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Horobet, Alexandra and Ilie, Livia

Academy of Economic Studies Bucharest, Lucian Blaga University of Sibiu

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ON THE DYNAMIC LINK BETWEEN STOCK PRICES AND EXCHANGE RATES: EVIDENCE FROM ROMANIA

Alexandra Horobet
Academy of Economic Studies Bucharest
6 Piata Romana, Bucharest-1, Romania
E-mail: alexandra.horobet@rei.ase.ro

Livia Ilie
University Lucian Blaga Sibiu
5-7 Ion Ratiu Street, Sibiu, Romania
E-mail: ilieliv@yahoo.com

Abstract

The theoretical linkages between exchange rates and stock prices are microeconomic as well as macroeconomic in nature and may be observed on the short- and long-run. The paper examines the interactions between the exchange rates and stock prices in Romania, after 1997, taking into account the change in the monetary regime occurred in 2005 – the shift towards inflation targeting. The analysis uses bivariate cointegration and Granger causality tests, applied on daily and monthly exchange rates and stock prices data collected over the 1999 to 2007 period. Three types of exchange rates are used: the nominal effective exchange rates of the Romanian leu, the bilateral nominal exchange rates of the leu against the US dollar and the euro, and the real effective exchange rates of the leu. In terms of stock prices, the BET and BET-C indices of the Bucharest Stock Exchange are used, denominated in the local currency.

Key words: exchange rates, stock exchange, cointegration, Granger causality

JEL Classification: F30, G10

1. INTRODUCTION

From an emerging market perspective, the analysis of the interactions between stock prices and exchange rates is interesting for a couple of reasons. First, emerging markets have been in recent years in the forefront of financial market liberalization, including here the foreign exchange market. Moreover, their exchange rate regimes have moved towards more flexibility, from pegged arrangements to managed floating and even free floating regimes. Second, emerging countries' stock markets have developed, but they also became more prone to contagion effects once their integration in the global financial markets intensified.

The existing literature sets the theoretical foundations of the linkages between stock prices and exchange rates on two perspectives, typically referred to as the microeconomic and the macroeconomic level. From the microeconomic level standpoint, the exchange rate is seen as influencing the value of domestic and multinational companies, and the research undertook in this area deals with the issue of domestic economies' exposure to exchange rate risk. Fluctuations in exchange rates can significantly have an effect on firm value, as they influence the terms of competition, the input and output prices, and the value of firm's assets and liabilities denominated in foreign currencies. Although firms with foreign operations, from exporting to international production, are more affected as compared to "pure" domestic firms, virtually no company can be considered as fully isolated from the effects of exchange rates changes. Consequently, all firms' prices may react sooner or later to changes in the exchange rates. Depending on the moment in time when exchange rates change, a company might face: (1) *transaction exposure*, that arises whenever the firm commits or is contractually bounded to make or receive a payment at a future date denominated in a foreign currency; (2) *translation exposure*, arising from the need to globally consolidate the financial reports of a multinational company from affiliates' reports denominated in various currencies; and (3) *economic exposure*, seen as the change in the firm's present value as result of changes in the value of the firm's expected future cash flows and cost of capital, induced by unexpected exchange rate changes. As opposed to transaction and translation exposure, a firm will be confronted with economic exposure to exchange rates when unanticipated real, not only nominal exchange rate changes, have a non-zero effect on its expected future cash flows. Two main mechanisms that generate economic exposure can be identified: a conversion effect – given the lower amount in home currency that will be obtained after converting the same amount in a foreign currency at a lower exchange rate; a competitive effect – given the change in the firm's competitive position that follows an asymmetric sensitivity of its revenues and expenses to exchange rate changes.

For what concerns empirical evidence on corporate exposure to exchange rate risk, two features are noteworthy: first, it is almost entirely concentrated on the case of companies originated from developed countries, given the higher data availability for performing tests; second, in most studies, the impact of nominal exchange rate changes, as opposed to real exchange rate changes is tested, following the rationale that inflation rates are so small, that any change in the nominal exchange rate level will directly generate changes in the real exchange rate level. Albeit this might be true for developed countries, traditionally displaying low inflation rates, in the case of less developed countries, where inflation rates are higher, the connection between nominal and real exchange rates is not as direct. Jorion (1990) opens the road for academic research in the field by examining US multinational corporations exposure to exchange rate risk for a 17 years period and concludes that share prices of these companies are not systematically influenced by changes in nominal exchange rates. Further research on American multinationals reaches to mixed results: while Bartov and Bodnar (1994), as well as Choi and Prasad (1995) confirm Jorion's findings, Allayannis (1996), Miller and Reuer (1998), Gao (2000) and Koutmos and Martin (2003) seem to detect a more significant link between the American companies share prices and changes in the nominal exchange rate of the dollar against various currencies. The latter authors also identify lagged exposures, as well as an asymmetry in the response of share prices to changes in the dollar value, higher exposures being associated to phases of dollar depreciation as compared to phases of dollar appreciation. Research conducted on companies outside the United States also addresses the corporate exposure of companies in developed countries: Glaum et al. (2000) investigate German companies' exposure to changes in the nominal exchange rate of the German mark against the dollar during1974-1997 and find it as being significant. Their result is confirmed by Entorf and Jamin (2002), that identify the company's degree of involvement into international business and the level of the exchange rate as being two important factors in explaining the exposure, and by Bartram (2004) that discovers significant linear and non-linear exposures of German companies against the dollar and other developed countries' currencies. Dutch companies have been researched by De Jong et al. (2002) that find more significant exposures in phases of the Dutch guilder depreciation, after investigating 117 companies over a 5-year period (1994-1998). Doukas et al. (2003) examine the relation between the rate of return on a number of 1079 Japanese companies' shares and unexpected changes in the Japanese yen exchange rates between 1975 and 1995 and find significant exposures, which are higher in the case of multinational and exporting companies, being also positively linked to the degree of international involvement of the firm, on one hand, and negatively linked to the firm's size and its financial leverage. British companies also display significant exposure, according to El-Masry (2003), but depending to a large extent on the industry. As mentioned above, less developed countries were less interesting for researchers: to our knowledge the only study released so far – Kyimaz (2003) – investigates Turkish companies for the period 1991-1998 and finds significant exposures to exchange rate risk, but also variable in magnitude from one industry to another.

