Essay in International Economics:
"Time Series Analysis of Russian Ruble"

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Introduction

This essay is devoted to the analysis of russian ruble exchange rate from the break down of the USSR up to the end of 2007. In this essay we would like to present stylized facts on ruble exchange rate behaviour.[1]

Russian ruble is an interesting example as Russian economy has been experiencing a transition process from command to market economy; USSR for more than 70 years did not have a free floated convertible and trusted national currency, which could be used in international trade and finance. Introduction of ruble in 1992 in Russia was accompanied by hyper inflation, instability, mass privatization, etc.

From the perspective of international investors it might be very useful to know properties of exchange rates in developing or economies in transition. If there is a patern of exchange rate behavior, or, at least, if we can predict when currency can be modeled with standard models depending on country characteristics, global investors will be able to control currency risk exposure or exploit this pattern in a profitable way.

This essay consists of two parts. First part is devoted to analysis of distribution of exchange rate changes - normality, skewness, kurtosis, autocorrelation, evidence on volatility clustering, etc. In the second part, we will analyze whether Russian ruble can be explained by random walk model and use GARCH modeling[1] to evaluate the properties of time-varying volatility of the exchange rate returns.

Descriptive statistics

We start our analysis from descriptive statistics (Table 1). For all sample from 1992-2007 distribution is non-normal: excess kurtosis (fat-tailed and peaked distribution), large negative stock returns occur more often than large positive ones: negative skewness[2].

Table 1. Descriptive Statistics: Russian Ruble

Year	1992-2007	1992-2002	2002-2007
Mean	0.00161	0.00129	-0.00010
Median	0.00013	0.00019	0.00000
St.Deviation	0.01826	0.02012	0.00185
Skewness	2.60	-0.01	0.04
Kurtosis	135.10	106.94	8.33
p-value of Jarque-Bera	0.00	0.00	0.00

If we split sample into two subsamples with a threshold in 2002[3], we will find a dramatic change in properties of distribution: almost zero skewness, much lower kurtosis, ten times lower st.deviation. Figure 1 illustrates this with daily returns (change in exchange rate) - for full sample we see a lot of extreme values and no clear and consistent pattern of exchange rate behaviour. Subsample for 2002-2007, we see a

[1] One can hardly find stylized facts about ruble exchange rate behaviour gathered in one paper. Good exceptions are papers by Sosunov and Sonin[3] and Merlevede et al. [2]

[2] In our case we define exchange rate as a dollar/ruble ratio, so positive estimate of skewness implies that a large depreciations of ruble occur more often

[3] We choose 2002, because it is a first year with stable and liquid exchange market after the crisis of 1998.

typical patter on high frequency time series - volatility clustering, almost no significant autocorrelations in returns, small, but very slowly declining autocorrelations in squared and absolute returns (Figure 2).

