European Union Enlargement and the Dynamic Relation between Stock Prices and Exchange Rates

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Abstract

One of the main aspirations of the European Union is that of a large eastward enlargement in the forthcoming years. However, as it is regularly highlighted by the EU policy makers, this will not occur if the potential members will not fulfil a number of conditions, to allow them to reach certain objectives set by the European Union. Two important of these objectives are namely, the liberalisation of the financial institutions and markets, and the stability in the exchange rate market, especially since the long run objective of the new potential members is perceived to be the participation to the EMU.

While theoretical considerations suggest an interrelation between these two objectives, and more precisely between exchange rate volatility and equity markets, to date there are few empirical findings on the nature of this interaction. This paper provides an empirical analysis of the interrelation between exchange rate fluctuations and equity prices of the new potential Eastern and Central European members of the European Union. The main implication of the results is that the policy makers should be aware of the interconnections between stock prices and the exchange rate.

The techniques employed in this paper are both bivariate and trivariate cointegration methodology, following Ajayi and Mougoue (1996), Abdalla and Murinde (1997), Phylaktis and Ravazzolo (1999), and Grambovas (2000). The paper also performs multivariate Granger causality tests following Hassapis, Pittis and Prodromidis (1999) in an effort to identify short run dynamics in the relationship. Additionally, the study explores whether the exchange rate – stock price connection is influenced from a third variable, specifically the New York, London and Frankfurt stock market indices, respectively, as proxies for overall international market sentiment. From a European point of view this can be significantly important considering the increasing number of EU investment to Eastern Europe and the interlisting of several companies between the EU capital markets and the equity markets of the transition economies.

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1. INTRODUCTION

One of the main aspirations of the European Union is that of a large eastward enlargement in the forthcoming years. However, as it is regularly highlighted by the EU policy makers, this will not occur if the potential members will not fulfil a number of adaptations, to allow them to reach certain objectives set by the European Union. Two important of these objectives are namely, the liberalisation of the financial institutions and markets, and the stability in the exchange rate market, especially since the long run objective of the new potential members is perceived to be the participation to the EMU. Therefore, a possible interrelation between these two objectives would be of a great interest for the Eastern and Central European (ECE) countries' authorities.

This paper analyses the interaction between changes in exchange rates and equity prices in all the Eastern and Central European (ECE) emerging financial markets which are the potential members for the next two waves of the European Union Enlargement. The first wave of the enlargement includes the Czech Republic, Estonia, Hungary, Poland, and Slovenia (along with Cyprus), while Bulgaria, Latvia, Lithuania, Romania and Slovakia are included in the second wave. We were forced to exclude Bulgaria from the analysis since her Stock Exchange (SE) did not start operating until 1997. When finally the Bulgarian SE was launched the authorities were forced to postpone the introduction of a general index due to the vast economic crisis which the country faced in 1997. The general index was finally established (and named SOFIX) as late as November 2000, and therefore there is not any available data set for our study.

Economic theory suggests a relation between stock returns and exchange rates. The traditional approach argues that a change in the exchange rate can produce a shift in the stock prices. A multinational firm will see a change in the costs and gains of a foreign subsidiary if there is a change of the value of the exchange rate. This will lead to changes in the current account by creating a profit or a loss, which after their announcement will affect directly the stock price. Similarly, domestic firms will be affected if they are importing inputs and/or if they are exporting goods. Furthermore, in a more indirect way, domestic companies will be affected by the changes of the prices in the goods or services of the aforementioned firms with some of which might trade. One could also add in this sequence of events the herding and contagion effects which may affect the stock prices, i.e. the fall in the prices of many firms as a direct effect of a devaluation can lead to declines in the prices of others – indirectly affected – firms, just because the stock market ‘crisis’ can be considered as general and widespread by investors.

On the other hand, the portfolio approach supports that, movements in the stock prices causes changes in the exchange rate. The rationale behind this approach lies on the fact that a fall in stock prices leads to the shrinking of the wealth of local investors. This, in turn, reduces the demand for money, which have as an effect a decline in the interest rates, which can lead to capital outflows. The outflows of capital, however, are considered to be an important determinant of the devaluation of a currency. In addition, the indirect result of a change in the stock returns occurs through the perception of the stock market as the barometer of the economy. Negative developments in the stock market when being perceived as mirroring the current economic situation might lead to a turbulence in the exchange rate market.

In an empirical context, Solnik (1987) and Ma and Kao (1990) tested this interrelation by using monthly data for eight and six developed countries respectively, from 1973 to 1983. The former study includes observations from Canada, France, W. Germany, Japan, the UK, the USA, the Netherlands, and Switzerland, while in the latter the last two countries are excluded and Italy is included. Both studies are using time series regressions and they identify the existence of weak evidence that real exchange rate depreciation is associated with general increases in equity prices.

Frennberg (1994) maintains that exchange rate sensitivity can change over time due to switches in exchange rate regimes. However, he attempts to shed light on the same issue from a different point of view, by using discrete data and considering the impact of four large exchange rate adjustments in Sweden. His event study utilises a cross-sectional approach in which he tests the relation between the general SE index and prices of individual equity of 43 non-financial firms listed on the Stockholm stock market. His results seem to support that the market index reacts positively to devaluation events.

Antecedents of this study in the recent literature utilise variants of Granger causality and cointegration methodology in an effort to identify the short and long-run relationship between changes in stock prices and exchange rates. Qiao's (1996) analysis is based on three Asian countries (Japan, Hong Kong and Singapore) with contrasting results. In the short-run, he supports the existence of a bi-directional causal relationship between real exchange rates and stock prices for the case of Japan. In the short-run Hong Kong case however, exchange rates Granger cause changes in stock prices, but no relationship is identified for Singapore. Qiao reckons that the results imply different macroeconomic trading strategies among the countries. Furthermore, cointegration tests, using the Johansen-Juselius (J-J) procedure, detect an interconnection between the levels of stock prices and exchange rates for all the countries. This result is attributed by Qiao to the intensive globalisation of the three Asian financial centres.

Two papers employing the Engle and Granger two-step procedure are those of Ajayi and Mougoue (1996) and Abdalla and Murinde (1997). In the former the same countries as Ma and Kao (with the exception of the Netherlands) are studied, and the results suggest that an increase in stock prices induces a depreciation of the currency in the short-run. The authors conjecture that this is due to increasing inflationary expectations generated by a bullish stock market. On the other hand, the long-run results support that booms in stock prices lead to the appreciation of the currency, which they suggest arises from an increased demand for the currency, partly driven by investors revealed willingness to hold assets denominated in that currency.

