Linkages between Stock Prices and Exchange Rates in the EU and the United States

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Abstract

This paper investigates the nature of the causal relationship between stock prices and effective exchange rates in four old EU-member countries (Austria, France, Germany, and the UK), four new EU-member countries (Czech Republic, Hungary, Poland, and Slovakia) and in the USA. Both the long-run and short run causalities between these variables are explored using monthly data. Cointegration analysis, vector error correction modeling and standard Granger causality test are employed to examine whether stock prices and exchange rates are related to each other or not and what kind of causality direction exist. The paper also tries to answer the question whether the linkages between analyzed economic variables are of the similar intensity and direction in the old and new part of the EU and how is the relationship changing over the analyzed period. The results show much stronger causality in countries with developed capital and foreign exchange markets (old EU-member countries and the USA) than in the new-comes. Evidence also suggests more powerful long-run as well as short-run causal relations in the period 1993-2003 than during 1970-1992. Causalities seem to be predominantly unidirectional with a direction running from stock prices to exchange rates. Finally, we also detected the real effective exchange rate as a more suitable variable than nominal effective exchange rate for such kind of analysis.

Keywords Stock Prices; Exchange Rates; Causality Analysis; European Union

JEL classification C32, G15

This version April 28, 2004

*The paper was prepared due to support of the Grant Agency of the Czech Republic.
Project No. GAČR 402/02/1408 "Comparison of financial markets development in the Czech Republic and in the European Union"*

1. INTRODUCTION

Mutual relations between foreign exchange markets and stock markets have attracted much attention of researchers and academics since the beginning of 1990s. The last quarter of a century has witnessed significant changes in the international financial system such as emergence of new capital markets, gradual abolishment of capital inflows barriers and foreign exchange restrictions, or adoption of more flexible exchange rate arrangements in emerging and transition countries. All mentioned features have broadened the variety of investment opportunities but, on the other hand, they have also increased volatility of exchange rates and added a substantial portion of risk to the overall investment decision and portfolio diversification process. Studying of interaction between foreign exchange and stock markets has become thereby more complex and has received more research interest than before.

There is theoretical consensus neither on the existence of relationship between stock prices and exchange rates nor on the direction of the relationship. Considering "flow-oriented" models and "stock-oriented" models as two basic approaches to the exchange rate determination, a cardinal disagreement can be found. Flow models assume that the exchange rate is determined largely by a country's current account or trade balance performance. These models posit that changes in exchange rates affect international competitiveness and trade balance, thereby influencing real economic variables such as real income and output (Dornbusch and Fisher, 1980). Stock prices, usually defined as a present value of future cash flows of firms, should adjust to the economic perspectives. Thus, flow oriented models represent a positive relationship between stock prices and exchanges rates with direction of causation running from exchange rates to stock prices.[1] The conclusion about positive relationship stems from the assumption of direct exchange rate quotation using.[2]

On the other hand, stock oriented models put much stress on the role of financial (formerly capital) account in the exchange rates determination. These models can be

[1] Causation can be explained as follows: domestic currency depreciation makes the local firms more competitive, making their exports cheaper in international comparison. Higher exports lead to higher incomes and increase in firms' stock prices.

[2] Direct quotation defines exchange rate as the price of one unit of foreign currency in domestic currency terms. Thus domestic currency depreciation means raise (increase) in exchange rate.

distinguished on portfolio balance models and monetary models. Portfolio balance models postulate a negative relationship between stock prices and exchange rates and come to the conclusion that stock prices have an impact on exchange rates.[3] Such models presume an internationally diversified portfolios and the role of exchange rates to balance the demand for and the supply of domestic as well as foreign assets. A rise in domestic stocks prices leads to the appreciation of domestic currency through direct and indirect channel. A rise in prices encourages investors to buy more domestic assets selling simultaneously foreign assets to obtain domestic currency indispensable for buying new domestic stocks. Described shifts in demand and supply of currencies cause domestic currency appreciation. The indirect channel grounds in the following causality chain. An increase in domestic assets prices results in growth of wealth, which leads investors to increase their demand for money, which in turn raises domestic interest rates. Higher interest rates attract foreign capital and initiate an increase in foreign demand for domestic currency and its subsequent appreciation. According to monetary approach an exchange rate is the price of an asset (one unit of foreign currency) and therefore the actual exchange rate has to be determined by expected future exchange rate similarly like prices of other assets.[4] The only factors influencing the actual exchange rate are those which affect future value of exchange rate. Since developments of stock prices and exchange rates may be driven by different factors the asset market approach emphasizes no linkage between stock prices and exchange rates.[5]

As theoretical economics as well as empirical researchers are far from any consensus related to the interactions between stock markets and foreign exchange markets it is advisable to carry out further tests and analysis of this kind of issue. However, this paper is mainly motivated by some other aspects. The vast majority of already done empirical research has been focused on developed countries and on the USA above all. A wave of currency and financial crises in 1990s redirected an interest to the emerging economies suffering from the crises' consequences, too. The European

[3] For more about portfolio balance approach see Frankel (1983) or Branson and Henderson (1985).

[4] More details about basic asset market models are given in Frenkel (1976), Dornbusch (1976), and Frankel (1979). For comprehensive review of asset market models see for instance MacDonald and Taylor (1992).

[5] If there are some common factors that affect both stock prices and exchange rates (such as interest rates) then we might expect an association between these two variables.

continent generally and region of the Central and Eastern Europe principally have been neglected so far. Concentration of our study on four old and four new EU-member countries along with the USA may provide another insight into the issue. Moreover, our motivation is strengthened by the enlargement of the EU which took place on May 1, 2004. Ten countries joined the EU, which opened a space for comparison with the old member countries in many characteristics. The main purpose of this paper is to detect whether there have been any relationships between stock prices and exchange rates in the old and some new members of the EU and to realize what kind of causality prevail in the case of its existence. The paper also tries to answer the question whether the linkages between analyzed economic variables are of the similar intensity and direction in the old and new part of the EU and in the USA. All studies use either nominal or real exchange rates but they do not employ both into analysis with the same data on stock prices. Since we perceive the differences between the development of nominal and real exchange rates, mainly in transition countries, as significant this paper is the first attempt to evaluate the causalities using two types of exchange rates simultaneously.

In order for our purposes to be accomplished, this study proceeds as follows. The next section presents review of relevant empirical literature. Section 2 explains methodological issues and describes data employed. Section 3 contains empirical results and the last section discusses findings and summarizes the conclusions.

