Impact of the Main Currencies Exchange Rates on the Romanian Economic Policy Transformation

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ABSTRACT

Evolutions of the exchange rates in a contemporary competitive economy represent an influential marker in evaluating the effects of the governmental policies in field of monetary policy and marks future directions in developing the specific policies in the field. This study investigates how the exchange rates of EUR, USD, GBP and CHF were influenced by disturbing factors and the existence of potential quantitative correlations and dependencies among the four exchange rates in terms of uncertainty. In this context the starting premise of the research took into account the exchange rate developments for these four currencies for the period January 2008 – October 2015, period marked by two major disruptive events, which highly influenced the exchange rates of the main currencies on the Romanian market, such as the financial crisis started in late 2008 and CHF exchange rate's significant variation at the beginning of 2015 that triggered a deep debt crisis in the case of mortgage loans in Romania. The research results reveal particular evolution patterns in the case of the exchange rates of the four currencies taken into analysis, confirming the existence of disturbing factors and the correlations and quantitative dependencies between them.

INTRODUCTION

Recent developments in the European economy have shown its vulnerability to a range of internal and external factors that determined both an increase in exchange rates volatility and also the instability of national monetary policies in the case of countries that are not yet part of the European Monetary Union. From this perspective, Romania's integration into the European economic and social space has brought not only the need for compliance with requirements of the Community model but also for implementing monetary policy measures which would facilitate adopting the Euro.

The analysis of the relationship between exchange rate volatility of various currencies and the national one constitutes a defining element in understanding the behavior in terms of monetary policy and to outline intervention measures and instruments in order to counteract its effects' propagation within the national economy.

The available literature points out various opinions regarding the characteristics of exchange rates and the determinants of their evolution. Such studies as Chinn and Meese (1995) and Mark (1995) argue that the evolution of the exchange rate can be predicted and somehow managed for long periods of time, while other views (Della Corte and Tsiakas, 2012; Verdelhan, 2013) highlight the randomness of the exchange rate evolution and the impossibility of predicting it.

Ahmed, Liu and Valente (2016) analyzing the predictability of the exchange rates using linear factor models in the case of three currency-based risk factors reach the same conclusions expressed in previous studies (Meese and Rogoff, 1983), according to largely fail to outperform the benchmark random walk. On the other hand, Ahmed and Straetmans (2015) try to predict the cyclical behavior of exchange rates by using five risk factors, namely violations of uncovered interest rate parity (UIP), relative purchasing power parity (RPPP), pseudo-parity for equity returns, relative (cross-country) TED spreads and relative term spreads. Their conclusion highlights the usefulness of using financial variables and exchange rates as warning financial indicators for investors and especially for policy makers.

On one hand, the exchange rate evolution reflects to a high extent both the effects of monetary policy promoted by the National Bank and the result of government measures taken in order to strengthen fiscal strategy applied in the case of excised products, which depend on the exchange rate, particularly against the EUR, and on the other hand, major implications are also received from main retailers which are forced to make transnational payments in order to pay off capitalized goods within the retail chain.

The existence of substantial economic imbalances in the national economy correlated with enhanced effects of the CHF crisis on an important part of bank loans has led to persistent disparities regarding the evolution of the main currencies in the forex market. This situation derives from a multitude of factors that influence aggregate currency demand and supply tending to propagate negative effects on the entire economy. Between January 2008 and October 2015, the exchange rates of EUR, USD, GBP and CHF against RON pointed out developments with alternating increases and decreases spread around upward trends which characterized the period under review taken as a whole.

Most empirical studies conducted in this field reveal the existence of diffusion (at least indirect and incomplete) of exchange rate fluctuations within the price mechanism in the national economy. In this context, understanding the trends of the exchange rates of the four currencies taken into analysis – EUR, USD, GBP and CHF – and the factors that influenced their evolution, such as identifying and highlighting possible correlations and quantitative dependencies between the four exchange rates constitute the central objective of this article.

The models developed in this paper complement previous research conducted in this field (Berg and Miao, 2010; Ghiba, 2010; Fidrmuc and Horváth, 2008; Nuti 1996 or Babetskii et al., 2004), thus contributing to outspreading this knowledge area by highlighting both the characteristics of the evolution of the four main currencies considered for this analysis and the implication of any factors and quantitative dependencies in determining exchange rates. We contribute to the empirical literature by identifying, building and testing various models type AR (p), MA (q) and ARIMA (p, i, q).

We have organized the paper in four sections. The following section summarizes the methodology employed in the study. Third section called Results and discussions contains the analysis of the characteristics of the trend of exchange rates and the correlations between exchange rate developments as well as a time series analysis. The empirical results are also reported in this section. The last section of the paper is represented by the conclusions.

