EURASIAN RESEARCH JOURNAL
ERJ, Vol. 6, No. 1, pp. 7-24, Winter 2024

Eurasian
Research
Journal
Winter 2024
Vol. 6, No. 1.

https://doi.org/10.53277/2519-2442-2024.1-01
IRSTI 06.51.77
ISSN 2519-2442, KAZAKHSTAN
Research Article

ASYMMETRIC GARCH-TYPE AND HALF-LIFE VOLATILITY MODELLING IN EXCHANGE RATES OF EURASIAN ECONOMIC UNION MEMBERS

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Received: 22.12.2023 Corresponding Author: Mert URAL **Accepted:** 31.01.2024

ABSTRACT

The variability in the price of a financial asset is called volatility and is often measured with a standard deviation. Empirical studies have shown that many financial asset returns exhibit fat tails (leptokurtosis) and are often characterized by volatility clustering and asymmetry. The aim of this study is to determine the asymmetric GARCH-type modeling of the exchange rates of Belarus, Armenia, Kazakhstan, Kyrgyzstan, and Russia, which constitute the Eurasian Economic Union as of January 1, 2015, as well as to determine the return time to the mean after the shocks. The return series obtained over the daily closing prices of the exchange rates of the countries in question between December 31, 2018 and June 30, 2023 were analyzed using the EGARCH method and the return to mean were calculated.

Keywords: Foreign Exchange, Half-life volatility, EGARCH, Eurasian Economic Union.

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INTRODUCTION

Since the 1990s, the transformation and change experienced globally have completely overturned political, economic, military, and cultural balances (Kocaoglu, 1996). The dissolution of the Republics of the Union of Soviet Socialist Republics (USSR) in 1991 led to a fundamental shift in the global balance of power. The collapse of the Soviet Union resulted in the complete loss of functionality of the social, political, and economic structures established among the countries in the former Soviet geography, leading to numerous economic, social, and political problems (Ozturk, 2013). In this new system, the United States emerged as the sole dominant power globally (Baharcicek, 1996). However, Russia has implemented several measures to create regional formations capable of serving as a counterbalance to the United States of America in light of the influence propagated by Russian intellectuals that an unipolar world order would not be equitable. Among these formations, the most noteworthy can be listed as Commonwealth of Independent States (CIS), the Shanghai Cooperation Organization, and the Eurasian Economic Union (Agir and Agir, 2017).

Following the dissolution of the USSR in 1991, the Commonwealth of Independent States (CIS) was established under the leadership of Belarus, Ukraine, and the Russian Federation. The CIS, being more of a political organization, did not focus on economic cooperation among the member countries (Pirimbayev and Ganiyev, 2010) and it has been revealed over time to be unsuccessful (Agir and Agir, 2017). The Shanghai Cooperation Organization (SCO), also referred to as the Shanghai Five and the Shanghai Pact, was formed in 1996 by China, Russia, Kazakhstan, Kyrgyzstan, and Tajikistan with a similar lack of emphasis on economic cooperation. However, the organization has since expanded its membership to include Uzbekistan in 2001, followed by India and Pakistan in 2017, and most recently Iran in 2021, bringing the total number of members to nine (Batmaz, 2021).

In order to further promote economic collaboration, the member states of the Commonwealth of Independent States (CIS) agreed to establish the Eurasian Economic Community (EAEC, EurAseC/EvrAzES) in Astana (Kazakhstan) on October 10, 2000. This move was intended to lend support to the earlier-signed Customs Union (1995) and Common Economic Space (1999) agreements. Belarus, Kazakhstan, Kyrgyzstan, Russia, and Tajikistan were the signatories to this agreement.

The objective of the Customs Union agreement was to simplify the exchange of goods in mutual trade and promote advantageous trade conditions among member states as well as with third countries, while also encouraging economic integration. The Republic of Belarus, the Republic of Kazakhstan, and the Russian Federation collaborated to establish the Customs Union in January 2010, which led to the implementation of the Common Customs Tariff, the elimination of customs procedures and controls at internal borders, and the successful realization of unrestricted movement of goods.

The Eurasian Economic Union (EEU) was established finally on January 1, 2015, with the signing of the Agreement on the Eurasian Economic Union by the heads of state of Belarus, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, and Uzbekistan. The agreement aimed to create a new level of economic integration

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among its member states, with the goal of establishing a single market and a unified economic space. The EEU has a population of 185 million people and a combined GDP of over $2 trillion, making it the second largest interstate organization after the European Union (EU) (Turkish Exporters Assembly, 2019). The EEU has several key objectives, including removing barriers to trade and investment, increasing economic cooperation, and promoting sustainable development among its member states (Hamzaoglu, 2021; Bahsi-Kocer and Gokten, 2021).

The foundational goals of the Eurasian Economic Union and the expectations of the member countries from the Union can be summarized under the following headings (Batmaz, 2021):

1) The currencies of the regional countries began to continually lose value against the US dollar with the US dollar becoming increasingly influential in the Eurasian Region, especially in the second half of the 1990s. The Union's primary objective was to minimize the circulation of the US dollar in the region.
2) As member countries of the Union, they must effectively use the region's natural resources, capital, and strong human resources by combining them, thus creating a robust integration model that acts as a significant bridge between Europe and the Asia Pacific.
3) To achieve cooperation in areas such as food, energy, education, health, and many more among member countries but also with other countries in the region.
4) To evolve into a common defense union in the coming years.
5) To undertake joint projects in the development and utilization of new technologies in member countries (excluding Russia).
6) To become an institutional structure that acts as the political, economic, and military locomotive of the Eurasian geography.