From the macroeconomic level perspective, stock prices that reflect real economic activity may affect exchange rates through the increase in the demand for real money and, subsequently, the value of domestic currency. The relation between exchange rates and stock prices at the macroeconomic level may be sensitive to the exchange rate regime in force. Economic theory suggests that currency appreciation under a floating exchange rate regime reduces the competitiveness of countries' exports and, consequently, is expected to have a negative effect on the domestic stock market. Conversely, for a country relying on imports, an appreciation of the domestic currency lowers input costs and may generate a positive effect on the stock market.

More recently, given the increasing trend towards liberalization and globalization of financial markets, a considerable amount of research has been dedicated to the study of the dynamic interactions between stock prices and exchange rates. This research abandons uses advanced econometric models to analyze the relationship between these variables, such as bivariate and multivariate cointegration methods, Granger causality tests and GARCH models. The countries and regions are diverse and the results are also mixed, no definite conclusion being possible to be drawn from them. Kim (2003) investigates the existence of long-run equilibrium relationships among the aggregate stock price, industrial production, real exchange rate, interest rate and inflation rate in the United States, applying Johansen's cointegration methodology. For the 1974-1998 period he finds that the S&P 500 index is positively related to the industrial production but negatively related to the rest of the variables. When the error correction analysis is used, it reveals that the stock prices, industrial production and inflation adjust to correct disequilibrium among the five variables. At the same time, the research indicates that stock prices are driven to a significant extent by innovations in the interest rate. Dong et. al (2005) examined six emerging Asian countries over 1989 and 2003 and found no cointegration between their exchange rates and stock prices, but they detected bi-directional causality in Indonesia, Korea, Malaysia and Thailand. Except for Thailand, the stock returns show significantly negative relation with the contemporaneous change in the exchange rates, which implies that currency depreciations generally accompany falls in stock prices. Ibrahim (2000) studies the interactions between the foreign exchange market and the stock market in Malaysia and his results indicate that despite the lack of a long-run relationship between the exchange rate measures and stock prices in bivariate cointegration models, there is evidence of such long-run relations in multivariate models that include M2 money supply and foreign reserves.

Pacific Basin countries were studied by Phylaktis and Ravazollo (2005), which examine the long-run and short-run dynamics between stock prices and exchange rates and the channels through which exogeneous shocks impact on these markets by using cointegration methodology and multivariate Granger causality tests. For the period 1980-1998, their results suggest that these markets are positively related and that the US market acts as a leading factor for these links. Moreover, the links between the stock prices and exchange rates were found to be determined by foreign exchange restrictions. Gunduz and Abdulnasser (2004) investigate the causality between the exchange rates and stock prices in the Middle East and North Africa region before and after the Asian financial crisis and they find uni-directional Granger causality from exchange rates to stock prices for Israel and Morocco before and after the crisis, and for Jordan after the crisis. Additionally, no relationship is identified between the two variables for Egypt. Another interesting research was developed by Murinde and Poshakwale (2004) that investigate price interactions between the foreign exchange market and the stock market in a number of three European emerging financial markets – Hungary, Poland and Czech Republic – before and after the adoption of the euro. Using daily observations on both stock prices and exchange rates, they find that for the pre-euro period stock prices in these countries uni-directionally Granger cause exchange rates only in Hungary, while bi-directional causality relations exist in Poland and Czech Republic. After the euro adoption, exchange rates uni-directionally Granger-cause stock prices in all three countries. The authors interpret these results as being consistent with the dynamic nature of the transition process, suggesting that causality is much easier to detect as the markets become more integrated with the EU.