1. METHODOLOGY

In order to determine the factors that influenced the evolution of exchange rates for the four currencies under analysis and to build econometric models the ANOVA methodology was used (Montgomery, 2001, Moore and McCabe 2003). We have considered it more suitable for this case, although specialized studies on models for determining exchange rates tend to use more frequently the so-called Taylor rule models deriving from Engel and West (2005 and 2006) previous works, which are very popular in this field.

The period January 2008 – October 2015 was marked by at least two events that influenced the exchange rates of the main currencies on the Romanian market: the financial and economic crisis that started in late 2008 and CHF exchange rate significant alteration in early 2015. Based on these findings, the empirical model employed in this study aimed at proposing and testing three hypotheses, as follows:

− The first hypothesis is based on the argument that rates have been significantly influenced by disturbing factors;
− The second hypothesis envisages a development that is not significantly different in the case of the four currencies EUR, USD, GBP and CHF;
− The third and final tested hypothesis assumes the existence of significant correlations between EUR, USD, GBP and CHF respectively.

In order to determine and analyze the statistical significance of the trend for the case of all 4 currencies (ER) addressed in this paper, several models were developed under the (1):

$$ER = f(t) + \varepsilon, \quad t = \overline{1,1976}, \quad \varepsilon \sim N\left(0, \sigma_\varepsilon^2\right). \tag{1}$$

while for emphasizing the quantitative relation between EUR, USD, GBP and CHF, a model has been tested using (2):

$$EUR = f(USD, GBP, CHF) + \varepsilon \tag{2}$$

Determining the parameters of models (1) and (2) has been conducted using the least squares method, ANOVA methodology (Montgomery 2001, Moore and McCabe 2003) was used for testing the validity of the acquired models, while the validation of their parameters was achieved using t-Test (2-tailed). For primary regression testing, we employed the Durbin-Watson test (Durbin and Watson, 1951), using the following equation:

$$d = \frac{\sum_{i=2}^{n}\left(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1}\right)^2}{\sum_{i=1}^{n}\hat{\varepsilon}_t^2} \tag{3}$$

and to eliminate autocorrelation of order p, values ρ_p were identified by applying the least squares method on the following model:

$$\hat{\varepsilon}_t = c + \sum_{i=1}^{p}\rho_i \cdot \hat{\varepsilon}_{t-i} + e_t \tag{4}$$

where e_t are not auto correlated (Andrei et al. 2008, Săvoiu and Necşulescu 2009).

The series EUR, USD, GBP and CHF were analyzed as time series. To test their stationarity Augmented Dickey-Fuller was used with Null Hypothesis: The series has a unit root. For obtaining stationary series the first difference was employed (5):

$$\Delta y = y_t - y_{t-1} = (1-L)y_t \tag{5}$$

In (5), L is *backward shift operator* in order to achieve $L^k y_t = y_{t-k}$.

For all 4 time series we have tested AR(p), MA(q) and ARIMA(p,i,q). A stationary series $\{y_t\}_{t\in Z}$ follows a process $AR(p)$ if the following condition is met (Zaharia and Gogonea, 2009):

$$y_t - \sum_{k=1}^{p} \phi_k y_{t-k} = \varepsilon_t, \quad \forall t \in Z \tag{6}$$

where $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ stationary series, $M(\varepsilon_t) = 0$, $M(\varepsilon_t^2) = \sigma^2$ and $\mathrm{cov}(\varepsilon_t, \varepsilon_i) = 0 \; \forall t \neq i$.

Using lag operator L and denoting by $\Phi_p(L) = 1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_p L^p$, formula (6) can be re-written under the form $\Phi_p(L)y_t = \varepsilon_t$, whose characteristic polynomial is:

$$P(\lambda) = \lambda^p - \phi_1 \lambda^{p-1} - \phi_2 \lambda^{p-2} - \ldots - \phi_p \tag{7}$$

The stationary series condition is $|\lambda_i| < 1 \; \forall \; i = \overline{1, p}$.

In the case of moving average processes MA(q), the stationary series $\{y_t\}_{t\in Z}$ can be represented by (8):

$$y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \ldots - \theta_q \varepsilon_{t-q} = \Theta_q(L)\varepsilon_t \text{ where } \varepsilon_t \sim N(0, \sigma_\varepsilon^2). \tag{8}$$

In order to process the evolution of the 4 analyzed currencies, after developing stationary data series for EUR, USD, GBP and CHF, ARMA (p, q) models were tested whose general form is (Zaharia and Gogonea, 2009):

$$y_t = \phi_0 + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \tag{9}$$

In carrying out the analysis contained herein, we have used initial EUR, USD, GBP and CHF data series taken from the database of The National Bank of Romania (The National Bank of Romania, 2015).

