The Impact of Oil Price on Russian Ruble Exchange Rate

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Crude oil plays a critical role in the industrial production and daily transportation. Oil sector accounts for over 68% of Russia's export in 2013. Between July to December 2014, the negative oil price shock dampens Russia's exports. This paper, using both West Texas Intermediate (WTI) and Brent (BRNT) oil prices, studies the relationship between oil price and Ruble exchange rate (RUB/USD). It discovers that oil price Granger-causes RUB/USD and not vice versa. This result indicates that oil price is important to the value of Russian currency since the Russian economy heavily depends on the oil sector. Moreover, only long-run conintegration relationship has been observed.

Key Words: Oil price; Exchange rate; Unit Root; Cointegration; Granger Causality; Error Correctin Model

Introduction

In the 2000s, prices of energy and base metals first surged around 150% but lost most of the gains in the global financial crisis due to the sluggish demand. Specific movements are observed in Figure 1 & 2 in which Australian Dollar (AUD) and Brazilian Real (BRL) moved with the iron ore price. Russian Ruble (RUB) fluctuated with the oil price (Figure 3). Henceforth, for countries

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heavily dependent on commodity exports, such as Russia and Malaysia, the violent movements in the commodity markets drive the fluctuations in the countries' trade balances and current accounts. (Shafi and Liu, 2014).

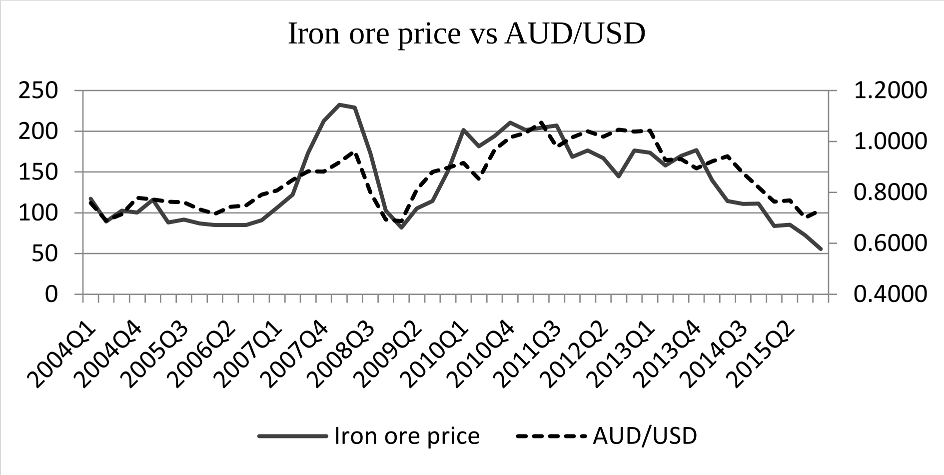

Figure 1. Iron ore price and AUD/USD (Data Source: CEIC WebCDM)

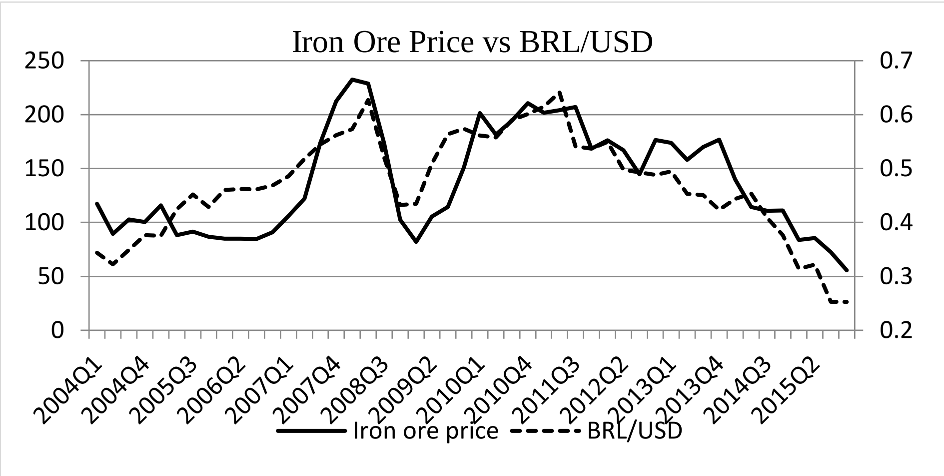

Figure 2. Iron ore price and BRL/USD (Data Source: CEIC WebCDM

Various literatures attempted to analyze the relationship between commodity prices and commodity currencies. For instance, Bashar and Kabir (2013) discovered a significant connection between the commodity price and the AUD exchange rate. Parker and Wong (2014) conducted a similar study on a New Zealand base. Weng (2011) found the causal relationship between oil price and exchange rate of Malaysia Ringgit. Yet, instead of strong short-run comovement, a long-run cointegrating relation between oil price and Canadian Dollar was found in Aguilar (2013). In the meantime, though oil sector is the pivot of Russian economy and Ruble frequently fluctuated when the oil price plummeted in 2014, existing literature focused on Russia Ruble is limited. Thus, this paper aims at quantitatively examining the relationship between oil price and RUB/USD.