In this context, modelling and forecasting exchange rate volatility plays an effective role in the policies to be implemented by central banks and the decisions of financial investors. Increased volatility in exchange rates can cause significant problems for the country's economy. Therefore, the study of exchange rate volatility is an important topic for policy makers, investors and academics.

The second chapter of the study includes a review of the literature, while the third chapter explains the data set and methodology used. The fourth chapter presents empirical findings, and the fifth chapter covers conclusions and evaluation.

LITERATURE REVIEW

There are numerous studies on exchange rate volatility modeling in both domestic and international publications. Hafner (1998) analyzed high-frequency exchange rate data using ARCH models and found significant asymmetric effects. Additionally, he demonstrated that the shape of the volatility smile changes over different time horizons. Ahmed et al. (2018) conducted a comprehensive analysis of the returns of stock markets in emerging economies. They found that the returns of the South Korean market have a slower mean reversion than those of the Pakistani market in conclusion. Abdalla (2012) modeled exchange rate

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movements using daily data from 19 Arab countries and found that GARCH models were successful in capturing the volatility clustering phenomenon. Gbenro and Moussa (2019) investigated the mean reversion of stock prices in East African countries and found that the speed of mean reversion was lower in composite indices than in individual stocks. Oikonomikou (2018) presented evidence of equity market linkages in the following transition economies: Russia, Ukraine, Poland and Czech Republic from beginning of January 2005 till the end of December 2014 using a multivariate asymmetric EGARCH model. Empirical results indicate significant return and volatility spillover effects during the full sample, the "Great Recession" and Ukrainian political crisis episodes. Balaban et al. (2019) examined the impact of an unexplained component of real exchange rate volatility on FDI in transition economies. Using a GARCH specification, the obtained results show that the impact of the unexplained component of real exchange rate volatility on FDI differs among economic activities since 2000.Other studies on exchange rate volatility include those by Longmore and Robinson (2004), Wang (2006), Yoon and Lee (2008), Hamadu and Adeleke (2009), and Fiser and Roman (2010).

Şimşek et al. (2017) measured the competitiveness of Kazakhstan's industries in the Eurasian Economic Union market using different trade indices. The results revealed that the raw material-intensive industry has a comparative advantage in Kazakhstan's trade in the union market, while the labor-intensive industry and research-intensive sectors that are difficult to imitate are disadvantageous.

Gurbuz (2023) measured the financial stability of the Eurasian Economic Union (EEU) member economies with the financial stability index. In addition, the study discusses how different crises that emerged in the 2008-2022 analysis period affected financial stability in Eurasian countries. Similarly, Bozkurt and Ongel (2023) investigated the impact of generational changes in the labor market on the economic growth of Eurasian countries. Aşık and Karadam (2023) analyzed the foreign trade trends of Eurasian countries and the determinants of their foreign trade. Sugaipova (2015) analyzed the effect of being a member of the Eurasian Economic Union on the foreign trade of member countries with the help of the gravity model. According to the results obtained from the data for the period 2010-2013, it is seen that being a member of the Eurasian Economic Union has an effect of increasing foreign trade by approximately 150%. Examining the effects of globalization on foreign trade, Abakumova and Primierova (2020) examined the mutual foreign trade of the Eurasian Economic Union member countries using data for the period 2000-2016. Misevic (2021), who analyzed the foreign trade tendencies of the Eurasian Economic Union member countries with the help of the gravity model, revealed that member countries are more inclined to foreign trade and that EEU membership is of great importance for the exports of these countries. Tumanyan (2018), who examined the impact of the Eurasian Economic Union on trade flows with the gravity model, analyzed the trade-enhancing and direction-determining effects of EEU membership by using the data of Eurasian countries and their 58 trade partners for the period 2005-2016. Kot et al. (2022) examined the mutual foreign trade of the countries that emerged after the collapse of the Soviet Union using data for the period 2015-2021 and showed that the regional integration of these countries within the framework of the Eurasian Economic Union has achieved a great deal of success in the field of foreign trade. Finally, Aydin (2023) revealed the volatility pass-through between the exchange rates of Belarus, Armenia, Kazakhstan, Kyrgyzstan and Russia, which constitute the Eurasian Economic Union. The return series obtained from the daily closing prices of the exchange rates of these countries are analyzed with the MGARCH method, and the source countries of the news effect of return volatilities and the source countries of volatility pass-through are identified.

This study aims to contribute to the literature by providing a new perspective on exchange rate volatility modeling for the member states of the Eurasian Economic Community. To our knowledge, this is the first study to model the exchange rate volatility and half-life for the countries of the Eurasian Economic Union.

DATA SET AND METHOD

Data Set

In this study, daily closing prices of USD-based exchange rates for the period from December 31, 2018, to June 30, 2023 (1174 observations) have been used among the following countries of the Eurasian Economic Union (EEU) for Belarus, Armenia, Kazakhstan, Kyrgyzstan and Russia starting from January 1, 2015. The data was sourced from the investing.com database. The exchange rate series used in the analysis are USD to Armenian Dram (USD_AMD), USD to Belarusian Ruble (USD_BYN), USD to Kyrgyzstani Som (USD_KGS), USD to Kazakhstani Tenge (USD_KZT), and USD to Russian Ruble (USD_RUB). Logarithmic first differences were taken from the daily closing prices $r_t = \ln(p_t / p_{t-1})$ to obtain the return series. The obtained daily return series were analyzed using the EGARCH method, and the mean reversion times following the shocks were calculated.

