THE GLOBAL EVOLUTION OF THE EXCHANGE RATE IN THE LAST DECADE

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Abstract. *During this period, the capital markets are dealing with the serious effects caused by the Coronavirus pandemic and the ongoing war between Russia and Ukraine. Against the background of these problems, the volatility of the stock market indices is also affected by unfortunate events and starting from the fact that investors want to maximize their profits as quickly as possible and obtain the highest income possible, resorting to the method of speculation on the currencies of other countries, we chose to analyze the exchange rates. Using the variations of the exchange rates in which we chose the euro as the base currency and forming pairs with the following currencies: the Romanian leu, the Swiss franc, the US dollar, and the pound sterling, we followed the influence between these currency pairs, as well as the impact of a stock market index on them, using different statistical and econometric tests. The tests of stationarity, multicollinearity, and homoscedasticity, preceding and applied to multiple regressions, show that the data series used are statistically significant, do not suspect the presence of multicollinearity, and do not respect the presence of the hypothesis of homoscedasticity. The multiple regressions performed on the analyzed exchange rates indicate the existence of direct influence relationships in certain cases and indirect relationships, and from the results of the econometric tests applied to these regressions, we concluded that the quality of the regression model was not damaged. Considering the recent fluctuations of the euro and the US dollar, we made a forecast of this currency pair through the various econometric methodologies using the autoregressive integrated moving average model, trying to estimate, and forecast the evolution of this pair in the next period.*

Keywords: *currency pairs; homoscedasticity; multiple regression; multicollinearity; stationarity*

Introduction

In recent years, the global economy has been facing unprecedented situations, considering the Coronavirus pandemic and Russia's shocking invasion of Ukraine, resulting in a sudden increase in world prices for key commodities, especially fuel, and food, which have accelerated concerns about the security of energy and food supplies around the world. In these conditions, Russia's military aggression against Ukraine, which occurred at a time when the Coronavirus pandemic still had an impact on the economy, became an obstacle that will slow down the growth of the global economy and increase inflation, which, from a macroeconomic point of view, it's already largely seen in commodity markets. The European Union, thanks to the common agricultural policy, is largely self-sufficient, with a single market that demonstrates its role in absorbing shocks and ensuring food security for its citizens, guaranteeing income support for farmers. However, the reduction in imports of corn, wheat, oil, rapeseed, and sunflower from Ukraine strongly impacts feed prices and the food industry, with higher food prices and inflationary trends. The growth of the global economy, the GDP, is linked to the sudden increase in energy prices, prices that have increased since the middle of last year, culminating with the increase in fuel prices and with Russia's decision to suspend deliveries and cut off gas supplies to several member states of the European Union after Russia's unprovoked and unjustified aggression against Ukraine.

The present paper wants to reflect on the economic impact produced by the ongoing Coronavirus pandemic and the armed conflict between the two countries, which led to areas of currency volatility. The Russian ruble is hitting all-time highs, even if the Russian stock market was closed for almost a month after February 25, 2022, while Eurozone currencies have become more exposed to risk, as the euro against other foreign exchange reserves have become more exposed to volatility, given the eurozone's dependence on Russian energy sources. The paper aims to show the role and performance in the current conditions of three currencies: the Romanian RON, the Swiss franc, the American dollar, and the British pound, chosen to quote with the same base currency, the euro. The American dollar, the reserve currency of the world, used in most international transactions, has seen a spectacular increase lately in conditions where inflation fears are growing, and the economy is showing signs of slowing down, just like the Swiss franc, whose value is increasing , unlike the euro currency which feels the pressure on the European economies due to the armed conflict between Russia and Ukraine, a conflict which pushes the currencies of the eurozone down. However, currency markets are extremely difficult to predict, so it is difficult to say whether these currencies will continue to rise or fall soon. The exchange rates for the analysis carried out in this paper were: EUR/RON, EUR/CHF, EUR/USD, and EUR/GBP, which were made following the daily observations (5 days/week) from 02 January 2012 – 30 August 2022, with a total number of 2782 observations.

Literature review

Following the vast specialized literature in the field, one of the important papers used for this study was that of Edwards (2006), which shows the differences between the countries that are controlling their economy mostly through monetary policies compared to those that have an inflation targeting plan. The paper aimed to illustrate that the exchange rate plays an important role in the inflation targeting mechanism.