As observed in the previous research, both nominal and real exchange rates are used in the study of interactions between the foreign exchange market and the stock market. Nominal exchange rates are either bilateral exchange rates of the domestic currencies against the currencies of the country's main trading partners (typically, these currencies are the US dollar or the euro), or nominal effective exchange rates. The nominal effective exchange rate of a country (NEER) or, equivalently, the "trade-weighted currency index" of the country aims to track changes in the value of the country's currency against the currencies of its main trading partners. The real effective exchange rate (or, equivalently, the "relative price and cost indicators") aims to assess a country's competitiveness in terms of prices and costs against its main competitors in international goods and services markets. The existing literature employs a wide range of prices to calculate real effective exchange rates, such as: consumer price index (CPI), GDP deflator, industrial production prices index (PPI), nominal unit labour costs for the total economy or for the manufacturing industries, and the ratio between the prices of tradable and non-tradable goods. As an indicator of international competitiveness, the real effective rate is best to be used over a long-run horizon. Still, despite its widespread use, this indicator has some disadvantages. Specifically, the concept of international competitiveness is difficult to be measured at the economy level, as the indicator does not take fully into account the competition at firm level that includes factors such as product quality, innovation and reputation. Nevertheless, the use of real exchange rates may be explained by the fact that firms' international performances are highly influenced by macroeconomic evolutions, particularly in emerging countries.

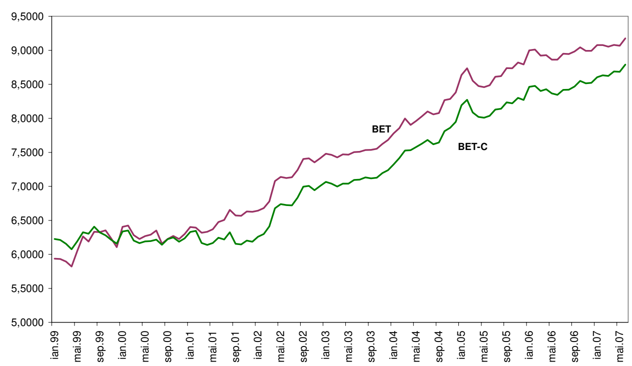
The methodologies used for the computation of the effective exchange rates differ between the International Monetary Fund, European Central Bank and OECD. In our research we have used the rates calculated according to the European Central Bank methodology. Specifically, the NEER is calculated as a weighted geometric average of the bilateral exchange rates against the currencies of trade partner countries and reported as an index; a rise in the index indicates a strengthening of the currency. The REER corresponds to the NEER deflated by nominal unit labour costs for the total economy and consumer prices (CPI/HICP); a rise in the index signifies a loss of competitiveness.

Our research investigates the interactions between the stock prices and the exchange rates for the Romanian market during 1999-2007, with a focus on their dynamics driven by developments on the foreign exchange market after the end of 2004. The paper is structured as follows: Sections 2 and 3 present the data and the research methodology, respectively, Section 4 outlines the main results of our analysis and Section 5 concludes.

2. DATA DESCRIPTION

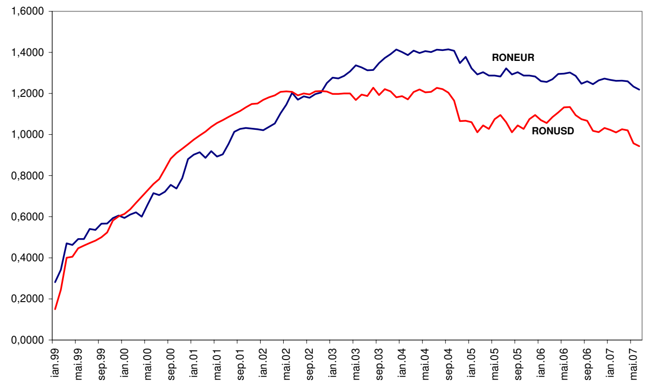
The research we undertook employs two main sets of data over the January 1999 – June 2007 period: on one hand, data on the exchange rate of the Romanian currency, leu (RON), and, on the other hand, data on the Romanian stock exchange performance. In the first set of data we included the bilateral nominal exchange rates of the leu against the US dollar and the euro (RONUSD, RONEUR), as well as nominal effective exchange rates and real effective exchange rates of the leu computed against the euro-13 area countries, the EU-27 member countries and the main 41 trading partners (NEER_EU13, NEER_EU27, NEER_41, REER_EU13, REER_EU27, REER_41). All data were collected on a monthly basis and at the end of period and were retrieved from the Romanian National Bank (bilateral rates) and from the database of the Directorate General for Economic and Financial Affairs of the European Commission. To track the performance of the Romanian stock exchange we used the end of month values of the two indices reported by the Bucharest Stock Exchange, denominated in leu: BET and BET-C. Figures 1 to 3 present the evolution of these indicators over the considered period

Figure-1: BET and BET-C indices of the Bucharest Stock Exchange, January 1999-June 2007 (values as natural logarithms)