Abdalla and Murinde (1997) study a number of Asian emerging markets. They are not able to identify any long-run relationship between the general indices of the SEs and the exchange rates for South Korea or Pakistan, although such a relation is detected in the cases of India and the Philippines. In the short-run, exchange rates movements Granger cause stock price adjustments in all countries but the Philippines, where the reverse causality is detected. Testing data from the Turkish economy provides Bahmani-Oskooee and Domac (1997) with rather interesting results. They identify a bi-directional Granger causality, and also a long-run cointegrating relationship between the Turkish stock prices and the two leading exchange rates (Turkish lira/USD and Turkish lira/DM), whereby a depreciation of the currency is related to an increase in the stock prices.

Phylaktis and Ravazzolo (1999) perform cointegration tests (J-J), on the stock returns and exchange rate interrelationship for Pacific Basin countries. As in this study, they explore the possibility of omitted variable bias by employing bivariate and trivariate specifications, incorporating the US stock index as an additional variable. They find that the US stock prices variable appears to act as a conduit through which the exchange rates and the domestic stock exchanges are connected. On the same grounds, Grambovas (2000) employed long and short run tests for the hypothesis of an interrelation between stock prices and exchange rates, but for a European – never previously examined – group of countries. His data set included observations from the Czech Republic, Greece and Hungary for a period of six years. The author identifies the existence of a bivariate long run relation for Hungary, while the absence of such a relationship for the case of Greece is due to the omission of the international environment factor. On the other hand, the Czech exchange rate seem to be affected in the short run by changes in the Prague stock market when they are combined with similar movements in the New York SE.

The notion of volatility spillovers is introduced in the relation between stock returns and exchange rates by Kanas (2000). The author tests the G6 countries by utilising both cointegration methodology and – more significantly – a bivariate EGARCH model for conditional variances with which he analyses the effects of stock prices volatility on the volatility of the changes in the exchange rate. He identifies the existence of volatility spillovers from stock returns to the exchange rate changes for all countries (except Germany), whereas the reverse seem to not be supported by the evidence.

Finally, Granger, Huang and Yang (2000) examine the interdependence of stock returns and exchange rates by using data from nine countries of East Asia. Since the time period of the data set includes the events of the Asian financial crisis of 1997 all economies exhibit pronounced structural breaks. Thus, the unit root tests employed are adjusted in order to account for structural breaks. Their results seem to suggest that changes in stock returns tend to lead changes in the exchange rate, and that for

Hong Kong, Malaysia, Singapore, Thailand and Taiwan there is a strong feedback interaction between the two.

This study is organised as follows. In Section 2 the data is discussed and the methodology to be employed is analysed. Section 2.1 describes the data set, whereas in Section 2.2 the cointegration procedure is analysed. The empirical evidence is presented in the next section, which is divided into long-run and short-run causal effects. In Section 4 this study discusses the results in the context of previous literature. Finally, we attempt to summarise the conclusions and to point out some relevant policy implications.

2. DATA AND METHODOLOGY

2.1 Data Description

The data consists of weekly observations (Friday closing values), of the general stock exchange indices of the local markets of the nine ECE countries (Prague PX-50, Tallinn TALSE, Budapest BUX, Warsaw WGI, Ljubljana SBI, Riga RICI, Vilnius LITING, Bucharest BET, and Bratislava SAX16) and London (FTSE 100), New York (Dow Jones Industrials- DJI), and Frankfurt (DAX 30). Also, weekly observations are used for the spot mid-point foreign exchange rates (i.e. the average of the buy and sell prices) for the currencies of the nine aforementioned countries in relation both to the British pound (GBP) and to the Deutschmark (DM). The starting date of the sample period is the 7/1/94, while from that year the majority of the countries under discussion had a Stock Market fully operating. There were, however, some late starters, with the latest one being the Latvia SE, which launched its general index (RICI) the first week of November 1997. Since the ending date of the sample is the 16/6/2000 for all the countries, the sample for Latvia consists of 133 observations, while for the countries with observations from the starting date the relevant number is 337. Despite these differences the number of observations in all cases is considered to be adequate for our analysis. All data were collected from Datastream, except from the BUX, the RICI and the LITING indices, which were obtained directly from Budapest, Riga and Vilnius stock markets respectively, and all data are transformed in natural logarithms.

2.2 Cointegration Methodology

The methodology employed follows the antecedents by Qiao (1996), Bahmani-Oskooee and Domac (1997), Phylaktis and Ravazzolo (1999), and Grambovas (2000). The majority of the recent papers, which consider the interdependence between stock returns and exchange rates, utilise cointegration methodology. The notion of cointegration was initiated by Granger (1983), and a major improvement was made by Engle and Granger (1987), when the two step residual-based procedure was defined and employed. In the years following the seminal paper by Engle and Granger (E-G), researchers identified problems occurring from different arbitrary normalisation, which can bias the results of the two-step procedure. Johansen (1988) and Johansen and Juselius (1990) took the opportunity and improved the proposed methodology by introducing another procedure to test for cointegration.

The Johansen – Juselius (J-J) procedure applies the maximum likelihood estimation method to simultaneously regress vector autoregressions. One major advantage of the J-J procedure is the ability to identify the exact number of the cointegrating vectors, which in addition to the invariance of the procedure to arbitrary normalisation, makes it far more preferable from that of Engle and Granger. Furthermore, Granger, Huang and Yang (2000) use the modifications of the E-G procedure by Zivot and Andrew (1992) and Gregory and Hansen (1996) in order to account for structural breaks. However, in their paper the issue of structural breaks should be addressed since the East Asian countries under discussion clearly face them. In our case, the sample data do not seem to indicate the existence of structural breaks and thus the Granger, Huang and Yang (2000) example is not followed. Henceforth, this study employs both bivariate and trivariate cointegration by using the J-J procedure. In the bivariate case, the relationship to be examined in general terms can be depicted as:

$$(1) \qquad SE_t = \alpha_0 + \alpha_1 XR_t + v_t ,$$

where SE_t is the general index of the domestic stock exchanges, XR_t is the exchange rate of the countries under discussion towards the British Pound or the Deutschmark, and v_t is a disturbance term with standard properties.

Economic theory suggests – through the Traditional and Portfolio approaches – the existence of a long-run relation in the system described in equation (1). Such a relationship derives from the interrelation of both the exchange rate and equity returns with the level of general economic activity, as described above and as demonstrated in Phylaktis and Ravazzolo (1999). Moreover, recent empirical analyses have identified the existence of a significant relation in a number of countries (see Qiao (1996), and Bahmani-Oskooee and Domac (1997) among others). Furthermore, in the case of non-detection of a long run relation evident, the recent developments in the cointegration methodology (due to the J-J procedure) suggest that this can be a result of the omission of one or more significant variables from the model.

Therefore the bivariate proposed system (equation (1)) can be extended to a multivariate one. The choice of extra variables should be very carefully examined since one has to take under consideration economic viable reasoning. In addition, except from the general economic reasons the researcher should address the specific reasons according to the case under discussion. Based on the above, Bahmani-Oskooee and Domac (1997) include inflation as the omitted variable from the system, since their case concerns Turkey. Turkey at the time that the sample was taken, but also nowadays, experiences high and very volatile levels of inflation despite all the efforts of the authorities to tame this macroeconomic variable. This does not seem to be the situation in our choice of countries while the majority of the discussed economies managed to reduce their inflation rates at single digits or just above 10% (with the exception of Romania) and all of them experience very low volatility levels. Therefore, inflation is not considered to be the omitted variable, even though there are often good reasons (in studies of other countries) for such choice.