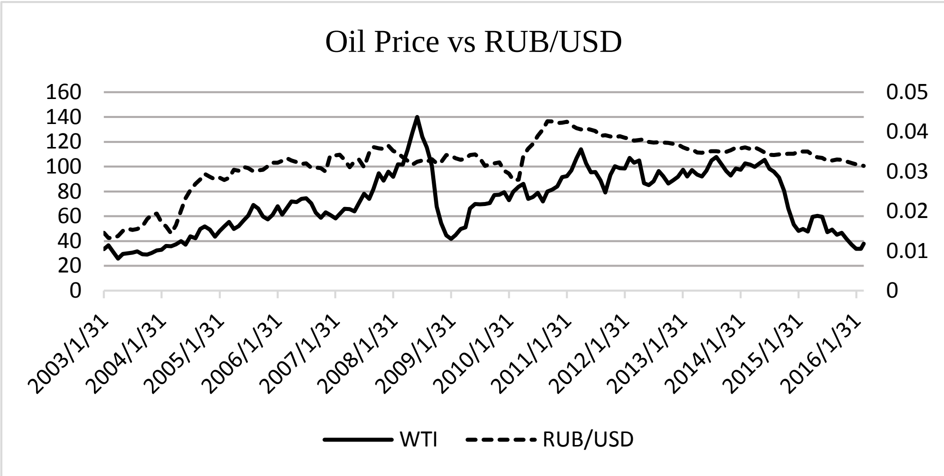

Figure 3. Oil price and RUB/USD (Data Source: Bloomberg)

It is hard to overestimate the importance of oil sector for the Russian economy. As the world's second largest oil exporter, oil sector accounts for over 68% of Russia's export. (EIA, 2014) Between July and December 2014, oil price dropped more than 50% (Figure 3) which led to a sharp decrease in Russia's exports. Motivated by the huge impacts of oil price on Ruble, this paper builds up econometric models to quantify the influences. Moreover, vector error correction model (Engel and Granger, 1987) was applied.

The rest of the paper is structured as follows. Section I presents the data selection as well as the unit root test. Section II, given the observed nonstationary, performs the cointegration test on Ruble and oil price. Granger causality test and vector error correction model are discussed in Section III. Finally, Section IV concludes the paper and suggests potential future works.

Section I. Data Selection and Unit Root Test

The data being used are monthly observations of RUB/USD exchange rate and West Texas Intermediate (WTI) Crude Oil spot price in USD from January 2002 to March 2016 obtained from Bloomberg. Both of these two variables are transferred into logarithmic forms so that the elasticity is clearly displayed.

Table 1
Data of Russia Total Exports and Crude Oil Export from 1999 to 2015. (Data Source: International Monetary Fund; Federal Customs Service; CEIC WebCDM)

Year	Russia Exports (Million in USD)	Russia Crude Oil Exports (Million in USD)	Crude Oil Exports/ Total Export
1999	75551	13413	17.8%
2000	105036	23644	22.5%
2001	101884	24563	24.1%
2002	107301	27445	25.6%
2003	135929	36833	27.1%
2004	183207	55088	30.1%
2005	243799	79216	32.5%
2006	303926	96675	31.8%
2007	354403	114268	32.2%
2008	471765	151655	32.1%
2009	303388	93528	30.8%
2010	400420	129126	32.2%
2011	515408	171696	33.3%
2012	527433	180916	34.3%
2013	523293	173670	33.2%
2014	496516	153888	31.0%
2015	342243	--	--

Additionally, to verify the robustness of the results, Brent Crude Oil (BRNT) spot price has been used as well (see Appendix I). Moreover, the research time period from 2002 to 2016 is selected intentionally. As Table 1 shows, during 2002-2014, the ratio of Russia Crude Oil Export in USD to Russia Total Export were around 25% which jumped above 30% starting from 2004. Considering the weightage of oil export in the total export highly correlates with the effect of oil price changes on Ruble, the paper unfolds studies in 2003 to 2016.