2. REVIEW OF RELEVANT LITERATURE

Early studies estimating relationship between stock prices and exchange rates considered only simple regression and the correlation between the two variables. The first study was the paper by Franck and Young (1972). They pointed out no significant interaction. The first stage of the post-Brettonwood system, characteristic by more volatile exchange rates, was firstly taken into estimation in Aggarwal (1981). He found a positive correlation between effective exchange rate of the US dollar and changes in indices of US stock prices for the period 1974-78. Giovannini and Jorion (1987) also detected empirical regularities between exchange rates and stock markets in the USA.

On the other hand, next studies from the “pioneer” era came to different conclusions. For instance Solnik (1987) analyzed influence of several economic variables including exchange rate on stock prices in nine industrialized countries. Changes in exchange rate proved to be non-significant factor in explaining development of stock prices. Jorion (1990) found moderate relations between stock returns of US multinational companies and the effective US dollar exchange rate for the period 1971-87. On the contrary, Soenen and Hennigan (1988) reported strong negative interaction using monthly data of the US dollar effective exchange rate and US stock market index during 1980-86. Ma and Kao (1990) explained differences among countries by the nature of their economies, primarily by the export or import orientation.

Empirical work from the early stage was focused on the linkage between the returns in the stock and foreign exchange markets and did not use the levels of the series. Such a limitation was due to econometric assumptions about insufficient stationarity of financial data series. Stationarity is strictly required in regression analysis to avoid spurious inferences. By differencing the variables some information regarding a possible linear combination between the levels of the variables may be lost. The use of cointegration technique overcomes the problem of nonstationarity and allows an investigation in both the levels and differences of exchange rates and stock prices (Phylaktis and Ravazzolo, 2000).

Bahmani-Oskooee and Sohrabian (1992) were among the first to use cointegration and Granger causality to explain the direction of mutual relationship between the two variables. They employed monthly data on S&P 500 index and US dollar effective exchange rate for the period 1973-88 and showed bidirectional causality, at least in the short run. Since then many other papers investigating these aspects in various countries have applied these econometric procedures and have reported very mixed and diverse results. Ajayi and Mougoue (1996) observed significant interactions in eight industrial economies during 1985-91. More concretely, they revealed a negative short-run and positive long-run effect of increase in domestic stock prices on domestic currency value. However, currency depreciation influences the stock market in a negative way in the short-run.

Yu (1997) employed daily data on markets of Hong Kong, Tokyo, and Singapore for the period 1983-94 and detected bidirectional relationship in Tokyo, no causation for the Singapore market and causality running from changes in exchange rates to changes in stock prices. Abdalla and Murinde (1997) applied cointegration approach to examine stock prices – exchange rates relationship in four Asian countries using data form 1985 to 1994. Their results reject an occurrence of causality in Pakistan and Korea but support its existence in Indian and Philippines. However, the direction is not similar. While results for India show causality from exchange rates to stock prices, the reverse causation was found for Philippines. Bhattacharya and Mukherjee (2003) investigated the nature of the causal relationship between stock prices and macroeconomic aggregates in the foreign sector including exchange rate in India and found no significant linkage. Muhammad and Rasheed (2003) used monthly data on four South Asian countries for the period 1994-2000. They concluded that there is no relationship between exchange rates and stock prices in Pakistan and India either in short-run or in long-run. Markets in Bangladesh and Sri-Lanka appeared to be bidirectionaly linked.

Some studies have focused on particular industries rather than on the whole economy. Chamberlain *et al.* (1997) reported that US banking stock returns were very sensitive to exchange rates but those of Japanese banks were not. Griffin and Stulz (2001) noted that changes of weekly exchange rates had neglible impacts on industry stock indices in developed countries. Rim and Mohidin (2002) examined relations between industry indices and exchange rates using monthly data before and during the Asian financial crisis. Results show that industry indices had long-run positive effects on exchange rate, and exchange rate also had long-run positive effects on most indices. Short-run effects proved to be generally negative in both directions.

Ajayi *et al.* (1998) provided evidence to indicate unidirectional causality from the stock to the foreign exchange markets for the advanced economies (USA, Korea) and no consistent causal relations in the emerging markets (Malaysia). Pan *et al.* (2000) noted that exchange rates had significant effects on stock prices in seven Asian countries during 1988-98. They reported much stronger interaction during and after financial crisis in 1997, which corresponds with conclusions of Granger *et al.* (2000). They investigated the relation during the Asian crisis period and detected in general some feedback reaction. Phylaktis and Ravazzolo (2000) analyzed a group of Pacific Basin countries over the period 1980-98 and their results suggest that stock and foreign exchange markets are positively related and that the US stock market acts as a conduit for these links. Ramasamy and Yeung (2001) considered causality between the two markets in nine East Asian economies and realized that the direction of causality can vary according to the period of study. For the period of the entire four years of the crisis (1997-2000) all countries, apart from Hong Kong, showed that stock prices cause movements in the exchange rates. Results on Hong Kong indicate bidirectional causality.

3. METHODOLOGY AND DATA

Thirty years ago, Granger and Newbold (1974) firstly pointed out that using non-stationary macroeconomic variables in time series analysis causes superiority problems in regression. The issue of unit root of such variables was empirically demonstrated in Nelson and Plosser (1982) and since than this important property of macroeconomic and financial data series has been generally accepted. Many studies[6] have lately shown that majority of time series variables are non-stationary or integrated of order 1.[7] Thus, a unit root test should precede any empirical study employing such kind of variables. There have been variety of proposed methods for implementing stationarity test and principally Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test have been widely used in econometric literature.[8] The ADF test can be run as showed below:

$$\Delta y_t = \alpha + \beta t + (\rho - 1) y_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta y_{t-1} + \varepsilon_t \tag{1}$$

where $\Delta = 1 - L$ y_t is a macroeconomic variable such as exchange rate or stock price; t is a trend variable; ε_t is a white noise term and k is the lagged values of y_t that are included to allow for serial correlation in the residuals. The null hypothesis is H_0: $\rho = 1$ and y_t is said to possess the unit root property if one fails to reject H_0.

A unit root can be alternatively tested by the PP test that is, like the ADF test, a test of the hypothesis H_0: $\rho = 1$ in the equation:

$$\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t \tag{2}$$

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[6] For instance Engle and Granger (1987).

[7] Time series variable is integrated of order 1 if its changes are stationary.

[8] ADF test is based on the results by Dickey and Fuller (1979) and PP test grounds in Philips and Perron (1988).

Unlike the ADF test, there are no lagged difference terms. Instead, the equation is estimated by OLS (with optional inclusion of constant and time trend) and then the *t*-statistic of the coefficient is corrected for serial correlation in t. Also this study, as a first step, executes both unit root tests to investigate whether the time series of exchange rates and stock prices are stationary or not.