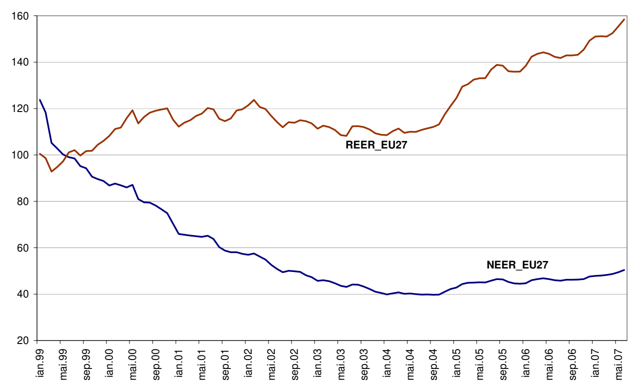
The increase in the overall performance of companies listed on the Bucharest Stock Exchange was obvious during 1999-2007, and particularly after May 2002. Both BET, the first index developed by BSE and considered the reference index for the market, which is calculated as a free float weighted capitalization index of the most liquid 10 companies listed on the BSE regulated market, as well as BET-C, the composite index calculated as a market capitalization index that reflects the price movement of all the companies listed on BSE regulated market, first and second category, excepting the SIFs, increased, with two noticeable picks, one in February 2005 and the other one in February 2006. Their evolution suggests, at the same time, that the market performance is mainly driven by the most liquid 10 stocks, which is quite typical for an emerging market, where the stock markets are concentrated around the most important listed companies.

Figure-2: Exchange rates of Romanian leu against US dollar and euro, January 1999-June 2007 (values as natural logarithms)



The analysis of the bilateral exchange rates against the leu shows the existence of two main sub-periods, both from the euro exchange rate and the dollar exchange rate. The first sub-period extends from January 1999 to October 2004 and is characterised by a depreciation of the leu in nominal terms, while the second covers the November 2004 – June 2007 and indicates an appreciation of the currency in nominal terms. Moreover, the second sub-period sees a higher volatility in exchange rates, as a result of higher capital inflows to Romania and of National Bank's policy directed towards more flexibility in exchange rates that accompanies the shift to the inflation targeting framework for the monetary policy.

Figure-3: Nominal and real effective exchange rates of Romanian leu against EU-27 countries, January 1999-June 2007 (1999 =100)



As indicated by Figure-3, while the NEER_EU27 indicates a strengthening of the leu in nominal terms, the REER_EU27 trajectory tells a different story, as it shows a loss of competitiveness against Romania's trading partners. The real appreciation of the currency was due to a number of specific factors, such as: the increase of capital inflows as result of privatisation transactions, particularly in the utilities sector (energy, oil, gas), the significant number of Romanian citizens employed outside the country that contributes to the financing of Romania's current account deficit, and the use of euro as the major foreign currency on the foreign exchange market after March 2003.

3. RESEARCH METHODOLOGY

Our research objective was directed towards the detection of significant interactions between the stock exchange and the exchange rates, either on a bilateral or multilateral basis. We developed our analysis by using two types of analysis: a cointegration test and a Granger causality test.

The concept of cointegration was first developed by Engle and Granger (1987), which discuss the case of variables that are integrated of order one and are included in a regression. We know that I(1) variables should be differenced before they are used in linear regressions in order to make them I(0), otherwise the regression is spurious. Engle and Granger advanced the idea that sometimes the regression of two I(1) variable might not be spurious, but meaningful, in case the two variables are cointegrated. Generally, if y_t and x_t are two I(1) processes, then, in most of the cases, $y_t - \beta x_t$ is also a I(1) process for any number β. Nevertheless, it is possible that for some $\beta \neq 0$, $y_t - \beta x_t$ is not an I(1), but an I(0) process, with constant mean, constant variance and autocorrelation that depends only on the time distance between any two variables in the series, and it is asymptotically uncorrelated. If such β exists, the series y_t and x_t are said to be cointegrated and β is called the cointegrating parameter. As a result, a regression of y_t on x_t would be meaningful, not spurious.

Economically speaking, cointegration of two variables indicates a long-term or equilibrium relationship between them, given by their stationary linear combination (called the cointegrating equation). We test for the existence of cointegration between the stock market indices and the exchange rates using two methodologies: the one developed by Engle and Granger (1987) and the other one by Johansen (1988) and Johansen and Juselius (1990). The Engle–Granger test is a procedure that involves an OLS estimation of a pre-specified cointegrating regression between indices, followed by a unit root test performed on the regression residuals previously identified. The null hypothesis of no cointegration is rejected if it is found that the regression residuals are stationary. This procedure has some weaknesses, as the test is sensitive to which variable is used as a conditioning left-hand-side variable, which is problematic in the case of more than two variables (Ibrahim: 2000, 40). The Johansen-Juselius procedure is based on the maximum likelihood estimation in a VAR model, and calculates two statistics – the trace statistic and the maximum Eigenvalue – in order to test for the presence of *r* cointegrating vectors. The trace statistic tests the null hypothesis that there are at most r cointegrating vectors against the hypothesis of r or more cointegrating vectors. The maximum Eigenvalue statistics tests for r cointegrating vectors against the hypothesis of r+1 cointegrating vectors. The Johansen-Juselius procedure considers all variables included in the cointegration test as being endogeneous and therefore it avoids the issue of cointegrating vector normalization on one of the variables or of imposing a unique cointegrating vector, as implied in the Engle-Granger test. Beside its ability to determine the number of cointegrating vectors, the Johansen-Juselius procedure is generally considered to have more power than the Engle-Granger test.

