# THE COMPARATIVE ANALYSIS OF ROMANIAN AND HUNGARIAN STOCK MARKET INDICES AND EXCHANGE RATES

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*Nowadays, when we are witnessing a serious macro-level changes, to deal with financial and economic indicators becomes more and more important in the economy, in particular to evaluate the changes of these indicators and especially their impact to the private sector. This paper aims to analyze in comparison for two countries, in what extent can explain the changes of the most important stock market indices with the fluctuations of those two countries national currency exchange rates in euro. To determinate the relationship between the macro indicators we've used traditional statistical methods, namely simple linear regression model and the Bayesian statistics. In case of both Romania and Hungary, the analyses show that there is a relationship between exchange rates and the changes of stock indices. If we compare the analysis results of the two countries, we can see that the relationship between the BET index and Lei/EUR exchange rate is much more stronger than between the BUX index and Ft/EUR exchange rate, in the latter case we can see a much weaker relationship.*
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*JEL Codes: G01, G15, G18, G19*

## 1. Introduction

Recently evolved world economic-financial crisis revealed many economic and financial problems in several European Union's member states which have led to serious economic crisis in some countries. Especially, there has brought to light serious economic problems in the southern European countries such as Greece, Italy, Spain and Portugal. Romania and Hungary, such as recently joined European Union's ex- socialist member states, has also faced economic and financial problems. The main similarity of these countries is the critical fiscal situation, and the infringements of Stability and Growth Pact rules. Forasmuch, the compliance of the public debt and/or public deficit rule is the current problem of mentioned EU member states, the budget adjustments plays an important role for the economic stability.

Considering the current macro-level changes, we find that it is important to analyze the evolution of these macro-indicators in comparison in mentioned two post-socialist countries. Therefore, we consider that to analyze the relationship between several macro-level indicators has a special importance.

## 2. Literature analyses

This paper aims to examine the relationship between two macro-indicators, namely the Romanian and Hungarian stock market indices and the national currency exchange rate in euro of these two countries. A number of foreign articles deal with the examination of relationship between two or more macroeconomic indicators. The macroeconomic indicators used most commonly in recent researches, are for example, interest rate, inflation rate, stock market indices, stock prices etc. Ahmad–Rrehman–Raoof (2010) concluded that there is a relationship between the changes of exchange rates and stock market indices. Studying the Istanbul's stock index, a researcher show that the trends of stock market indices are strongly influenced by several factors, such as exchange rate, oil price, money supply. He also concluded that there is no effect between stock index changes and the price of gold as well as the consumer price index (Büyükşalvarci, 2010).

In the most research, the evolution of stock market indices is explained with various macroeconomic indicators. Dimitrova (2005) also tries to explain the reltionships between stock market share prices, exchange rate and economic – fiscal and monetary - policies with using a multivariate model. The research results show that the changes of interest rate and exchange rate affect the stock market share prices. In their 2009's research, Sulaiman–Hussain–Jalil concerned to show by tools of AR and ARIMA models, the relationship between the evolution of stock prices and other macroeconomic indicators such as interest rate, exchange rate and price index. The researchers concluded that there is strong relationship between exchange rate and stock market share prices. In another study, the researchers have founded that except the exchange rate, which has a positive impact on the stock market index, the other indicators such as interest rate, money supply, consumer price index have a negative effect on the evolution of stock market index (Frimpong, 2006).

**3. Research methodology**

In this research, in the exploration of correlation between two indicators we want to take advantage of the possibilities of both the traditional and the *Bayesian statistics*, and their combination too. The combination of these methods allows that using parameters determined with basic statistics methods, to perform the simulation, in order to a better parameter estimation. This kind of model permits a deeper analysis than the conventional methods alone. Using Bayesian statistics, it is possible to take into account the earlier results, estimations and another advantage of this approach is that the certain assumptions could be incorporated into the model (prior probabilities). The *prior density function* includes the earlier information to a developed model's parameters, which may have a subjective or objective nature. The function based on the information resulting from the sample, we know as *likelihood function.* This function shows that in case of the concrete distribution and various parameters, how credible it is, that the sample results during sampling. The essence of Bayesian statistics is the linkage between the *prior* and *posterior density functions*. The posterior distribution function is proportional with the product of prior probability density function and likelihood function.

The Bayesian statistics is an important tool in modern macro-level analysis, because it insures a special approach for analysis based on macro-data, therefore it is not surprising that the Bayesian statistical models are commonly used in macroeconometrics. The Bayesian statistics may give an answer in explaining of economic time series fluctuations caused by the macroeconomic policies or other factor changes.

