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Research paper

Monetary behavior theory in long-term and turbulent conditions on the Russian Ruble

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Abstract:
In this study, based on the monetary behavior theory, we first present a model for determining the fair value of the Russian ruble in the long run from 1999 to 2021 based on macroeconomic indicators including inflation, and GDP per capita. And then we modeled the effect of widespread Russian economic sanctions on the value of the Russian ruble during the turbulent days of February 9 to April 9. Our research results show that there is not much difference between market value and fair value in the long run. Also, by observing the behavior of the ruble during the turbulent days of February 25, 2022, to April 26, 2022, and by entering the conditional risk factor and weighted average of the ruble, the USD to ruble equality between 76.23 and 91.6 was evaluated.

Keywords: Russian Ruble, Inflation, Monetary Theory
MSC2010 Classification: 65D12, 91G30.

1 Introduction

The exchange rate of any country is normally affected by macroeconomic indicators; in other words, in the long run, macroeconomic indicators determine the value of a country's currency. But in times of turmoil, such as severe economic sanctions, the exchange rate does not wait for macroeconomic indicators to change in the long run and then change. And due to the expectation of a bad economic situation in the short term, the exchange rate begins to jump and fluctuate sharply. In other words, this time the devaluation of a country's currency will drive an economic downturn, such as rising inflation and declining GDP. In order to explain and predict the crisis of a country, including currency crises, several models have been developed by many studies worldwide including the research by Tajdini et al. (2021) inventing a model

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of monetary behavior in the Iranian currency crisis. In this study, we generalize and complete the model of monetary behavior theory for fair valuation for both periods of low/high turbulence, for the Russian ruble in the normal or long-term period (1999 to 2021) and the short-term or turbulent period with the introduction of two lower and high edges in the period 25 Feb 2022 to 26 April 2022 after the Russian invasion of Ukraine.

2 Literature Review of Purchasing Power Parity Theory

Since purchasing power parity (PPP) is applied in our model, we introduced this model shortly. It is a popular metric used by macroeconomic scientists that compare different countries' currencies through a "basket of goods" approach. Taylor (1995), Ragoff (1996), Taylor and Peel (2000), Sarno and Taylor (2002), Lothian and Taylor (2008), Sue et al. (2012), Steven, Miguel and Ramirez (2015), Lothian (2016) Wu, Bahmani Chang (2018), Guris and Traolu (2018), Truong and Ha (2018), Zayed, Chowdhury, and Hasan (2018), Zhao. L and Zhao. Y (2018), Fischer and Lipovská (2018), Rani and Kumar (2018), Wang and Liu (2018), Bahmani-Oskooee and Wu (2018), Khan (2020), and Nagayasu (2021) have made significant contributions to purchasing power parity theory literature. Tajdini et al. (2021) offered a novel riskbased approach that is based upon a variety of volatility of the exchange rates which can inscribe the extreme changes that could not be clarified by common theories.The purchasing power parity theory establishes the idea that the ratio of price levels between two countries and the exchange rate between them must be equivalent. This means that a product should cost the same in two countries, a law known as the law of one price. Relative purchasing power parity relates the change in two countries' expected inflation rates to the change in their exchange rates. Inflation reduces the real purchasing power of a nation's currency. If a country has an annual inflation rate of 10%, that country's currency will be able to purchase 10% less real goods at the end of one year, unless exchange rates adjust proportionally. Relative purchasing power parity implies that if the inflation rates in two countries change, the exchange rate will adjust to compensate for inflation differentials.
The relationship can be expressed as follows:

$$E(S_t) = S_0 \times [1 + \inf\ FC - \inf\ UC]^t \tag{1}$$

Where inf FC is the domestic inflation and inf US is inflation in the United States and S_0 is the current value against USD and E(St) is the expected value.