The Granger causality test (Granger, 1969) was developed as a more efficient approach as compared to the basic correlation tool, which does not imply causation between correlated variables in any significant sense of the word. The Granger test addresses the issue of whether the current value of a variable y – y_t - can be explained by past values of the same variable – y_{t-k} – and then whether adding lagged values of another variable x – x_{t-k} – improves the explanation of y_t. As such, the variable y is said to be Granger-caused by x if the coefficients on the lagged values of x are found to be statistically significant. The general form of a Granger test is the following:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + ... + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + ... + \beta_k x_{t-k} + \varepsilon_t$$
$$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + ... + a_k x_{t-k} + b_1 y_{t-1} + b_2 y_{t-2} + ... + b_k y_{t-k} + u_t$$

where α_0 and a_0 are the constants, and ε_t and u_t are residuals. The statement "x Granger causes y" does not necessarily imply that y should be seen as the effect or results of x, as the Granger test measures only precedence and information content on variable y, and does not indicate causality in the common sense of the word. The only significant piece of information the Granger test reveals is whether the x variable helps in a better prediction of the y variable.

In our research we performed bivariate Granger causality tests on stock exchange logarithmic returns and first logarithmic differences in exchange rates, using the standard methodology proposed by Granger (1969, 1986) and Engle and Granger (1987). In order to test for Granger causality among the stock market index x_t and exchange rate y_t we estimated the following equations

$$\Delta \ln y_t = c + \sum_{i=1}^{k} \delta_i \Delta \ln y_{t-i} + \sum_{i=1}^{k} \beta_i \Delta \ln x_{t-i} + \varepsilon_t$$
$$\Delta \ln x_t = g + \sum_{i=1}^{k} \phi_i \Delta \ln x_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta \ln y_{t-i} + \omega_t$$

and performed an F test for joint insignificance of the coefficients β_i and γ_i, i=1…k. The null hypothesis was that x_t does not Granger cause y_t or y_t does not Granger cause x_t. Therefore, when the null hypothesis is rejected this indicates a presence of Granger causality. For each pair of stock market index and exchange rate we performed two Granger causality tests in order to identify unilateral causation (x_t causes y_t *or* y_t causes x_t), bilateral causation (x_t causes y_t *and* causes x_t) or no causation.

The effective application of the Granger test raises a number of issues that are critical for the significance of the test's results. The first issue is related to the number of lags used in the OLS regressions, since the test's results are highly sensitive on this number (Gujarati, 2003; Hamilton, 1994; Wooldridge, 2006). Various approaches towards the finding of the critical lag are proposed (see Cerny, 2004; Wooldridge, 2006; Foresti, 2006; Murinde and Poshakwale, 2004), that are more or less of the "trial and error" type. The method we used relied on the estimation of an autoregressive model for each variable and using various lag length selection criteria to determine how many lags should appear in the Granger equation. The criteria used are standard in the literature: LR – sequential modified LR test statistic, FPE – Final prediction error, AIC – Akaike information criterion, SC – Schwarz information criterion, and HQ – Hannah-Quinn information criterion. Since the number of lags indicated by these different criteria was sometimes different for the same variable, we performed the Granger causality tests for all length that were found significant by any of the above-mentioned criteria.

The second issue is linked to the specification of the Granger causality tests. As shown by MacDonald and Kearney (1987), Miller and Russek (1990) and Lyons and Murinde (1994), the Granger causality tests are well specified if they are applied in a standard vector autoregressive form to first differenced data only for non-cointegrated variables. Statistically, the presence of cointegration excludes non-causality between the variables under consideration. Therefore, if two variables are found to be cointegrated, then there must be causality in the Granger sense between them, either uni-directionally or bi-directionally. In such a case, the Granger test can be correctly specified by including in the equation referring to two cointegrated variables an error correction (EC) term, representing the residuals from the cointegrating regression. The general form of the equation we used is

$$\Delta \ln y_t = c + \sum_{i=1}^{k} \delta_i \Delta \ln y_{t-i} + \sum_{i=1}^{k} \beta_i \Delta \ln x_{t-i} + \lambda_i EC_{t-1}^{y/x} + \varepsilon_t$$

$$\Delta \ln x_t = g + \sum_{i=1}^{k} \phi_i \Delta \ln x_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta \ln y_{t-i} + \mu_i EC_{t-1}^{x/y} + \omega_t$$

where y_t and x_t are two cointegrated variables, while $EC^{y/x}_{t-1}$ and $EC^{x/y}_{t-1}$ are the residuals from the cointegrating regressions where y_t was the dependent variable and x_t the independent variable and vice versa. In such a test, the EC term indicates the adjustment of the dependent variable to the lagged deviations from the long-run equilibrium path. If the coefficient attached to the EC term is statistically significant, it means that the dependent variable adjusts towards its long-run level. For this test we also used the various information criteria to indicate for the number of lags to be introduced in the regression.

Given the fact that exchange rates evolution indicated a change in trend after the end of 2004, we split the entire period (January 1999 – June 2007) in two sub-periods (January 1999 – October 2004 and November 2004 – June 2007) and performed the cointegration and Granger causality tests for the entire period and for each of the sub-periods, in order to identify potential changes in the behaviour of these variables after the introduction of a more flexible exchange rate regime at the beginning of 2005.