A number of foreign articles, through the usage the statistical methods distinguish two main categories of statistical analysis "Bayesian" and "not Bayesian" analysis (Poirier, 2006). Like as any methods, the Bayesian statistics method has also advantages and disadvantages compared to the basic statistical methods. Earlier researches assign many *advantages* for this statistical method, such as: (1) more useful and provide more natural conclusions; (2) it is able to utilize more available information, so that the results obtained are more reliable; (3) it is more suitable for complex problems analysis. The *disadvantages* of Bayesian statistics are the following: (1) involves subjectivity, which the basic statistical methods doesn't; (2) the model is much more complicated and in many cases requires software programs, which sometimes are difficult to access, or there are quite costly (Luce-O' Hagan, 2003).

At the question of how objective is the Bayesian statistics, Berger (2006) write that it would be misleading to talk about objectivity, because the some data analysis process entails subjective choices.

In present research, to determinate the relationships between macro- indicators, we will use simple linear regression model combined with the facilities offered by Bayesian statistics. During the regression analysis, we want to analyze the impact of changes of the two neighboring

countries Lei/EUR and Ft/ EUR exchange rates on their main stock market indices, namely BET (Bucharest Exchange Trading) and BUX (Budapest Stock Exchange).
To determinate the macroeconomic relationships of two countries, we have used the following data Lei/EUR and Ft/EUR exchange rate, like monthly data series, for 6 years, as well as the selected countries main stock market indices. The Romanian data referring to the exchange rate were collected from the databases of National Bank of Romania and Bucharest Stock Exchange. The Hungarian data were also collected from databases of the National Bank of Hungary and Budapest Stock Exchange.
The statistical analysis waa built on the R statistical software system, such as a solving program. In the R statistical system there are available all the packages (modules) which is necessary for this analysis. The R statistical system is open source software, that ensure many analyzing, modeling and visualization facilities and another advantage is that it could be connected with Excel spreadsheet, which facilitates the usage of different databases.
At the first step at the study we apply the linear regression calculation, known by the traditional statistics, which correspond with the original regression and the prior distribution. We assume that the error factor ($\varepsilon$) follows the normal distribution with 0 expected value and constant variance ($\sigma^2$).
After the traditional statistics computation, by tools of R statistics program we will simulate from prior distribution the regression coefficient $\beta$ vector and the error variance ($\sigma^2$), so determines the values for $\sigma^2$ from its marginal posterior density $g(\sigma^2 \mid y)$ and $\beta$ values from the conditional posterior density $g(\beta|\sigma^2, y)$. After this operation, the program generates a new $\sigma$, based on gamma distribution, then the $\sigma^2$ (posterior distribution) is the inverse of gamma distribution, with $((n-k)/2, S/2)$ parameters, where (1) n = number of observation, (2) k = number of explanatory variables, (3) S = ()' (y − Xˆβ) (Albert, 2007).
The previous computation plays a central role in determination of $\beta$ coefficient. After this, leaving the degree of freedom from the initial distribution, execute the simulation so that the $\beta$ will be the average, by following a multivariate normal distribution. The posterior distribution of the regression vector $\beta$ conditional on the error variance $\sigma^2$, $g(\beta|y, \sigma^2)$, is multivariate normal with mean $\beta\hat{}$ and variance-covariance matrix $V_\beta\sigma^2$ y − Xˆβ, where

$$\beta\hat{} = (X' X)-1\ X' y \text{ and } V\beta = (X' X)-1.$$

**4. Results of the research**

By simple linear regression we analyze the relationship between Romanian stock market index, BET and Lei/EUR exchange rate, and the relationship between Hungarian stock market index, BUX and Ft/EUR exchange rate. The regression model for the tested model is:

$$BET = \beta_0 + \beta_1 * Lei/EUR,\ BUX = \beta_0 + \beta_1 * Ft/EUR,$$

where the question is that the changes of Lei/EUR, Ft/EUR exchange rate can explain the evolution of BET, BUX index. The calculated regression coefficient correspond essentially to the two countries stock market index $\beta$ coefficient, which shows that the two countries currency in EUR exchange rate changes explain the changes of BET and BUX index.
In the R statistical software system, the regression computation was carried out using the lm() module, and the results of these calculation are the following linear function:

$$BET_i = 20733{,}2 - 3878{,}3 * Lei/EUR_i,\ BUX_i = 49982{,}99 - 109{,}79 * Ft/EUR_i$$

For testing the reliability of coefficients of regression model, the software determines the T-test values and associated significance level, which values will be presented into table 1. and 2.
Table 1. shows that in the case of BET the significance level for each coefficient value is around 0, which means that both coefficients has different value from 0, and thus these coefficients can be used to examine the relationship between two variables. The table 2. for BUX index indicates the similar results with table 1., so in this case too, the parameters of regression function can be used to describe the relationship between two variable.