If the series under consideration turn out to be integrated of the same order, it is possible to proceed testing for cointegration relationship between the integrated variables. In this paper, cointegration tests were carried by means of the method developed by Johansen (1988) and Johansen and Juselius (1990) The Johansen method applies the maximum likelihood procedure to determine the presence of cointegrating vectors in non-stationary time series as a vector autoregressive (VAR):

$$\Delta Z_t = C + \sum_{i=1}^{K} \Gamma_i \Delta Z_{t-1} + \Pi Z_{t-1} + \eta_t \qquad (3)$$

where Z_t is a vector of non-stationary (in log levels) variables and C is the constant term. The information on the coefficient matrix between the levels of the Π is decomposed as $\Pi = \alpha\beta'$ where the relevant elements the α matrix are adjustment coefficients and the β matrix contains the cointegrating vectors. Johansen and Juselius (1990) specify two likelihood ratio test statistics to test for the number of cointegrating vectors. The first likelihood ratio statistics for the null of exactly r cointegrating vectors against the alternative r+1 vectors is the maximum *eigenvalue statistic*. The second statistic for the hypothesis of at most r cointegrating vectors against the alternative is the *trace statistic*. Critical values for both test statistics are tabulated in Johansen and Juselius (1990).

If the variables are non-stationary and are cointegrated, the adequate method to examine the issue of causation is the Vector Error Correction Model (VECM), which is a Vector Autoregressive Model (VAR) in first differences with the addition of a vector of cointegrating residuals. Thus, this VAR system does not lose long-run information. In the absence of any cointegrating relationship between the variables, the standard Granger causality test based on Granger (1988) would be applied. The Granger test involves the estimation of the following equations:

$$\Delta y_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \qquad (4)$$

$$\Delta y_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \quad (5)$$

in which y_{1t} and y_{2t} represent stock prices and exchange rates. Failing to reject the H_0: $\alpha_{21} = \alpha_{22} = ... = \alpha_{2k} = 0$ implies that exchange rates do not Granger cause stock prices. Likewise, failing to reject H_0: $\beta_{11} = \beta_{12} = ... = \beta_{1k} = 0$ suggest that stock prices do not Granger cause exchange rates.

If cointegration exists between y_{1t} and y_{2t}, the VECM is required in testing Granger causality as shown below:

$$\Delta y_{1t} = \alpha_0 + \delta_1 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \quad (6)$$

$$\Delta y_{2t} = \beta_0 + \delta_2 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \quad (7)$$

in which δ_1 and δ_2 denote speeds of adjustment. According to Engle and Granger (1987), the existence of the cointegration implies a causality among the set of variables as manifested by $|\delta_1|+|\delta_2|>0$. Failing to reject H_0: $\alpha_{21} = \alpha_{22} = ... = \alpha_{2k} = 0$ and $\delta_1 = 0$ implies that exchange rates do not Granger cause stock prices while failing to reject H_0: $\beta_{11} = \beta_{12} = ... = \beta_{1k} = 0$ and $\delta_2 = 0$ indicates stock prices do not Granger cause exchange rates.

Four old, four new EU-member countries, and the USA were selected for the empirical analysis. Since all countries under estimation are open economies with foreign trade and investment relations with many different countries and currency areas we consider effective exchange rate as more appropriate than bilateral exchange rate for such kind of analysis. As mentioned above, one of the aims of this paper is to show differences in results using real exchange rate (REER) and nominal exchange rate (NEER). Therefore, monthly data on both types of exchange rate for all countries were employed and derived from the IMF International Financial Statistics. Development of prices on local stock markets is embodied by monthly data on stock indices. As we foresaw problems stemming from the non-consistent construction of the local stock indices and differences in the techniques of their definition and calculation, we decided to use national stock indices based on a uniform methodology. Thus, we used the MSCI Standard National Indices expressed in local currencies provided by Morgan Stanley.[9]

[9] MSCI Index for Slovakia was substituted by the SAX – official index of the Bratislava Stock Exchange.

The sample period varies for each country depending on availability of data. Regarding NEER, for Austria, France, Germany, UK, and the USA the sample period is 1969:12-2003:12; for Poland 1993:12-2003:12; for the Czech Republic 1994:12-2003:12; for Hungary 1995:01-2003:12; and for Slovakia 1995:06-2003:12. Considering REER the sample period for the first group of the countries is smaller, particularly 1978:01-2003:12. The sample period for the new-member countries is of the absolutely same length like in the NEER case. To check for possible changes in intensity or direction of mutual relationships during the time and to overcome disproportion in the length of data on old and new EU-member countries, we divided the whole analyzed period into two sub-intervals. The first period covers the time 1969:12(1978:01)-1992:12 and data strictly on developed economies. The second period includes data on all analyzed countries taken from the time interval 1993:01-2003:12.

4. EMPIRICAL RESULTS

4.1 Test for Stationarity and Cointegration Analysis

As a first step in analysis we transformed all time series into natural logarithm values. Thus, first differences correspond to growth rates. Consequently we tested for unit roots in all stock market indices and the NEER and REER for both periods. We used the ADF test with and without trend as recommended by Engle and Granger (1987) and backed up their results by the PP test again with and without trend.[10] The lag length and bandwith in the unit root test were allowed to vary across individual countries so as to mop up any residual serial correlation. The optimal number of lags was chosen according to Schwartz Info Criterion (SIC) and the bandwith was based on Newey-West using Barlett kernel spectral estimation method. To conserve the space the results are not reported here but may be obtained from the author upon request.

Considering stock market indices we found that the null hypothesis of a unit root in levels must be accepted in all cases. However, it can be rejected for all series considering the first differences. NEER turned out to be integrated of order 0 in two

[10] Identical results of all four alternative tests were needed to conclude about stationarity of any time series. If even one test showed non-stationarity, the time series was treated as non-stationary.

countries (Hungary and Poland).[11] The rest of NEER time series are integrated of order 1. ADF and PP tests led to acceptation of the null hypothesis of a unit root in REER levels in all countries which means that all REER time series are stationary at first differences. Summarizing all above, more than one I(0) time series appeared in no country.

On the basis of the above unit root tests, we performed the Johansen's cointegration test to see whether any combinations of the variables are cointegrated. According to Johansen (1997) the selection of variables to be included in cointegration test should be based on economic reasoning, i.e. stationary variables should be included only if reasonable. However, at least two variables need to be non-stationary to perform a cointegration test. Since we employ two variables only in tests, the results of test including Polish and Hungarian NEER must show two cointegrating equations to be relevant and significant.[12] The lag length is chosen by applying the SIC and Akaike Info Criterion on the udifferenced VAR following the procedure by Thaneepanichskul (2001). Relevant results are presented in Table 1.