Before stepping into multivariate modeling and inference, properties of time series data (e.g. stationarity) need to be checked, which is to build up a solid foundation for the subsequent complexed data analysis. Hence, Phillips and Perron (1988) test (PP test) and Dickey and Fuller (1979) test (DF test) are firstly applied to do the unit root test. Both PP and DF tests are with null hypothesis of "unit root exists".

Table 2
Result of tests for stationary of RUB/USD and WTI Crude Oil price (from 2002-2016) by PP, DF and ADF tests

Variable	PP p-value	DF p-value	ADF lags*	ADF p-value
lg(RUB/USD)	0.99	0.98	2	0.85
lg(WTI)	0.28	0.96	2	0.62

**The number of lags is obtained by observing the graphs of partial autocorrelation (PAC) function.*

As shown in Table 2, large p-values of both tests provide no evidence of rejecting the null hypothesis. In other words, unit root exists -- the auto regression is spurious with mysteriously high R-square and slowly dying out autocorrelation function (ACF).However, DF test only applies to AR(1) time series data. To take the p-th auto regression into account, Augmented Dickey Fuller (ADF) test is recommended. Before conducting ADF test, the number of lags is chosen by observing the graph of partial autocorrelation (PAC) function. The test draws the same conclusion as the PP test and DF test. Therefore, both RUB/USD exchange rate and WTI crude oil price are non-stationary.

Next, same approach is applied to the first differences of both data series. According to the result shown in Table 3, the p-values of both first differenced variables under various types of tests, namely PP test, DF test and ADF test, are all 0.00. This provides strong evidence to reject the null hypothesis which stating that the time series data has unit root. Hence, the first differences of both data series are stationary. In conclusion, RUB/USD exchange rate and WTI crude oil price are both on-stationary time series level data while their first differences are stationary, which subsequently allows us to conduct the Johansen cointegration test to check whether RUB/USD exchange rate and WTI Crude Oil Price have a long-term relationship.

Table 3
Result of tests for stationary of first differences of RUB/USD and WTI Crude Oil price (from 2002-2016) by PP, DF and ADF tests.

Variable	PP p-value	DF p-value	ADF lags*	ADF p-value
1st Differences of lg(RUB/USD)	0.00	0.00	1	0.00
1st differences of lg(WTI)	0.00	0.00	2	0.00

**The number of lags is obtained by observing the graphs of partial autocorrelation (PAC) function.*

Section II. Cointegration Test

DF test as well as PP test in Section I show that both oil price and Ruble follow a nonstationary process. In other words, a standard regression model is unable to be created because two time series data behave arbitrarily overtime. Fortunately, the notion of cointegration which was first introduced by Engle and Granger (1987) is a significant breakthrough because it allows meaningful regressions involving *I(1)* variables. A traditional approach dealing with two *I(1)* variables is taking differences and then regressing the difference of one variable on the other. Moreover, taking difference does not necessarily affect the coefficients of the original interested variables. Hence, when it comes to economic interpretation, those estimated coefficients are still consistent with explanations of the underlying mechanism between the two original variables.

For two *I(1)* processes, say $\{y_t: \mathrm{t} = 0,1, \dots\}$ and $\{x_t: \mathrm{t} = 0,1, \dots\}$, $y_t - \beta x_t$ would normally be an *I(1)* process. Whereas, it might be the case that under some conditions, $y_t - \beta x_t$ is an *I(0)* process, which means it has constant mean, constant variance, and it's autocorrelation only depends on the time intervals between any two variables in the series; and it is asymptotically uncorrelated. If such a parameter β exists, we say that y_t and x_t are cointegrated. In our study, given the nonstationary oil price and RUB/USD, such β is predicted to exist even before performing the cointegration test because it has an economic interpretation. Specifically, if y_t and βx_t were not cointegrated, the difference between them would become very large. However, based on a simple arbitrage argument, it is not likely to happen. Suppose the oil prices continue to go up, one would sell Ruble further to buy crude oil and RUB/USD would subsequently rise. Thus the logarithm of oil price increases and so is the logarithm of RUB/USD, which narrowing the gap between these two variables. Therefore, large deviation between the logarithm of these two variables are not expected.