**1. table: Estimation the parameters of BET (Romania) function**

| Statistical attributes | Estimation | Std. Error | T- value | Pr(>\|t\|) |
|---|---|---|---|---|
| **Intercept** | 20733,2 | 1683,7 | 12,314 | < 2e-16 *** |
| **Regression coefficient** | -3878,3 | 438,3 | -8,849 | 8.4e-14 *** |
| **Standar error of regression** | 1477 | | | |
| **R-squared ($R^2$)** | 0.4709 | | | |
| **Correlation coefficient (R)** | 0.6862 | | | |

*Source: Own computation*

**2. table: Estimation the parameters of BUX (Hungary) function**

| Statistical attributess | Estimation | Std. Error | T- value | Pr(>\|t\|) |
|---|---|---|---|---|
| **Intercept** | 49982.99 | 6698.17 | 7.462 | 8.04e-11 *** |
| **Regression coefficient** | -109.79 | 25.29 | 4.341 | 4.02e 05 *** |
| **Standar error of regression** | 3781 | | | |
| **R-squared ($R^2$)** | 0.1869 | | | |
| **Correlation coefficient (R)** | 0.4323 | | | |

*Source: Own computation*

The table 1. and table 2. shows the function coefficients of determination ($R^2$), which in the case of BET is 0.4709 and in the case of BUX is 0.1869. This means that in the BET case, the dependent variable variance could be explained by independent variable in proportion of 47,09%, while in the case of BUX, this is only 18,69%. With other words, this means that the BUX index evolution could be explained much less by the exchange rate changes. The mentioned tables also shows the correlation coefficient (R), for which in the BET case it is 0,6862 and in the BUX case 0,4323. Therefore in the BET case it means a medium-strong correlation, while in BUX case it we could talk about a moderate-weak correlation. The software performs the variance analysis too, for this regression, which is presented in the tables 3. and 4.

***3. table: Variance-analysis / ANOVA table for BET (Romania)***

| | Degree of freedom Df | Sum of square Sum Sq | Mean of square Mean Sq | F-value | F-test Significance level |
|---|---|---|---|---|---|
| **BET** | 1 | 170720473 | 170720473 | 78.305 | 8.397e-14 *** |
| **Error** | 88 | 191856766 | 2180191 | | |

*Source: Own computation*

***4. table: Variance-analysis / ANOVA table for BUX (Hungary)***

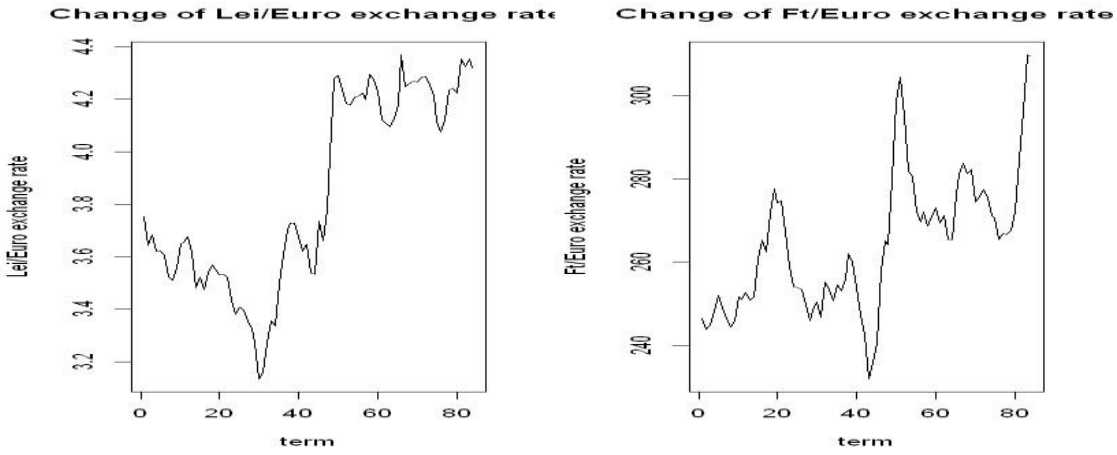
| | Degree of freedom Df | Sum of square Sum Sq | Mean of square Mean Sq | F-value | F-test Significance level |
|---|---|---|---|---|---|
| **BUX** | 1 | 269443851 | 269443851 | 18.848 | 4.016e-05 *** |
| **Error** | 82 | 1172253096 | 14295769 | | |