3. RESULTS

Before specifying any cointegration or Granger causality test, we test for unit root in the indices and exchange rates levels, as well as in first differences. Table 1 exhibits the results of the Augmented Dickey-Fuller (ADF) terms of t-statistic for the indices levels and first differences. The ADF tests involved the estimation of the following regression

$$\Delta x_t = \alpha + \beta t + \delta x_{t-1} + \sum_{i=1}^{k} \Delta x_{t-1} + \varepsilon_t$$

where *x* is the variable under consideration. As one may observe, the levels are non-stationary, while the first differences are stationary at the 1% statistical significance level. Consequently, we proceed with the development of the cointegration test for levels of variables and afterwards with the Granger causality test for their first differences.

The next step consisted in carrying out a pairwise cointegration test, first by applying the Engle-Granger methodology, and second by employing the Johansen-Juselius procedure. Using the Engle-Granger methodology, we estimate a simple linear relationship between pairs of time series represented by the each of indices levels (y_t), on one hand, and by each of the exchange rates (x_t), on the other hand, as follows:

$$\ln y_t = c_1 + \alpha \ln x_t + e_t$$
$$\ln x_t = c_2 + \alpha \ln y_t + u_t$$

Table-1: Unit root tests, January 1999 – June 2007

	ADF test results on levels		*ADF test results on first differences*	
	t-statistic	*p-value*	*t-statistic*	*p-value*
BET	-2.6256	0.2701	-8.8465	0.0000
BET_C	-2.41198	0.3712	-9.0592	0.0000
NEER_41	-1.1587	0.9129	-7.8949	0.0000
NEER_EU13	-0.7558	0.9655	-7.7276	0.0000
NEER_EU27	-1.3837	0.8600	-7.7865	0.0000
REER_41	-1.4109	0.8520	-7.9081	0.0000
REER_EU13	-1.2903	0.8846	-7.5203	0.0000
REER_EU27	-0.8519	0.9565	-7.6155	0.0000
RONEUR	-1.2174	0.9012	-10.2273	0.0000
RONUSD	-3.2978	0.0725	-9.2651	0.0000

Then, we apply the ADF test to the estimated residuals e_t and u_t from each of the above equations, which means we estimate the equations

$$e_t = c + \delta e_{t-1} + \varphi t + \sum_{i=1}^{k} \phi_i \Delta e_{t-1} + \varepsilon_t$$

$$u_t = h + \lambda u_{t-1} + \beta t + \sum_{i=1}^{k} \eta_i \Delta u_{t-1} + \upsilon_t$$

In case the time series of the residuals ε_t is stationary, we claim that the stock market indices y_t and the exchange rate x_t are cointegrated. Otherwise, the residuals ε_t are non-stationary and no cointegration relationship is detected. Cointegration between the variables x_t and y_t indicates the presence of a long run equilibrium relationship represented by the linear relation between them. At the same time, the presence of a cointegrating relationship among the variables indicates that performing a Granger causality test in a standard form is useless, since at least a unidirectional causality between them should exist.

The results of the test using the Engle-Granger methodology indicated that no cointegration exists between the variables, as all the residuals from the previous regressions were found to be non-stationary for the entire period and for the two sub-periods. Therefore, we tried to see whether this result is confirmed by Johansen-Juselius methodology; the results of the tests are presented in Table 2. Our results suggest the presence of cointegration between the two stock market indices and the exchange rates, either nominal bilateral, nominal effective or real effective rates. What is interesting is that none of the cointegrating relations found for the entire period is also discovered for at least one of the sub-periods. For the overall interval, both the trace and the eigen-value statistics indicate cointegration between BET and two of the nominal effective rates (NEER_41 and NEER_EU13), as well as between BET and the real effective exchange rate against the EU-27 partners (REER_EU27). The other stock exchange index, BET-C, is found to be cointegrated with the nominal effective rate against Romania's main 41 trading partners (NEER_41) and with the bilateral RONEUR exchange rate. No cointegration is detected between this index and one of the real exchange rates. For the first sub-period, January 1999 – October 2004, only one cointegrating relation is found, between BET and the bilateral RONUSD exchange rate, while for the second sub-period both indices are cointegrated with a real effective exchange rate (REER_EU13).

Table-2: Cointegrating relations between stock market indices and exchange rates (4 lags)

January 1999 – June 2007			*January 1999 – October 2004*			*November 2004 – June 2007*		
	Trace	*Eigen*		*Trace*	*Eigen*		*Trace*	*Eigen*
BET – NEER_41	29.31**	22.28**	BET - RONUSD	33.93*	28.77*	BET – REER_EU13	25.44**	18.55***
BET – NEER_EU13	29.46**	22.46**				BET_C – REER_EU13	27.68**	17.74
BET – REER_EU27	30.15**	23.15**						
BET_C – NEER_41	31.60**	23.47**						
BET_C – RONEUR	26.06**	18.60***						

Note: * indicates significance at 1% level, ** at 5% level and *** at 10% level

As mentioned above, we performed Granger standard tests on non-cointegrated variables and modified tests on cointegrated variables after deciding on the number of lags identified by the use of a VAR test. A number of information criteria on the number of lags were used and the lags indicated by each of them are presented in Table 3. When all criteria indicated that an autoregressive model cannot be applied to the time series, we did not perform the Granger test with this variable considered as dependent: this occured for the REER_41 and REER_EU27 for the first sub-period and for the BET, BET_C and RONUSD for the second sub-period.