2. RESULTS AND DISCUSSIONS

2.1 Characteristics of the exchange rates' trend

Within the analyzed timeframe the largest fluctuations were recorded by the GBP (Figure 1). On the opposite side in terms of fluctuations' amplitude was EUR. Regarding the relationship between the exchange rates of the four currencies, from the start of the timeframe up to September 2010, GBP ranks first, with quotations from 4.0777 RON/GBP (30th December 2008, the absolute minimum for GBP) to 5.3722 RON/GBP (29th June 2010), followed by EUR with quotations from 3.4719 RON/EUR (6th August 2008, the absolute minimum for the EUR) to 4.3688 RON/EUR (30th June 2010), USD with quotations from 2.2319 RON/USD (23rd April 2008, the absolute minimum for the USD) to 3.5697 RON/USD (29th June 2010), respectively CHF quotations from 2.1256 RON/CHF (7th August 2008, the absolute minimum for the USD) to 3.3089 RON/CHF (1st July 2010).

From October 2010 until the end of the analyzed period, CHF exchange rate outran the USD, evolving between 3.1046 RON/CHF (1st November 2010) and 4.5817 RON/CHF (23rd January 2015, the absolute maximum for CHF), while the USD exchange rate evolved between 2.7408

RON/USD (29th May 2011) and 4.2107 RON/USD (16th March 2015, the absolute maximum USD). Within the same time frame, GBP quotations evolved between 3.2107 RON/GBP (4th May 2011) and 6.3547 RON/GBP (29th January 2015, the absolute maximum for GBP) while EUR quotations evolved between 4.0735 RON/EUR (24th April 2011) and 4.6481 RON/EUR (3rd August 2012, the absolute maximum for EUR).

Figure 1. Evolution trends of main currencies during 03.01.2008-12.10.2015
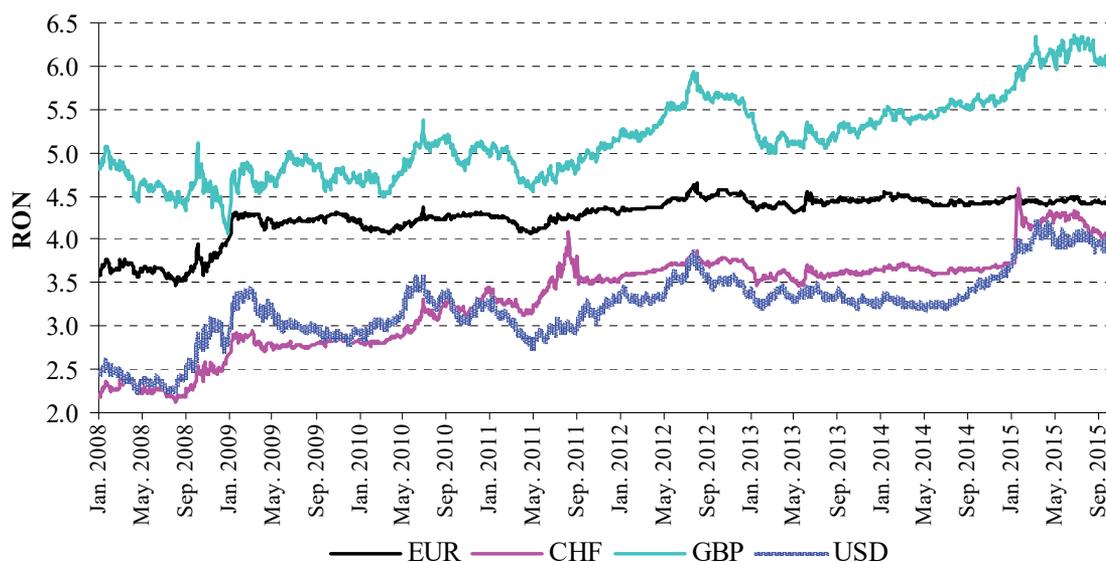
Source: authors based on The National Bank of Romania, 2015

Table 1. Testing the influence of random factors on exchange rate fluctuations

Null Hypothesis (H_0): The exchange rate was significantly influenced by random factors Model type: $f(t)=a_0+a_1 t$ Period: 3 January 2008 – 12 October 2015. Number of observations: 1976										
	Model					Coefficients				
	R^2	F	Sign. F	Acc		Value	P-value	Lower 95%	Upper 95%	Acc
EUR	0.6286	3341.67	0.000	H_1	a_0	3.91185	0.000	3.89821	3.92549	H_1
					a_1	0.00035	0.000	0.00034	0.00036	H_1
CHF	0.8648	12625.8	0.000	H_1	a_0	2.43029	0.000	2.41238	2.44820	H_1
					a_1	0.00089	0.000	0.00088	0.00092	H_1
GBP	0.7494	5904.41	0.000	H_1	a_0	4.45521	0.000	4.43444	4.47599	H_1
					a_1	0.00071	0.000	0.00069	0.00073	H_1
USD	0.6590	3815.37	0.000	H_1	a_0	2.64685	0.000	2.62591	2.66779	H_1
					a_1	0.00058	0.000	0.00056	0.00059	H_1

Source: authors' own calculation

A first examination aimed at emphasizing the characteristics of exchange rates' developments, expressed in RON for the entire period of time. The null hypothesis was tested regarding the randomness of these developments. In order to test the null hypothesis several type (1) models were settled, whose statistical significance was tested by F test (Table 1). Given that for all 4 currencies under investigation $F > F_{0.05;1;1974} = 4.84$, respectively $Sign.F = 0.000 < \alpha = 0.05$, the null hypothesis is rejected and the alternative hypothesis (H1) is accepted: the exchange rate was not significantly influenced by random factors. Particularly, trends in exchange rates of EUR, CHF, GBP and USD during the time frame January 2008 – October 2015 turned out to be linear.