Rockinger and Urga (2001) attempt, by using a time-varying parameter model, to identify the existence of integration between the Central European stock exchanges and the major world stock markets (German, British, and American). They conclude that there is integration between the Prague market and both London and Frankfurt, the Warsaw market and mainly London but also Frankfurt, whereas there is not identified an integrating relation between the Budapest market and any international SE. On the other hand, Jochum, Kirchgassner and Platek (1999) test the existence of a long run cointegrating relationship between Eastern and Central European capital markets with the New York SE, as well as amongst themselves. Their results indicate that there is a strong relation between the Budapest SE and New York, while a cointegrating relationship is identified between the Prague SE and the Warsaw SE with the US stock market. Based on the above papers one can suggest the use of the international capital markets as the omitted variable from our system. However, such suggestion should not be based solely in previous empirical antecedents, but also to the economic theory.

We suggest that the omitted variable of the system is the performance of the world capital markets. Fluctuations in the world stock markets can lead to movements in the relevant domestic stock exchange due to international investor sentiment issues. Capital inflows or outflows (perhaps following fluctuations in interest rates) can create fluctuations in the exchange rates, as suggested by the portfolio approach. In addition, it has been argued that since there is a relation between the stock market and economic activity, changes in the major world stock exchanges can affect the developed economies' trade balances. This in turn can effect the performance of domestic (ECE) exporting companies and may have consequences for the exchange rate of the local currencies. Such an argument may not be so convincing regarding the US stock market, but seems very important for the German and the UK capital markets, since the vast majority of the international trade of the countries under consideration is conducted with countries of the EU (see Table 1).

Finally, the increasing integration of world capital markets has moved many global investors into the stock exchanges under discussion, and therefore, psychological factors may deter them from investing in one of the ECE domestic stock markets if the world capital markets are in decline. Therefore, we suggest that the omitted variable, due to both theoretical and empirical considerations, is the performance of the international capital markets, as proxied by the Frankfurt (important geographical and political proximity, significant trade partner), London (largest capitalisation in Europe, trade partner), and New York (largest capitalisation in the world) stock exchanges.

Thus, the trivariate case can be described as

$$(2) \qquad SE_t = \alpha_0 + \alpha_1 XR_t + \alpha_2 IM_t + v_t ,$$

where IM_t is the International Market, meaning the British (FTSE 100), American (Dow Jones Industrials), or the German (DAX 30) stock indices. The rest of the notation is to be regarded as in equation (1).

In the notation of Johansen (1988) and Johansen and Juselius (1990) the vector Z_t contains all variables of the model, which are SE_t and XR_t in the bivariate case and SE_t, XR_t and IM_t in the trivariate case. If the elements of Z_t are cointegrated, the data generating process can be represented by a vector error correction model (VECM) of the form:

$$(3) \qquad \Delta Z_t = \mu + \sum_{i=1}^{k-1} \Pi_i \Delta Z_{t-i} + \Pi_k Z_{t-1} + \varepsilon_t ,$$

where μ is a 2 x 1 (3 x 1 in the trivariate case) vector of drift, k is the maximum lag, Π's are 2 x 2 (3 x 3) matrices of coefficients, and ε_t is a 2 x 1 (3 x 1) white noise vector.

If the Π matrices have rank r = 0, then all the variables in Z have unit roots, which suggests no long-run relationship. If, in turn, the Π matrices have rank $0 < r < n$, there are r cointegrating vectors among the variables. Johansen and Juselius employed two methods of likelihood ratio (LR) testing, in order to identify the number of cointegrating vectors. In the first one, the LR test is based on the maximal eigenvalues, where the null hypothesis is tested for the existence of r cointegrating vectors, against the alternative of r + 1 vectors. On the other hand, the LR test based on the trace of the stochastic matrix tests the null hypothesis of the existence of less than or equal to r cointegrating vectors, against the alternative hypothesis of r or more vectors. Cheung and Lai (1993) suggest that the LR tests based on the trace are more appropriate to non-normality of errors concluding that this method should be preferred, and Phylaktis and Ravazzolo (1999) agree with that too. However, Enders

(1995) and Charemza and Deadman (1997) support that the tests based on the maximal eigenvalues are preferred because they employ the sharpest alternative hypothesis which makes us able to identify the number of cointegrating vectors, while the tests on trace have a very general alternative. Henceforth, in this study whereas there are conflicting results between the two tests, the ones based on the maximal eigenvalues will be used.

3. EMPIRICAL RESULTS

Long-run effects

Before applying the J-J procedure one should first test all the variables in terms of stationarity. Despite the fact that the majority of the financial data tend to be integrated of order one (I(1)) there may appear cases that the variables are I(0). This is the first step of the J-J procedure since if the two variables are not found to be integrated of the same order they can not be tested for cointegration. Therefore, the Augmented Dickey-Fuller (ADF) test with the null hypothesis of non-stationarity is performed. All variables are found to be integrated of order one except of the exchange rates of the Estonian Kroon, the Polish Zloty and the Slovenian Tolar towards the Deutschmark. These results are reported in Table 3.

Since the beginning of the transition period the Estonian authorities established a Currency Board and the Kroon was pegged to the DM at the rate of 8:1. The Estonian policy was to support very strictly this peg through the currency board arrangement and therefore as it can be seen in Graph 1 the value of the Estonian Kroon has been stationary very tightly around the 8:1 rate. In the Slovenian case, the authorities have chosen to follow a different exchange rate policy as one can observe in Table 2. From its creation, the Tolar was allowed to follow a very tightly managed float (especially after mid-1992) towards the DM, and henceforth the stationarity of the exchange rate when a trend is included comes with no surprise (see Graph 3).

Poland, on the other hand, changed exchange rate policies several times since the beginning of the ‘90s. For the period that the sample was taken (1/94 - 6/00) the Polish policy changed from an explicit narrow peg, to a basket of currencies (mainly the US dollar and the DM) to broad band which the authorities kept broadening by the time until March 1999 when the ERM +/- 15% very broad band was adopted (Table 2). However, with whatever band was used the Zloty exchange rate tended to float at the upper end of the band by thus creating a stationary sequence when a trend is taken under consideration as one can observe in Graph 2.

In Table 3, one can observe that the general index of the Prague SE is found to be stationary in levels in an ADF test which includes only a constant. However by the inclusion of a trend the series becomes non-stationary in levels and the issue is resolved. In order to account for this consideration, the cointegration tests which are followed in the case of the Czech Republic will include an unrestricted set of intercepts in contrast to the restricted set which is employed in all the other cases. The use of an unrestricted set of intercepts allows for a deterministic trend in the levels of the variables and therefore is considered to be the appropriate choice for the Czech case.