*Source: Own computation*

In the tables 4-5. the BET and BUX indioces means the SSR, that is the regression deviation of Sum of Squares, namely the estimated BET and BUX (y') and the Sum Squares of difference of BET and BUX average ($\bar{y}$), denoted by $SSR = \sum(y_i' - \bar{y})^2$. The Error is not other than SSE

(Sum Squares for Error), that is error factor, which could be calculated like difference of Sum Squares between original (y) value and estimated (y') value $SSE = \sum(y_i - \tilde{y}_i)^2$. From the sum of SSR and SSE we obtained the SST (total sum of squares), so that $SST = \sum(y_i - \bar{y})^2$.
Related with variance analysis, the F-test answer to the question if the model is acceptable in the sense that the independent variables explain satisfactorily the BET and the BUX index. The F-value is equal with: Mean Squares (BUX) / Sum Squares (Error). Because F- value's significance level in both of cases are closed to 0, we can conclude that the explanatory variable effect is significantly greater than the error effect, so the regression function will be useful in the description of this kind of connections, that also shows that we could reject the null hypotesis, so in both of cases, the dependent variable variance could be explained by the variance.of independent variable, the '***' suggest that all that could be determined at a 0,001 significance level.

**1.graph: Lei/EUR and Ft/EUR excahnge rates changes between 2005-2011**

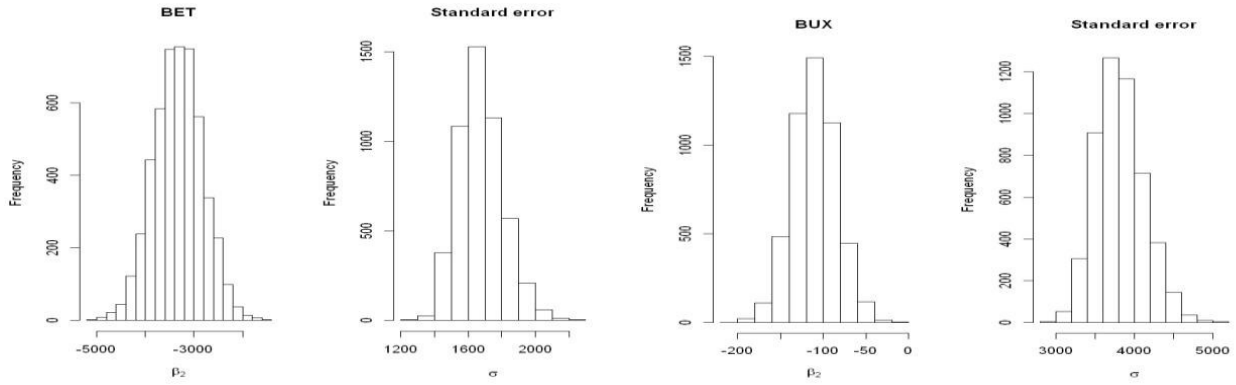



*Source: Own computation*

The graph 1. shows that in the analyzed period, between 2005 and 2011, both the Lei/EUR and Ft/EUR exchange rate records a serious fluctuations, but despite the fact that we analyze two neighboring country, exactly their national currency compared to the European currency, the graph shows a very different trends. In the first section of graph we can see a completely opposite trends for these two countries exchange rate, while in the left side, the graph shows a gradually appreciation of Romanian national currency compared to euro, in the right side of graph we can see a depreciation of Hungarian national currency compared to euro, followed by a same degree of appreciation. In the next period the national currency of Hungary depreciates again, but this time to a lesser extent, then in the pre-crisis period appreciated and after that, at the influence of financial crisis, we assist to an Ft/EUR devaluation, touching the bottom. Despite the fact that in time of financial crisis, the trend of both two countries exchange rate was similar, it is clear that the two rates do not move together, so the fluctuation of Ft/EUR is larger , shows a quite rapid changes from one period to another and Ft/EUR depreciation amplitude is also different. In the post crisis period, the Ft/EUR exchange rate registers a suddenly appreciation and in the next period depreciated again. In post crisis period, the Lei/EUR exchange rate fluctuates gradually into limits of a certain band.
For the following analysis we've used Bayesian statistics. The calculations were performed by tools of R statistical system, using LearnBayes module. Using the traditional regression results (prior) we perform new computations (posterior), which is formally similar to the normal sampling model. After the calculation of regression model, the program generate new data (by using the original data), through 5000 runing. The program execut the 5000 running with

retaining of original value of σ. The histograms of regression coefficient (β) and standard deviation (σ) obtained after calculation, based on Bayes statistics posterior distribution, are shown in the next illustration.