Table-3: Lag length selection results

	January 1999 – June 2007	*January 1999 – October 2004*	*November 2005 – June 2007*
BET	0 lags – SC 2 lags – LR, FPE, AIC, HQ	0 lags – SC 2 lags – LR, FPE, AIC, HQ	0 lags – FPE, AIC, SC, HQ
BET_C	0 lags – SC, HQ 2 lags – FPE, AIC	0 lags – SC, HQ 2 lags – FPE, AIC	0 lags - FPE, AIC, SC, HQ
NEER_41	1 lag – FPE, AIC, SC, HQ 7 lags – LR	0 lags – SC, HQ 1 lag – FPE, AIC	1 lag – SC, HQ 2 lags – FPE, AIC 10 lags - LR
NEER_EU13	1 lag – SC, HQ 6 lags – LR 7 lags – FPE, AIC	0 lags – SC 1 lag – FPE, AIC, HQ	1 lag – LR, FPE, AIC, SC, HQ
NEER_EU27	1 lag – SC, HQ 6 lags – LR 7 lags – FPE, AIC	1 lag – FPE, AIC, SC, HQ	1 lag – FPE, AIC, SC, HQ 10 lags – LR
REER_41	1 lag – LR, FPE, AIC, SC, HQ	0 lags –FPE, AIC, SC, HQ	1 lag – HQ 2 lags – SC, HQ 10 lags – LR
REER_EU13	1 lag – LR, FPE, AIC, SC, HQ	0 lags – SC, HQ	1 lag – LR, FPE, AIC, SC, HQ

		1 lag – FPE, AIC	
REER_EU27	1 lag – LR, FPE, AIC, SC, HQ	0 lags – FPE, AIC, SC, HQ	1 lag – LR, FPE, AIC, SC, HQ
RONEUR	0 lags – SC, HQ 7 lags – LR, FPE, AIC	0 lags – FPE, AIC, SC, HQ 5 lags - LR	0 lags – SC, HQ 1 lag – FPE, AIC
RONUSD	1 lag – SC 2 lags – HQ 9 lags – LR, FPE, AIC	2 lags – SC 5 lags – LR, FPE, AIC, HQ	0 lags – FPE, AIC, SC, HQ

The results of the Granger tests performed on non-cointegrated variables are shown in Table-4. We report only the Granger causality relations identified as statistically significant.

Table-4: Bivariate causality results on non-cointegrated variables

January 1999 – June 2007	
Null hypothesis	*F-statistic*
BET dnc RONUSD	3.2705*** [1]
BET_C dnc NEER_EU13	2.9270*** [1]
BET_C dnc NEER_EU27	3.1249*** [1]
BET_C dnc RONUSD	5.5361** [1]
BET dnc RONUSD	2.5454*** [2]
BET_C dnc RONUSD	3.5671** [2]
January 1999 – October 2004	
Null hypothesis	*F-statistic*
BET_C dnc RONUSD	3.0.3474 [2]
RONUSD dnc BET_C	3.3625** [2]
November 2005 – June 2007	
Null hypothesis	*F-statistic*
BET dnc NEER_41	7.7095* [1]
BET dnc NEER_EU13	8.1231* [1]
BET dnc NEER_EU27	7.8902* [1]
BET dnc REER_41	3.3904*** [1]
BET dnc RONEUR	9.5728* [1]
BET_C dnc NEER_41	9.9490* [1]
BET_C dnc NEER_EU13	9.9722* [1]
BET_C dnc NEER_EU27	9.6242* [1]
BET_C dnc REER_41	4.4096** [1]
BET_C dnc REER_EU27	3.0129*** [1]
BET_C dnc ROEUR	7.3393* [1]
BET_C dnc NEER_41	4.6294** [2]

Note: *, ** and *** indicate significance at 1%, 5% and 10%, respectively. The numbers in squared brackets indicate the number of lags of the causal variable used in the Granger test.

The results of the Granger tests are interesting from a number of perspectives. First, the causation is present mostly when the entire period is used and in the second sub-period, while only a bidirectional causation is identified in the first sub-period. The lack of causality in the first sub-period might be explained by the control exercised by the Romanian National Bank on the exchange rate in the framework of an interventionist managed float currency regime. The higher flexibility permitted for the exchange rate after the end of 2004, coupled with the adoption of the inflation targeting framework for monetary policy can explain the higher number of causality relations discovered in the second sub-period. Second, all causality relations indicate the stock market is the leading variable for the exchange rates, with the exception of the first sub-period, when the causality goes from the exchange rate (RONUSD) to the stock market (BET_C) and vice versa. The null hypothesis of no causation from the stock prices to the exchange rates is rejected at conventional levels of significance. Moreover, all exchange rates are involved in the causality relations: bilateral rates, nominal effective rates and real effective rates.