Furthermore, when two variables are not integrated of the same order cointegration tests can not be performed and this is the case with all the bivariate tests concerning the Kroon, Zloty, and Tolar exchange rates towards the Deutschmark. In the multivariate case, however, Charemza and Deadman (1997) argue that tests for cointegration can be performed even if all the variables are not integrated of the same order. The authors reason that the cointegration relationship will be 'balanced' overall even when the dependent variable is of a lower order of integration than each of the other (two in our case) variables, if at least two of these variables are cointegrated to this lower order. Hence, while the exchange rate series is I(0), if the domestic stock market and the international stock market series are I(1) then cointegration tests can be performed. At this point, we examine initially the bivariate results.

3.1 Bivariate results

In the bivariate case the lag length should be initially selected. Two criteria are used, the Akaike Information Criterion (AIC) and the Schwartz Information Criterion (SC) on the undifferenced VAR. From the results of the two criteria one should choose the minima, however there are occasions that the two criteria contradict. In such cases the values of SC are preferred, since it has been shown to be more powerful. Considering the frequency of the sample of our study (weekly) one has to expect higher numbers of lags in some of the cases in contrast to other studies that use monthly data sets. This is particularly true for Slovenia, Romania and Slovakia when in some of the cointegrating relations (mainly in the trivariate case) the lag length reaches two and three months.

In Table 4 one can observe the results of the bivariate cointegration tests for the countries for which a cointegrating relationship was identified. In the Hungarian case, a cointegrating relationship is identified between both the exchange rates and the BUX index, whilst for Poland the only possible test (since the PZL/DM rate is I(0)) also shows strong evidence of cointegration. In both countries the H_0 of zero cointegrating vectors are rejected at a 5% significance level. A long run relationship seems to exist for the local exchange rate towards the DM and the local stock market both in the Czech Republic and in Romania. Finally, some evidence of cointegration is shown between the LAT/GBP rate and the RICI index in Latvia, while the null hypothesis is rejected only at a 10% significance level.

Several factors can be sited for the aforementioned results. Firstly, one important factor is the significance of the foreign investors to these five countries and consequently to their stock markets. In the third column of Table 1 one can observe that these five countries received the highest amounts of foreign direct investment for the ten years reported. Such high foreign investor participation could mean that a depreciation of the local currency would lead to high capital inflows since investment is cheaper, and hence the local stock markets would be directly affected. This is in particular significant for the Hungarian economy where the cointegration coefficient α_1 of equation 1 (for a normalised coefficient –1 for the BUX index) is –1.911, indicating that an increase in the HUF/DM rate (i.e. depreciation of the Forint) will lead to an increase in the BUX index. Hungary led the transition for the ECE countries, opened its economy much faster and allowed international investors to enter when some of the other countries were not even independent yet. This result is consistent with Grambovas (2000) for the same country and with Qiao (1996) and Abdalla and Murinde (1997) for a different set of countries.

Another significant consideration is the role that the performance of exporting firms can play in the local stock exchanges. In an event of a depreciation (appreciation), the exports of the local economy will grow (fall) which directly affects the price of the stocks of the exporting firms in the stock market. The opposite occurs when one considers the performance of importing firms in the SE. This argument takes a further boost by the fact that exports and imports accounted for more than 110% of the GDP of the Czech Republic and Latvia for 1998 (see Table 1). The cointegration coefficients α_1 for these countries but also for Poland have a positive sign implying that an increase in the exchange rate (depreciation) will lead to a decline in the stock indices, highlighting by this the importance of importing-orientated companies in these local stock markets. On the other hand, the α_1 coefficient has a negative sign in the case of Romania, indicating a significant influence of the performance of the exporting-orientated firms in the Bucharest stock market. The above results seem to be consistent with the results for a number of countries of Ma and Kao (1990) and Ajayi and Mougoue (1996).

Finally, one must not preclude from the explanations the function of the stock market as the barometer of the performance of an economy. Based on that, a boom of the stock market may signal a growth of the economy as a whole, which in turn can lead to inflationary pressures (depending of course on the state of monetary policy). Accordingly, the inflationary pressures could lead to speculation in the exchange rate market. This seems to be important for Romania but also for Hungary, where the negative sign of the coefficients (with a normalised –1 coefficient for the SE's) indicates that a boom in the stock prices would result to increases in the exchange rate (depreciation). Ajayi and Mougoue (1996) and Granger et al (2000) identify the existence of a similar relationship.

3.2 Multivartiate results

Moving to the multivariate results, as it has been pointed out previously, the non-rejection of the null hypothesis of no-cointegration in the bivariate case may be due to the omission of an important variable from the system. Therefore, in the cases that bivariate cointegration was not detected, trivariate tests will be performed with the inclusion of the selected (possibly omitted) variable. The performance of the world capital markets is considered to be that variable and more precisely, the general indices of the London, New York and Frankfurt stock markets will be used. Once again the selection of the lag length is important before initiating the multivariate cointegration tests and hence the AIC and SC criteria are used.

In Table 5 one can observe the results of the trivariate tests for the countries of the first wave of the EU enlargement and mainly for the cases that some evidence of cointegration was detected. In three of the results, namely in relations among the Tallinn SE, the EKR/DM rate and the DAX 30 index, and the Ljubljana SE with the SIT/GBP rate and the Dow Jones index, or with the SIT/DM rate and DAX 30 index, we have a contradiction of the two tests. As mentioned previously we have chosen to prefer in our study the LR test based on Maximal Eigenvalues and henceforth the null hypothesis of zero cointegrating vectors can not be rejected for these three cases.

The Czech result indicates strong evidence of cointegration between the PX 50 index, the CZK/GBP rate and the FTSE 100 index. This is consistent with the Rockinger and Urga (2001) result of a significant level of integration between the Prague and the London stock markets. In addition, decreases in the PSE affect negatively the currency (increase in the CZK/GBP rate) when there is unfavourable international environment (fall in the City) as it is indicated by the signs of the cointegration coefficients α_1 and α_2 of equation 2. One can explain such a relationship by the view that international investors will avoid investing in the Prague market, reducing, consequently, the demand for Czech Korunas and widening the current account deficit of the Czech Republic. Therefore speculative pressures would appear against the Czech currency. This result appears to be consistent with the results of Grambovas (2000) for Greece but not for the Czech Republic. However Grambovas has used the DJI index as the omitted variable and not the FTSE 100 index. When we use the Dow Jones Industrials index no evidence of cointegration is identified exactly as in Grambovas (2000).