Evidence suggests that for the first period the null hypothesis of no cointegration can be rejected in none of the countries. Analyzed financial markets in all developed countries do not share the same stochastic trend and consequently no stable long-run linkages between stock prices and exchange rates exist. Our hypothesis of REER as considerably distinct expression of exchange rate development than the NEER is not verified because the results are rather mixed. Whereas Austria, Germany and the UK demonstrate stronger relationship between stock market indices and the REER, France and the USA show evidence of higher trace statistics using the NEER. Similarly, while there are no noticeable differences in the long-run linkages in Austria, France, and the USA, results in Germany and the UK vary significantly involving NEER and REER into analysis.

[11] Stationarity of the NEER time series in Poland and Hungary stems from specific exchange rate arrangements valid during the economic transformation process. Crawling peg and crawling band are quasi-fixed exchange rate regimes that provide very stable development resulting from gradual devaluation made by small steps defined and announced in advance.

[12] As the cointegration rank increases by the number of stationary variables, the correct number of cointegration equations is equal to the number of equations found by the Johansen's test minus the number of stationary variables.

Bivariate Cointegration Test **Table 1**

	1969:12(1978:1) - 1992:12		1993:1 - 2003:12	
	r=0	*r ≤1*	*r=0*	*r ≤1*
		Austria		
MSCI/NEER	3.283185	0.326759	10.56136	0.007898
MSCI/REER	4.876845	0.755855	16.91531**	4.366820 **
		Czech Republic		
MSCI/NEER	n.a.	n.a.	10.30382	0.134413
MSCI/REER	n.a.	n.a.	9.181978	0.991493
		France		
MSCI/NEER	12.19328	0.917407	10.63396	2.722841
MSCI/REER	10.74320	0.635402	13.87845	1.860813
		Germany		
MSCI/NEER	7.732358	0.376639	13.44555	4.495134
MSCI/REER	12.74433	1.891833	22.65806 *	6.318900 **
		Hungary		
MSCI/NEER	n.a.	n.a.	25.20498 *	3.502783
MSCI/REER	n.a.	n.a.	7.391830	0.000063
		Poland		
MSCI/NEER	n.a.	n.a.	26.19535 *	3.707052
MSCI/REER	n.a.	n.a.	14.26361	3.163351
		Slovakia		
MSCI/NEER	n.a.	n.a.	6.751800	0.890310
MSCI/REER	n.a.	n.a.	10.02985	1.153015
		United Kingdom		
MSCI/NEER	5.182784	0.097877	11.77710	4.037124
MSCI/REER	12.86464	0.868828	16.10427 **	4.409677 **
		United States		
MSCI/NEER	6.456333	0.006646	19.28301 **	2.610145
MSCI/REER	5.960585	0.474434	23.18048 *	4.535531 **

Note: * and ** denote significance at 1 and 5 percent levels. The critical values of trace statistics for the null hypothesis of no cointegration (H_0: *r=0*) are 20.04 (1 % level) and 15.41 (5 % level), respectively. The critical values for the null hypothesis of at most one cointegrating relationship (H_0: $r \leq 0$) are 6.65 (1 % level) and 3.76 (5 % level), respectively.

It is found in the Table 1 that exchange rates and stock market indices proved to be cointegrated in six out of nine analyzed countries during the second period. However, we should recall that NEER time series in Hungary and Poland were identified to be of I(0). This fact may affect the significance of cointegration test results negatively. Thus, we consider such results as invalid and we do not involve them into further analysis. Anyway, one could conclude in three interesting ways.

First, we found substantial differences in the power of cointegration between two geographical areas. While the data series do indeed possess a long-run equilibrium relationship between themselves in the traditional part of the EU and in the USA[13],

[13] Cointegration between MSCI and REER in France is significant at 10 % level.

stock prices and exchange rates seem to be really cointegrated in none of the new EU-member countries. One exception is relationship between Polish MSCI index and REER that shows trace statistics very close to the 5 percent level critical value and may be therefore treated as cointegrated at 10 percent level.

Secondly, concerning time point of view, there is a clear evidence of markedly stronger long-run linkages between analyzed economic variables in all developed countries during the second period. Elimination of barriers and obstacles of free capital flows in the international scale along with relaxing currency restrictions and shifts towards more flexible exchange rate arrangements have created more favorable environment for relationships between stock and foreign exchange markets to appear.

Thirdly, results report obvious predominance of REER in detecting cointegration in majority of economies. REER is more complex indicator of exchange rate development than NEER since it reflects, besides nominal exchange rate, relative price level in the home economy and abroad. For that reason NEER and REER not need to follow the same way and direction as it is apparent from figures in Appendixes 1a and 1b. Higher inflation in home country than abroad may contribute to real appreciation of domestic currency even in the case of nominal depreciation. Real appreciation forces domestic companies and exporters to increase international competitiveness by costs reduction, improvement of productivity or increase in efficiency. Level of such abilities would be subsequently mirrored in the stock prices and stock market development. Accepting such type of the “flow-oriented” models’ assumptions one can state that REER is expected to have more powerful long-run relationship with the stock market development than the NEER only. Considering “stock-oriented” models, stock prices development should determine exchange rates. Growth of stock prices attracts foreign investors and causes domestic currency nominal appreciation, which in circumstances of stable and common rate of inflation automatically means concurrent real appreciation. Increase of stock prices based on economic fundamentals and growth is usually accompanied by some rate of inflation that multiplies and strengthens mutual relationship between stock prices and exchange rate expressed by REER. Moreover, stock prices are derived from expected future dividends whose level depends on profit and profitability. In inflationary environment, profits rise equally with inflation and therefore stock prices should also increase. Knowing the impact of inflation on real exchange rate, it may be pointed out that stock market development is linked with REER more tightly than with NEER.

4.2 Vector Error Correction Modeling and Granger Causality Test

Given the VEC mechanism that is embedded in the Johansen's procedure, the deviation from long-run equilibrium is corrected through a series of partial short-run adjustments. The VECM specification restricts the long-run behavior of the variables in the system to converge to their long-run relationship while allowing a wide range of short-run dynamics. The VECM is therefore a suitable framework to examine the short-term adjustments needed by two variables to reach a long-run equilibrium. Table 2 shows the estimates of the VECM for each country where cointegration appeared.