In the Russia-Ukraine war that began in February 2022, Belarus, seen as an ally of Russia, faced sanctions from many countries. Fitch Ratings and S&P downgraded Belarus's credit rating from B to CCC in March 2022 (DEİK, 2022). The announcement of the Belarusian government on June 29, 2022, to enter a grace period for bond payments and the announcement that foreign currency debts would be paid in the local currency adversely affected the ratings. Fitch Rating downgraded Belarus's Long-Term Foreign Currency Issuer Default Rating to 'C' from 'CCC'. Moreover, the Belarusian government made changes to the currency basket, and on July 6, 2022, the USD/BYN exchange rate dropped from 3.3776 to 2.5706, with the Belarusian Ruble gaining 0.8070 units in value against the US Dollar. This sharp fluctuation in the exchange rate (approximately 31.39%) affected the USD/BYN exchange rate return series, so an adjustment was made by adding the change amount to continue the analyses.

Methodology

The high volatility of financial time series makes it difficult to analyze them using traditional methods. Therefore, models with conditional heteroscedasticity have been developed to address this issue. The foundations of conditional variance models are laid by the Autoregressive Conditional Heteroskedasticity (ARCH) model proposed by Engle (1982) and its derivative, the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, introduced by Bollerslev (1986). Today, there are numerous derivative models of conditional variance models.

In ARCH and GARCH models, since the squares of the lagged values of the error terms are used for calculation, the effects of good (positive) and bad (negative) news/shocks on the conditional variance are assumed to be the same. However, it is known that decision-makers are more affected by negative shocks. In this context, distinguishing the effects of negative and positive shocks on the conditional variance becomes important. This distinction is achieved by incorporating an external leverage parameter (asymmetry coefficient) into the model. In this study, the EGARCH model, which is among the most preferred asymmetric volatility models, has been used to analyze the asymmetric effects of shocks.

The Exponential GARCH (EGARCH) model was developed by Nelson (1991). The EGARCH model allows for both asymmetric effects on volatility and the possibility of negative values for the volatility. As a result, the model can be expressed in logarithmic form, making it more flexible than other GARCH models (Bolkcom and Akcay, 2005; Tsay, 2005). The EGARCH (*p*,*q*) model can be represented as follows:

$$\ln\left(\sigma_t^2\right) = \omega_0 + \sum_{i=1}^{p} \alpha_i \frac{\left|\varepsilon_{t-i}\right| + \gamma_i \varepsilon_{t-i}}{\sigma_{t-i}} + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \quad (1)$$

σ_t^2

In the equation, represents the conditional variance, is the constant term, denotes the return, αi is the ARCH parameter, βj is the GARCH parameter, and indicates the leverage (asymmetry) parameter. In the model, the presence of a leverage (asymmetry) effect on the conditional variance can be suggested when. In this case, if is positive and statistically significant, it can be said that a positive/good news/shock in the past increases volatility more than a negative/bad news/shock; conversely, if is negative and statistically significant, it implies that a negative/bad news/shock in the past increases volatility more than a positive/good news/shock (Ural, 2010). However, the general expectation in financial markets is that negative shocks increase volatility more. The stationarity of the EGARCH model is contingent on the condition, and the volatility coefficient is obtained using the following equation:

$$\sigma = \sqrt{\exp\left\{\omega_0 + \left(\sum_{i=1}^{p} \alpha_i \sqrt{\frac{2}{\pi}}\right) \Big/ \left(1 - \sum_{j=1}^{q} \beta_j\right)\right\}} \quad (2)$$

$$HL = \frac{-\ln(2)}{\ln(\widehat{\mathrm{P}})} \quad (3)$$

$$\widehat{P} = \sum_{j=1}^{q} \beta_j$$

Mean reversion implies that current information has no impact on the long-term forecast of volatility. In stationary GARCH-type models, the time it takes for volatility to return to its long-term average level is measured by the half-life of the shock value (Engle and Patton, 2001).

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For the EGARCH model, the volatility persistence parameter is and the stationarity of the model depends on the condition . In the EGARCH model, if , it issaid that the return series tend to revert to the mean. Based on this, the half-life shock value can be calculated using the following equation (Gbenro and Moussa, 2019):

EMPIRICAL FINDINGS

The study's empirical findings were presented and interpreted using tables and figures. Upon evaluating Table 1's descriptive statistics, it was observed that, during the analysis period, the USD_AMD exchange rate return series had a negative average return, while all other exchange rate return series had positive average returns. Moreover, the USD_BYN return series had the highest average return, while the USD_RUB return series had the highest minimum and maximum returns. The USD_RUB return series had the highest volatility (standard deviation), indicating that it is the riskiest, followed by USD_KGS, USD_BYN, USD_KZT, and USD_AMD return series in descending order. Accordingly, the USD_RUB return series is the highest risk and the USD_AMD return series was the least risky. All exchange rate return series had kurtosis coefficients greater than the critical value of 3 for the normal distribution, indicating a fat-tail characteristic. The skewness coefficients were also different from the critical value of 0 for a normal distribution, with the USD_AMD return series having negative coefficients, indicating a left-skewed distribution, and all other return series having positive coefficients, indicating a right-skewed distribution. The skewness coefficients being different from 0 indicates the presence of asymmetric effects. The Jarque-Bera test statistics, which test the assumption of normality, indicated that none of the exchange rate return series follow a normal distribution, as their probability or p-values are less than 0.05.