Hacker et al. (2010) started from what Fisher demonstrated in his work from 1930, namely that there is a positive relationship between the interest rate and inflation. The authors aimed to find a relationship between the exchange rate and the difference between the domestic interest rate and the foreign interest rate and concluded that there is a negative relationship in the short term. Numerous papers deal with the same topic, as the paper by Abdurehman and Hacilar (2016), shows a strong relationship between the exchange rate and inflation. Using models such as GARCH, the authors concluded that there is a strong relationship between the two elements and that the purchasing power parity in Turkey is non-existent due to laws and transaction costs.
Leiva-Leon et al. (2020) show the importance of the exchange rate (mainly the EUR and USD), which turns into a price that reacts to every news or new information on the market. The authors demonstrated that, in countries that are guided by certain monetary policies for controlling interest rates, the governments have a high influence on the yield of the financial asset of an economy, but also a risk from the point of view of sudden changes in the exchange rate that are very difficult to predict. Olamide et al. (2022) observed, mainly in countries with economies that are still developing, that the fluctuation of the exchange rate and of the GDP represents an impediment in the development of the economy. The authors concluded that there is a direct relationship between inflation and the exchange rate.

Bruno et al. (2022) showed the influence of the exchange rate variation on the existing financial conditions in a certain country. Thus, in their paper, the authors investigate, taking into account the weighted index of the American dollar according to trade, how the returns of the stock market produce changes at the level of exchange rates. The authors' results showed that introducing a new indicator that represents the ratio between the shares with values expressed in USD and the returns on shares expressed in a certain country's currency will exceed the value of 1. The weighted index of the dollar becomes an important factor in determining stock returns. The sensitivity of stock returns to variations in the weighted dollar index shows that investors are determined to bear the risk from the exchange rate because they expect high stock returns.

Liao et al. (2019) developed a network of exchange rate correlations, i.e. the "Spanning Tree" method, which promotes communication, cooperation, and commercial exchange at the global level. In their paper, it is specified that there are both favorable and unfavorable effects from the depreciation of the exchange rate, considering that, on the one hand, it can lead to an improvement in exports, but, at the same time, it can also cause an increase in import prices, which leads to an increase in inflation. The authors came to the conclusion that certain countries, mainly those from the Eastern region of Europe, play an important role in propagating exchange rate risks.

Zhu et al. (2022) illustrated, in parallel, the evolution and influence between exports and exchange rates from Asian countries over a period of 35 years. The authors presented the relationship between exports of goods and services and exchange rates. The results showed that the more undervalued a country's currency is, the more exports are stimulated, resulting in a favorable impact that leads to economic growth. The authors mentioned that a balanced policy can improve the connection between exchange rates, exports, and economic growth.

Long Vo and Hong Vo (2022) illustrate the major importance of exchange rate variations on the imports and exports of the studied countries. The authors concluded that arbitrageurs have a very strong effect on the correlation between the exchange rate and price by redistributing resources, which eliminates distortions created by long-term variations in exchange values.

Cuestas et al. (2022) contributed through their study to determine the real exchange rate by using models with structural and non-linear breaks. Their paper concluded that the models were different before and after the 2008 crisis, affecting the results of the long-term equations for countries like Cyprus and Malta, while the estimated coefficients for Central and Eastern Europe were different. Gründler et al. (2022) studied the nominal exchange rate of US monetary policy. The authors pointed out that, in the case of a monetary policy shock, the exchange rate appreciates much faster and stronger than in the case of an impact of new information appearing on the market about interest rates and share prices. In conclusion, they've shown that, although the short-term effects on the exchange rate are primarily due to monetary policy shocks, it is determined by informational effects in the medium term. Yilmazkuday (2022), by using a VAR (vector autoregressive) model applied to the exchange rates of the monetary policy, studied the spillover effects of US monetary policy on some emerging markets and some advanced economies in the pre-pandemic period and in the pandemic. The study's results suggested that the propagation effects were effective before the pandemic, but during the pandemic, they had an effect only for certain countries.
Lilley et al. (2022) studied the impact of exchange rates over a series of economic variables, before and after the financial crisis from 2008. The authors concluded that, after 2008's financial crisis, the role of the US dollar as an international and safe-haven currency has surged.

