

EFFECTS OF RESERVE ASSETS ON EXCHANGE RATE OF THE RUSSIAN RUBLE

VALERYA GORINA

Bachelor, IFF, Financial University, Russia

Academic Advisor ILONA V. TREGUB

ScD (Economics), Professor, Financial University, Russia

E-mail: ITregub@fa.ru

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1. INTRODUCTION

Eurasian Economic Union (EAEU) is an economic union founded in 2014, consisting of states located primarily in northern Eurasia. The Russian Federation was one of the founder-states (along with Belarus and Kazakhstan), which supported the initiative of the beginning of economic and trade integration in Eurasia.

The initial incentive to create EAEU belongs to the leader of Kazakhstan, Nursultan Nazarbayev. However, the role of the Russian Federation in the establishment process should not be underestimated. Taking into consideration the geopolitical situation of 2014, it is quite understandable why Russian leaders supported the idea of the independent Eurasian economic cooperation development.

It is a well-known fact that economies of the union are willing to increase the degree of their integration and cooperation. There are even some ideas to create the monetary union, similar to Eurozone, in the long-run.

This work is targeted at the creation of the Russian ruble exchange rate model. Through the process of creation and interpretation of this model we are able to resolve the following questions:

- What are the main factors influencing the “strength” of ruble?
- Is the monetary policy of the Russian Federation able to directly influence the ruble exchange rate?
- Is the monetary policy of the Russian Federation somehow connected with economic factors of EAEU states?

Answering the questions mentioned above, we will be able to understand the current situation and the stage of integration in terms of monetary policy.

2. STATISTICAL DATA

The first question was, which particular exchange rate should be considered as endogenous variables. The main options were, somehow, the world's top currencies, such as: euro, US dollar, yen and yuan. The key factor pushing us to choose USD/RUB exchange rate was the fact that for a long time, ruble was in fact **pegged to United States dollar**, which meant that it was supposed to “float” within some borders directly connected with US economy's fluctuations.

The data was primarily taken from the U.S. international statistics website. The data on the Russian Federation economic performance is generally available for the period 1992-2016. However, due to the significant fluctuations Russian economy had to face in 90s, the stable period **2000-2015** was more preferable to be considered in the framework of the model creation.

To increase the number of observations (with a view to add the accuracy to the model), quarterly data was taken. Thus, the model was created based on **Q1 2000 – Q4 2012** data, totaling in **52** observations. Data for **Q1 2013-Q1 2015** was used to create forecasts and compare them with actual observations.

To build the model of ruble to US dollar exchange rate, various factors were taken into consideration. It goes without saying, that there were attempts to involve other EAEU states' economic determinants in the model creation. Nevertheless, all of them failed. According to observations and calculations, none of such determinants proved to be significant exogeneous variables for the model. Thus, the process of search remained being focused on US and RF economic variables.

After dozens of factors' combinations, the most appropriate exogeneous variables proved to be:

1. **United States Gross-Domestic Product:** generally speaking, it depicts the size of US economy, which surely directly affects the purchasing power of US dollar, and thus ruble, pegged to it. The unit of measurement is the dollar, backed to the basis 2009 year. The main reason for preferring it to the nominal GDP is to avoid the dependency of exogeneous variables on the endogenous ones.
2. **United States Fed Refinancing Rate:** is one of the main instruments of monetary regulations in US. It is the interest rate on which the Fed (US Central Bank) provides loans to other banks in the state, making lending either more or less affordable to the citizens. Changes in consumption preferences (whether people prefer to invest, to borrow or spend money they have) directly affect the volumes money aggregates circulating in the economy, thus resulting in changes of US dollar exchange rate. The unit of measurement is percent.
3. **Production of total industry in the Russian Federation:** determines the size of the Russian economy. The first option was to take RF GDP, but it proved to be less significant variable. The reason for this is that Production of total industry is presented in the form of the **index** rather than absolute value. It depicts the fluctuations in the size of the Russian economy independently from the inflationary processes. The unit of measurement is the index with 2010 basic year.
4. **Reserve Assets for the Russian Federation:** proved to be one of the main instruments of monetary policy in Russia. Reserve assets are represented in the form of currency, commodities and other financial capital help by the Central bank. They are used to finance trade imbalances, check the impact of foreign exchange fluctuations and address other issues under the control of the central bank. The unit of measurement is the number of special drawings rights.