VECM Estimates **Table 2**

model	*cointEq*	SI_{t-1}	SI_{t-2}	SI_{t-3}	ER_{t-1}	ER_{t-2}	ER_{t-3}	
Austria MSCI	-0.178 (-3.50)	0.105 (1.16)	0.193 (2.12)	-0.019 (-0.22)	0.557 (1.01)	0.035 (0.06)	0.005 (0.01)	R^2: 0.1229 Adj. R^2: 0.0709 F-stat: 2.3633
Germany REER	-0.011 (-3.78)	0.006 (0.54)	-0.023 (-2.02)	0.008 (0.69)	0.421 (4.74)	-0.230 (-2.47)	-0.123 (-1.40)	R^2: 0.3289 Adj. R^2: 0.2892 F-stat: 8.2645
UK REER	0.034 (3.32)	-0.058 (-1.71)	0.088 (2.60)	-0.51 (-1.47)	0.173 (1.99)	-0.047 (-0.56)	0.076 (0.96)	R^2: 0.2250 Adj. R^2: 0.1790 F-stat: 4.8945
US MSCI	-0.218 (-3.50)	0.165 (0.62)	-0.226 (-0.82)	-0.106 (-0.41)	-0.142 (-1.47)	-0.169 (-1.77)	-0.029 (-0.30)	R^2: 0.1168 Adj. R^2: 0.0639 F-stat: 2.2098
USA REER	-0.041 (-1.91)	0.380 (4.16)	-0.143 (-1.49)	0.009 (0.10)	0.001 (0.01)	0.036 (1.08)	-0.03 (-0.95)	R^2: 0.1867 Adj. R^2: 0.1381 F-stat: 3.8383
USA NEER	-0.067 (-2.25)	0.331 (3.62)	-0.138 (-1.45)	0.063 (0.70)	0.001 (0.03)	0.027 (0.82)	-0.02 (-0.69)	R^2: 0.1609 Adj. R^2: 0.1119 F-stat: 3.2861

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels. SI is MSCI stock market indices and ER represents particular exchange rate expression.

Estimation of the VECM leads to miscellaneous results. Test for the UK and the USA implicitly supports principles of the "stock-oriented" models. Significance of the cointegration factor's coefficient documents the long-run relation between stock prices and REER. Innovation of the stock markets indices are transmitted to the exchange rate in a positive way. An increase in stock prices has positive effects on REER (i.e. real currency appreciation).[14] Such results are absolutely in accordance with unique position of the UK and the USA in the world economy and among financial centers. Stock markets in the UK and the USA belong to the prestigious group of the most efficient and developed markets with the largest turnover and market capitalization and they play a leading role and attract domestic as well as foreign investors. Consequently, development on the stock markets drives demand for and supply of national currency and affects the exchange rate significantly. Solidity of this long-run linkage in the USA is intensified by the same causality found between market indices and NEER. Explanatory power of models with REER as a dependent variable is quite high and sufficient reflecting the fact of only one explanatory variable included.

On the contrary, Austria tends to causality running from changes in REER to changes in stock prices and justifies in this ways assumptions of the "flow-oriented" models that real depreciation initiates increase in stock prices. Austrian stock market plays somewhat regional role and does not considerably influence behavior of global investors. The annual turnover of Austrian Stock Exchange was 19.31 bln EUR in 2003. Development of stock prices rather tends to reflect international competitiveness, economic situation and perspectives of Austrian companies that are, due to degree of Austrian economy openness, substantially determined by REER.[15] However, this relation is very weak and also explanatory power of the VECM is not sufficient.

The most statistically significant VECM includes German MSCI and REER time series and reveals a long-run effect of shifts in domestic stock prices on domestic currency value. The causation is however negative, which means that increase in stock prices results in real depreciation of the currency. One may conclude that such estimation clearly confirms outcomes of monetary models that stock prices and exchange rates are independent variables affected by different factors. Detected long-run equilibrium relation and its direction should be therefore considered as econometric-based instead of fundamentally-based. Explanation may be as follows. While the German stock market was copying the general and long-lasting boom of the world capital markets in the 1990s, the real economy experienced, after the unification

[14] Effective exchange rates are commonly expressed in the form of index and quoted indirectly.

[15] Total amount of goods and services export equaled to almost 60 percent of the Austrian GDP in 2003.

blossom, a significant slowdown. Post-unification Germany had an overvalued real exchange rate and needed a substantial real depreciation.[16]

The short-run dynamics of the system may be examined by performing bivariate Granger causality tests. We apply the tests with the aim to seek a presence of short-run relationship where no long-run causality appeared, and to confirm the VECM results where the cointegration between stock prices and exchange rates exists. Granger causality test requires that all data series involved are stationary. Otherwise the inference from the F-statistics might be spurious because the test statistics will have nonstandard distributions. Accordingly, we employed the first differences of all log-level series. The test results of Granger causality are given in Appendixes 2a – 2d. We experimented with lags of one to four months hoping such period would be adequate to get effects of one market to another.

Considering the first analyzed period, we detected unidirectional short-run relations only in the case of France (MSCI do Granger cause REER) with three months lag at 10 percent level and in the case of Germany (MSCI do Granger cause NEER) with one month lag at 10 percent level. There is evidence of no universally stronger relation running either from one variable to another or emerging at particular number of lags. During the second period stock and foreign exchange markets turned out to be short-run linked in much more cases. Restricting our focus on developed countries, we found unidirectional causality running from stock market indices to exchange rates. More concretely we may see the strongest relations in the USA where stock market has a positive effect on REER and, to a lesser degree, also on NEER. Relations with same direction but lower intensity were detected in Germany and the UK, too. Such results may be treated as confirmation of the long-run causality in the short-run horizon.

Four new EU-member countries do not embody so homogenous group as they are frequently perceived and described. Accordingly, estimates of the Granger causality

[16] That has been accomplished, maybe temporarily, by the post-1995 weakness of the German Mark and then the Euro. Within a monetary union, real depreciation may occur through relatively low inflation (or, more precisely, relatively low increases in unit labor costs in the common currency). According to US Bureau of Labor Statistics the Germany's hourly compensation costs in manufacturing were the highest in the world in 2001. As they are not offset by higher productivity, and as the euro has been appreciating against external currencies, the real depreciation could be achieved only through an extended period of low inflation or even deflation.

vary significantly among these countries. While Czech NEER as well as REER do Granger cause the Czech stock market, relation in Hungary is reverse and Hungarian stock market do Granger cause NEER with lags of three and four months. Tests did not reveal any short-run relations in Poland and Slovakia. In addition, values of t-statistics in Slovakia's models indicate that any causality is very hard to find.