Methodology

Following the specialized literature and observing that the financial markets are influenced by the exchange rates, as the price of the exchange rate reacts to any new information from the market, we wanted to show the role of the currency pairs collected and analyzed in the paper in regard to the economy. We've tested the hypotheses formulated on the linear regression model through a series of tests. Stationarity testing was performed using the Augmented Dickey-Fuller test characterized by the formula:

$$\Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \qquad 1)$$

The hypotheses of this test are: the null hypothesis (H_0), in which the series is not stationary and the alternative hypothesis (H_1), in which the series is stationary.
Testing the hypotheses formulated on the linear regression model involved testing the normality of errors (Jarque-Bera Test), testing the hypothesis of non-correlation of errors, testing the hypothesis of homoscedasticity, and testing the hypothesis regarding the lack of multicollinearity (Klein Criterion).
The Jarque-Bera test is characterized by the formula:

$$\text{JB} = \frac{n}{6}\left[S^2 + \frac{(k-3)^2}{4}\right] \qquad 2)$$

having as hypotheses: (H_0): the series of residuals come from a normal distribution ($S = 0, K = 3$), where S is the coefficient for skewness, K for kurtosis and the alternative hypotheses (H_1): the series of residuals does not come from a normal distribution.

We've tested the hypothesis of non-correlation of errors using the Breusch-Godfrey test, whose equation is:

$$\hat{\varepsilon}_t = b_0 + b_1 \cdot t + \rho_1 \cdot \varepsilon_{t-1} + \rho_2 \cdot \varepsilon_{t-2} + u_t \quad 3)$$

with the hypotheses of the model being the null hypothesis (H_0): $\rho_1 = \rho_2 = 0$ (no autocorrelation exists) and the alternative hypothesis (H_1): $\rho_1 \neq 0 \; or \; \rho_2 \neq 0$ (autocorrelation exists).
We tested the hypothesis of homoscedasticity using the White test whose characteristic formula is:

$$\varepsilon_i^2 = b_0 + b_1 \cdot x_1 + b_2 \cdot x_1^2 + b_3 \cdot x_1 \cdot x_2 + b_4 \cdot x_2 + b_5 \cdot x_2^2 + u_i \quad 4)$$

and the hypotheses of this model are the null hypothesis (H_0) that attests the existence of homoscedasticity and the alternative hypothesis (H_1) that admits that, if there is a $b_i \neq 0$, then the phenomenon of heteroscedasticity is present.
The Klein criterion is very useful when the hypothesis regarding the lack of collinearity needs to be tested because it compares the correlation coefficients with $R^2$of the regression. To see if the parameters used in this work are stable, we've used the Chow test, which involves dividing the initial data into several approximately equal sub-samples relative to the parameter t we chose. The hypotheses of this test are the null hypothesis (H_0), in which the parameters are stable, and the alternative hypothesis (H_1), in which the parameters are not stable.

Results and discussions

In carrying out this work, we've chosen the currencies: the Romanian leu (RON), the American dollar (USD), the Swiss franc (CHF), and the British pound (GBP) to be quoted with the same base currency, namely the euro (EUR). The pairs of exchange rates become as follows: EUR/RON, EUR/USD, EUR/CHF, and EUR/GBP with the currencies EUR, USD, and GPB particularly important, given the economic power of their respective country. The database collected from Investing.com includes daily observations (5 days/week) over a period of approximately 10 years (02 January 2012 - 30 August 2022), summing up a total number of observations of 2782 of observations. The data series used to represent the daily percentage variation of the exchange rates was calculated by using the formula:

$$\Delta(\%) = ln(\frac{P_1}{P_0}) * 100 \quad 5)$$

In order to be able to see the influence of the variation of the currency pairs EUR/RON, EUR/USD and EUR/CHF on the variation of the EUR/GBP exchange rate, we performed a multiple regression where the endogenous (dependent) variable is EUR/GBP and the exogenous (independent) variables are the other pairs. It should be mentioned that the data series used is stationary, a fact tested using the Augmented Dickey-Fuller (ADF) stationarity test.