In Estonia the results indicate strong evidence of a cointegrating relationship between the TALSE and the EKR/DM, when the Dow Jones Industrials index is included in the model. The New York SE index acts here more as a proxy of the international investment sentiment while there is not a strong correlation between the Estonian and the American markets. This result suggests that even small changes in the exchange rate (despite that the EKR/DM rate is almost stable around the official rate (8:1)) when combined with a relevant international environment can create movements in the Estonian stock market. This seems to occur mainly due to the behaviour of exporting firms while as it can be seen in Table 1 the exports and imports consisted the 170% of the Estonian GDP in 1998. Thus, when there is a slight depreciation in the Kroon (increase in the EKR/DM rate) the Estonian exported goods become cheaper. In addition, a boom in the international capital markets can signal a rise in the rates of growth and hence an increase in the aggregate demand of the main trade partners of Estonia, which leads to higher demand for Estonian exports. Consequently, the stock prices of the exporting Estonian companies will increase giving a rise to the general index as well. Similar results are identified in Phylaktis and Ravazzolo (1999) for the majority of the countries and the time periods.

Furthermore, some evidence of a long run relation is shown between the TALSE and the EKR/GBP rate when the DAX 30 index is the third variable. One can argue that since the arrangement of the currency board safeguards the relevant stability of the EKR/DM exchange rate, changes in the EKR/GBP rate reflect analogous changes in the DM/GBP exchange rate. In addition, when the DAX 30 index is included in the relation, it can be argued that this evidence of cointegration reflects the importance of the events in Germany for the Tallinn capital market. Therefore, movements in the Frankfurt stock market when combined with changes in the DM exchange rate, have an impact in the Estonian SE. This is predictable through both the peg of the Kroon with the DM (thus, affecting both Estonian exporting firms, but most importantly the Estonian interest rates) and also from the huge significance of Germany as a trade partner.

In Poland, after identifying evidence of bivariate cointegration when the exchange rate towards the GBP was employed, in the trivariate relationship with the PZL/DM rate in all cases strong evidence of a long run relationship is detected. In addition to the arguments mentioned above, one can suggest that the inclusion of the three international capital markets in the model enhances the result due to the high level of foreign investor participation in the Warsaw stock market and to the high degree of integration with the world capital markets. Furthermore, this explanation is enhanced by the results of Jochum, Kirchgassner and Platek (1999) and Rockinger and Urga (2001), who identify that the Warsaw SE is integrated with the New York SE and with the London and Frankfurt SE's respectively.

Last but not least of the first-wave of the 'enlargement countries', Slovenia, experiences a significant influence from the London capital market. The cointegration coefficients indicate that negative changes in the general index of the City when combined with positive changes in the exchange rate of the Tolar both towards the GBP and the DM (depreciation) can lead to positive changes in the Slovenian stock market. Thus, a fall in the FTSE 100 index might direct international investors towards diversifying their investment portfolios by including emerging markets. When this is combined with a depreciation of the Tolar which makes investing to Slovenia cheaper, it may encourage the foreign investors to choose the Ljubljana SE. In turn, this would lead to an increase in the SBI index. A strong evidence of cointegration is also indicated when the Dow Jones index is employed aside with the SIT/DM exchange rate. The explanations in this case tend to be similar with the previous two, taking also under consideration the geographical distance of the American market and also the fact that the cointegrating coefficients indicate the same kind of relation. Overall, the results for Slovenia seem to be consistent with the result of Grambovas (2000) for the trivariate case of Greece.

In Table 6 the results which identify the existence of cointegration in the trivariate tests for the countries of the second wave of the EU enlargement are reported. The conclusions from the bivariate cases for Latvia and Romania are reinforced and the choice of the international capital market performance as the omitted variable seems to be correct. In the Romanian case all three international capital markets employed justify the existence of a long run relation between the Romanian stock prices and the Leu exchange rate towards the British pound. On the other hand, in the case of Latvia the London capital market seems to be only one to affect the relation between the Latvian stock prices and the Lat exchange rate towards the Deutschmark. For Slovakia, a cointegrating relationship is detected between the SAX 16 index and the SLK/DM rate when the German stock market is included as the omitted variable. That can suggest the importance of Germany due to geographic proximity, increased trade relations and the peg of the Slovak Koruna with a basket of currencies where the DM played a significant part (lifted recently but existent in a large part of the sample period).

Finally, in the Lithuanian results there is not any long run relation detected between stock prices and the exchange rate of the Lita neither in the bivariate nor in the trivariate case. A reason for this could be the incorrect choice of the omitted variable while it is possible that another important variable should be used. However, it is rather more probable that the primer reason was the stagnation of the Lithuanian stock prices in the largest part of the sample period. Actually, after a promising start at the beginning of 1996 a free fall started around the autumn of 1997 which was transformed to a complete stagnation after a year and till the end of the sample period. The fact that the inclusion of the international stock exchanges does not influence the relation might be attributed to the failure of the Lithuanian market to integrate with the world capital markets.

Short-run effects

The discussion now will turn to the short run effects that can be identified for the same relationship. The methodology to be used is Granger Causality testing as developed by Granger (1983) and extended for multivariate tests by Hassapis, Pittis and Prodromidis (1999). Both bivariate and trivariate tests were performed including all the aforementioned variables. Selected results are presented for all countries in the Tables 7 to 15.

For the Czech Republic and Latvia, the Koruna and the Lat exchange rates (both towards the GBP and DM) Granger cause in the short run the PX 50 and the RICI indices respectively, and the influence seems to become even greater when the international capital markets are included in the relationship. These results seem perfectly consistent with the behaviour of the two markets in the long run as well, and one could provide the similar reasoning. In addition the results are consistent with those of Frennberg (1994) for Sweden. On the other hand the PX 50 index when combined only with the Dow Jones Industrials index Granger cause the exchange rate, while the RICI index when combined with the FTSE 100 Granger causes the LAT/DM rate. The explanation on the latter result lies on the fact that movements in the London stock market might affect the DM exchange rate towards other strong currencies. This in turn will affect the Lat which is pegged with the DM. At the same time the movements in London will have effects at Riga as well due to the high integration of the Latvian SE with the world capital markets. Ajayi and Mougoue (1996) identify similar short run relationships for their sample of countries.

Significant is the result for Hungary, Poland and Slovakia. The general index of the local stock exchange when combined with the international stock markets Granger causes in the short run the local exchange rate towards the DM. The above can be explained by the fact that movements in the world stock markets might affect the DM exchange rate towards other strong currencies. This in turn will affect the local currencies which are (or were till recently) pegged with the DM. At the same time the movements in the international capital markets will have effects at Budapest, Warsaw and Bratislava as well, due to the high integration of those markets with the world financial markets. The changes then in the three ECE countries' stock markets will affect the exchange rate, through the function of the SE as an indicator of the state of the economy. This result seems to be consistent with Phylaktis and Ravazzolo (1999) when they include the US stock market in the short run relationship.