2.1 Literature of conditional risk

several researchers showed that conditional risk of GARCH models vs unconditional risk perform better in the prediction of risk. Abdelaal (2011), Liu and Hung (2009), Dritsaki (2017), Andreea - Cristina and Stelian (2017), Guo (2017a, 2017b), Sarkar and Banerjee (2006), Liu and Hung (2009), Intaz, Subhrabaran, and Niranjan (2016), Coffie, Tackie, Bedi, and Aboagye-Otchere (2017), Nilsson (2017), Mehrara and Tajdini (2020) and Tajdini, Mehrara and Tehrani (2019, 2020). Daniel, Hodrick, and Lu (2017); Della Corte, Sarno, and Tsiakas (2009); Della Corte, Jeanneret, and Patelli (2020) using construct mean-variance optimal portfolios and conditional risk factors sought to forecast currency excess returns.

2.2 GARCH

If an autoregressive moving average (ARMA) model is assumed ARCH for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH) model. The GARCH model that Bollerslev (1986) proposed can be presented as follows (Tsay, 2010):

$$\sigma_t^2 = \aleph_0 + \sum_{i=1}^{u} \alpha_i \sigma_{t-i}^2 + \sum_{j=1}^{v} \beta_j \sigma_{t-j}^2 \tag{2}$$

Parameters $\alpha_0, \alpha_1, \ldots, \alpha_u, \beta_0, \ldots, \beta_v$ of the conditional variance equation.

2.3 IGARCH

Integrated Generalized Autoregressive Conditional Heteroskedasticity (IGARCH) is a restricted version of the GARCH model, where the persistent parameters sum up to one and import a unit root in the GARCH process. This procedure is as follows:

$$\sum_{i=1}^{p} \alpha_i + \sum_{i=1}^{q} \beta_{i-1} = 1 \tag{3}$$

2.4 GJR-GARCH

The GJR-GARCH model was introduced in 1993 by Glosten, Jagannathan, and Runkle. In general form, it is given by:

$$\sigma_t^2 = \omega + \sum_{i=1}^{u} \alpha_i a_{t-i}^2 + \sum_{j=1}^{v} \beta_j \sigma_{t-j}^2 + \gamma_i I_{i-t} a_{t-i}^2 \tag{4}$$

where α, β, and γ are constant parameters, and I is the indicator function that takes the value zero when $a_{t-i}$is positive, and one when is negative. So, this dummy variable distinguishes positive and negative shocks, and the asymmetric effects are captured by γ (Smolovic, 2017).

2.5 EGARCH

To keep the conditional variances generated by the GARCH (p, q) model nonnegative, Bollerslev (1986) imposed nonnegativity constraints on the parameters of the process. Nelson and Cao (1992) showed that these constraints can be substantially weakened and so should not be imposed in estimation. Therefore, they proposed another model. The exponential generalized autoregressive conditional heteroskedastic (EGARCH) model is another form of the GARCH model.
If $\gamma \neq 0$ is significant, then the effects of the shocks on the conditional variance are asymmetric. In this model, leverage effects can be tested assuming γ(Dhamija and Bhalla, 2010).

$$\epsilon_t = \sigma_t z_t \quad \ln \sigma_t^2 = \omega + \alpha_i \epsilon t - i^2 + \sum_{j=1}^{q} \lambda_j \ln \sigma_{t-j}^2 + \sum_{i=1}^{p} \gamma_i \frac{|\epsilon_{t-i}|}{\sigma_{t-i}} - \sqrt{\frac{2}{\pi}} \tag{5}$$

2.6 PGARCH

The basic GARCH model can be also extended to allow for leverage effects. This is made possible by treating the basic GARCH model as a special case of the power GARCH (PGARCH) model. This model, developed by Taylor (1986), uses the conditional standard deviation as a measure of volatility instead of the conditional variance. PGARCH was generalized by Ding, Granger, and Engle (1993) using the PGARCH model as follows:

$$\sigma_t^\delta = \omega + \sum_{i=1}^{q} \alpha_i (|\mu_i| - \gamma \mu_{t-i})^\delta + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^\delta \tag{6}$$