Table 1. Multiple regression (Source: Investing.com; processed in Eviews10)

Dependent Variable: EUR_GBP				
Method: Least Squares				
Sample: 1/02/2012 8/30/2022				
Included observations: 2782				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EUR_RON	0.111541	0.045811	2.434820	0.0150
EUR_CHF	0.052527	0.019140	2.744347	0.0061
EUR_USD	0.348527	0.018197	19.15302	0.0000
C	0.004218	0.008603	0.490241	0.6240
R-squared	0.134125	Mean dependent var		0.001108
Adjusted R-squared	0.133190	S.D. dependent var		0.487127
S.E. of regression	0.453528	Akaike info criterion		1.257916
Sum squared resid	571.3997	Schwarz criterion		1.266444
Log likelihood	-1745.761	Hannan-Quinn criter.		1.260995
F-statistic	143.4379	Durbin-Watson stat		1.931376
Prob(F-statistic)	0.000000			

The obtained results show that with an increase in the variation of the EUR/RON exchange rate by 1 unit, the variation of the EUR/GBP exchange rate will increase by *0.1115* units, while with an increase in the variation of the EUR/CHF exchange rate by 1 unit, the variation of the EUR/GBP exchange rate will increase by only *0.0525* units and with the same increase in the variation of the EUR/USD exchange rate, the variation of the EUR/GBP exchange rate will increase by *0.3485* units. Thus, we can state that the most visible influence on the variation of the EUR/GBP exchange rate is that of the EUR/USD exchange rate, followed by the EUR/RON variation.

From the point of view of the significance of the parameters, it can be observed that the probabilities of the three currency pairs: EUR/RON, EUR/USD and EUR/CHF present values that are below the accepted significance threshold of 0.05, which shows that the chosen parameters are statistically significant. The constant shows a probability that exceeds the threshold of 0.05, which shows that the free term is not representative of the chosen model, as it's statistically insignificant.

We have introduced a new variable into the model, the SPX stock index (S&P500) so that the EUR/GBP variable is influenced by the SPX (the data used has been calibrated) for which we've performed the stationarity test on the return of the SPX index and we've observed that the series is stationary. Analyzing the probabilities of the variables used in Table 2, we can note that we've obtained values below the 0.05 threshold, which means that they are stationary, apart from the EUR/RON currency pair and the free term. What can be observed from the obtained results is the presence of an indirect relationship between the EUR/GBP currency pair and the SPX, more precisely, when the stock index increases by one unit, the percentage variation of the EUR/GBP exchange rate will decrease by *0.0892* percentage points.

Table 2. Multiple regression – Index SPX (Source: Investing.com; processed in Eviews10)

Dependent Variable: EUR_GBP
Method: Least Squares
Sample: 1/03/2012 8/30/2022
Included observations: 2683

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EUR_RON	0.054130	0.046082	1.174646	0.2402
EUR_CHF	0.072649	0.019246	3.774709	0.0002
EUR_USD	0.357027	0.018135	19.68740	0.0000
SPX	-0.089203	0.008231	-10.83771	0.0000
C	0.007304	0.008689	0.840656	0.4006

R-squared	0.171191	Mean dependent var	-0.000446
Adjusted R-squared	0.169953	S.D. dependent var	0.493174
S.E. of regression	0.449316	Akaike info criterion	1.239679
Sum squared resid	540.6466	Schwarz criterion	1.250665
Log likelihood	-1658.030	Hannan-Quinn criter.	1.243653
F-statistic	138.2855	Durbin-Watson stat	1.977989
Prob(F-statistic)	0.000000		

The Jarque-Bera test applied to the multiple regression shows a probability lower than 0.05, which means that the series of residuals does not come from a normal distribution. From the point of view of the skewness coefficient, a positive value different from 0 is observed, which shows a positive asymmetry to the right, and from the point of view of the flattening coefficient (kurtosis), a positive value greater than 3 is observed which shows that the series of residuals come from a leptokurtic distribution.