5. CONCLUSION

After performed analysis and tests of long-run and short-run dynamics between stock prices and exchange rates in a group of nine countries we have come to following conclusions.

First, evidence suggests that long-run relationships between considered variables did not appear during the first analyzed period covering years 1970-1992. One of possible explanations may be exchange rate arrangements prevailing in the developed countries under estimation in the 1970s, 1980s, and first years of 1990s. Brettonwood system, currency snake, and European Exchange Rate Mechanism provided extremely limited space for exchange rate volatility because nominal exchange rates were allowed to fluctuate only within very tightly defined band. Thus, mutual relations between stock prices and exchange rates could not emerge completely. The period from 1993 to 2003 shows much stronger long-run causality preferably in the developed countries. Cointegration between stock prices and exchange rates appeared in four of nine economies. Direction of the relations is unfortunately not uniform and differs among countries. Nevertheless, the UK and the USA may be highlighted because their stock markets evidently give impulses to the exchange rate development. Long-run equilibrium in the new EU-member countries was not confirmed. Reasons should be sought in relative underdeveloped stock markets and in quasi-fixed exchange rate regimes in Poland and Hungary. Although tests for short-run relations resulted to mixed conclusions concerning direction, intensity as well as type of exchange rate, all cases of Granger causality were likely to be unidirectional.

Secondly, as it indicated above, neither intensity nor direction of causal relations are the same in the developed economies and the new EU-member countries. Stock markets in the post-communist countries are not so tightly linked with real economy and do not efficiently reflect companies' actual and expected performance. Similarly, stock markets in the new EU-member countries play regional and rather marginal role. In addition, they are flat and not sufficiently attractive for international investors. Consequently, it is very hard to register any long-run or short-run relation between stock prices and exchange rates.

Thirdly, REER proved to be better expression of exchange rate that NEER. While cointegration using REER was found in four countries, we registered long-run causality employing NEER only in the USA. Therefore, we see REER as more appropriate variable to fulfill preconditions of both "flow-oriented" as "stock-oriented" models.

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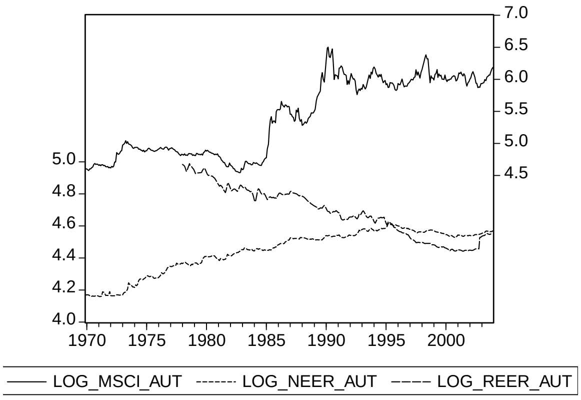
Appendix 1a

Austria



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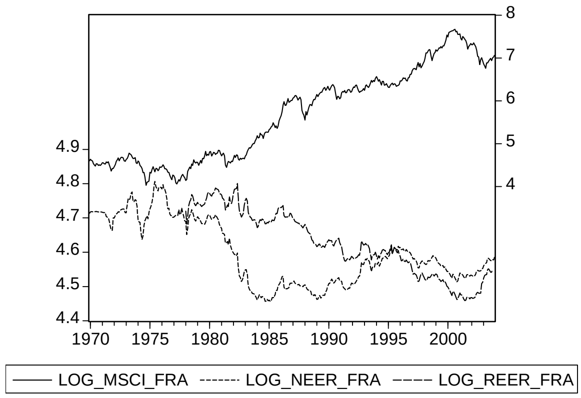
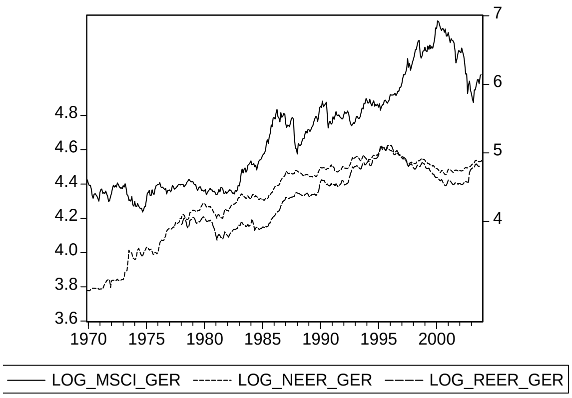
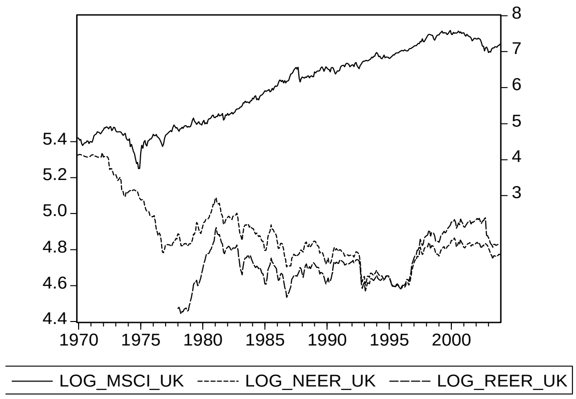