Regarding the coefficients a_0 and a_1 for the 4 models, they are statistically significant (for all P-value=0.00<α=0.05). By analyzing the values of the regressors (a_1), the CHF recorded the most pronounced evolution (an increase of 0.00089 RON per trading day, in a confidence interval between 0.00088 and 0.00092 RON per day), followed by GBP with a daily increase of 0.00071 RON (the confidence interval being comprised between 0.00069 and 0.00073 RON per day). At the opposite side we find EUR whose average daily increase was 0.00035 RON (2.54 times lower than CHF and 2.03 times lower than GBP), the confidence interval being between 0.00034 and 0.00036 RON. During the same period, USD recorded an average daily increase of 0.00056 RON (1.69 times higher than the EUR, but 1.2 times lower than the GBP and 1.53 times lower than CHF), the confidence interval being situated between 0.00056 and 0.00059 RON .

For testing the hypothesis of no significant differences between the EUR, USD, GBP and CHF exchange rates' evolution during the time frame under review, the dispersion analysis of the 4 data series was conducted, determining variances between groups and with groups, and thus applying the F test. The resulting information is comprised in Table 2, where *SS* – Sum of Squares, *df* – Degrees of Freedom, *MS* – Mean Square, *P-value* – probability corresponding to the value of *F* and *F crit* – critical value for $F_{\alpha;k;n-k-1}$.

Table 2. ANOVA table for testing Null Hypothesis: There are no significant differences between the evolutions of EUR, USD, GBP and CHF exchange rates within the period under review

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4916.7801	3	1638.9267	8686.7231	0.0000	2.6060
Within Groups	1490.4954	7900	0.1887			
Total	6407.2755	7903				

Source: authors' own calculation

Given that the for the chosen significance threshold α=0.05, the value of F statistics is much higher than $F_{crit} = F_{0.05;3;7900} = 2.6060$, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted: there are significant differences between the data series corresponding to analyzed exchange rates. In conclusion, although the exchange rates for the 4 currencies recorded an upward trend, the influence of random factors proving to be insignificant, during January 2008 – October 2015 the evolution of the exchange rates for EUR, USD, GBP and CHF differ significantly.

2.2 Correlations between exchange rates' fluctuations

Based on the series of data containing the exchange rates of EUR, GBP, CHF and USD against RON, over the time interval January 2008 – October 2015, table 3 shows the Pearson correlation coefficients corresponding to exchange rates' fluctuations.

A first observation relates to the fact that by testing their statistical significance (t-Test 2-tailed) for the significance threshold $\alpha=0.005$, it results that all are statistically significant (therefore null hypothesis regarding their insignificance was rejected).

A second observation relates to their values (r). Except for the relationship between the EUR and GBP for which r=0.702 shows a direct medium correlation, in all other cases the values of correlation coefficients highlight direct correlation of strong intensity. The strongest direct correlation was determined between USD and CHF (r=0.879), which emphasizes that the modification of one's exchange rate will determine, with 95% probability, the modification in the same direction of the other. Moreover, for the time frame subject to analysis, strong correlations have been determined between CHF and EUR (r=0.870), USD and GBP (r=0.867), GBP and CHF (r=0.857) and also between USD and EUR (r=0.826).

Table 3. Pearson Correlation Coefficients corresponding to the evolution trends of the main currencies during January 2008 – October 2015 and the results of their statistical significance testing

		EUR	CHF	GBP	USD
EUR	Correlation Coefficient	1			
	Sig. (2-tailed)	-			
CHF	Correlation Coefficient	0.870	1		
	Sig. (2-tailed)	0.000	-		
GBP	Correlation Coefficient	0.702	0.857	1	
	Sig. (2-tailed)	0.000	0.000	-	
USD	Correlation Coefficient	0.826	0.879	0.867	1
	Sig. (2-tailed)	0.000	0.000	0.000	-

Source: authors' own calculation

To conclude, both the values of correlation coefficients between EUR, CHF, GBP and USD exchange rates (Table 3) and the results of the statistical significance testing confirmed the hypothesis concerning their interactions for the period January 2008 – October 2015. In order to highlight the connection between EUR the other 3 currencies, a linear model was tested using (10):

$$EUR = c + a_1 \cdot CHF + a_2 \cdot GBP + a_3 \cdot USD + \varepsilon \qquad (10)$$

The results obtained by applying the least squares method for determining the parameters (c, a_1, a_2, a_3) and the ANOVA method for validating model (10) are shown in table 4.