We turn next to the results of modified Granger causality tests on cointegrated variables, that include an error correction terms indicated the adjustment of the dependent variable to the lagged deviations from the long-run equilibrium path. If the coefficient of the EC term is statistically significant, it means that the dependent variable adjusts towards its long-run level in the next month. For this test we used the various number of lags indicated in Table-2. We report the findings in form of F-statistic and error correction coefficient in Table-5.

Table-5. Modified bivariate Granger causality tests results

Null hypothesis	*F-statistic*	*Error correction coefficient* (t-statistic)
	January 1999 – June 2007	
NEER_41 dnc BET	1.9204*** [2]	-1.7119*** (0.0902)
BET dnc NEER_41	1.8967 [1] 0.5900 [7]	1.7142*** (0.0897) 1.5627 (0.1121)
NEER_EU13 dnc BET	2.0158*** [2]	-1.8679*** (0.0649)
BET dnc NEER_EU13	1.8593 [1] 0.5689 [6] 0.5585 [7]	1.6109 (0.1104) 1.4193 (0.1596) 1.4012 (0.1651)
REER_EU27 dnc BET	2.0376*** [2]	-1.6985*** (0.0927)
BET dnc REER_EU27	1.2295 [1]	1.4682 (0.1453)
NEER_41 dnc BET_C	1.3446 [2]	1.8004*** (0.0750)
BET_C dnc NEER_41	1.9235 [1] 0.6832 [7]	1.6904*** (0.0942) 1.8088*** (0.0743)
RONEUR dnc BET_C	1.3023 [2]	1.6784*** (0.0966)
BET_C dnc RONEUR	0.3395 [7]	-1.3135 (0.1928)
	January 1999 – October 2004	
RONUSD dnc BET	2.9902 [2]	-0.5544 (0.5813)
BET dnc RONUSD	2.3422 [2] 1.7369 [5]	0.0592 (0.9530) -0.3655 (0.7162)
	November 2004 – June 2007	
BET dnc REER_EU13	1.5134 [1]	1.8411 (0.0766)
BET_C dnc REER_EU13	0.8011 [1]	1.1515 (0.2596)

Note: *, ** and *** indicate significance at 1%, 5% and 10%, respectively. The numbers in squared brackets indicate the number of lags of the causal variable used in the Granger test. The numbers in round brackets indicate the p-value for the t-statistic.

In the Granger sense, the results do not confirm the previous findings that stock prices are the leading variables for the exchange rates. On the contrary, but only for the entire period, the modified tests indicate that exchange rates are leading variables for the stock prices. Two of the nominal effective exchange rates (NEER_41 and NEER_EU13) as well as one of real effective exchange rate (REER_EU27) have explanatory power for the current values of the BET, but only at 10% significance level.

The coefficients of the error correction terms, which represent an additional channel of causality, validate the previous findings of cointegration between the variables. We find that the stock market adjusts to correct for disequilibrium, but quite dramatically, as coefficients that are statistically significant have values below -1 or above 1. These results might be a sign of an over-reaction of the stock market to shocks in the exchange rates, which goes beyond the correction of the stock market to the long-run equilibrium with exchange rates.

4. CONCLUDING REMARKS

The study uses standard bivariate cointegration tests, using both the Engle-Granger and the Johansen-Juselius methodology, as well as standard and modified Granger causality tests to explore the interactions between exchange rates and stock market prices applied to Romania, one of the emerging economies in Central and Eastern Europe and a new member of European Union since January 2007. In the analysis, three types of exchange rates of the Romanian currency are used: bilateral rates against the euro and the US dollar, effective nominal rates and real effective rates. The two indices of the Bucharest stock exchange were capturing the evolution of stock prices. The analysis involved the January 1999 – June 2007 period, but also two sub-periods (January 1999 - October 2004 and November 2004 – June 2007) to take into account the alteration of the Romanian foreign exchange market occurring after the end of 2004.

The procedures employed for the cointegration results offer contradictory results. While the application of the Engle-Granger methodology indicates no cointegration between the exchange rates and the stock prices, the use of the Johansen-Juselius procedure suggests the presence of cointegration between the two stock market indices and the exchange rates, either nominal bilateral, nominal effective or real effective rates. At the same time, cointegration is identified only for the entire period considered. The lack of cointegration indicated by the Engle-Granger procedure may be due to the lower power of the test, as recognized in the literature.

When standard Granger causality test were performed on non-cointegrated variables, we identified unilateral causality relations from the stock prices to exchange rates for the entire period and the second sub-period, and one bilateral causality relation between the stock prices and the bilateral exchange rate against the US dollar for the first sub-period.

The lack of causality in the first sub-period might be explained by the control exercised by the Romanian National Bank on the exchange rate, while the higher flexibility in the exchange rate after the end of 2004 in the context of an inflation targeting framework can explain the higher number of causality relations found in the second sub-period. The results of modified Granger tests indicate that exchange rates are the leading variables for the stock prices and that the stock market adjusts quite dramatically to changes in the exchange rates in one month time. The magnitude of adjustment might indicate even an over-reaction of the stock market to developments on the foreign exchange market, which points toward a central role played by the exchange rate in the Romanian economy, on one hand, and in the decision of players in the stock market, on the other hand.

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