Table 4
Selection-order criteria

Lags	LR	FPE	AIC	HOIC	SBIC
0	--	.00	-2.46	-2.44	-2.42
1	1020.70	3.9e-07	-9.08	-9.03	-8.96
2	24.99	3.5e-07	-9.19	-9.11*	-8.99*
3	6.51	3.5e-07	-9.18	-9.07	-8.90
4	10.28*	3.5e-07	-9.19	-9.05	-8.84
5	8.06	3.5e-07*	-9.19*	-9.02	-8.76
6	3.54	3.6e-07	-9.16	-8.96	-8.65

If cointegration between these two variables could be detected, it can concluded that the price of oil captures the dominant influence on Ruble's exchange rate. A systematic approach developed by Johansen and Juselius (1990).

Before proceeding into Johansen and Juselius test, a suitable number of lags is to be selected under the selection-order criteria with the maximum lag to be 6, as shown in Table 4. With various criteria such as AIC and SBIC, asterisk reveals the best number of lags to be chosen under a certain criteria. Therefore, Table 4 suggests a tie between 2 lags and 5 lags. All of the remaining tests are conducted based on 5 lags while the case of 2 lags has been checked also and gives the same conclusion.

Table 5

Result of Johansen - Juselius test (time trend is added and the assumption of restricted drift is hold, maximum lag order =5*)

Maximum rank	Trace statistic	5% critical value
0	19.43	18.17
1	0.52	3.74
2	--	--
Maximum rank	Max statistic	5% critical value
0	18.91	16.87
1	0.52	3.74
2	--	--

** The number of lags is obtained from Table 4 – Selection Order Criteria*

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Table 5 gives the results of Johansen tests. It contains two criteria in order to double check the reliability of each single test. The first criterion is based on the trace statistics which is 19.43 and larger than the critical value with 5% significant level. It implies that the null hypothesis “zero cointegration exists” is to be rejected. Hence, with moving down to the second row whose null is “one cointegration exists”, the trace statistics gets less than the critical value, which means that the null should be accepted. Therefore, this criterion shows evidence of cointegration between these two variables. Additionally, the second criterion is based on the max statistics, which gives the same result. Hence, regardless of the types of test statistic, Johansen test suggests that RUB/USD is cointegrated with oil prices.

Section III. Causality and Error Correction Model

The cointegration observed in Section II implies that oil price and Ruble have the same trend in the long run. Specifically, at least one of two variables would Granger-cause the other or both Granger-cause each other simultaneously. To discover whether the hypothesis of "unidirectional causality of oil price on Ruble" is correct, Granger test is applied.

Table 6
Granger Causality

Dependent variable	Independent variable	Number of lags*	p-value
lg(RUB/USD)	lg(WTI)	5	0.01
lg(WTI)	lg(RUB/USD)	5	0.15

**The selected lag is based on the selection-order criteria shown in Table 4*

The result in Table 6 shows that oil price causes Ruble and not vice versa. Specifically, the null hypothesis corresponding to the second row is H_0: oil price (WTI) changes do not cause changes in Ruble exchange rate. With the p-value to be 0.01, there is strong evidence to reject the null hypothesis at 1% significant level. In other words, the result shown in the second row implies a Granger causality of oil price (WTI) on Ruble. Analogously, the third row, with p-value to be pretty big, i.e. 0.15, the null hypothesis "Ruble does no cause oil price (WTI)" is accepted. Therefore, Table 6 displays the unidirectional causality of oil price on Ruble.

Given the Granger causality of oil price on Ruble exchange rate displayed in Table 6 and the cointegration between oil price and RUB/USD discussed in Section II, the error correction model is to be developed. This allows the study in short run dynamic relationship between oil price and Ruble. The result is shown in Table 7.

Table 7
Error Correction Model

		Coeff.	Std. Err	z	p >|z|
lg(RUB/USD)	ECT*	-0.002	0.001	-2.26	0.02
lg(WTI)	LD	-0.085	0.044	-1.94	0.05
	L2D	-0.063	0.043	-1.46	0.15
	L3D	-0.076	0.042	-1.82	0.07
	L4D	-0.046	0.043	-1.08	0.28

* Error correction term

VECM analysis contains two parts, namely the long run causality and the short run causality. Firstly, Table7 displays a negative error correlation term, also called speed of adjustment, with statistical significance. This means that there exists long run causality running from oil price to Ruble. Meanwhile, the results show that there is no short run causality between oil price and Ruble. Since all coefficients are with p-values larger than 5% significant level.