Table 4. Results of parameters determination and of linear model (10) testing

Dependent Variable: EUR				
Method: Least Squares				
Included observations: 1976				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.158838	0.032778	96.37084	0.0000
CHF	0.357469	0.010570	33.81916	0.0000
GBP	-0.192746	0.011901	-16.19644	0.0000
USD	0.282568	0.014880	18.98968	0.0000
R-squared	0.799894	F-statistic		2627.584
Durbin-Watson stat	0.015848	Prob(F-statistic)		0.000000

Source: authors' own calculation

Although both the model (10) and coefficients thereof are statistically valid (Prob(F-statistic)=0.000<α=0.05, respectively Prob.=0.000 for all coefficients), the value d=0.015848 (Durbin-Watson test) indicates a strong positive autocorrelation of residual values and therefore the model (10) cannot be used.

Table 5. AR(2) model of error autocorrelation

Dependent Variable: RESID01				
Method: Least Squares				
Included observations: 1974 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000998	0.035321	-0.028257	0.9775
AR(1)	1.136575	0.022284	51.00324	0.0000
AR(2)	-0.145567	0.022288	-6.531286	0.0000
R-squared	0.984534	F-statistic		62733.18
Durbin-Watson stat	1.987151	Prob(F-statistic)		0.000000

Source: authors' own calculation

An AR(2) model was used in order to remove autocorrelation, and parameter values $\rho_1 = 1.136575$ and $\rho_2 = -0.145587$ (Table 5), given that e_t errors are not auto correlated. Taking this into account and based on data series corresponding to the evolution trends of the EUR, CHF, GBP and USD exchange rates, the series MEUR, MCHF, MGBP and MUSD were generated by applying transformations as (11):

$$y_t = x_t - \left(1.13658 \cdot x_{t-1} - 0.145567 \cdot x_{t-2}\right) \tag{11}$$

Under these circumstances, with 95% probability, the linear regression model which describes the quantitative dependencies between all 4 currencies taken into analysis (Table 6) is:

$$MEUR = 0.023471 + 0.195492 \cdot MCHF + 0.128190 \cdot MGBP + 0.198096 \cdot MUSD + \varepsilon \tag{12}$$

Bearing in mind the value of Prob(F-statistic)=0.000<α=0.05 it turns out that model (12) is statistically valid. Likewise, the value of *Prob*=0.000 indicates that all model's parameters are statistically significant. Parameter values a_1=0.195492, b=-0.02758 and c=0,403236 point out which was, over the observed time frame, the effect of modification by 1 RON of the exchange rate of CHF, GBP and USD respectively upon the exchange rate of EUR.

Table 6. The characteristics of the quantitative dependencies' model between EUR, CHF, GBP and USD exchange rates during January 2008 – October 2015

Dependent Variable: MEUR				
Method: Least Squares				
Included observations: 1974 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.023471	0.000446	52.58829	0.0000
MCHF	0.195492	0.010743	18.19705	0.0000
MGBP	0.128190	0.009024	14.20561	0.0000
MUSD	0.108096	0.012427	8.698562	0.0000
R-squared	0.461440	F-statistic		562.6343
Durbin-Watson stat	1.973466	Prob(F-statistic)		0.000000

Source: authors' own calculation

2.3 A time series analysis

For obtaining more information regarding the evolution trends of the EUR, CHF, GBP and USD exchange rates in Romania, for the period January 2008 – October 2015, the quotations of the 4 currencies were analyzed as time series. Testing of the stationarity hypothesis has been conducted using Augmented Dickey-Fuller test. For the chosen significance threshold $(\alpha = 0.05)$, both Prob. values (table) which are strictly higher than 0.05 and the fact that all ADF values are higher than the critical value (-2.862803) lead to accepting the null hypothesis for all 4 data series. Subsequently, all series are not stationary. Still, we need to make the observation that for the significance threshold $\alpha = 0.1$ (Confidence Level 90%), for the EUR data series the stationarity hypothesis was not accepted.

Table 7. The results of applying Augmented Dickey-Fuller test for the EUR, CHF, GBP and USD data series

Null Hypothesis: The series has a unit root				
Series	Test critical value (5% level)	ADF test statistic	Prob.	Conclusions
EUR	-2.862803	-2.574052	0.0986	EUR has a unit root
CHF	-2.862803	-1.659365	0.4519	CHF has a unit root
GBP	-2.862803	-1.434326	0.5668	GBP has a unit root
USD	-2.862803	-1.628341	0.4678	USD has a unit root

Source: authors' own calculation

For obtaining stationary series, the transformation provided by equation (5) was used, based on which the series DEUR, DCHF, DGBP and DUSD were generated. Testing their stationarity led to rejecting the null hypothesis (The series has a unit root) and to accepting alternate hypothesis. Therefore, DEUR, DCHF, DGBP and DUSD series are stationary and can be employed in identifying autoregressive and moving average processes which describe the fluctuations of the 4 currencies.