The optimal quantity of covariates was figured out in the process of calculations and tests. The point is that no combination of three covariates provided the good coefficient of determination (generally

speaking, could not fully explain the behavior of dependent variables). Combinations of five covariates, oppositely, did not add much to the determination of the model, provided by four-covariate ones.

3. ECONOMETRIC MODEL

Initially, if the linear equation could perfectly reflect the connections between variables, it would take the form:

$$Y_i = \beta_1 + \beta_2 \times x_{i1} + \dots + \beta_{i(t+1)} \times x_{it} + u_i$$

Where Y_i – actual value of Y of the i^{th} observation, dependent on t variables x of this observation with $\beta_{1,2,\dots,t}$ actual coefficients, and u_i is the disturbance term. However, as we cannot know the coefficients and disturbance terms for each and every observation in particular, we create the approximate linear model. In our case, it will be the linear equation with four main factors, influencing Y, presented in the form:

$$\hat{Y}_i = b_1 + b_2 \times x_{i1} + b_3 \times x_{i2} + b_4 \times x_{i3} + b_5 \times x_{i4}$$

Where \hat{Y}_i is the approximated Y_i , $b_{1,\dots,5}$ are the approximated coefficients $\beta_{1,\dots,5}$, and $x_{i1,\dots,i4}$ – exogenous variables described above.

The most common way to calculate approximated coefficients $b_{1,\dots,5}$ is to use the **Least Squares Regression method**, the main target of which is to minimize the sum of squared deviations from Y_i observed:

$$\begin{cases} RSS(residual\ squares\ sum) = e_1^2 + \dots + e_i^2 \rightarrow 0 \\ e_{1,\dots,i} = (Y_i - \hat{Y}_i) \end{cases}$$

This target can be reached using the 1st order conditions for a minimum ($\frac{\sigma_{RSS}}{\sigma_{b_1}} = 0; \dots; \frac{\sigma_{RSS}}{\sigma_{b_i}} = 0$). However, in this computational analytical work, taking into consideration the relatively big number of observations, it would be more appropriate to use the **analysis functions of Excel**.

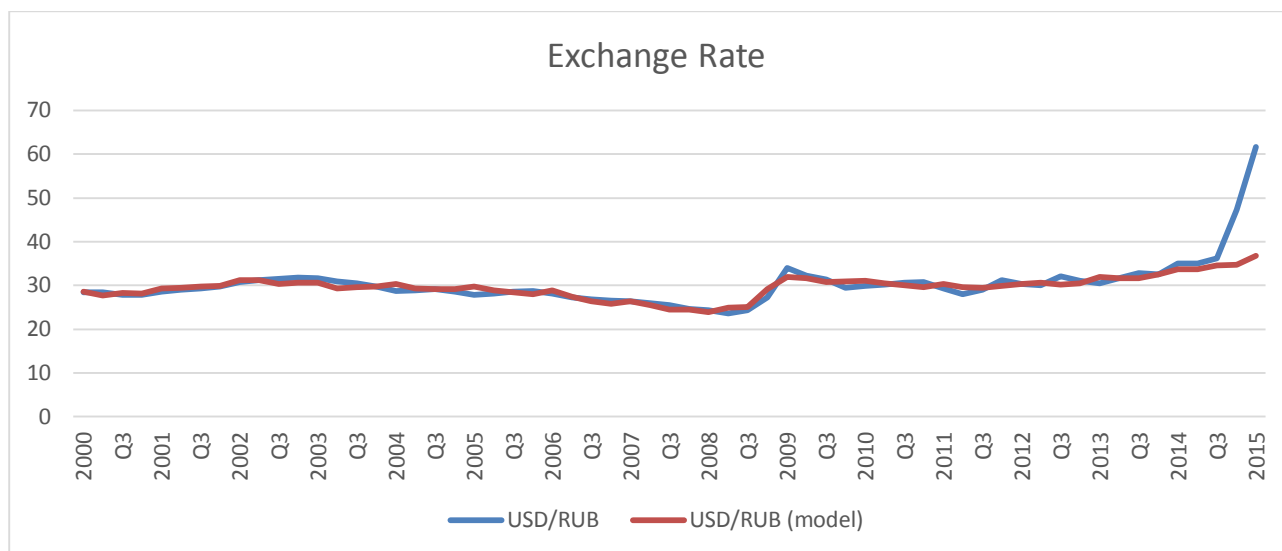
Opening the function **data analysis**, choosing $Y_{1,\dots,i}$ observations and all corresponding exogeneous variables, presented in the table and dated in accordance with conditions mentioned in the previous chapter, we observe the following coefficients calculated by Excel:

	<i>Coefficients</i>
Y-intersection	24.65505753
US Fed Ref. Rate	-0.522471434
US GDP (\$)	0.003620204
	-
Reserve Assets of RF	0.0000000000156244482
Production of total industry in RF	-0.443601201

Thus, the final equation could be presented in the form (coefficients are rounded for simplification of equation writing, not for the further calculations):

$$\hat{Y}_t = 24,66 - 0,52 \times x_{i1} + 0,004 \times x_{i2} - 1,56 \times 10^{-11} \times x_{i3} - 0,44 \times x_{i4}$$

In general, the model was efficient in terms of approximation of the real statistical observations, plus it managed to forecast the correct exchange rates for the period **Q1 2013 – Q3 2014**, when ruble was pegged to dollar.



REGRESSION TESTS

According to Excel calculations, the following regression statistics for significance level 0,05 could be observed:

<i>Regression Statistics</i>	
Multiple R	0,905205475
R-squared	0,819396951
Normalized R-squared	0,804026479
Standard deviation	0,986359547
Number of observations	52

For the linear model, **R-squared** should be considered with a view to state the level of the model’s determination. It means that approximately **82%** of variances of actual endogenous variables’ variances were explained by the model, which is a relatively good result.

Standard deviation is also relatively small for this number of observations, determining that in general the difference between actual Y and the approximated one is about **0,99**.

DISPERSION ANALYSIS

	<i>df</i>	<i>SS</i>	<i>F</i>	<i>Significance of F</i>
Regression	4	207,4615552	53,30980982	6,91177E-17
Residue	47	45,72654228		
Total	51	253,1880974		

Residue df represents the number of **degrees of freedom**, calculated as the number of observations minus number of regressors (mentioned in Regression df line) minus one. Residue SS represents the sum of residual squares (**RSS**).

To check whether those numbers are significant, it should be proved that all the Residuals are subject to **Fisher-distribution**. F critical for this could be calculated using Excel formula FPACΠOБP (Significance level; Number of degrees of freedom; number of regressors), which in our case is equal **5,70**. F received

is much greater than the model one, which is also proved by the Significance of F (the lesser 0 the better, because it represents the probability of some random residual's not fitting into the F distribution).

COEFFICIENTS' ANALYSIS

	<i>Standard Deviation</i>	<i>t-statistics</i>	<i>P</i>
Y-intersection	2,488933541	9,905872184	4,34187E-13
US Fed Ref. Rate	0,082694165	-6,318117307	8,86758E-08
US GDP (\$)	0,00045124	8,02279388	2,35537E-10
Reserve Assets of RF	3,51184E-12	-4,449074842	5,26722E-05
Production of total industry in RF	0,049644311	-8,935589849	1,06271E-11

Generally speaking, the most important point in checking out whether coefficients are sufficient or not, the T-test should be provided. To satisfy it, the absolute value of t-statistics of each and every regressor should exceed the critical one, which can be calculated in Excel using formula CTБЮДPACΠOБP (significance level=0,05; degrees of freedom = Residue df = 47). The critical value of this model equals **2,012**. As we can see, all the regressors chosen do satisfy this condition. This statement is approved by the P-values, which should be **less than significance level (0,05)**.