In addition, the Polish stock market is Granger caused by the exchange rate and the FTSE 100 or the DJI. The absence of effects from the German market and the existence of effects from the British and American markets is related to the fact that the test regards short run causality. In the short run, the Warsaw market seems to be influenced by the international environment in general as this is proxied by the FTSE 100 and the DJI. The German market is more interrelated with the Polish one and therefore it is expected to play a more permanent role affecting the long run relationship much more the short run one. This result is consistent with Qiao (1996) where he identifies a long run relationship but not a short run one for the case of Singapore. One should note that the world financial environment might affect the relationship both in the short but also in the long run. This seem to be the case for Romania as well, even though the DAX 30 index combined with the RML/GBP Granger cause the BET index in a 10% confidence interval only.

Not surprisingly due to the currency board arrangement, the Estonian Kroon exchange rate towards the DM does not seem to be Granger caused by any other variables, while the exchange rate towards the GBP is granger caused in the short run by the TALSE and the FTSE 100 and DJI indices. In the case of Slovenia it is worth highlighting that neither in the short run nor in the long run the German stock market plays any role. This is peculiar if one considers the close relation that the Slovenian economy is perceived to have with the German one, which is also enhanced by the tightly managed peg of the Tolar. Furthermore, the SBI index combined with the FTSE 100 or the DJI indices, Granger causes the Tolar exchange rate towards the British pound. Finally, the only relation identified for Lithuania is that the LITING index combined with the Dow Jones Industrials index Granger causes in the short run the Lita exchange rate towards the Deutschmark, and that only at a 10% significance level.

5. CONCLUSION

This study attempts to provide an analysis of the interrelation between stock prices and exchange rates in an Eastern and Central European (ECE) context. This relationship and its implications are important for the countries that plan to join the European Union as well as for the Union itself. A major problem of the authorities world-wide is the managing of multiple policy goals simultaneously and therefore the policy implications of the existence or not of such an interrelation are various and differing from country to country. However, the European Commission has set the same conditions for all the countries and therefore the local authorities should differentiate their policies according to the specific country needs.

The results appear to be consistent with the vast majority of the previous research. The ECE countries included in the first wave of the EU enlargement (the Czech Rep., Estonia, Hungary, Poland and Slovenia) show evidence of higher levels of integration with the international capital markets. Hungary, in particular, has attracted a high number of international investors and there is significant evidence of a strong relationship between the Budapest stock market and the Forint. This relation implies that the Hungarian authorities should consider seriously the effects of their exchange rate policy on the Budapest SE. Furthermore, similar attention has to be paid by the authorities of the four other first-wave countries both concerning the long run and the short run. In Poland the relation between the stock market and the exchange rate market is very strong both in the long run and in the short run, making in this way the choice of relevant policy measures very important for the performance of both markets. In the Czech Republic after the adoption of a flexible exchange rate regime the existence of a connection between stock prices and exchange rates implies that the authorities should be careful on their intervention to the Prague stock market while this can lead to changes in the Czech Koruna exchange rate. Estonia has to face another important issue, that of the future of the currency board arrangement in the prospect of EU accession. The events regarding the future of the Estonian currency can affect indirectly in the long run and directly in the short run the Tallinn stock market. Similar considerations might affect the Slovenian authorities and the Ljubljana Stock exchange.

From the countries included in the second wave of EU enlargement, Latvia and Romania seem to be the most advanced in the issue of world capital market integration. The interrelationship between stock prices and the exchange rates appears to be very important for these two countries and furthermore the international environment seems to play a very significant role to this relation. In Slovakia on the other hand the interconnection between the exchange rate market and the local capital market seems to be weak, while the international environment does not appear to have a great influence. Finally, the Lithuanian results indicate that the Vilnius authorities have to undertake certain policy measures in order to attract more foreign investment with a target to integrate their stock market with the international capital markets as soon as possible.

Overall, the implementation of a successful exchange rate policy, the improvement of the performance of the local stock markets, the liberalisation of the financial markets and the openness in general to international investors, are key factors for the future of the ECE countries in the achievement of the medium-term objective of EU accession. The policy makers ought to be aware of possible interactions of these targets and to adopt the most appropriate policies. These implications do not apply only for the ECE countries but for all emerging markets and the Euro-zone in particular especially with the initial problems of the Euro and the future creation of a (Pan-) European Stock Exchange.

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TABLES AND GRAPHS

Table 1. Trade Indicators and Foreign Direct Investment.

Countries	Exports and Imports as % of GDP (1998)	Trade with the EU (1998). % of total trade	FDI: Cumulative inflows 1989-1998 (m $)	FDI: Cumulative inflows per capita 1989-1998 (m$)
Bulgaria	**98**	**46**	**1,352**	**163**
Czech Rep.	**116**	**60**	**8,053**	**782**
Estonia	**170**	**70**	**1,467**	**1,005**
Hungary	**122**	**70**	**14,508**	**1,429**
Latvia	**110**	**55**	**1,645**	**666**
Lithuania	**107**	**46**	**1,566**	**422**
Poland	**55**	**67**	**14,680**	**380**
Romania	**59**	**58**	**4,489**	**199**
Slovakia	**119**	**49**	**1,331**	**247**
Slovenia	**115**	**68**	**1,199**	**603**

Source: IMF, Finance and Development (Sep. 2000)

Table 2. Exchange Rate Regimes in Eastern Europe.

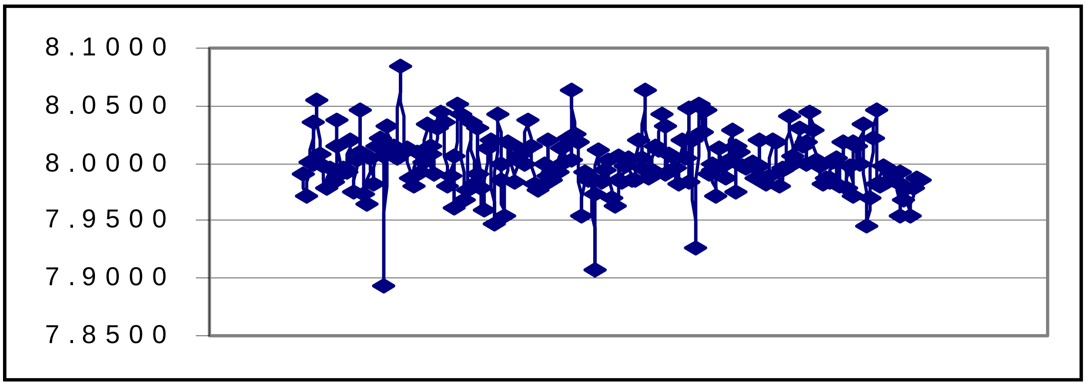
	Fixed		Limited Flexibility		More Flexible	
	Currency Board	**Conventional Peg**	**Explicit Narrow Peg**	**Tightly Managed**	**Broad Band**	**Relatively Free Float**
Bulgaria	***Jul. ‘97*** ←					***Feb. ‘91***
Czech Rep.		***Feb. ‘93*** →			***Jan. ‘96*** →	***May ‘97***
Estonia	***Jun. ‘92***					
Hungary		***Mar. ‘89*** →	***Mar. ‘95***			
Latvia		***Feb. ‘94***				
Lithuania	***Apr. ‘94*** ←					***Jun. ‘92***
Poland		***May ‘91*** →	***Oct. ‘91*** →		***May ‘95*** →	***Mar. ‘99***
Romania				***Apr. ‘94*** →		***Feb. ‘97***
Slovakia				***Feb. ‘93*** →		***Oct. ‘98***
Slovenia				***Oct. ‘91***		

Notes: The dates denote the starting month of the regime adoption. The → indicates a regime change. The structure of the Table based on Corker, Beaumont, van Elkan and Iakova (2000).