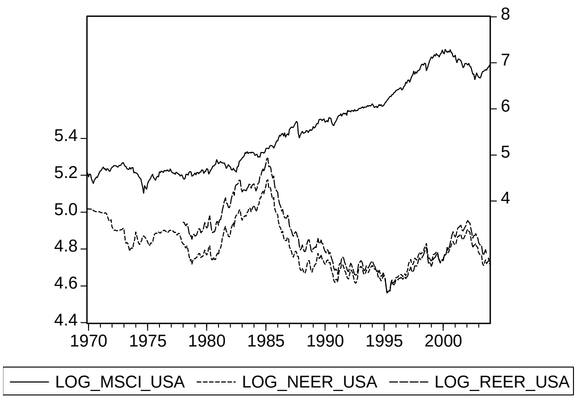
Germany



United Kingdom

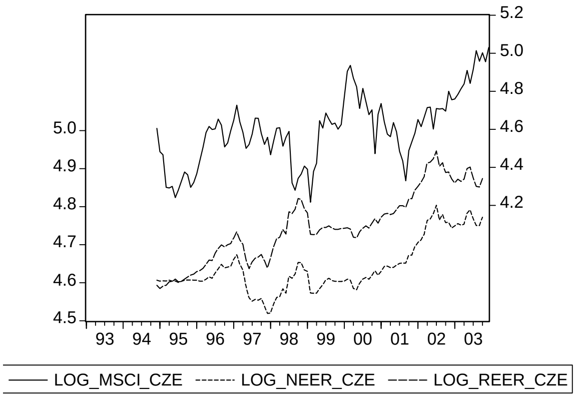


United States

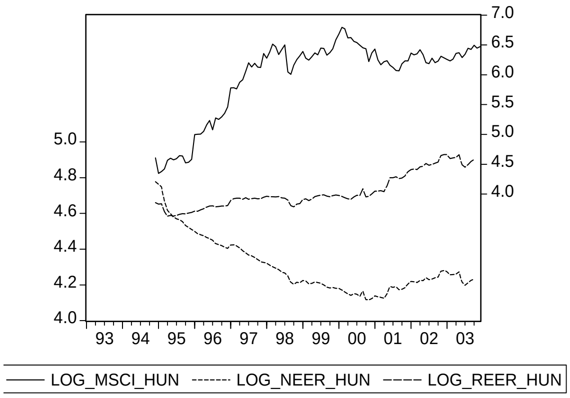


Appendix 1b

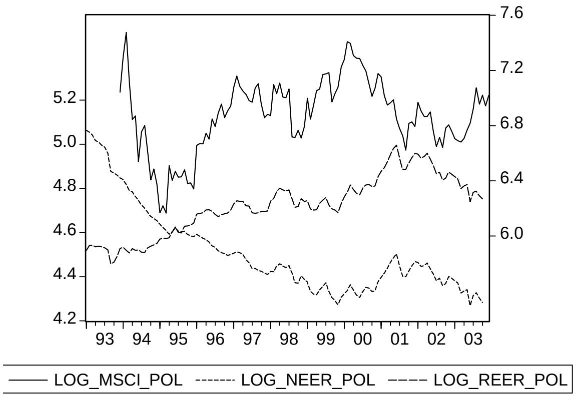
Czech Republic



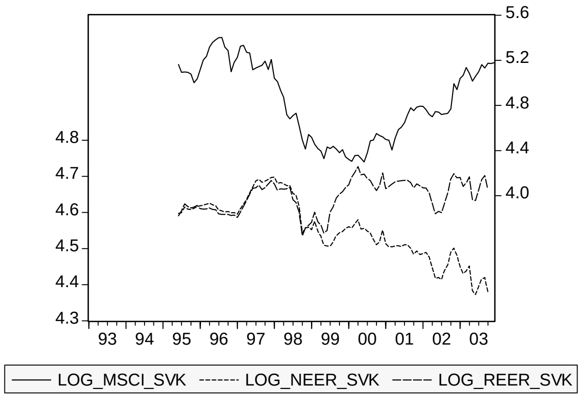
Hungary



Poland



Slovakia



Appendix 2a

Granger Causality Test for Austria

	1969:12(1978:1) - 1992:12		*1993:1 - 2003:12*	
	t-statistics	***probability***	***t-statistics***	***probability***
		1 lag		
NEER -/->MSCI	0.03374	0.85440	0.63848	0.42575
MSCI -/->NEER	0.43742	0.50893	0.01467	0.90378
REER -/->MSCI	0.07295	0.78741	0.95057	0.33146
MSCI -/->REER	0.29906	0.58517	0.23616	0.62785
		2 lags		
NEER -/->MSCI	0.65333	0.52113	0.59202	0.55477
MSCI -/->NEER	0.36121	0.69717	0.10226	0.90287
REER -/->MSCI	0.02719	0.97318	0.63350	0.53247
MSCI -/->REER	0.52240	0.59404	0.47260	0.62452
		3 lags		
NEER -/->MSCI	0.42474	0.73542	0.38354	0.76504
MSCI -/->NEER	0.41520	0.74223	0.11249	0.95265
REER -/->MSCI	0.01214	0.99816	0.30832	0.81934
MSCI -/->REER	0.60660	0.61159	0.34351	0.79390
		4 lags		
NEER -/->MSCI	0.53075	0.71324	0.25894	0.70363
MSCI -/->NEER	0.38280	0.82086	0.15566	0.96010
REER -/->MSCI	0.02356	0.99891	0.27227	0.89533
MSCI -/->REER	0.43906	0.78025	0.80858	0.52213

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Granger Causality Test for France

	1969:12(1978:1) - 1992:12		*1993:1 - 2003:12*	
	t-statistics	***probability***	***t-statistics***	***probability***
		1 lag		
NEER -/->MSCI	0.50512	0.47787	0.11060	0.74001
MSCI -/->NEER	0.11881	0.73059	5.95530**	0.01605
REER -/->MSCI	0.03733	0.84701	1.25282	0.26516
MSCI -/->REER	2.44747	0.11952	2.64262	0.10655
		2 lags		
NEER -/->MSCI	0.59306	0.55335	0.44112	0.64432
MSCI -/->NEER	0.24533	0.78262	2.91304***	0.05804
REER -/->MSCI	0.51226	0.60005	1.09337	0.33835
MSCI -/->REER	1.66643	0.19196	1.94398	0.14754
		3 lags		
NEER -/->MSCI	0.70262	0.55121	0.18308	0.90772
MSCI -/->NEER	0.25394	0.85849	2.31601***	0.09912
REER -/->MSCI	0.37752	0.76933	0.58470	0.62619
MSCI -/->REER	2.19788***	0.09017	1.37829	0.25278
		4 lags		
NEER -/->MSCI	0.72113	0.57816	0.33666	0.85279
MSCI -/->NEER	0.62769	0.64314	1.87289	0.11972
REER -/->MSCI	0.33809	0.85198	0.52603	0.71679
MSCI -/->REER	1.79805	0.13157	1.81481	0.13063

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Appendix 2b

Granger Causality Test for Germany

	1969:12(1978:1) - 1992:12		*1993:1 - 2003:12*	
	t-statistics	***probability***	***t-statistics***	***probability***
		1 lag		
NEER -/->MSCI	0.17468	0.67631	0.30817	0.57978
MSCI -/->NEER	3.37567***	0.06726	1.19153	0.27709
REER -/->MSCI	0.06401	0.80056	1.19355	0.27672
MSCI -/->REER	0.20182	0.65381	0.00092	0.97589
		2 lags		
NEER -/->MSCI	0.20614	0.81385	0.11090	0.89512
MSCI -/->NEER	1.76184	0.17370	0.55011	0.57829
REER -/->MSCI	1.42859	0.24248	0.53861	0.58494
MSCI -/->REER	0.45825	0.63316	3.49142**	0.03354
		3 lags		
NEER -/->MSCI	0.30859	0.81917	0.06333	0.97901
MSCI -/->NEER	1.25037	0.29191	0.50769	0.67771
REER -/->MSCI	0.99158	0.39822	0.64721	0.58621
MSCI -/->REER	0.15527	0.85750	2.35808***	0.07514
		4 lags		
NEER -/->MSCI	1.05482	0.37940	0.13975	0.96715
MSCI -/->NEER	1.53372	0.19272	1.20350	0.31303
REER -/->MSCI	1.26201	0.28703	0.47416	0.75462
MSCI -/->REER	0.37727	0.82467	2.70536**	0.03372