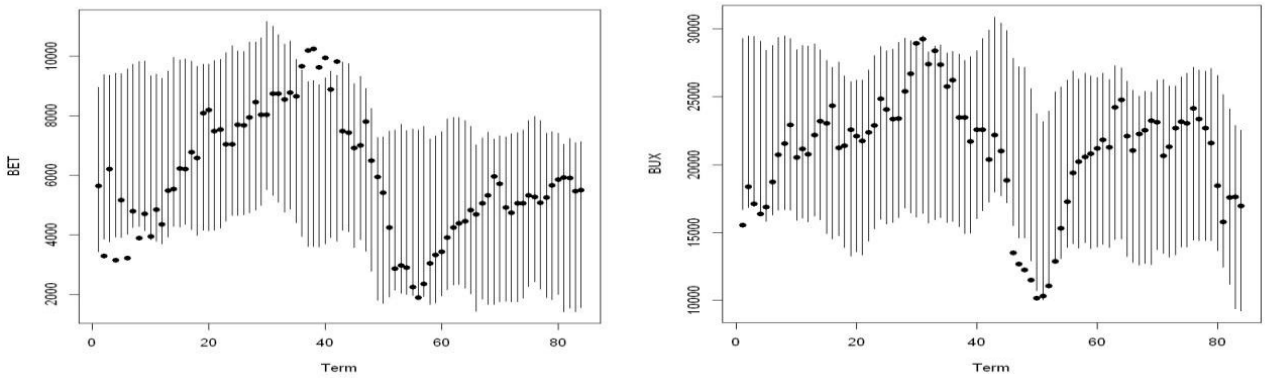
**2. graph: The distribution of BET and BUX index coefficients and standard error**




*Source: Own computation*

After 5000 running, the results shows that the major part of BET index coefficients are situated between -4000 and -3000, while the values of standard error are situated between 1600 and 2000. In the case of BUX index, the major part of regression coefficients are situated in -150 and -100 interval and the standard error larger part are into 3900-4500 interval. We can also see from this illustration, that the values related to BET index are much more closer to normal distribution which also implies that in the BUX index case also the values of the standard error shows an more uniform distribution. In the case of BET index the values of standard error are more concentrated around average value.

**3 graph: The estimated interval for BET and BUX index using Bayesian statistics**




*Source: Own computation*

The graph 3. shows the interval regression calculations performed by the Bayesian methods. The resulted " host range" illustrate with a 95% probability which is the band where the original values falls. We can see from the illustration that with few exceptions, the larger part of analyzed data (points) are within this interval, in the lower, middle or upper limits of this. The resulted "interval-function" could be well used to perform predictions.
In conclusion, it is clearly visible that the values of BUX index moves into a wider range than the BET index, which indicates greater uncertainty. This means that in the case of BUX index the predictions referring to the stock market index may be uncertain.

## 5. Conclusions

The research results clearly shows that there is a connection between the changes of Lei/EUR and Ft/EUR exchange rate and the BET and BUX stock market index. But if we compare the results of these two countries, we can see that there is a stronger relationship between BET index and Lei/EUR exchange rate, than in the case of Hungary, where the relationship between BUX index and Ft/EUR exchange rate reveals a much weaker connection. The comparison of these two countries national currency compared to the euro exchange rates denote in the analyzed period that in the first half of period, these two exchange rates have a completely opposite running, while in the second half of the period we assist to these two countries national currency devaluation, which was heavily influenced by the global financial crisis.

For the effectiveness of predictions we've exploit the opportunities of Bayesian statistics, with which we determine the interval associated with regression line. The usefulness of Bayesian statistics applied at the regression calculation, derived from the fact that it gives a different approach of statistical analysis. As we have emphasized, a greater advantage of Bayesian statistics compared with the basic statistics, is that in the case of basic statistics we can say with 95% probability that the values falls in the certain band, while according to the Bayesian statistics approach we can say that the 95% of values will be into this certain interval.

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