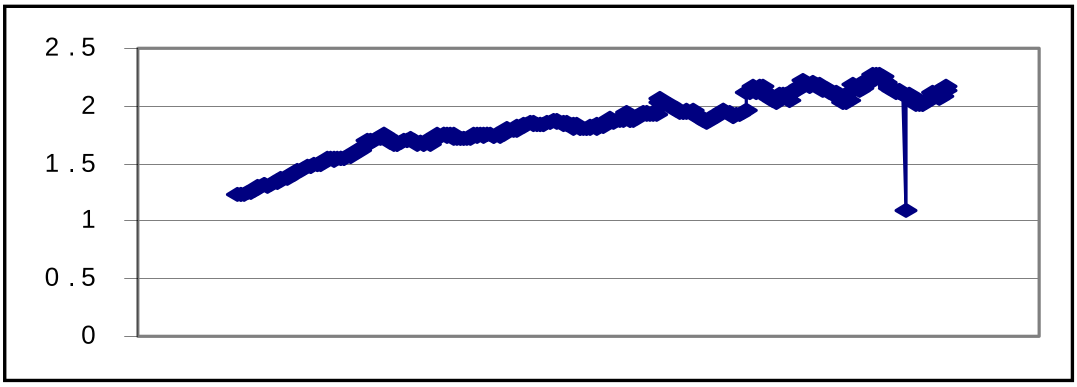
Table 3. Integration Tests for the Stock Prices and the Exchange Rates.

	ADF with Constant	ADF with Constant and Trend
ESK / DM rate	- 10.1795 **	- 10.8678 **
PLZ / DM rate	- 2.7210	- 5.1731 **
SIT / DM rate	- 0.80559	- 3.7766 **
PX 50 Index	- 3.6486 **	- 3.2174

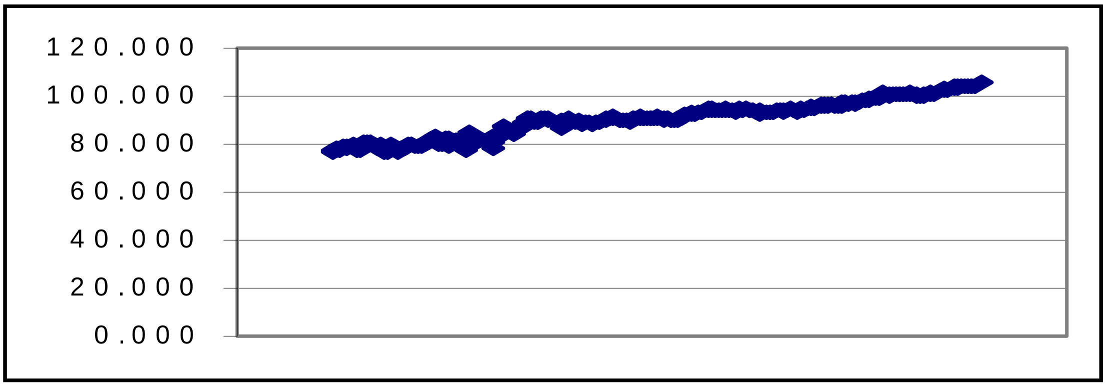
Notes: The critical values for the ADF statistics are according to McKinnon's statistics. ** denotes statistical significance at the 5% level.



Graph 1. Estonia Kroon / Deutschmark Exchange Rate (7/6/96 – 16/6/00).



Graph 2. Polish Zloty / Deutschmark Exchange Rate (7/1/94 – 16/6/00).



Graph 3. Slovenian Tolar / Deutschmark Exchange Rate (7/1/94 – 16/6/00).

Table 4. Bivariate Cointegration tests.

	LR TEST BASED ON MAXIMAL EIGENVALUE		LR TEST BASED ON TRACE	
	$H_0 : r = 0$ $H_1 : r = 1$	$H_0 : r <= 1$ $H_1 : r = 2$	$H_0 : r = 0$ $H_1 : r >= 1$	$H_0 : r <= 1$ $H_1 : r = 2$
Czech Rep. [f] **(P)**	***10.889***	***0.648***	***11.537***	***0.648***
(M)	***13.919 ****	***7.037 ****	***20.956 *****	***7.037 ****
Hungary (P)	***31.685 *****	***4.089***	***35.774 *****	***4.089***
(M)	***38.598 *****	***3.673***	***42.270 *****	***3.673***
Latvia (P)	***14.326 ****	***4.393***	***18.719 ****	***4.393***
(M)	***12.136***	***3.188***	***15.323***	***3.188***
Poland (P)	***17.034 *****	***7.694****	***24.729 *****	***7.694 ****
(M)	-	-	-	-
Romania (P)	***13.763***	***2.963***	***16.726***	***2.963***
(M)	***27.325 *****	***3.789***	***31.115 *****	***3.789***

Notes: (P) and (M) show cointegration tests of the general index of the local SE with the local exchange rate towards the British Pound and the German Mark respectively. [f] All cointegration tests for the Czech Republic include unrestricted intercepts. The critical values for the estimated results are given in Johansen and Juselius (1990). ** denotes statistical significance at a 5% level. * denotes statistical significance at a 10% level.

Table 5. Trivariate cointegration tests for the first wave of the EU Enlargement.