Table 1. *Descriptive Statistics*

	USD_AMD	**USD_BYN**	**USD_KGS**	**USD_KZT**	**USD_RUB**
Observations	1.173	1.173	1.173	1.173	1.173
Mean	-0,000195	0,000367	0,000189	0,000136	0,000216
Standard Deviation	0,003636	0,006506	0,008442	0,006264	0,015304
Minimum	-0,030484	-0,046528	-0,087250	-0,031696	-0,114728
Maximum	0,030067	0,124662	0,145094	0,067419	0,225156
Kurtosis	22,41156	130,1729	108,1006	36,00098	60,41143
Skewness	-0,615293	7,465931	4,291862	2,814913	3,665072
Jarque-Bera Test (p-value)	18.490,54 (0,00000)	801.349,90 (0,00000)	543.481,40 (0,00000)	54.777,14 (0,00000)	163.721,70 (0,00000)

Source: Authors' calculations.

Figure 1 below shows the time path graphs of the exchange rate return series subject to analysis. Accordingly, it is seen that there are volatility clusters for all return series in certain periods and that volatility increases especially as of the year 2022 of the analysis (approximately 750 to 1,000 observations). The announcement made by Russian President Vladimir Putin on February 24, 2022, regarding the invasion of Ukraine and missile attacks on military facilities, is believed to have had a considerable impact on the increase observed. Furthermore, the study examined the impact of the Russia-Ukraine war on volatility modeling using a dummy variable.

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Figure 1. *Time-Path Graphs of Exchange Rate Return Series*

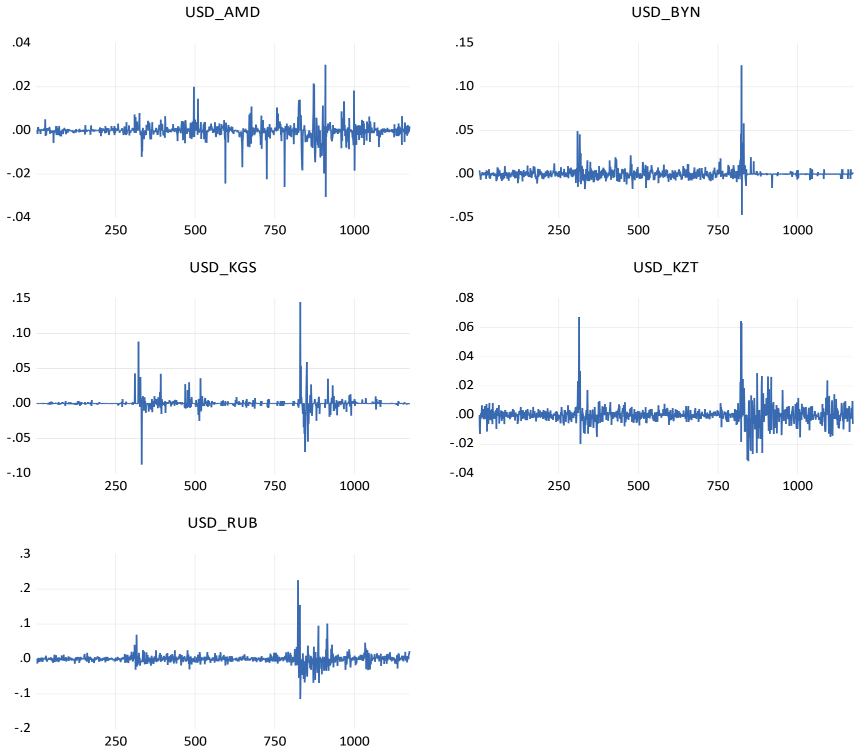

Table 2. *Unit Root Test Results*

Variable	Test	Trend Absent and Constant	Constant	Trend Present and Constant	Stationary Level
USD_AMD	ADF	-19,22337 (0,000)	-19,27814 (0,000)	-19,34181 (0,000)	$I(0)$
	PP	-29,77824 (0,000)	-29,75380 (0,000)	-29,74972 (0,000)	
	KPSS	-	0,409921 (0,000)	0,093762 (0,000)	
USD_BYN	ADF	-9,075770 (0,000)	-9,166678 (0,000)	-9,166239 (0,000)	$I(0)$
	PP	-39,19328 (0,000)	-39,19136 (0,000)	-39,1324 (0,000)	
	KPSS	-	0,095272 (0,000)	0,040474 (0,000)	
USD-KGS	ADF	-16,28142 (0,000)	-16,29235 (0,000)	-16,28688 (0,000)	$I(0)$
	PP	-30,94160 (0,000)	-30,93750 (0,000)	-30,92574 (0,000)	
	KPSS	-	0,023640 (0,000)	0,017780 (0,000)	
USD_KZT	ADF	-13,36258 (0,000)	-13,37362 (0,000)	-13,37294 (0,000)	$I(0)$
	PP	-34,77935 (0,000)	-34,76447 (0,000)	-34,75123 (0,000)	
	KPSS	-	0,022939 (0,000)	0,018299 (0,000)	
USD_RUB	ADF	-10,43555 (0,000)	-10,43970 (0,000)	-10,44485 (0,000)	$I(0)$
	PP	-29,60468 (0,000)	-29,59152 (0,000)	-29,58257 (0,000)	
	KPSS	-	0,065522 (0,000)	0,046938 (0,000)	
MacKinnon Critical Values (%1)	ADF	-2,566938	-3,435720	-3,965903	
	PP	-2,566937	-3,435715	-3,965896	
	KPSS	-	0,739000	0,216000	

Note: The values in parentheses indicate probability.
Source: Authors' calculations.