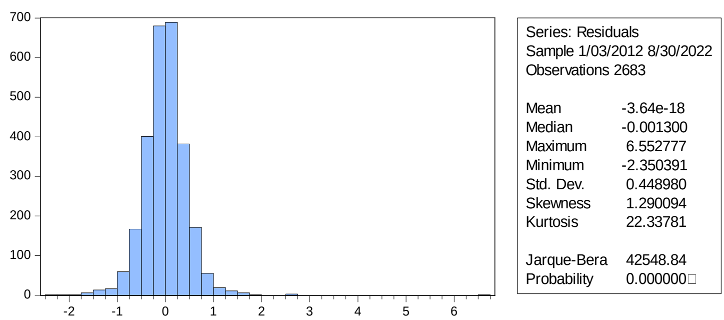


Figure 1- Testing for normality of errors (Jarque-Bera Test) (Source: processing in EViews 10)

Using the Breusch-Godfrey test we will verify the existence of autocorrelation of errors, and, after analyzing the results obtained in Table 3, explain the probabilities for

$RESID(-1)$ and $RESID(-2)$ that exceed the threshold of 0.05, we can conclude that there is no autocorrelation of order I or II in the data.

Table 3. Breusch-Godfrey Test (Source: processing in Eviews10)

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.446933	Prob. F (2,2676)		0.2355
Obs*R-squared	2.898301	Prob. Chi-Square (2)		0.2348
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Sample: 1/03/2012 8/30/2022				
Included observations: 2683				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EUR_RON	0.000189	0.046074	0.004108	0.9967
EUR_CHF	-0.000317	0.019246	-0.016457	0.9869
EUR_USD	-0.000977	0.018141	-0.053836	0.9571
SPX	0.000357	0.008248	0.043271	0.9655
C	-3.69E-05	0.008687	-0.004245	0.9966
RESID (-1)	0.011148	0.019370	0.575530	0.5650
RESID (-2)	-0.031078	0.019339	-1.607026	0.1082

To see if the homoscedasticity hypothesis is respected or not, we've performed the White test and, according to the results obtained in the table below, the homoscedasticity hypothesis is not respected, considering that the three probabilities: Prob. F (14.2668), Prob. Chi-Square (14) and Prob. Chi-Square (14) has a value of 0.0000, which does not exceed the allowed threshold of 0.05.

Table 4. White Test (Source: processing in Eviews10)

Heteroskedasticity Test: White				
F-statistic	32.23344	Prob. F (14,2668)		0.0000
Obs*R-squared	388.1527	Prob. Chi-Square (14)		0.0000
Scaled explained SS	4125.745	Prob. Chi-Square (14)		0.0000
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Included observations: 2683				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.060533	0.019618	3.085598	0.0021
EUR_RON^2	-0.093586	0.148901	-0.628510	0.5297
EUR_RON*EUR_CHF	-0.559623	0.310448	-1.802628	0.0716
EUR_RON*EUR_USD	-1.093821	0.159059	-6.876829	0.0000
EUR_RON*SPX	-0.432385	0.098087	-4.408176	0.0000
EUR_RON	0.230593	0.089405	2.579190	0.0100
EUR_CHF^2	-0.024642	0.009066	-2.717944	0.0066
EUR_CHF*EUR_USD	0.150533	0.103457	1.455029	0.1458
EUR_CHF*SPX	0.129776	0.047384	2.738844	0.0062
EUR_CHF	-0.014495	0.059103	-0.245250	0.8063
EUR_USD^2	0.387457	0.040875	9.479018	0.0000
EUR_USD*SPX	0.189368	0.024635	7.686974	0.0000
EUR_USD	-0.150216	0.036101	-4.161040	0.0000
SPX^2	0.015699	0.003666	4.282556	0.0000
SPX	-0.016053	0.016296	-0.985092	0.3247
R-squared	0.144671	Mean dependent var		0.201508
Adjusted R-squared	0.140183	S.D. dependent var		0.930998
S.E. of regression	0.863280	Akaike info criterion		2.549420
Sum squared resid	1988.334	Schwarz criterion		2.582376
Log likelihood	-3405.047	Hannan-Quinn criter.		2.561342
F-statistic	32.23344	Durbin-Watson stat		1.792472
Prob(F-statistic)	0.000000			

Following the Klein Criterion, we've tested the hypothesis regarding the lack of multicollinearity and we can say, according to Table 5, that no correlation coefficient exceeds R-squared (0.134125) and, thus, the presence of multicollinearity is not suspected and the quality of the regression model is undamaged (the regression coefficients are precisely estimated).