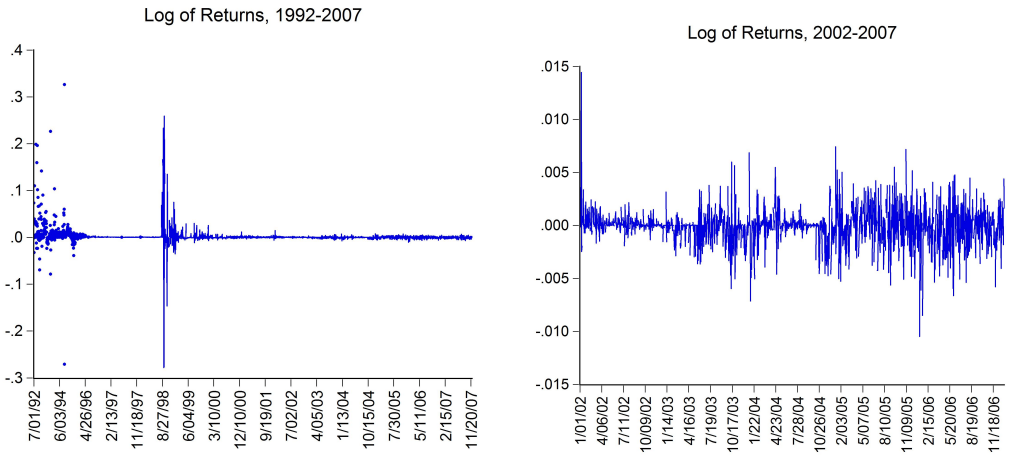

Figure 1: Log of Returns of Russian Ruble Excange Rate, Daily data

Given this, we see that exchange rate behavior does not have a standard pattern, when we analyse data with the transition period. This period was also accopmained by low trade volume, a lot of skeptis about ruble and large movements in the market, which may be due to insider trading and other illegal or semi-legal trade. This in turn raises question whether it is possible to model such a behavior.

As the most difficult part of transition crisis is over[4] and Russia is becoming more and more integrated, exchange market becomes more liquid and transparent (as regulator is learning by doing). And in the end, exchange rate behavior is becoming more standard.

[4]This is especially true for Russia, because Russian economy was military biased: more than half (some economist suggest estimate as much as 70%) of national product was interrelated with military sector. Transformation crisis was one of the most severe among the post soviet economies as many military related jobs were closed.

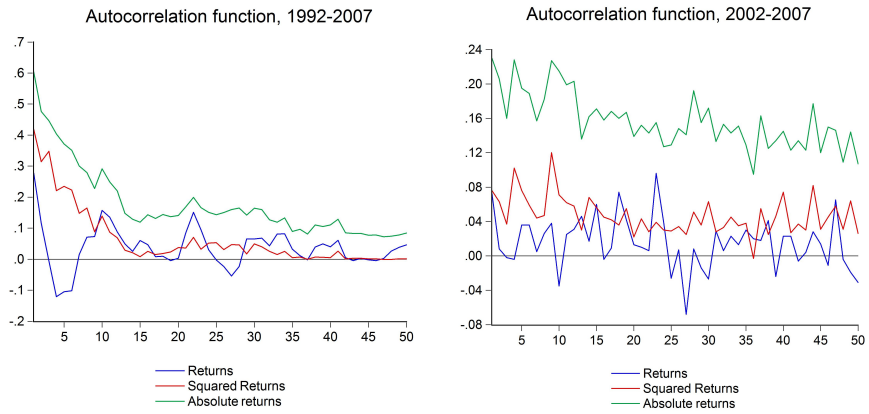

Figure 2: Empirical Autocorrelation Function for Log of Returns of Russian Ruble Excange Rate, Daily data

Random Walk?

Random walk is known as one of the best model to explain short term movements of exchange rate. Figure 3 demonstrates that we cannot reject random walk hypothesis both with full sample and a 2002-2007 subsample. In both cases current exchange rate (RUR) is almost equal to the previous exchange rate ($RUR - LAGED$ on the graph).

However, it is worth mentioning that there is much less outliers for 2002-2007 subsample, than for a full sample: for the latter, exchange rate behaviour deviates from random walk when exchange rate is in the range of 10-20 rubles per dollar. This is a case for 1998-2001, soon after the 1998 crisis, when there was a lot of uncertainty about future of Russian economy.

These outliers may be the main explanation for high autocorrelation in returns for full sample (Figure 2) and as soon as the uncertainty about future of Russian economy decreased, autocorrelation in returns disappeared (Figure 2 graph for subsample).