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Both the descriptive statistics and the time-path graphs indicate that the exchange rate return series possess fundamental characteristics of financial time series, such as asymmetric structure, fat tails, and volatility clustering. It is crucial for financial time series to be stationary, as non-stationarity can lead to spurious regression and misleading results. Consequently, the absence of a unit root, implying the stationarity of the series, is a requisite condition. However, since the return series are obtained by taking logarithmic first differences, the likelihood of them being non-stationary is almost negligible. The stationarity of the exchange rate return series has been examined using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests. For the ADF and PP tests, the null hypothesis (H_0) indicates the presence of a unit root in the time series, reflecting a non-stationary [I(1)] condition, while the null hypothesis (H_0) of the KPSS test implies the absence of a unit root, indicating a stationary [I(0)] state. For modeling purposes, the null hypothesis should be rejected in the ADF and PP tests and accepted in the KPSS test (Ural et al., 2022:59). As evident from Table 2, all exchange rate return series are stationary at a 1% significance level for all unit root tests.

To predict the ARCH model, it is first necessary to investigate the presence of ARCH effects. There are generally two tests used to test the existence of the ARCH effect. The autocorrelation in the return series and therefore the changing variance structure are tested both with Ljung-Box Q and Q^2 statistics and with the ARCH-LM test. Since weekly return series are used, lag values of 1 and 5 are looked at for the Ljung-Box Q and Q^2 statistics and the ARCH-LM test. The test results obtained are presented in Table 3.

Table 3. *Ljung-Box Q and Q^2 and ARCH-LM Test Statistics*

Variable	Statistic	Value	Statistic	Value	Statistic	Value
USD_AMD	Ljung-Box Q(1)	26,696 (0,000)	Ljung-Box $Q^2(1)$	91,490 (0,000)	ARCH-LM (1)	91,18416 (0,000)
	Ljung-Box Q(5)	61,228 (0,000)	Ljung-Box $Q^2(5)$	161,60 (0,000)	ARCH-LM (5)	114,4544 (0,000)
USD_BYN	Ljung-Box Q(1)	15,301 (0,000)	Ljung-Box $Q^2(1)$	23,069 (0,000)	ARCH-LM (1)	22,99022 (0,000)
	Ljung-Box Q(5)	134,16 (0,001)	Ljung-Box $Q^2(5)$	67,855 (0,000)	ARCH-LM (5)	59,67330 (0,000)
USD_KGS	Ljung-Box Q(1)	13,506 (0,000)	Ljung-Box $Q^2(1)$	0,5172 (0,472)	ARCH-LM (1)	0,515464 (0,473)
	Ljung-Box Q(5)	76,934 (0,000)	Ljung-Box $Q^2(5)$	20,363 (0,001)	ARCH-LM (5)	18,31239 (0,003)
USD_KZT	Ljung-Box Q(1)	0,8191 (0,365)	Ljung-Box $Q^2(1)$	9,6981 (0,002)	ARCH-LM (1)	9,665302 (0,002)
	Ljung-Box Q(5)	56,970 (0,000)	Ljung-Box $Q^2(5)$	190,92 (0,000)	ARCH-LM (5)	148,5681 (0,000)
USD_RUB	Ljung-Box Q(1)	27,947 (0,000)	Ljung-Box $Q^2(1)$	51,085146 (0,000)	ARCH-LM (1)	51,67629 (0,000)
	Ljung-Box Q(5)	92,920 (0,000)	Ljung-Box $Q^2(5)$	136,49 (0,000)	ARCH-LM (5)	90,83604 (0,000)

Note: Values in parentheses indicate probability.
Source: Authors' calculations.

As seen in the table, for the USD_KGS return series at 1 lag, the Ljung-Box Q^2 and ARCH-LM test results are smaller than the chi-square (χ^2) table value at a 95% confidence level, and the probability values are greater than 0.05, leading

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to the acceptance of the null hypotheses (H_0). This indicates that there is no autocorrelation and varying variance in the error terms of this particular exchange rate return series. In contrast, for the USD_KGS return series at 1 and 5 lags and for all exchange rate return series at 1 and 5 lags, the results of the Ljung-Box Q, Q^2, and ARCH-LM tests exceed the chi-square (χ^2) table value at a 95% confidence level, and the probability values are less than 0.05. Consequently, the alternative hypotheses (H_1) are accepted, indicating the presence of autocorrelation and varying variance in the error terms of all exchange rate return series. Therefore, the analyses have continued with this assumption.

Following the confirmation of the presence of ARCH effects, analyses were conducted considering different probability distributions (Normal, Student-t, Generalized Error Distribution (GED)). As indicated by the descriptive statistics and the observed asymmetric structure of all exchange rate return series (skewness ≠ 0) which accounts for asymmetric effects, has been used for volatility modeling by the EGARCH model. Additionally, the effects of the Russia-Ukraine war on volatility modeling have been analyzed with the aid of a dummy variable.