Table 5. Matrix of correlation coefficients for multiple regression (Source: processing in Eviews10)

	EUR_RON	EUR_CHF	EUR_GBP	SPX
EUR_RON	1.000000	-0.040459	0.040040	-0.119472
EUR_CHF	-0.040459	1.000000	0.132204	0.1201410
EUR_GBP	0.040040	0.132204	1.000000	-0.164881
SPX	-0.119472	0.120141	-0.164881	1.000000

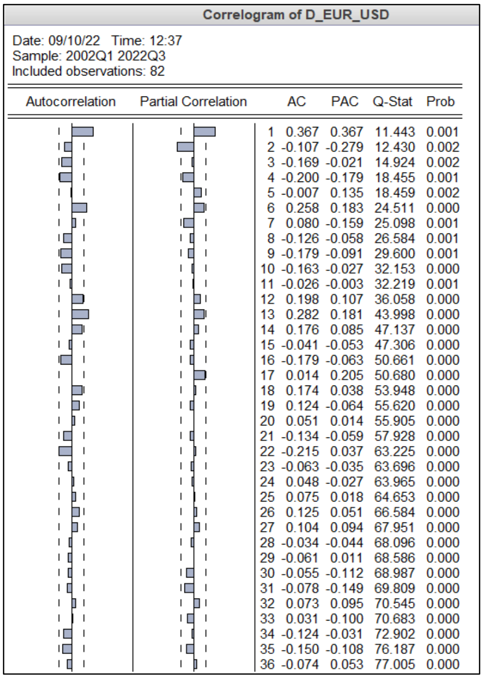
We've applied the Chow test for parameter stabilization, which involves dividing the initial data into two or more approximately equal sub-samples with respect to the *t* parameter that we've chosen to be the date 13 July 2022. Considering that the three probabilities Prob. F (5.2673), Prob. Chi-Square (5) and Prob. Chi-Square (5) exceeded the 0.05 threshold, we must note that we've failed to reject the null hypothesis, so the parameters are stable.

Table 6. Chow Breakpoint Test (Source: processing in Eviews10)

Chow Breakpoint Test: 7/13/2022			
Null Hypothesis: No breaks at specified breakpoints			
Varying regressors: All equation variables			
F-statistic	0.360328	Prob. F (5,2673)	0.8758
Log likelihood ratio	1.807769	Prob. Chi-Square (5)	0.8751
Wald Statistic	1.801638	Prob. Chi-Square (5)	0.8759

The currency pair EUR/USD, with sudden changes closely related to the evolution of the war in Ukraine, brings to the financial market a massive increase of the dollar against the EURO world, the dollar exceeding the parity of the EURO currency in certain periods from August 2022. In order to be able to observe this evolution, we've collected the quarterly data of the EUR/USD exchange rate over a period of 20 years (01 January 2002 - 31 August 2022). We've studied for a longer period because we wanted to analyze the degree of the influence between the currency pairs and a forecast on the EUR/USD evolution, which will help us see its trend in the next period.

Through the Augmented Dickey-Fuller test, we noticed that the collected data series was not stationary, so we had to make it stationary by differentiating it to order I, so we've created a new series called D_EUR_USD and continued with the application of the Box-Jenkins methodology to determine the orders *p* and *q* of the process. The orders *p* and *q* are approximately determined based on the shape of the stationary series correlogram, according to Figure 2.



Correlogram of D_EUR_USD

Date: 09/10/22 Time: 12:37
Sample: 2002Q1 2022Q3
Included observations: 82

Lag	AC	PAC	Q-Stat	Prob
1	0.367	0.367	11.443	0.001
2	-0.107	-0.279	12.430	0.002
3	-0.169	-0.021	14.924	0.002
4	-0.200	-0.179	18.455	0.001
5	-0.007	0.135	18.459	0.002
6	0.258	0.183	24.511	0.000
7	0.080	-0.159	25.098	0.001
8	-0.126	-0.058	26.584	0.001
9	-0.179	-0.091	29.600	0.001
10	-0.163	-0.027	32.153	0.000
11	-0.026	-0.003	32.219	0.001
12	0.198	0.107	36.058	0.000
13	0.282	0.181	43.998	0.000
14	0.176	0.085	47.137	0.000
15	-0.041	-0.053	47.306	0.000
16	-0.179	-0.063	50.661	0.000
17	0.014	0.205	50.680	0.000
18	0.174	0.038	53.948	0.000
19	0.124	-0.064	55.620	0.000
20	0.051	0.014	55.905	0.000
21	-0.134	-0.059	57.928	0.000
22	-0.215	0.037	63.225	0.000
23	-0.063	-0.035	63.696	0.000
24	0.048	-0.027	63.965	0.000
25	0.075	0.018	64.653	0.000
26	0.125	0.051	66.584	0.000
27	0.104	0.094	67.951	0.000
28	-0.034	-0.044	68.096	0.000
29	-0.061	0.011	68.586	0.000
30	-0.055	-0.112	68.987	0.000
31	-0.078	-0.149	69.809	0.000
32	0.073	0.095	70.545	0.000
33	0.031	-0.100	70.683	0.000
34	-0.124	-0.031	72.902	0.000
35	-0.150	-0.108	76.187	0.000
36	-0.074	0.053	77.005	0.000