Following the testing of several types of models and the analysis of their quality, the AR-MA(3,4) models have been selected for DEUR series. For this particular series we identified an autoregressive and moving average type ARMA(3,4) model. Except for constant C (Table 8) for which $\Pr ob = 0.2328 > \alpha = 0.05$ and thus the null hypothesis is accepted: constant C is not significantly different than zero, for all other variables the coefficients' values are statistically significant for the confidence level of 95% (coefficients of AR(3) and MA(1) are statistically significant for a confidence level of 99%).

Table 8. Characteristics of ARMA(3,4) model
Dependent Variable: DEUR
Method: Least Squares
Included observations: 1972 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000417	0.000349	1.193589	0.2328
AR(3)	-0.063642	0.022489	-2.829902	0.0047
MA(1)	0.183513	0.022122	8.295312	0.0000
MA(4)	-0.053883	0.022120	-2.435971	0.0149
Durbin-Watson stat: 2.007027		F-statistic: 27.07592		Prob(F-statistic): 0.0000
Breusch-Godfrey Serial Corr. LM Test:		F-statistic: 0.808657		Probability: 0.4456

Source: authors' own calculation

Also, the statistical value DW=2.007027 shows that residual values are not auto correlated, *Probability=0.4456* being higher than the significance threshold corresponding to the statistical value Breusch-Godfrey Serial Corr. LM Test emphasizes the absence of serial correlations.

Taking all these aspects into consideration, the equation for DEUR model becomes (13):

$$\Delta EUR_t = 0.000417 - 0.063642 \cdot \Delta EUR_{t-3} + \varepsilon_t + 0.183513 \cdot \varepsilon_{t-1} - 0.053883 \cdot \varepsilon_{t-4} \quad for\ t \geq 5$$

(13)

The moment in time *t=5* corresponds to the date of 9th of January 2008.

Based on (13) and on the fact that $\Delta EUR_t = EUR_t - EUR_{t-1}$, the model which corresponds to RON/EUR exchange rate evolution is ARIMA(3,1,4). The explicit equation of the model for the EUR fluctuations during 9th of January 2008 – 12th of October 2015 is:

$$EUR_t = 0.000417 + EUR_{t-1} - 0.063642 \cdot EUR_{t-3} + 0.063642 \cdot EUR_{t-4} +$$
$$+ \varepsilon_t + 0.183513 \cdot \varepsilon_{t-1} - 0.053883 \cdot \varepsilon_{t-4}\ , for\ t \geq 5$$

(14)

On the other hand, for the DCHF series the autoregressive and moving average model is type ARMA(1,3). In this case too, the constant C (Table 9) is not statistically significant for a confidence level of 95% ($\Pr ob = 0.1102 > \alpha = 0.05$). The coefficients of AR(1) and MA(3) variables are statistically significant for a confidence level higher than 99%).

Table 9. Characteristics of ARMA(1,3) model
Dependent Variable: DCHF
Method: Least Squares
Included observations: 1974 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000935	0.000585	1.598203	0.1102
AR(1)	0.117577	0.022379	5.253981	0.0000
MA(3)	-0.091962	0.022444	-4.097419	0.0000
Durbin-Watson stat: 2.003628		F-statistic: 21.66278		Prob(F-statistic): 0.0000
Breusch-Godfrey Serial Corr. LM Test:		F-statistic: 0.260936		Probability: 0.7704

Source: authors' own calculation

Therefore, for the DCHF data series the actual equation of the autoregressive and moving average model is:

$$\Delta CHF_t = 0.000935 + 0.117577 \cdot \Delta CHF_{t-1} + \varepsilon_t - 0.091962 \cdot \varepsilon_{t-3} \quad for\ t \geq 4\ (15)$$

The moment in time *t=4* corresponds to the date of 8th of January 2008.

Starting from equation (14) the model which describes the evolution of the RON/CHF exchange rate for the time frame between 8th of January 2008 – 12th of October 2015 is:

$$CHF_t = 0.000935 + 1.117577 \cdot CHF_{t-1} + 0.117577 \cdot CHF_{t-2} + \varepsilon_t - 0.091962 \cdot \varepsilon_{t-3} \quad for\ t \geq 4\ (16)$$

The autoregressive and moving average model assigned to the evolution of DGBP is type ARMA(3,1). Again, except for constant C (Table 10) which is not statistically significant for a confidence level of 95% ($\Pr ob = 0.4669 > \alpha = 0.05$), the coefficients of variables AR(1) and MA(1) are statistically significant for confidence level above 99%, while the coefficient of variable AR(3) is statistically significant for a confidence level of 95%.