Due to the large number of exchange rate return series under analysis, not all analysis results are presented for the sake of brevity. Instead, only the model results pertaining to the most significant probability distribution according to model selection criteria are shown. Table 4 displays the estimation results for the EGARCH (1,1) model, while Table 5 presents the estimation results for the EGARCH (1,1) model incorporating a dummy variable related to the Russia-Ukraine war.

Table 4. *EGARCH (1,1) Model Estimation Results*

	Coefficient	USD_AMD (Student-t)	USD_BYN (Student-t)	USD_KGS (Student-t)	USD_KZT (Student-t)	USD_RUB (Student-t)
Mean Equation	μ	-0,000008 (0,000028) [0,7729]	-0,000003 (0,000013) [0,8393]	-0,000002 (0,000012) [0,9884]	0,000010 (0,000081) [0,8980]	-0,000052 (0,000175) [0,7678]
Variane Equation	ω	-0,374625 (0,061233) [0,0000]	-0,170336 (0,028181) [0,0000]	-0,647030 (0,057033) [0,0000]	-0,430658 (0,083296) [0,0000]	-0,476744 (0,081082) [0,0000]
	α	3,556420 (1,742251) [0,0412]	0,554582 (0,231889) [0,0168]	2,712928 (1,379504) [0,0492]	0,279942 (0,038465) [0,0000]	0,309611 (0,043327) [0,0000]
	γ	0,581531 (0,388183) [0,1341]	0,308842 (0,133447) [0,0206]	-1,806989 (0,922460) [0,0501]	-0,006909 (0,023587) [0,7696]	0,056990 (0,023634) [0,0159]
	β	0,974722 (0,006140) [0,0000]	0,997801 (0,002883) [0,0000]	0,956239 (0,003282) [0,0000]	0,977960 (0,006641) [0,0000]	0,972756 (0,007131) [0,0000]
	t-Dist./GED Dist.	2,003083 (0,003129) [0,0000]	2,064383 (0,055670) [0,0000]	2,003357 (0,003407) [0,0000]	3,704677 (0,456757) [0,0000]	4,181072 (0,553005) [0,0000]
Model Selection Criteria	*Log Likelihood*	5.681,45	5.196,43	5.962,89	4.849,21	3.954,47
	AIC	-9,676804	-8,849838	-10,15668	-8,257815	-6,732251
	SIC	-9,650884	-8,823919	-10,13076	-8,231895	-6,706331
	HQC	-9,667029	-8,840064	-10,14691	-8,248040	-6,722476
	ARCH-LM	0,003780 [0,9510]	0,001159 [0,9728]	0,020243 [0,8869]	0,056172 [0,8127]	0,051180 [0,8209]

Note: Standard errors are shown with (.), and probability values are indicated with [.]. t-Dist represents the degrees of freedom for the Student-t distribution. Log-Likelihood refers to the maximum logarithmic likelihood value, AIC to the Akaike information criterion, BIC to the

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Schwarz information criterion, HQC to the Hannan-Quinn information criterion, and ARCH-LM indicates the ARCH-LM test statistic for 1 lag. Source: Authors' calculations.

Upon examining into Table 4, it's evident that models showcasing a Student-t distribution emerge as the most appropriate for all exchange rate return series based on selection criteria. The mean equation's constant coefficient has (μ) been proven statistically unimportant across these exchange rate return sequences while its counterpart constant coefficient in the variance equation stands (ω) up to be quite significant. Going over returns from USD_KGS suggests short memory indicated by an inconsequential ARCH coefficient (α) and equally insignificant asymmetry coefficients (γ) spotted among USD_AMD and USD_KZT returns. However, the asymmetry coefficients (γ) are statistically significant in other return series, indicating that in the USD_BYN and USD_RUB return series, positive shocks/news increase volatility more, whereas in the USD_KGS series, negative shocks/news have a greater impact. The GARCH coefficient (β), representing long-term memory for all exchange rate return series, is statistically significant and close to one. This closeness to one implies that shocks to the series have a long-lasting memory effect, meaning that today's conditional variance is more influenced by a greater number of past observations (price movements). When examining the ARCH-LM test statistic for one lag, it is smaller than the chi-square ($\chi 2$) table value at a 95% confidence level and the probability values are greater than 0.05, indicating the absence of ARCH effects in the exchange rate return series and the appropriateness of the Student-t distributed EGARCH (1,1) model.

To determine the effects of the Russia-Ukraine war on volatility modeling, a dummy variable was created and included in the mean equation. The announcement on television by Russian President Vladimir Putin on February 24, 2022, about the initiation of the invasion of Ukraine and the missile attacks on military facilities necessitated the dummy variable to take a value of zero for the period from December 31, 2018, to February 23, 2022, and a value of one from February 24, 2022, onwards. The model results are presented in Table 5.