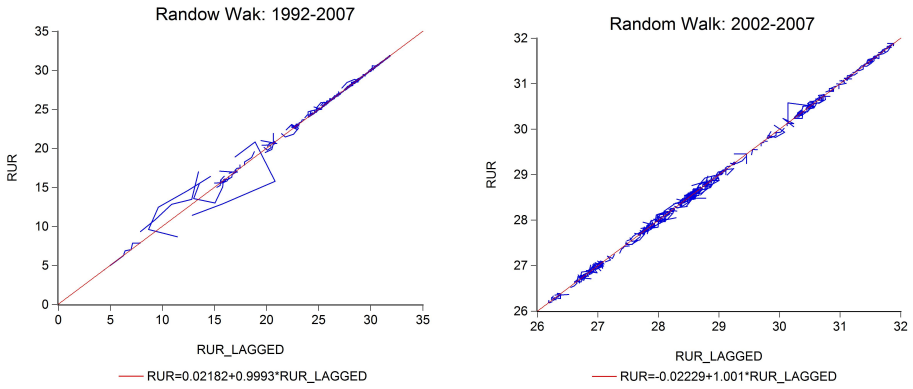

Figure 3: Random Walk in Exchange Rate, Daily data

There are at least two reasons why we should be very critical about any high estimates of autocorellation in returns: firstly, if there is high autocorrelation in returns, it contradicts random walk hypothesis, which is not rejected for large number of other currencies. Secondly, it may be a basis for active trading strategies: If there is a pattern differen from random walk (e.g. ARIMA model) and you know it, you can exploit it.

Despite the fact, that we see a pattern in our estimates it does not imply that market for Russian ruble is inefficient, because either estimated autocorrelation might be a statistical mirage due to outliers or there are barriers to exploit the pattern. A barrier may be a limitation for free capital movement for non-residence, high cost of arbitrage, additional risks, etc.

GARCH modeling

Hence, ruble, as other currencies, has a random walk pattern, so it is almost impossible to predict exchange rate returns for this high-frequency data. However, we can still explain and predict other stylized facts of high-frequency data, namely - time-varying volatility. Maybe volatility modeling has better perspective of explaining ruble's behavior for the period of 1992-2007.

For this purpose we use standard GARCH(1,1) model (Bollerslev [1]):

$$h_t = w + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$$

Again, if we estimate GARCH(1,1) model for the full sample we will find out that estimates of α_1 and β_1 are such, that GARCH(1,1) is not covariance stationary since $\alpha_1 + \beta_1 > 1$ (Table 2).

Again, estimates for the period of 2002-2007, when most part of transformation crisis was over, are very close to those we observe for other currencies and stocks - very high β_1, low α_1 and almost zero w.

Table 2. GARCH(1,1): Estimates of variance equation

Sample	1992-2007	2002-2007
w	0.00000	0.00000
α_1	0.56752	0.08404
β_1	0.70541	0.91358
No. observation	3272	1353

Apparently, this means inability to use standard GARCH(1,1) model (and, more likely, other models for time-varying volatility) to explain the behavior in transition period. Again, there are might be reasons to explain this (estimation problems, arbitrage limits, market segmentation, etc.), but they most probably will not give us an answer in which direction the model should be developed. Moreover, we do not know whether it is possible to model these extreme movements (in transition period) in exchange rates or not.

What is really important is the implication of these notions - we cannot model exchange rate behavior for transition period, but after ten years, since USSR collapse in 1992, we see ruble having the same pattern as most other currencies and stocks. Given the size of transformation from command to market economy, 10 years may be seen as quite a short period of time. Other post USSR countries, with less severe disproportions between military and non-military sectors like Poland, Lithuania, Kazakhstan, Slovenia, etc. had stabilization of exchange rate market in 6-8 years.

But nevertheless, our inability to explain exchange rate behavior for the transition period also implies that we cannot give recommendations to investor concerning the future value of currency in 6-10 years.

Conclusion

In this essay we have shown that Russian ruble behavior cannot be explained by standard models for returns and volatility applied to data with transition period (1992-2002).[5] Given this, if there is no way we can explain or model currency behavior in transition period, we can add little value to international investors. However, if we can model returns or/and volatility for currency similar to ruble in transition period, discovered patterns may be used for risk management and asset management purposes. Particularly, in this essay we have found large and significant autocorrelation in returns, which may be valuable to international investors, if they would be also found for other currencies and are true (not statistical mirage).

References

[1] Tim Bollerslev. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31:307–327, 1986.

[2] Bruno Merlevede, Bas Van Aarle, and Koen J. Schoors. Russia from bust to boom: Oil, politics or the ruble? *SSRN eLibrary*, 2004.

[3] Kirill Sosunov and Oleg A. Zamulin. Can oil prices explain the real appreciation of the russian ruble in 1998-2005? *SSRN eLibrary*, 2006.

[5] We cannot reject random walk hypothesis, but according to Figure 3 there are a lot of outliers for the period of 1998-2001, which do not fully comply with random walk pattern.