Figure 2-Correlogram D_EUR_USD (Source: processing in EViews)

Based on the correlogram, we've identified several peaks, both for the autoregressive process and for the moving average, so we've tested AR*(p)*, MA*(q)*, and ARIMA*(p,d,q)*. After testing AR(1), MA(1), and MA(4), we've concluded that the coefficients have lower probabilities than the accepted threshold of 0.05, which means that they are statistically significant, as we were able to deduce from the correlogram.

Table 7. ARIMA models (Source: processing in Eviews10)

Dependent Variable: D_EUR_USD
Method: ARMA Maximum Likelihood (BFGS)
Sample: 2002Q2 2022Q3
Included observations: 82

Model	***ariable***	***rob.***	***A IC crit.***	***B IC crit.***	***H Q crit.***	R^2
ARIM A (1,1,4)	R (1)	.0008	- 3.213639	- 3.096238	- 3.166505	0 .179223
ARIM A (1,1,4)	A (4)	.0464				
ARIM A (1,1,2)	R (1)	.0000	- 3.250564	- 3.133163	- 3.203430	0 .208445
ARIM A (1,1,2)	A (2)	.0046				
ARIM A (3,1,3)	R (3)	.0001	- 3.108824	- 2.991423	- 3.061689	0 .088925
ARIM A (3,1,3)	A (3)	.0196				

The generation of forecasts using ARIMA processes is done to choose the best model, by comparing the criteria regarding the information contained, the most frequently used criteria being: Akaike Info Criterion (AIC), Schwarz criterion (BIC), Hannan-Quinn criterion (HQ). The results obtained in this case show that the best forecasting model is ARIMA (1,1,2).

The forecast through confidence intervals was made for the stationary series with the ARIMA process (1,1,2) respectively ARIMA (1,1,4) and we've identified a change in the exchange rate of 0.001954 respectively 0.001753 units over the entire analyzed period.

Table 8. ARIMA Forecast (Source: processing in Eviews10)

	AR1_MA2.forecast d_eur_usdf	AR1_MA4.forecast d_eur_usdf	AR3_MA3.forecast d_eur_usdf
eriod	Values	Values	Values
019Q3	0.001954	0.001753	0.001588
019Q4	0.001954	0.001753	0.001705
020Q1	0.001954	0.001753	0.001739
020Q2	0.001954	0.001753	0.002029
020Q3	0.001954	0.001753	0.001933
020Q4	0.001954	0.001753	0.001905
021Q1	0.001954	0.001753	0.001665
021Q2	0.001954	0.001753	0.001744
021Q3	0.001954	0.001753	0.001767
021Q4	0.001954	0.001753	0.001966
022Q1	0.001954	0.001753	0.001901
022Q2	0.001954	0.001753	0.001881
022Q3	0.001954	0.001753	0.001717