DURBIN-WATSON AND GOLDFIELD-QUANT TESTS

To make sure that this model is the appropriate one, it should be proved that it satisfies **four Gauss-Markov conditions**:

1. **Linearity**: the dependent variable is assumed to be a linear function of the variables specified in the model;
2. **Strict exogeneity**: for all **n** observations, the expectation—conditional on the regressors—of the error term is zero ($E[\varepsilon_i | x_{1,...,n}] = 0$);
3. **Full rank**: the sample data should not be **singular**;
4. **Spherical errors**: the error term has uniform variance (**homoscedasticity**) and **no serial dependence**.

The first and fourth conditions are obviously satisfied. To prove the second and fourth one, the **Durbin-Watson** and **Goldfeld-Quandt** tests should be implemented.

Durbin-Watson test is a test statistic used to detect the presence of autocorrelation (a relationship between values separated from each other by a given time lag) in the residuals (prediction errors) from a regression analysis.

To perform it, the following formula is generally used:

$$d = \frac{\sum_t^T (e_t - e_{t-1})^2}{\sum_t^T e_t^2}$$

Generally speaking, $d=2$ is a perfect variant, as it shows no autocorrelation in the residuals. Still, for different number of observations and regressors, statistics, determining the absence of autocorrelation, may vary.

Using special table for significance level 0.05, we may consider the following intervals for d :

0	dl	du	2	4-du	4-dl
0	1,203	1,338	2	2,662	2,797

In the tables of Excel, the d calculated for the model equals 1.47, which means that it lies within an optimal interval $du-2$. Thus, we may say that there is no significant autocorrelation in the residuals.

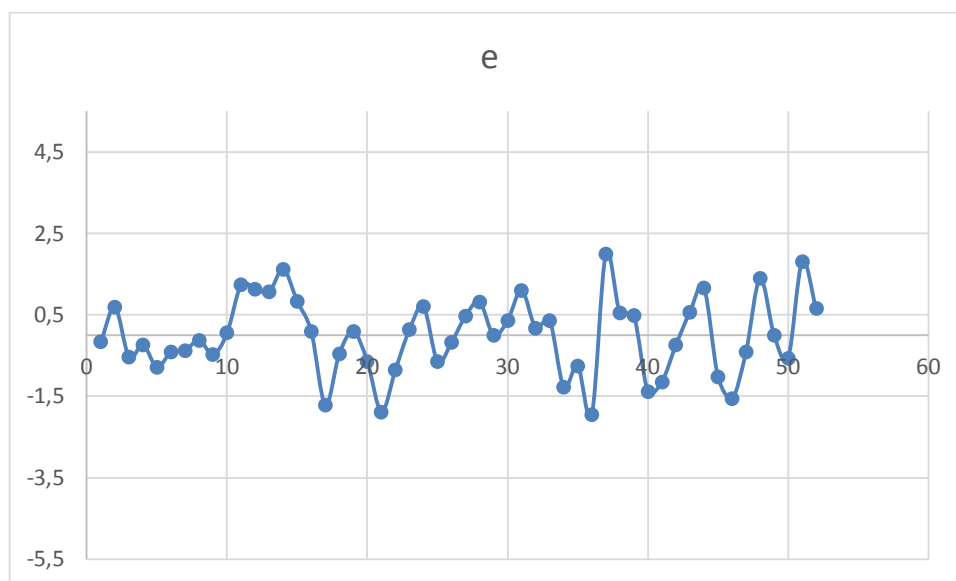
Goldfeld-Quandt test checks for homoscedasticity in regression analyses. It does this by dividing a dataset into two parts or groups, and hence the test is sometimes called a two-group test.

Grouping variables in accordance with their magnitude (sum of absolute values of regressors), we divide 52 observations into two samples sized 25 (deleting the middle two parts, as in general size of sub-samples should be less than a half of observations). Then provide the regression analysis for both of them the same we did it for the whole model. It is generally done to figure out the RSS for both samples. Thus we observe, that:

$$RSS_1 = 10.39 ; RSS_2 = 21.39$$

Dividing RSS_1 by RSS_2 , we receive GQ statistics, which is equal to **0.49**. In general, if both GQ and $1/GQ$ are less than the critical value (found by FPACИOБP[significance level;degrees of freedom of the first sample; degrees of freedom of the second sample]), then the homoscedasticity in the model is proved. It means that increase in exogeneous variables does not cause an increase in residuals. In our case:

$GQ = 0.49$, $1/GQ = 2.06$, and $F_{crit.} = 2,12$. It means that in our model there is no significant heteroscedasticity. It could also be observed from the following graph of deviations e :



All the tests above prove that the model generated is quite accurate and suitable for calculations of the USD/RUB exchange rate in the period 2000-2014.