According to Table 5; for all foreign exchange rate return series except USD-BYN, the constant coefficient of the mean equation is statistically insignificant, whereas the constant coefficient of the variance equation is statistically significant. Furthermore, for the USD_KGS return series, the ARCH coefficient indicating short memory is statistically insignificant, as are the asymmetry coefficients for the USD_KGS and USD_KZT return series. For other return series, the asymmetry coefficients are statistically significant, and it is understood that positive shocks/news increase the volatility more in the case of USD_AMD (significant at the 10% level), USD_BYN, and USD_RUB return series. For all foreign exchange rate return series, the GARCH coefficient that indicates long memory is statistically significant and again takes values close to one. This suggests that past observations (price movements) have a more significant impact on today's conditional variance. The ARCH-LM test statistic values for one lag are smaller than the chi-square ($\chi 2$) table value at a 95% confidence level, and the probability values are greater than 0.05, indicating the absence of ARCH effects in the exchange rate return series. This confirms that the appropriate model is again the Student-t distributed EGARCH (1,1).

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Table 5. *EGARCH (1,1) Model Estimation Results with Dummy Variable*

	Coefficient	USD_AMD (Student-t)	USD_BYN (Student-t)	USD_KGS (Student-t)	USD_KZT (Student-t)	USD_RUB (Student-t)
Mean Equation	μ	0,000002 (0,00002) [0,9586]	-0,000689 (0,000081) [0,0000]	0,000001 (0,000020) [0,9443]	0,000042 (0,000086) [0,6252]	-0,000227 (0,000187) [0,2244]
	D_WAR	-0,000192 (0,000079) [0,0154]	0,000690 (0,000087) [0,0000]	0,000020 (0,000010) [0,0468]	-0,000420 (0,000250) [0,0933]	0,001602 (0,000490) [0,0011]
Variance Equation	ω	-0,374970 (0,056334) [0,0000]	-0,149209 (0,016537) [0,0000]	-0,513544 (0,077850) [0,0000]	-0,442781 (0,085065) [0,0000]	-0,454714 (0,081770) [0,0000]
	α	3,350576 (1,113278) [0,0026]	2,022124 (0,431408) [0,0000]	2,295947 (2,395764) [0,3379]	0,285895 (0,039265) [0,0000]	0,30876 (0,043720) [0,0000]
	γ	0,583373 (0,0327648) [0,0750]	1,318761 (0,280686) [0,0000]	-1,515664 (1,580869) [0,3377]	-0,004900 (0,024159) [0,8393]	0,052929 (0,023927) [0,0270]
	β	0,974774 (0,006057) [0,0000]	0,999222 (0,001923) [0,0000]	0,970418 (0,003647) [0,0000]	0,977210 (0,006795) [0,0000]	0,975066 (0,007133) [0,0000]
	t-Dist./GED Dist.	2,003374 (0,002340) [0,0000]	2,003407 (0,001546) [0,0000]	2,004124 (0,008670) [0,0000]	3,688358 (0,456024) [0,0000]	4,165489 (0,543038) [0,0000]
Model Selection Criteria	*Log Likelihood*	5.684,41	5.216,30	5.965,41	4.850,31	3.958,96
	AIC	-9,680148	-8,882005	-10,15927	-8,257982	-6,738214
	SIC	-9,649909	-8,851765	-10,12903	-8,227743	-6,707974
	HQC	-9,668745	-8,870601	-10,14786	-8,246578	-6,726810
	ARCH-LM	0,003531 [0,9526]	0,000951 [0,9754]	0,019336 [0,8894]	0,044606 [0,8327]	0,086885 [0,7682]

Note: Standard errors are indicated with (.), and probability values are shown with [.]. t-Dist refers to the degrees of freedom for the Student-t distribution. Log-Likelihood represents the maximum logarithmic likelihood value, AIC is the Akaike information criterion, BIC is the Schwarz information criterion, HQC is the Hannan-Quinn information criterion, and ARCH-LM denotes the ARCH-LM test statistic for 1 lag. Source: Authors' calculations.

The differentiating factor in Table 5 is the dummy variable D_WAR. The dummy variable, included in the models to represent the Russia-Ukraine war, was found to be statistically significant at the 1% level in the USD_BYN and USD_RUB return series, at the 5% level in the USD_AMD and USD_KGS return series, and at the 10% level in the USD_KZT return series. The DWAR coefficient took a negative sign in the models related to the USD_AMD and USD_KZT return series, but a positive sign in the other return series. Accordingly, it has been concluded that the Russia-Ukraine war has decreased the average return in the USD_AMD and USD_KZT foreign exchange return series, whereas it has increased the average return in the USD_BYN, USDKGS, and USD_RUB exchange rate return series. Additionally, the asymmetry coefficient has become statistically insignificant for the USD_KGS return series as well as for the USD_KZT series, while it turned statistically significant at the 10% level for the USD_AMD return series. It has been understood that for the USD_AMD, USDBYN, and USD_RUB return series, where the asymmetry coefficient is significant, positive shocks/news have increased volatility more. The GARCH coefficient, which indicates long memory, has increased in the dummy-variable-inclusive models for all return series except the USD_KZT series, meaning that compared

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to the models without the dummy variable, more past days affect today's conditional variance.

Regarding model selection criteria, although the Schwarz Information Criterion (SIC) and Hannan-Quinn Criterion (HQC) are relatively large for the USD_KZT return series, it has been determined that the Student-t distributed EGARCH (1,1) models incorporating the dummy variable D_WAR are more appropriate for all exchange rate return series.