Table 10. Characteristics of ARMA(3,1) model
Dependent Variable: DGBP
Method: Least Squares
Included observations: 1972 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000575	0.000790	0.727640	0.4669
AR(1)	-0.754125	0.182975	-4.121465	0.0000
AR(3)	-0.048732	0.020200	-2.412479	0.0159
MA(1)	0.813871	0.177620	4.582088	0.0000
Durbin-Watson stat: 1.981455		F-statistic: 4.4716278		Prob(F-statistic): 0.0028
Breusch-Godfrey Serial Corr. LM Test:		F-statistic: 0.437954		Probability: 0.6454

Source: authors' own calculation

Subsequently, for the DGBP data series, the ARMA(3,1) autoregressive and moving average model becomes (16):

$$\Delta GBP_t = 0.000575 - 0.754125 \cdot \Delta CHF_{t-1} - 0.048732 \cdot \Delta CHF_{t-3} + \\ + \varepsilon_t - 0.813871 \cdot \varepsilon_{t-1}, \quad for \ t \geq 5 \qquad (16)$$

The moment $t=4$ corresponds to the date of 9th of January 2008. Since the model best describing the evolution of the RON/GBP exchange rate is type ARIMA(3,1,1), its explicit form turns out:

$$GBP_t = 0.000575 + 0.245875 \cdot GBP_t + 0.754125 \cdot CHF_{t-2} - 0.048732 \cdot CHF_{t-3} + \\ + 0.048732 \cdot CHF_{t-4} + \varepsilon_t - 0.813871 \cdot \varepsilon_{t-1}, \quad for \ t \geq 5 \qquad (17)$$

Table 11. Characteristics of ARMA(10,10) model
Dependent Variable: DUSD
Method: Least Squares
Included observations: 1965 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000690	0.000591	1.167796	0.2430
AR(10)	-0.970097	0.009642	-100.6097	0.0000
MA(10)	0.974898	0.011470	84.99207	0.0000
Durbin-Watson stat: 1.945866		F-statistic: 17.49418		Prob(F-statistic): 0.0000
Breusch-Godfrey Serial Corr. LM Test:		F-statistic: 1.313398		Probability: 0.2685

Source: authors' own calculation

Finally, for the RON/USD exchange rate, the data series DUSD is a type ARMA(10,10) autoregressive and moving average model, whose characteristics are presented in table 11. The equation describing this model is:

$$\Delta USD_t = 0.00069 - 0.970097 \cdot \Delta CHF_{t-10} + \varepsilon_t - 0.974898 \cdot \varepsilon_{t-10} \quad for \ t \geq 11 \qquad (18)$$

The moment $t=11$ corresponds to the date of 17th of January 2008. The model characterizing the fluctuation of the RON/USD exchange rate is ARIMA(10,1,10) and for the period 17th of January 2008 – 12th of October 2015, the appropriate equation is:

$$USD_t = 0.00069 + USD_{t-1} - 0.970097 \cdot CHF_{t-10} + 0.970097 \cdot CHF_{t-11} +$$
$$+ \varepsilon_t - 0.974898 \cdot \varepsilon_{t-10} \quad for \ t \geq 11 \tag{19}$$

Unlike the autoregressive and moving average processes corresponding to the other 3 currencies, in which cases the impact of previous trends became significant after 1 trading day for CHF and after 3 trading days for EUR and GBP, for the RON/USD exchange rate the time frame is wider (10 trading days). Also, while the time interval taken into calculation for the moving averages was comprised between 1 day (in the case of GBP) and 4 days (for EUR), the case of USD showed a 10 day-interval.

CONCLUSIONS

During 2008-2015, economic developments in most EU countries and Romania as well were significantly influenced by the economic crisis which started in the beginning of the proposed period. In Romania, even though at the beginning of 2008 the RON has appreciated against the other currencies subject to analysis, both during the crisis and afterwards the exchange rates presented an increasing trend, thus determining (between July 2008 – May 2015) an almost doubled RON/CHF exchange rate after just an average increase of 0.089 RON per trading day. During the same period, the price of USD had increased by 79%, and GBP and EUR were more expensive by 38% and 25% respectively.

Despite all economic oscillations, in Romania, their influence upon the exchange rates of main currencies did not create severe turbulences, the fluctuations associated with ascending trends of the main currencies being insignificant. Even though the RON/CHF exchange rate had 2 sudden increases in August 2011 (when the exchange rate exceeded 4 RON/1 CHF) and in January 2015 (when CHF exceeded 4.5 RON), these did not influence significantly the linear increasing trend observed for the whole period of time.

Another characteristic of the evolution of exchange rates in Romania is that although exchange rates for the four currencies recorded an increasing trend, and the correlations between them are significant, the correlation coefficients' values range from 0.702 (between EUR and GBP) and 0.879 (between USD and CHF), the dispersion analysis pointing out significant differences between their evolutions. This aspect is also underlined by the Durbin-Watson statistical value, corresponding to the first regression model showing the dependence between EUR and the other three currencies (Table 11), highlighting a strong autocorrelation of residual values and the influence of a factor not considered in the analysis carried out on EUR. Eliminating its influence has yielded a valid regression model which emphasizes that for a significance level of 95% the highest pressure on EUR was in fact exercised by CHF (a modification of one monetary unit leading to a change in the same direction of the EUR exchange rate of approximately 0.19 monetary units), followed by GBP and USD.

