause GDP	0.0051

- GBC granger causes Russia GDP.
- At the same time, Russia GDP does not granger cause GBC

Error Correction Model of GDP and GBC

Select Lags

AIC(n)	HQ(n)	SC(n)	FPE(n)
2	2	2	2

Then,

$$\Delta \mathrm{GDP}_t = 1.3997 - 0.1592(\mathrm{GDP}_{t-1} - 1.058511\mathrm{GBC}_{t-1}) + 0.4184\Delta \mathrm{GBC}_{t-1}$$

The residual of ECM

Test	Value
ADF	-5.0995***
Normality Test	0.0001
Ljung-Box Test	0.9994***

By using the ADF test, we can find out that the residual of ECM follow the I(0).

Thus, the long run are stationary.

Comparison of Engle-Granger Test and Johansen Test

First of all, the two methods are essentially different, and may disagree on inferences from the same data. The Engle-Granger two-step method for estimating the VEC model, first estimating the cointegrating relation and then estimating the remaining model coefficients, differs from Johansen's approach.
Secondly, the cointegrating relations estimated by the Engle-Granger approach may not correspond to the cointegrating relations estimated by the Johansen approach, especially in the presence of multiple cointegrating relations. It is important, in this context, to remember that cointegrating relations are not uniquely defined, but depend on the decomposition $C = AB'$ of the impact matrix.

Vector Autoregressive Model

- Reduced form

$$\begin{bmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{Kt} \end{bmatrix} = \begin{bmatrix} \phi_{11} & \cdots & \phi_{1K} \\ \vdots & \ddots & \vdots \\ \phi_{K1} & \cdots & \phi_{KK} \end{bmatrix} \begin{bmatrix} X_{1,t-1} \\ X_{2,t-1} \\ \vdots \\ X_{K,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \vdots \\ \varepsilon_{K,t} \end{bmatrix}, \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \vdots \\ \varepsilon_{K,t} \end{bmatrix} \sim N(0, \Sigma).$$

- Structural form

$$\begin{bmatrix} 1 & 0 & \cdots & 0 \\ l_{21}^* & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ l_{K1}^* & l_{K2}^* & \cdots & 1 \end{bmatrix} \begin{bmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{Kt} \end{bmatrix} = \begin{bmatrix} \phi_{11}^* & \cdots & \phi_{1K}^* \\ \vdots & \ddots & \vdots \\ \phi_{K1}^* & \cdots & \phi_{KK}^* \end{bmatrix} \begin{bmatrix} X_{1,t-1} \\ X_{2,t-1} \\ \vdots \\ X_{K,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t}^* \\ \varepsilon_{2,t}^* \\ \vdots \\ \varepsilon_{K,t}^* \end{bmatrix}, cov(\varepsilon_{i,t}^*, \varepsilon_{j,t}^*) = 0$$

- ARDL

$$\begin{cases} X_{1t} = \phi_{11}^* X_{1,t-1} + \cdots + \phi_{1K}^* X_{K,t-1} + \varepsilon_{1,t}^* \\ X_{2t} = \phi_{21}^* X_{1,t-1} + \cdots + \phi_{2K}^* X_{K,t-1} - l_{21}^* X_{1t} + \varepsilon_{2,t}^* \\ X_{3t} = \phi_{31}^* X_{1,t-1} + \cdots + \phi_{3K}^* X_{K,t-1} - l_{31}^* X_{1t} - l_{32}^* X_{2t} + \varepsilon_{3,t}^* \\ \vdots \\ X_{Kt} = \phi_{K1}^* X_{1,t-1} + \cdots + \phi_{KK}^* X_{K,t-1} - \Sigma_{i=1}^{K-1} X_{it} + \varepsilon_{K,t}^* \end{cases}$$