4. INTERPRETATION OF THE MODEL AND ITS FORECASTS

Generally speaking, the model created showed and proved the “pegged” condition of the ruble in the period 2000-2014. This fact led to the prevalence of US economic factors’ influence over the Russian exchange rate.

$$\hat{Y}_t = 24,66 - 0,52 \times x_{i1} + 0,004 \times x_{i2} - 1,56 \times 10^{-11} \times x_{i3} - 0,44 \times x_{i4}$$

From the final equation of the model, we can observe that factors x_{i1} (US Fed Refinancing Rate) and x_{i3} (Reserve Assets of RF) show the inverse relationship with the Exchange rate, meanwhile x_{i2} (US GDP) and x_{i4} (Production of total industry in RF) increase it. It could be easily explained:

- If **US Fed Refinancing Rate** increases, then all the banks of the US will impose higher interest rates on lending. Borrowing will become less available, and depositing – more attractive. Thus, people will be less willing to spend and more willing to save, either putting money on deposit or keeping them. This will lead to decrease of money volumes and appreciation of the dollar. Appreciation might mean that ruble will become cheaper, but it will have to adjust to this change and appreciate the currency too (through the mechanisms of the monetary policy). Thus, in the end, Russian currency will appreciate too. That is why USD/RUB exchange rate will decrease.
- To increase the number of **Reserve Assets**, Central Bank of RF will have to buy them, using rubles either directly or exchanging them for other currencies (in case it wants to buy foreign assets). Than will lead to the decrease of money aggregate, and thus to appreciation of ruble. Since dollar doesn’t need to correct its exchange rate in accordance with ruble, this effect will remain without changes. That is why USD/RUB exchange rate will decrease.
- **US GDP** reflects the size of the US economy. The bigger it gets, the stronger the economy is, and, as we can consider from the model, the stronger the dollar gets. The interesting fact is that an increase in **Russian Industry production** is also accompanied by the appreciation of dollar and weakening of ruble. To some extent it could be explained as the limitation of the pegged currency: ruble surely cannot get much weaker than dollar, but it **mustn’t become stronger than it either**.

Thus we may see that despite the fact that Russia had an influential tool of monetary policy allowing it to control the exchange rate, it could only use it to adjust ruble to the in US dollar's fluctuations, caused by the economic indicators' changes. Which defines that in general ruble was directly dependent on the US economy, leading to relative 'weakening' of incentives to develop its own economic performance. To some extent, pegging ruble to dollar supported the exchange rate at the competitive level, making it more attractive for other states. However, in case the growth could have caused the strengthening of the whole Russian economy and appreciation of ruble, this conditions wouldn't have allowed it to do so.

As we could consider from the graph given at the very beginning, and as we can conclude from the interpretation given above, after Q4 2014, when Russian ruble went 'floating', the model stops working. At the moment, there are new factors influencing ruble exchange rate, but there is no much data available to build the new model and make further forecasts.

5. MODEL vs RUSSIAN FEDERATION'S ROLE IN EAEU

Generally speaking, as it has already been mentioned before, in the process of model's creation it was actually proved that there is no significant correlation between monetary and economic determinants of EAEU states and Russia. To some extent it is connected with two general facts:

- 1) Currencies of Kirgizstan, Kazakhstan, Armenia and Belarus are still pegged to dollar, which means that at the moment they are as dependent on economic determinants (it was proved in the framework of analytical works of my colleagues);
- 2) EAEU is a relatively new union in the world market, and thus not enough time has passed to achieve the appropriate level of cooperation.

To sum everything up, we can conclude that EAEU is at the very beginning of its way towards the integration and the creation of the unified economic space. But, from the observations and the models interpretation we can clearly see an incentive to develop such a union – our economies are way too dependent of USA, which to some extent slows down the economic growth and trade activities.

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