3 Methodology

3.1 Monetary Behavior Theory

In this theory, in addition to the adherence of the exchange rate to the inflation difference between two countries, the exchange rate is affected by the mean difference of GDP per capita between two countries and the standard deviation of GDP per capita as well as the standard deviation of the dollar versus exchange rate during the study period. Adherence of the foreign exchange rates to only the inflation difference in former years is challenging, i.e. the market cannot be expected to evaluate and calculate the foreign exchange rates using the one-factor inflation approach of the purchasing power parity theory for the inflation rates in the previous years. In this theory, in addition to the inflation difference in the previous years, other factors such as the annual rate of GDP per capita, the standard deviation of the annual rate of GDP per capita, and the standard deviation of the dollar versus exchange rate are involved in determining the exchange rate value. Hence, in normal conditions for monetary behavior theory, the four-factor is modeled by equation 6. In these formulas, inf FC is the mean domestic inflation rate, inf US is the mean inflation rate in the U.S., S_0 is the current exchange rate of each country per U.S. dollar, and $E(St)$ is the future exchange rate of each country per U.S. dollar, $growth_{gpcUS}$ is the mean rate of GDP per capita in the U.S., $growth_{gpcFC}$ is the mean rate of GDP per capita of each country, σ_{gpcFC} is the standard deviation of the rate of GDP per capita of each country, $growth_{gpcUS} - growth_{gpcFC}$ is the mean standard deviation of the U.S. dollar versus the exchange rate of each country, σ_{EX} is the intensity of GDP per capita of each country, $\exp(\sigma_{EX})$ is the instability of the exchange rate of each country, and $\exp(\sigma_{gpcFC})$ is the instability of GDP per capita of each country.

$$E(S_t) = [S_0 \times [1 + (\inf\ FC - \inf\ US) + \frac{growth_{gpcUS} - growth_{gpcFC}}{\exp(\sigma_{gpcFC})}]^t] \times \exp(\sigma_{EX}) \quad (7)$$

In the Monetary Behavior Theory Model (Tajdini et al., 2021), the conditional change coefficient was used to apply the turbulence factor in the Iranian foreign exchange market during the turbulent period. But to measure the behavior of the Russian ruble during the turbulent 60-day period, due to Russia's ability to strengthen the ruble, at least in the short term, we cannot use the conditional change coefficient, and instead, we use the weighted average and optimal conditional standard deviation that we used during the turbulence period. In the turbulent days of unforeseen events such as war and sanctions, the value of a country's currency can no longer be measured by long-term data. On turbulent days, we suggest the lower and high edges to evaluate the exchange rate as follows. To evaluate the lower edge of the currency on turbulent days, the product of the fair value in the exp function of the conditional standard deviation according to the following equation was used.

$$rate = [S_0 \times [1 + (\inf\ FC - \inf\ US) + \frac{growth_{gpcUS} - growth_{gpcFC}}{\exp(\sigma_{gpcFC})}]^t] \times \exp(\sigma_{EX}) \quad (8)$$

To evaluate the high edge of the currency on turbulent days, the product of the weighted average in the exp function of the conditional standard deviation according to the following equation was used.

$$\exp(\sigma_{trouble\ days}) = \frac{\sum_{i=1}^{n} w_i FC_i}{\sum_{i=1}^{n} w_i} \quad (9)$$

where FC_i is USD vs foreign currency and i, w, are the number of turbulent days The data and statistics were obtained from the official website of the World Bank and were analyzed by EViews 8 software. In general, the Monetary Behavior Theory argues that to create business balance "a country with a strong economy should have strong money and vice versa"