The particularities of the four currencies' evolution are also stressed by their evolution models as time series. Consequently, the RON/EUR exchange rate developed an ARIMA(3,1,4) model, while the GBP exchange rate an ARIMA(3,1,1) model pointing out that the influence of previous exchange rates occurs after approximately 3 trading days. In the case of CHF, the influence manifests much rapidly, the model employed being type ARIMA(1,1,3). Unlike these, the autoregressive and moving average model – ARIMA(10,1,10) – which corresponds to the RON/USD exchange rate entails considering a much wider time frame.

REFERENCES

Ahmed, J., Straetmans, S. (2015), "Predicting exchange rate cycles utilizing risk factors", *Journal of Empirical Finance*, No. 34, pp. 112–130.

Ahmed, S., Liu, X., Valente, G. (2016), "Can currency-based risk factors help forecast exchange rates?," *International Journal of Forecasting*, Vol. 32, No. 1, pp. 75–97.

Andrei, T., Stancu, S., Iacob, A. I., Tuşa, E. (2008), *Introduction to Econometrics Using Eviews*, Economic Publishing House, Bucharest, (in Romanian).

Babetskii, I., Boone, L. Maurel, M. (2004), "Exchange rate regimes and shocks asymmetry: the case of the accession countries," *Journal of Comparative Economics*, Vol. 32, No. 2, pp. 212–229.

Berg, A., Miao Y. (2010), "The Real Exchange Rate and Growth Revisited: The Washington Consensus Strikes Back?", *IMF Working Paper*, WP/10/58, Washington, D.C.

Chinn, M. D., Meese, R. A. (1995), "Banking on currency forecasts: How predictable is change in money?", *Journal of International Economics*, Vol. 38, No. 1-2, pp. 161–178.

Della Corte, P., Tsiakas, I. (2012), "Statistical and economic methods for evaluating exchange rate predictability" in J. James, I. W. Marsh & L. Sarno (Eds.), *Handbook of exchange rates*, John Wiley & Sons, Hoboken, pp. 221-264.

Durbin, J., Watson, G. S. (1951), "Testing for Serial Correlation in Least Squares Regression", *II. Biometrika*, Vol. 38, No. 1–2, pp. 159–179.

Engel, C., West, K., (2005), "Exchange rates and fundamentals", *Journal of Political Economy*, Vol. 113, No. 3, pp. 485-517.

Engel, C., West, K. D.(2006), "Taylor rules and the deutschmark–dollar real exchange rate", Journal of Money, *Credit, Bank*, No. 38, pp. 1175–1194.

Fidrmuc, J., Horváth, R. (2008), "Volatility of exchange rates in selected new EU members: Evidence from daily data", *Economic Systems*, Vol. 32, No. 1, pp. 103-118.

Ghiba, N. (2010). "Implications of exchange rate volatility on international trade (The case of Romania)", Munich Personal RePec Archive. Available at: http://mpra.ub.uni-muenchen.de/ 28453/ (Accessed: February 10, 2017).

Mark, N.C. (1995), "Exchange rates and fundamentals: Evidence on long-horizon predictability", *American Economic Review*, Vol. 85, No. 1, pp. 201–218.

Meese, R. A., Rogoff, K. (1983), "Empirical exchange rate models of the seventies: Do they fit out of sample?", *Journal of International Economics*, No. 14, pp. 3–24.

Montgomery, D.C. (2001), Design and Analysis of Experiments, 5th ed., John Wiley & Sons, New York.

Moore, D. S., McCabe, G. P. (2003), Introduction to the Practice of Statistics, 4th ed., W. H. Freeman & Co, New York.

Nuti, D. M. (1996), "Inflation, interest and exchange rates in the transition", *Economics of Transition*, Vol. 4, No. 1, pp. 137-158.

Săvoiu, Gh., Necşulescu, C. (2009), *Econometrics*, University Publishing House, Bucharest (in Romanian).

The National Bank of Romania (2016), "Exchange rates". Available at: http://www.bnr.ro/ Exchange- rates- 1224.aspx (Accessed: October 12, 2017).

Verdelhan, A. (2013), "The share of systematic variation in bilateral exchange rates". Working paper, MIT Sloan School of Management. Available at: https://www.ecb.europa.eu/events/ pdf/conferences/130627/2.1a_A.Verdelhan_Paper.pdf?69013638c4b84e5f3c7e364fef9f3f 65 (Accessed: December 19, 2017).

Zaharia, M., Gogonea, R.-M. (2009), "Econometrics. Fundamental elements", University Publishing House, Bucharest (in Romanian).