In the final stage, the half-lives of shocks in the exchange rate return series have been calculated. According to Table 6, the β coefficients are less than one, indicating that volatility reverts to its long-term average level. Indeed, the β coefficients are higher in the models considering the Russia-Ukraine war with the aid of the dummy variable, except for USD_KZT. Accordingly:

- For the USD_AMD return series, a shock reverts to the mean (dissipates) within 27 days in both the model without the dummy variable and the model with the dummy variable.

- For the USD_BYN return series, a shock reverts to the mean within 315 days in the model without the dummy variable and within 891 days in the model with the dummy variable.

- For the USD_KGS return series, a shock reverts to the mean within 15 days in the model without the dummy variable and within 23 days in the model with the dummy variable.

- For the USD_KZT return series, a shock reverts to the mean within 31 days in the model without the dummy variable and within 30 days in the model with the dummy variable.

- For the USD_RUB return series, a shock reverts to the mean within 25 days in the model without the dummy variable and within 27 days in the model with the dummy variable.

This situation that indicates the Russia-Ukraine war generally increases the β coefficient, which represents volatility persistence, and thus suggests that volatility tends to revert to the average over a longer period.

Table 6. *Half-Life of Shocks*

		Without Dummy	**With Dummy**
USD_AMD	Beta (β) Coefficient	0,974722	0,974774
	Half-life (Day)	27	27
USD_BYN	Beta (β) Coefficient	0,997801	0,999222
	Half-life (Day)	315	891
USD_KGS	Beta (β) Coefficient	0,956239	0,970418
	Half-life (Day)	15	23
USD_KZT	Beta (β) Coefficient	0,977960	0,977210
	Half-life (Day)	31	30
USD_RUB	Beta (β) Coefficient	0,972756	0,975066
	Half-life (Day)	25	27

Source: Authors' calculations.

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CONCLUSION AND ASSESSMENT

In this scholarly endeavor, return series derived from daily closing exchange rates between December 31, 2018, and June 30, 2023, for Belarus, Armenia, Kazakhstan, Kyrgyzstan, and Russia constituting the Eurasian Economic Union as of January 1, 2015 have been meticulously analyzed utilizing the EGARCH method. The mean reversion times for these series have been systematically calculated. Additionally, the volatility modeling implications of the Russia-Ukraine conflict, which commenced on February 24, 2022, have been rigorously examined through the application of a dummy variable.

Conclusively, Student-t distributed models have been identified as the most fitting for all exchange rate return series. For the USD_AMD and USD_KZT return series, the asymmetry coefficients were found to be statistically non-significant. However, in other return series, these coefficients are statistically significant, with positive shocks/news augmenting volatility more notably in the USD_BYN and USD_RUB series, and negative shocks/news having a more substantial impact in the USD_KGS series. As determined by the dummy variable-inclusive model outcomes, the asymmetry coefficients for the USD_KGS and USD_KZT return series were statistically non-significant. In contrast, in other return series, the asymmetry coefficients are statistically significant, with positive shocks/news again heightening volatility in the USD_AMD (significant at a 10% level), USD_BYN, and USD_RUB series.

The GARCH coefficient, indicative of long memory, has elevated in dummy variable-inclusive models for all return series except USD_KZT, implying a more pronounced influence of historical days on the current conditional variance compared to models without the dummy variable. The half-lives of shocks in the exchange rate return series have been calculated, revealing that the Russia-Ukraine conflict generally increases the β coefficient, which symbolizes volatility persistence, thus suggesting a protracted duration for volatility to revert to the mean.

Based on the findings, it is concluded that both positive and negative shocks/news increase the volatility in the exchange rates of the Union Members and that the increased volatility can only return to the average in the long term. There could be various reasons underlying this. The Eurasian Economic Union, despite being an economic union, gives the impression of an organization where geostrategic concerns take precedence, and this could be considered one of the main reasons for the increased volatility. It does not seem likely in the near future that the organization dominated by Russia will turn into a strong international economic integration movement. Furthermore, recent instabilities in the exchange rates of the US dollar, increased risks and uncertainties in international trade can also contribute to an increase in volatility. Beyond these, significant differences among member countries in terms of basic macroeconomic indicators and foreign trade performance, geographical discontinuities among member countries, the natural resource-dependent fragile economies of Russia and Kazakhstan, inefficient and inadequate transportation routes, lack of an effective system in information exchange, absence of an effective international payment system, differences among member countries in terms of population, economic size, and political power, and historical problems among members and potential member countries, especially Armenia's regional tensions, negatively affect the

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volatility in the exchange rates of the Union and its member countries. To reduce volatility and strengthen the Union in line with its objectives, the following measures can be recommended:

- Developing an effective payment system and establishing monetary union in international trade among countries against the US dollar,
- Developing the Anti-Crisis Fund and expanding the scope of the fund,
- Using the fund in investment projects and the implementation of common policies,
- Signing economic agreements with China and benefiting from the opportunities created by the Belt and Road Initiative.

The inclusion of other powerful actors in the region such as China and Iran in the Union or strengthening strategic cooperation, the development of the customs union between Russia and Kazakhstan, an increase in the number of members, spreading to a wider geography, and most importantly, having political will, desire, and determination will accelerate the integration process and reduce volatility. In this context, a multilateral evaluation of Turkey's membership in the Union, as an experienced and more developed country among Eurasian countries and Turkic States, would be beneficial. The participation of a large economy and a moderately developed industry like Turkey could lead to an increase in the complementarity level in foreign trade and transportation among union countries, creating a development in favor of all countries.

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