4 Results

As shown in Table 1, the mean annual inflation rate is 0.135, and the mean annual rate of GDP per capita is 0.097, the mean standard deviation of annual rate GDP per capita is 0.21, and mean standard deviation of the annual exchange rate of the dollar versus ruble is 0.13. Considering the annual inflation rate of 0.022 and mean annual GDP rate per capita of 0.014 in the U.S. using the new model and Monetary

Balance Theory, the fair value of 74.8 units for the USD versus the ruble during the study period, was calculated as follows:

$$E(S_RUSSUIA) = 24.61 \times [1 + (0.135 - 0.22) + \frac{(0.014 - 0.097)}{\exp(0.21)}]^{22}$$
$$\times \exp(0.05) = 24.61 \times 2.67 \times 1.138 = 74.8$$

source:World Bank Open Data As shown in Table 2, the conditional risk of the

Table 1: Statistical data on the returns of monetary and trade variables in both China and the United States

Variable	Number of data	Max returns	Min returns	Average return	Middle return	Std
Inflation rate of Russia	22	0.85	0.029	0.135	0.093	0.17
Inflation rate of USA	22	0.038	-0.003	0.022	0.023	0.01
Annual rate per capita of Russia	22	0.32	-0.41	0.097	0.17	0.21
Annual rate per capita of USA	22	0.034	-0.037	0.014	0.017	0.016
Exchange rate	22	0.46	-0.139	0.051	0.032	0.130

Russian ruble during the 60-day turbulent period was estimated using the GARCH family of models. Among the GARCH, GJRGARCH, EGARCH, and PGARCH models, the IGARCH model was optimized and the optimal conditional standard deviation was estimated to be 0.012. After collecting 61 days of turbulent data

Table 2: Estimation of conditional standard deviation using the GARCH family models

	α	β	λ	δ	Conditional standard deviation
IGARH	0.18*	0.082*			0.019
GARCH	-0.056	1.05*			0.007
GJR-GARCH	0.003	0.98*	-0.13		0.0096
EGARCH	0.56*	-0.93^*	0.06		0.054
PGARCH	0.03	1*	-0.99^*	0.11	0.012

from "https://tradingeconomics. com/russia/currency", as shown in Table 3, the maximum, minimum, and average of USD to rub in Equation 3 based on the 60-day turbulent technical analysis, the value of USD to rub 92.5 was calculated.

$$rate = 24.61 \times [1 + (0.135 - 0.22) + \frac{(0.014 - 0.097)}{\exp(0.21)}]^{22} \times \exp(0.05)$$
$$\times \exp(0.019) = 74.8 \times 1.0192 = 76.22$$

Table 3: Data of the turbulent days of the Russian ruble

Variable	Number of data	Weighted Average USD/RUB	Average USD/RUB	Conditional deviation of return
Exchange rate	61	89.92	97.2	0.019

5 Conclusions and suggestions

Fair valuation of any country's currency is undoubtedly one of the most important factors in the economic health of that country. This becomes more difficult and complicated, especially when countries face critical situations such as economic sanctions. In this study, we seek to develop a new model called the theory of monetary behavior for the fair valuation of countries' currencies in both long-term and turbulent situations. In this study, we measure the fair value of the ruble in the long run, annual macroeconomic data including inflation, GDP per capita from 1999 to 2021, and also the fair value of the ruble during the turbulent period of February 25, 2022 to April 26, 2022. The results of this study showed that in the long run, the market value of the US dollar against the ruble is 76.23, which is close to the fair value provided by this model of 0.013. And in the turbulent period of economic sanctions, the value obtained by this model was approximately between 76.23 to 91.06 to the value of the dollar vs the ruble . In Tajdini et al.'s article, currency valuation was modeled based on the coefficient of conditional variation of the exchange rate in accordance with the permanence in critical conditions, but in this article, the model for both permanence and temporariness of critical conditions was modeled based on the arithmetic mean. Overall, the observation of the 60-day trend after the massive sanctions against the Russian economy showed that although the USD vs rub rose to 139, the Russian economy for four effective reasons, including, 1. High hopes for the end of the Ukraine war; 2. EU dependence on Russian gas and Russian role as a major producer of strategic products such as oil and wheat; 3. Effective economic policies; 4. Support from influential Russian allies, especially China, resists in the short term. Based on the theory of monetary behavior and technical movement of the ruble in the 61-day turbulent period, USD vs ruble on April 26 was estimated at 92.5. But due to the EU's heavy dependence on Russian gas and in particular Russia's decision to require the ruble to pay for Russian gas, the effects of the shock on the ruble diminished and the USD vs ruble returned to pre-turbulent times. it resists in the short term, that each of these cases can be an attractive topic for future research.