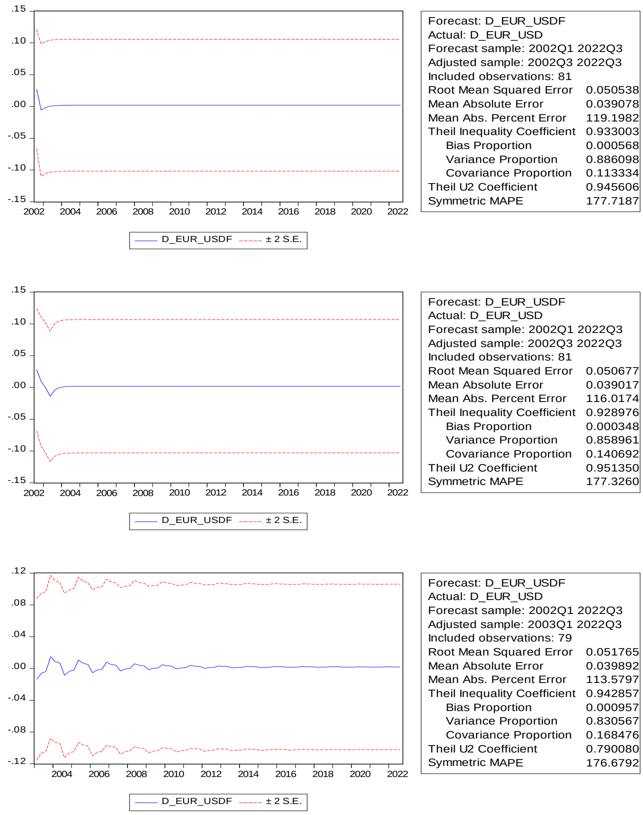


Figure 3-Forecast D_EUR_USD
(Source: processing in EViews)

The forecast was made on the stationary series with an ARIMA (3,1,3) process and we've identified a change in the exchange rate of *0.001588* units in the third quarter and *0.001705* units in the fourth quarter of 2019, *0.001739, 0.002029, 0.001933* and *0.001905* units for the four quarters of 2020. The four quarters of 2021 had changes of *0.001665, 0.001744, 0.001767,* and *0.001966* units, but for 2022 we've observed a decrease in the exchange rate, as follows: a decrease of *0.001901* units in the first quarter, followed by a decrease of *0.001881* units in the second quarter and *0.001717* units for the period of July-August.

Conclusions

The multiple regression model used in this paper, which aimed to showcase the influence of the EUR/RON, EUR/CHF, and EUR/USD exchange rates on the dependent variable EUR/GBP, is valid and, from the results obtained, we can state that the most influential variation on the EUR/ GBP is that of the EUR/USD exchange rate, followed by the variation of the EUR/RON exchange rate. The only insignificant variable in the model was the free term (intercept) with a probability of *0.6240*, which is normal because independent exchange rates can never be zero.
After introducing an SPX stock index (S&P500 Index) into the model, we could conclude that with an increase in the SPX stock index by one unit, the percentage variation of the

EUR/GBP exchange rate would decrease by *0.089203* units. After testing the assumptions of the regression model, we've noticed that the series of residuals does not come from a normal distribution and there is no autocorrelation of errors of order I or II, the hypothesis of homoscedasticity is not respected, the presence of multicollinearity is not suspected and, thus, the quality of the regression model was not damaged.

The Chow test for parameter stabilization demonstrated no structural breaks in the model and the parameters are stable. By applying the Box-Jenkins methodology, we've estimated the coefficients through three autoregressive ARIMA models, namely: ARIMA (1,1,2), ARIMA (2,1,2), ARIMA (1,1,4) for the D_EUR_USD series and, by analyzing the three information criteria: Akaike info criterion, Schwarz criterion, and Hannan-Quinn criterion, we've concluded that the ARIMA model (1,1,2) is the model where the predicted values was the closest to the real values recorded. For the prediction and evolution of the exchange rate in the future, we can say, by observing the ARIMA (1,1,2) and ARIMA (1,1,4) models, that there is a constant increase of the rate by *0.001954* units in the case of the model ARIMA (1,1,2), respectively *0.001753* units in the case of the ARIMA (1,1,4) model, those increases perpetuating over a long period of time. We cannot say the same about the ARIMA (3,1,3) model, which shows, during the different quarters of the last years, how dynamic changes in the exchange rate occurred because of the coronavirus pandemic and the Russian invasion of Ukraine. The best example is the decrease in the change of the EUR/USD exchange rate starting with the first quarter of 2020 (where the beginning of the pandemic is reflected) and the first three quarters of 2022 (which shows the impact of the Russia-Ukraine war). According to the model and forecast, we can speculate that the EUR/USD pair will decrease with small changes followed by sudden increases, but this aspect remains to be studied in the future.

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