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Granger Causality Test for the United Kingdom

	1969:12(1978:1) - 1992:12		*1993:1 - 2003:12*	
	t-statistics	***probability***	***t-statistics***	***probability***
		1 lag		
NEER -/->MSCI	1.23019	0.26835	0.95293	0.33083
MSCI -/->NEER	1.04503	0.30756	0.49731	0.48197
REER -/->MSCI	2.54980	0.11211	2.42669	0.12181
MSCI -/->REER	0.21855	0.64073	0.05423	0.81624
		2 lags		
NEER -/->MSCI	0.81451	0.44395	0.65224	0.52265
MSCI -/->NEER	0.63057	0.53307	3.33769**	0.03874
REER -/->MSCI	1.29574	0.27635	2.14978	0.12040
MSCI -/->REER	0.84720	0.43040	8.38378*	0.00039
		3 lags		
NEER -/->MSCI	1.16947	0.32180	0.54139	0.65486
MSCI -/->NEER	0.52690	0.66416	1.98585	0.11969
REER -/->MSCI	0.77009	0.51226	1.50831	0.21593
MSCI -/->REER	1.24001	0.29688	5.13011*	0.00226
		4 lags		
NEER -/->MSCI	0.88562	0.47300	0.60093	0.66270
MSCI -/->NEER	0.38721	0.81773	1.73464	0.14691
REER -/->MSCI	0.56571	0.68787	1.01832	0.40093
MSCI -/->REER	0.92624	0.45014	4.94753*	0.00102

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Appendix 2c

Granger Causality Test for the United States

	1969:12(1978:1) - 1992:12		*1993:1 - 2003:12*	
	t-statistics	*probability*	*t-statistics*	*probability*
		1 lag		
NEER -/->MSCI	0.60409	0.43770	0.35448	0.55265
MSCI -/->NEER	2.28706	0.13162	0.63546	0.42685
REER -/->MSCI	1.37872	0.24192	0.18628	0.66678
MSCI -/->REER	2.25871	0.13467	0.47539	0.49180
		2 lags		
NEER -/->MSCI	1.28555	0.27819	0.65259	0.52247
MSCI -/->NEER	1.18341	0.30782	2.11223	0.12530
REER -/->MSCI	1.33880	0.26996	0.85492	0.42787
MSCI -/->REER	0.98374	0.37600	2.40215***	0.09857
		3 lags		
NEER -/->MSCI	1.36081	0.25516	0.33003	0.80364
MSCI -/->NEER	0.70829	0.54780	1.43247	0.23667
REER -/->MSCI	1.43308	0.23492	0.50939	0.67657
MSCI -/->REER	0.76330	0.51613	1.61869	0.18873
		4 lags		
NEER -/->MSCI	1.06484	0.37434	0.25157	0.90820
MSCI -/->NEER	0.51477	0.72493	1.27611	0.28331
REER -/->MSCI	1.05971	0.37824	0.58905	0.67122
MSCI -/->REER	0.50084	0.73515	1.42583	0.22986

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Appendix 2d

Granger Causality Test for the Czech Republic and Hungary

	Czech Republic		*Hungary*	
	t-statistics	*probability*	*t-statistics*	*probability*
		1 lag		
NEER -/->MSCI	2.05172	0.15509	2.47321	0.11890
MSCI -/->NEER	0.08456	0.77180	2.02400	0.15788
REER -/->MSCI	2.44026	0.12135	0.88555	0.34891
MSCI -/->REER	0.13493	0.71414	3.95881**	0.04930
		2 lags		
NEER -/->MSCI	0.99946	0.37176	2.05984	0.13290
MSCI -/->NEER	0.16185	0.85079	1.11220	0.33291
REER -/->MSCI	1.25320	0.29008	1.49582	0.22909
MSCI -/->REER	0.71269	0.49282	1.94962	0.14775
		3 lags		
NEER -/->MSCI	3.18881**	0.02716	1.52572	0.21278
MSCI -/->NEER	0.26999	0.84689	2.44791***	0.06839
REER -/->MSCI	3.19972**	0.02679	1.24668	0.29719
MSCI -/->REER	0.80029	0.49669	1.63962	0.18532
		4 lags		
NEER -/->MSCI	2.22052***	0.07270	0.96674	0.42963
MSCI -/->NEER	0.26752	0.89816	2.40832***	0.05484
REER -/->MSCI	2.39036***	0.05634	0.95362	0.43686
MSCI -/->REER	0.65787	0.62282	1.72481	0.15109

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.

Granger Causality Test for Poland and Slovakia

	Poland		*Slovakia*	
	t-statistics	*probability*	*t-statistics*	*probability*
		1 lag		
NEER -/->MSCI	0.50186	0.48013	0.14880	0.70054
MSCI -/->NEER	2.29233	0.13278	0.31305	0.57712
REER -/->MSCI	0.51565	0.47417	0.13659	0.71251
MSCI -/->REER	1.01057	0.31690	0.77880	0.37971
		2 lags		
NEER -/->MSCI	1.73750	0.18071	0.33243	0.71803
MSCI -/->NEER	1.54774	0.21728	0.36859	0.69272
REER -/->MSCI	1.60307	0.20590	0.02595	0.97439
MSCI -/->REER	0.87383	0.42020	0.52291	0.59453
		3 lags		
NEER -/->MSCI	1.40323	0.24585	0.19202	0.90159
MSCI -/->NEER	1.47409	0.22568	0.50429	0.68029
REER -/->MSCI	1.04981	0.37369	0.30862	0.81909
MSCI -/->REER	1.30045	0.27811	0.72909	0.53728
		4 lags		
NEER -/->MSCI	1.75599	0.14330	1.06180	0.38039
MSCI -/->NEER	1.15263	0.33610	0.39421	0.81228
REER -/->MSCI	1.36634	0.25065	1.07441	0.37417
MSCI -/->REER	1.57086	0.18750	0.44590	0.77510

Note: * , ** and *** denote significance at 1 , 5 and 10 percent levels.