Bibliography

[1] Abdelaal, M. A., (2011). Modelling and forecasting time-varying stock return volatility in the Egyptian stock market. International Research Journal of Finance and Economics 78(4):96-113.

[2] AndreeaCristina, P., Stelian, S. (2017). Empirical results of modeling EUR/RON exchange rate using ARCH, GARCH, EGARCH, TARCH and PARCH models, Romanian Statistical Review 65(1), 57-72.

[3] Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity, Journal of Econometrics, 31(3) 307-327.

[4] Coffie, W., Tackie, G., Bedi, I. F., Aboagye-Otchere. (2017). Alternative Models for the Conditional Heteroscedasticity and the Predictive Accuracy of variance Models Emprical Evidence from East and North Africa Stock Markets. Journal of Accounting and Finance, 17(2).

[5] Daniel, K., R. J. Hodrick, and Z. Lu . (2017). The Carry Trade: Risks and Drawdowns. Critical Finance Review. 6, 211-262.

[6] Della Corte, P., A. Jeanneret, and E. Patelli. (2020). A Credit-Based Theory of the Currency Risk Premium, Working Paper.

[7] Della Corte, P., L. Sarno, and I. Tsiakas. (2009). An Economic Evaluation of Empirical Exchange Rate Models. Review of Financial Studies, 22, 3491-3530.

[8] Dritsaki, Ch.(2017) An empirical Evaluation in GARCH Volatility Modeling: Evidence from the Stockholm Stock Exchange. Journal of Mathematical Finance.7, 366-390.

[9] Dhamija, AK., and VK. Bhalla. (2010), Financial time series forecasting: comparison of neural networks and ARCH models, International Research Journal of Finance and Management, 49(1), 159-172.

[10] Guris, B. and Traolu M. (2018). The Validity of Purchasing Power Parity in BRICS Countries, Prague Economic Papers, 27(4), 1-10.

[11] Gyamfi, E.N. (2017). Testing the Validity of Purchasing Power Parity in the BRICS: Further Evidence. Euro Economic, 2(35), 1582-8859.

[12] James R. Lothian. (2016). Purchasing power parity and the behavior of prices and nominal exchange rates across exchange-rate regimes, Journal of International Money and Finance, 69, 5-21.

[13] Guo, Z.(2017) Models with short-term variations and long-term dynamics in risk management of commodity derivatives. EconStor Preprints 167619, ZBW - Leibniz Information Centre for Economics.

[14] Guo, Z-Y. (2017). GARCH Models with the heavy-tailed Distributions and the Hong Kong Stock Market Returns, International Journal of Business and Management, 12(9).

[15] Intaz, A., Subhrabaran, D., Niranjan R. (2016). Stock Market Volatility, Firm Size, and Returns: A Study of Automobile Sector of National Stock Exchange in India, International Journal of Innovative Research and Development, 5(4), 272-281.

[16] Liu, H-ChunLiua., Hung, Jui-ch. (2010). Forecasting SandP-100 stock index volatility: The role of volatility asymmetry and distributional assumption in GARCH models, Expert Systems with Applications, 37(7), 4928-4934.

[17] Lothian, J.R. Taylor, M.P. (2008). Real exchange rates over the past two centuries: how important is the HarrodBalassaSamuelson effect?, Economic Journal, 118, 1742-1763.