Vector Autoregressive After Difference

Select lag

AIC(n)	HQ(n)	SC(n)	FPE(n)
4	1	1	4

VAR with lag 1

$$GDP_t = 0.0137 + 0.2608GDP_{t-1} - 0.0751GOS_{t-1} - 0.2160REE_{t-1} + 0.3493GBC_{t-1}$$
$$GOS_t = 0.0133 + 0.6007GDP_{t-1} - 0.1079GOS_{t-1} - 1.0184REE_{t-1} + 0.2790GBC_{t-1}$$
$$REE_t = -0.0047 + 0.1723GDP_{t-1} + 0.00951GOS_{t-1} - 0.1514REE_{t-1} + 0.1003GBC_{t-1}$$
$$GBC_t = 0.0119 - 0.1878GDP_{t-1} + 0.06151GOS_{t-1} + 0.0187REE_{t-1} + 0.3949GBC_{t-1}$$

Breusch-Godfrey test

H0: There is no ACF of any order up to 10

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 Breusch-Godfrey LM test

data:  Residuals of VAR object Var_Mdl
Chi-squared = 94.911, df = 80, p-value = 0.1221
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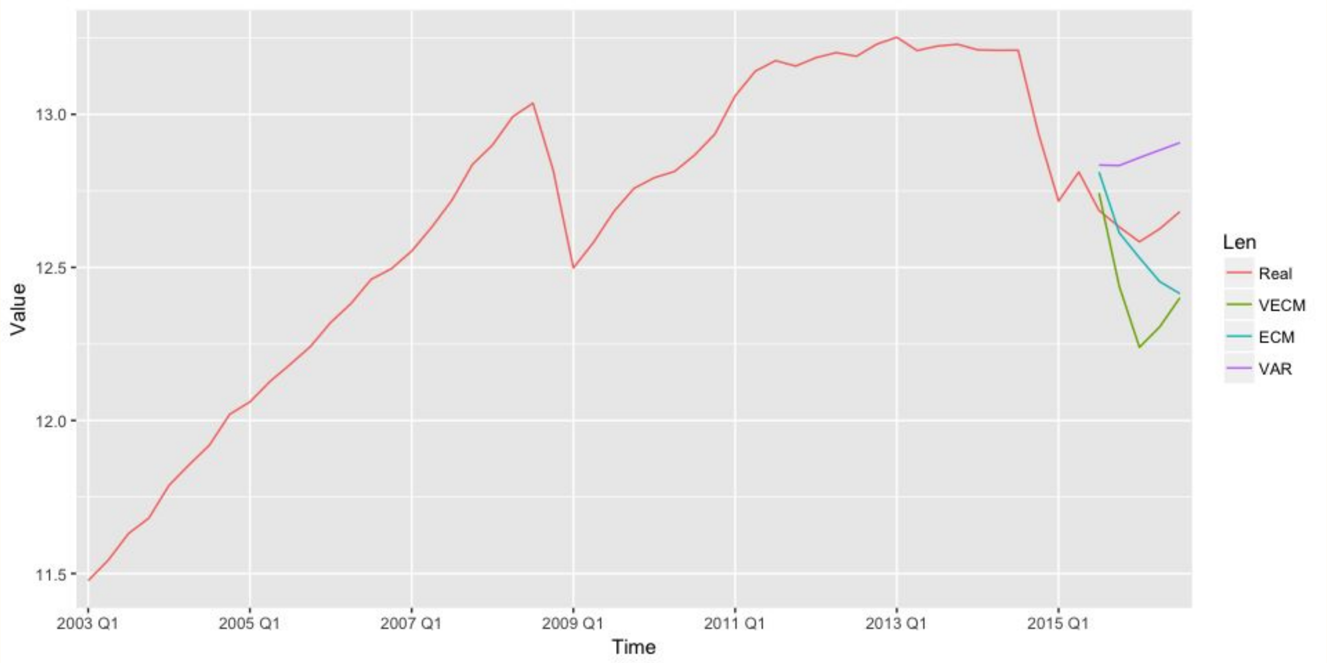
Predict GDP



13.0
12.5
12.0
11.5
Value
2003 Q1
2005 Q1
2007 Q1
2009 Q1
2011 Q1
2013 Q1
2015 Q1
Time
Len
Real
VECM
ECM
VAR

Conclusion

- We 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 interesting, we found Russia’s GDP and international oil prices has a long-run stationary relationship.