Table 8
Lagrange-multiplier test

lag	Chi2	Prob > chi2
1	2.40	0.66
2	3.29	0.51
3	2.88	0.58
4	4.18	0.38
5	2.98	0.56

**H_0: no autocorrelation at lag order*

Next, Table 8 shows the result of autocorrelation checking by Lagrange-multiplier test. It reports that all p-values of 5 different numbers of lags are too big to reject the null hypothesis, which leads to the desirable conclusion – there is no autocorrelation and the current model is reliable.

Section IV. Conclusion

In the 2000s, the commodity price experienced fluctuations. In the meantime, countries such as Australia, Canada, and Russia which depend heavily on commodity exports witnessed similar movements in their currencies. From 2001 to 2007, Ruble gained during the oil rally. As the weak global demand dramatically drove down the oil price, Russia suffered from drastic drops in oil export revenue and Ruble depreciation. Given the fact that oil price caused the violent movements in RUB/USD and the relevant literature on Ruble is thin, this paper attempts to analyze the impact of oil price on Ruble. Granger causality results tells that the oil price significantly drives RUB/USD. Furthermore, the model finds long-term cointegration between the oil price and rule.

Last but not least, improvements could be made in future works. Firstly, structural break test was not performed for this study. However, it is possible that the relationship between the oil price and Ruble was changed during the selected time framework. Hence, a structural break test and separate VECM model could be performed in the future study. Secondly, extensions could be made by comparing the impacts of different commodities on different currencies. For example, panel data could be used to analyze how copper, iron ore and oil prices impact Chile, Australia and Russia’s currencies.

Appendix I

Robustness checking by replacing WTI crude oil price with Brent oil spot price

Table A1

Result of tests for stationary of RUB/USD and Brent (BRENT) Oil price (from 2002-2016) by PP, DF and ADF tests

Variable	PP p-value	DF p-value	ADF lags*	ADF p-value
lg(RUB/USD)	0.99	0.97	2	0.85
lg(BRNT)	0.33	0.97	2	0.77

**The number of lags is obtained by observing the graphs of partial autocorrelation (PAC) function.*

Table A2

Result of tests for stationary of first differences of RUB/USD and Brent (BRENT) Oil price (from 2002-2016) by PP, DF and ADF tests

Variable	PP p-value	DF p-value	ADF lags*	ADF p-value
1st Differences of lg(RUB/USD)	0.00	0.00	1	0.00
1st differences of lg(WTI)	0.00	0.00	1	0.00

**The number of lags is obtained by observing the graphs of partial autocorrelation (PAC) function.*

Table A1 shows that level data of both time series variables are nonstationary, while the first difference data are stationary as shown in Table 2.

Table A3

Selection-order criteria

Lags	LR	FPE	AIC	HOIC	SBIC
0	--	.00	-2.11	-2.09	-2.07
1	1068.80	4.4e-07	-8.95	-8.90	-8.83
2	25.28*	4.0e-07*	-9.06*	-8.98*	-8.86*
3	7.19	4.0e-07	-9.06	-8.94	-8.78
4	7.00	4.0e-07	-9.05	-8.91	-8.70

Table A3 reports the selection-order criteria based on different measures, such as AIC and SBIC. It implies that choice of 2 lags is optimal for the following Johansen cointegration test, Grager causality test and error correction model. Table 4 provides the result of Johansen cointegration test which implies that “one cointegration exists”. Subsequently, Table 5 presents the Granger causality test and shows that oil price Granger-causes Ruble exchange rate. Last but not least, error correction model is found, which tells that oil price and RUB/USD have a long-term relationship but without a short one.

Table A4
Result of Johansen - Juselius test (time trend is added and the assumption of restricted drift is hold, maximum lag order =2*)

Maximum rank	Trace statistic	5% critical value
0	25.81	18.17
1	2.00	3.74
2	--	--
Maximum rank	Max statistic	5% critical value
0	23.81	16.87
1	2.00	3.74
2	--	--

** The number of lags is obtained from Table A3 – Selection Order Criteria.*

Table A5
Granger Causality

Dependent variable	Independent variable	Number of lags*	p-value
lg(RUB/USD)	lg(BRNT)	2	0.04
lg(BRNT)	lg(RUB/USD)	2	0.23

**The selected lag=2 is based on the selection-order criteria shown in Table A3*

Table A6. Error Correction Model

		Coeff.	Std. Err	z	p >|z|
lg(RUB/USD)	ECT*	-0.115	0.047	-2.41	0.02
lg(BRNT)	LD	-0.038	0.040	-0.95	0.34

**The selected lag=2 is based on the selection-order criteria shown in Table A3*

* Error correction term

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