[18] Mehrara, M., Tajdini, S. (2020). Comparison of profitability of speculation in the foreign exchange market and investment in Tehran Stock Exchange during Iran's currency crisis using conditional Sharpe ratio. Advances in Mathematical Finance and Applications, 5(3), 271-284.

[19] Nelson, D. B., Cao, C. Q. (1992). Inequality constraints in the univariate GARCH model. Journal of Business and Economic Statistics, 10(3), 229235.

[20] Rogoff, K. (1996). Purchasing power parity puzzle. Journal of Economic Literature, 34, 647-468.

[21] Sarkar, S., Banerjee, A. (2006). Modeling daily volatility of the Indian stock market using intra-day data, Indian Institute of Management Calcutta, Working Paper Series, 1- 32.

[22] Sarno, L. Taylor, M.P. (2002). Purchasing power parity and the real exchange rate. IMF Staff Papers, 49, 65-105.

[23] Smolovi, J.C., Lipovina-Boovi, M Saa Vujoevi . (2017). GARCH models in value at risk estimation: empirical evidence from the Montenegrin stock exchange, Economic Research-Ekonomska Istraivanja, 30(1), 477-498.

[24] Stephen A. Ross, Randolph W. Westerfield, Jeffrey Jaffe. (2011). Corporate Finance; CHAPTER 31 Efficient Capital Markets and Behavioral Challenges, Published by McGrawHill/Irwin, 973-985.

[25] Steven Yee and Miguel D. Ramirez. (2015). Purchasing Power Parity: A Time Series Analysis of the U.S. and Mexico, 1995 - 2007, Department of Econo.

[26] Tajdini, S., Hamooni, A., Maghsoudi, J., Jafari, F., Lotfi Ghahroud, M. (2021). Trade War and the Balanced Trade-Monetary Theory. Journal of Mathematics and Modeling in Finance, doi: 10.22054/jmmf.2021.62479.1038mics, Trinity College, Hartford, CT, 06106 USA.

[27] Tajdini, S., Mehrara, M., Tehrani, R. (2019). Double-sided balanced conditional Sharpe Ratio, Cogent Economics and Finance, 2019,7(1).

[28] Tajdini, S., Mehrara, M., Taiebnia, A. (2021). Investigating the fluctuations of exchange rate based on monetarybehaviour approach. International Journal of Finance Economics, 2021, 2021, 10(3)19.

[29] Tajdini, S., Mehrara, M. and Tehrani, R. (2021). "Hybrid Balanced Justified Treynor ratio", Managerial Finance, 47(1)1, 86-97.

[30] Taylor, M.P. (1995). The economics of exchange rates. Journal of Economic Literature, 33, 13-47.

[31] Taylor, M.P. Peel, D.A. (2000). Nonlinear adjustment, long-run equilibrium and exchange rate fundamentals. Journal of International Money and Finance, 19, 33-53.

[32] Truong, M. and Ha, T. (2018). Testing the Evidence of Purchasing Power Parity for Southeast Asia Countries. International Econometric Conference of Vietnam, 1061-1077.

[33] Wu, J., Bahmani-Oskooee, M. and Chang, T. (2018). Revisiting purchasing power parity in G6 countries: an application of smooth time-varying cointegration approach. Empirica, Volume 45, Issue 1, 187-196.

[34] Zayed, N. M., Chowdhury, F. N., and Hasan, K. R. (2018). Testing Balassa-Samuelson model to Examine purchasing power parity (ppp) of Bangladesh with reference to 1972-2016. Academy of Accounting and Financial Studies Journal 22 (1), 1-10.

[35] Zhao. L and Zhao. Y. (2018). Purchasing Power Parity and PriceFluctuations in Russia before July 1937. Frontiers of Economics in Russia 13 (3), 458-484, 2018.

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