	LR TEST BASED ON MAXIMAL EIGENVALUE			LR TEST BASED ON TRACE		
	$H_0 : r = 0$ $H_1 : r = 1$	$H_0 : r <= 1$ $H_1 : r = 2$	$H_0 : r <= 2$ $H_1 : r = 3$	$H_0 : r = 0$ $H_1 : r >= 1$	$H_0 : r <= 1$ $H_1 : r >= 2$	$H_0 : r <= 2$ $H_1 : r = 3$
Czech R.[f]						
(P-FTSE)	***19.323****	***9.526***	***0.708***	***29.558****	***10.235***	***0.708***
Estonia						
(P-DAX)	***21.037****	***7.511***	***5.202***	***33.749****	***12.713***	***5.202***
(M-DAX)	***19.167***	***8.999***	***4.584***	***32.750****	***13.583***	***4.584***
(M-DJI)	***89.769*****	***8.848***	***1.828***	***100.444*****	***10.675***	***1.828***
Poland						
(M-DAX)	***23.616*****	***10.877***	***7.350***	***41.843*****	***18.227****	***7.350***
(M-DJI)	***38.232*****	***14.804****	***12.856*****	***65.892*****	***27.660*****	***12.856*****
(M-FTSE)	***62.892*****	***9.974***	***3.314***	***76.179*****	***13.288***	***3.314***
Slovenia						
(P-FTSE)	***20.181****	***10.644***	***2.504***	***33.329****	***13.148***	***2.504***
(P-DJI)	***19.197***	***11.044***	***5.837***	***36.078*****	***16.881***	***5.837***
(M-DAX)	***19.048***	***11.507***	***3.412***	***33.967****	***14.919***	***3.412***
(M-DJI)	***27.918*****	***16.072*****	***3.819***	***47.810*****	***19.892****	***3.819***
(M-FTSE)	***32.485*****	***17.254*****	***4.678***	***54.417*****	***21.932*****	***4.678***

Notes: Notation as in Table 4.

Table 6. Trivariate cointegration tests for the second wave of EU Enlargement.

	LR TEST BASED ON MAXIMAL EIGENVALUE			LR TEST BASED ON TRACE		
	$H_0 : r = 0$ $H_1 : r = 1$	$H_0 : r <= 1$ $H_1 : r = 2$	$H_0 : r <= 2$ $H_1 : r = 3$	$H_0 : r = 0$ $H_1 : r >= 1$	$H_0 : r <= 1$ $H_1 : r >= 2$	$H_0 : r <= 2$ $H_1 : r = 3$
Latvia						
(M-DAX)	***18.014***	***9.387***	***5.516***	***32.917****	***14.903***	***5.516***
(M-FTSE)	***26.564*****	***17.551*****	***8.765****	***52.880*****	***26.316*****	***8.765****
Lithuania						
(P-FTSE)	***12.827***	***6.975***	***5.519***	***25.321***	***12.494***	***5.519***
Romania						
(P-FTSE)	***21.004*****	***9.228***	***5.161***	***35.393*****	***14.389***	***5.161***
(P-DJI)	***24.553*****	***10.643***	***4.438***	***39.634*****	***15.082***	***4.438***
(P-DAX)	***23.614*****	***8.009***	***5.106***	***36.730*****	***13.115***	***5.106***
Slovakia						
(M-DAX)	***20.982****	***16.648*****	***2.883***	***40.513*****	***19.531****	***2.883***

Notes: Notation as in Table 4.

Table 7. Granger non-causality tests for the Czech Republic. Selected Results.

Hypothesis -->	***PX 50*** **not** ***caused by***	**CZK/GBP not** ***caused by***	**CZK/DM not** ***caused by***
CZK/GBP	**10.032 ****		
CZK/DM	**26.219 *****		
CZK/DM & DAX	**16.727 *****		
CZK/DM & DJI	**30.607 *****		
CZK/DM & FTSE	**32.102 *****		
CZK/GBP & FTSE	**15.446 ****		
CZK/GBP & DAX	**20.019 ****		
CZK/GBP & DJI	**18.512 ****		
PX50 & DJI		**24.262 *****	
PX50 & DJI			**17.528 ***

Notes: All the results are χ^2 (chi-squared) values for different lag levels, with the critical values given by Microfit. ***, **, and * denote statistical significance at 1%, 5% and 10% levels respectively.

Table 8. Granger non-causality tests for Estonia. Selected Results.

Hypothesis -->	TSE not *caused by*	EKR/GBP not *caused by*	EKR/DM not *caused by*
EKR/GBP	**17.270 ****		
TAL & FTSE		**8.613 ***	
TAL & DJI		**11.586 ****	
EKR/DM & DAX	**18.717 ****		

Notes: Notation as in Table 7.

Table 9. Granger non-causality tests for Poland. Selected Results.

Hypothesis -->	*WGI* not *caused by*	PZL/GBP not *caused by*	PZL/DM not *caused by*
WGI & DAX			**35.102 *****
WGI & DJI			**22.120 *****
WGI & FTSE			**22.602 *****
PZL/DM & DJI	**16.599 ****		
PZL/DM & FTSE	**10.593 *****		
PZL/GBP & FTSE	**28.661 *****		
PZL/GBP & DJI	**17.455 ****		
WGI & DAX		**19.075 ***	

Notes: Notation as in Table 7.

Table 10. Granger non-causality tests for Slovenia. Selected Results.

Hypothesis -->	SBI not *caused by*	SIT/GBP not *caused by*	SIT/DM not *caused by*
SIT/GBP & FTSE	**7.192 ****		
SBI & FTSE		**10.967 *****	
SBI & DJI		**44.898 ***	
SIT/DM & DJI	**41.108 ***		

Notes: Notation as in Table 7.

Table 11. Granger non-causality tests for Hungary. Selected Results.

Hypothesis -->	*BUX* not *caused by*	HUF/GBP not *caused by*	HUF/DM not *caused by*
BUX & DAX			13.314 ***
BUX & DJI			11.967 **
BUX & FTSE			12.942 **
BUX & FTSE		8.356 *	
BUX & DJI		8.348 *	

Notes: Notation as in Table 7.

Table 12. Granger non-causality tests for Latvia. Selected Results.

Hypothesis -->	*RICI* not *caused by*	LAT/GBP not *caused by*	LAT/DM not *caused by*
LAT/GBP	15.476 **		
LAT/DM	8.343 *		
LAT/DM & DAX	30.039 ***		
LAT/DM & FTSE	52.550 ***		
LAT/GBP & FTSE	31.445 ***		
LAT/GBP & DJI	21.366 **		
LAT/GBP & DAX	29.529 ***		
RICI & FTSE			31.273 *

Notes: Notation as in Table 7.

Table 13. Granger non-causality tests for Romania. Selected Results.

Hypothesis -->	*BET* not *caused by*	RML/GBP not *caused by*	RML/DM not *caused by*
RML/DM & DJI	10.882 *		
RML/DM & FTSE	13.526 **		
RML/GBP & FTSE	11.062 *		
RML/GBP & DAX	11.795 *		
BET & DAX			31.264 *

Notes: Notation as in Table 7.

Table 14. Granger non-causality tests for Lithuania. Selected Results.

Hypothesis -->	LITING not *caused by*	LIT/GBP not *caused by*	LIT/DM not *caused by*
LITING & DJI			49.083 *

Notes: Notation as in Table 7.

Table 15. Granger non-causality tests for Slovakia. Selected Results.

Hypothesis -->	**SAX16 not *caused by***	**SLK/GBP not *caused by***	**SLK/DM not *caused by***
SLK/DM & FTSE	**20.135 ***		
SAX16 & DAX			**51.578 *****
SAX16 & FTSE			**33.353 *****
SAX16 & DJI		**34.769 ***	

Notes: Notation as in Table 7.