UNIVERSITY OF WUPPERTAL
BERGISCHE UNIVERSITÄT WUPPERTAL

EUROPÄISCHE WIRTSCHAFT
UND
INTERNATIONALE MAKROÖKONOMIK

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Interdependence Between Foreign Exchange Markets and Stock Markets in Selected European Countries

Diskussionsbeitrag 160
Discussion Paper 160

Europäische Wirtschaft und Internationale Wirtschaftsbeziehungen
European Economy and International Economic Relations
ISSN 1430-5445

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December 2008

Herausgeber/Editor: Prof. Dr. Paul J.J. Welfens, Jean Monnet Chair in European Economic Integration

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JEL classification: G15, F31, E44
Key words: Exchange Rate, Stock Markets, Cointegration, VAR, European Integration

Summary: In this analysis the interdependence between foreign exchange markets and stock markets for selected accession and cohesion countries is discussed. This includes basic theoretical approaches. Monthly data for the nominal stock market indices and nominal exchange rates are used, where Ireland, Portugal, Spain, Greece, Poland, Czech Republic, Slovenia, and Hungary are included in the analysis. From the cointegration analysis and VAR analysis both long-term links and short-term links for Poland are identified. Conversely, for Slovenia, Hungary, Ireland, Spain, and Greece merely short-term links resulted. Surprisingly, the direction of causation is unambiguously from the stock market index to the exchange rate for all six countries considered.

Zusammenfassung: In dieser Analyse wird die Interdependenz zwischen Devisen- und Aktienmärkten für die vier neuen EU-Beitrittsländer Polen, Tschechische Republik, Slowenien und Ungarn und die vier Kohäsionsländer Irland, Portugal, Spanien und Griechenland diskutiert. Diese Untersuchung berücksichtigt wesentliche theoretische Grundlagen. Für die nominalen Aktienkursindizes und nominalen Wechselkurse werden monatliche Daten verwendet. Aus der Kointegrations- und VAR-Analyse geht hervor, dass für Polen sowohl langfristige als auch kurzfristige Zusammenhänge identifiziert werden können. Dagegen resultieren für Slowenien, Ungarn, Irland, Spanien und Griechenland nur kurzfristige Beziehungen. Überraschend ist in diesem Zusammenhang, dass die Einflussrichtung für alle betrachteten sechs Länder vom Aktienmarktindex zum Wechselkurs geht.

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1. Introduction

Since the 1970s the discussion about the interdependence between foreign exchange markets and stock markets has been the subject of many studies. In the late 1990s, it even experienced a further intensification due to the financial and currency crisis in Asia, with fast and massive adjustments in both foreign exchange markets and stock markets being observed. The more traditional perspective was to assume that the exchange rate could influence both stock prices and stock market indices. An increasing significance of capital movements and its influence on exchange rates has already been taken into account in various theoretical approaches, e.g. in the theory of uncovered interest rate parity. Dominance of capital movements of financial transactions relative to trade is obvious in many countries, and as investment in stocks is a key element of international capital movements it is crucial to consider the potential interdependence between stock prices and the exchange rate.

Stock market capitalisation experienced a huge increase over the past decade, particularly in Eastern European countries due to high portfolio capital inflows and in particular due to high Foreign Direct Investments (FDI). The impact of stock markets on foreign exchange markets could be relatively strong in Eastern European emerging countries as these capital markets are relatively underdeveloped and strong capital inflows due to reduced capital flow barriers – or favourable changes in expectations – could temporarily have a significant influence on nominal and real exchange rate movements. If portfolio investments or Foreign Direct Investments concerns firms listed in stock markets, then capital inflows will have an impact on stock markets. In like manner, capital inflows will have an indirect effect to the extent that interest rates fall and hence stock market prices will rise (in line with CAPM).

An analysis of cohesion countries and accession countries offers an interesting opportunity to explore the links between the two markets in the context of EU eastern enlargement. Furthermore, the EU financial market is probably more integrated than, for example, the Asian financial markets. The impact of the EU single market in general and of financial market integration in particular implies a reduction of barriers to capital flows; hence stronger links between the foreign exchange market and the stock market could result. As regards comparable newly industrialised Asian countries, significant results for such type of linkages were found in many studies (e.g. GRANGER et al., 2000; AMARE/MOHSIN, 2000; AJAYI et al., 1998). Against this background it is interesting to analyze eastern European EU countries whose capital markets are still in a catching up process. Stronger links imply that central banks must also take this aspect into account when making decisions in terms of interest rate and money supply, as these decisions can have undesired impacts on the whole financial market. The links between the foreign exchange rate and stock market prices are particularly important in the context of the growing openness of eastern European countries and also because capital accumulation and catching-up will be reflected in the dynamics of large and medium firms quoted on the stock market.

In the following analysis the focus is on EU cohesion countries and selected post-socialist transition economies. The results of the subsequent analysis show that significant links exist for six countries (Ireland, Spain, Greece, Poland, Slovenia, and Hungary) in the short-term, where the stock market index Granger-causes the exchange rate. Thus the main channel for the eight countries considered is an impulse which runs from the stock market to the foreign exchange market. For Poland, additional long-term links exist with the same direction of causation.

The subsequent analysis is divided as follows: After the introduction a selective review of important literature is given in section two before theoretical foundations and methods employed are discussed in sections three and four, respectively. In the fifth section, empirical results are presented with respect to the analysis of long-term and short-term links between foreign exchange markets and stock markets in selected cohesion and accession countries. Finally, the paper ends with a summary and some concluding remarks.

2. Previous Literature

Most of the analyses on the links between foreign exchange markets and stock markets have focussed either on the US during the 1980s and 1990s, the most developed capital market, or on South Eastern and South Asian countries (especially after the East-Asian crisis in 1997). During this time, both foreign exchange markets and stock markets experienced huge volatility.

The first study on the interdependence between foreign exchange markets and stock markets was carried out by FRANCK/YOUNG (1972) who based their study on a simple correlation and regression analysis. They examined the repercussion of strong exchange rate volatility of foreign currencies with respect to the US dollar on stock prices of selected US multinational firms included in the S&P 500 and Dow-Jones index. No significant results could be found. After the collapse of the Bretton Woods System and therefore the correspondingly more volatile exchange rates, research on this topic advanced in various ways – e.g., the noteworthy study of AGGARWAL (1981). The intuition for a link between the exchange rate and the stock market assumes that a devaluation or depreciation of the currency makes exports more profitable and as most major exporters are quoted on the stock market, one will see a rise in stock market prices. For the period between January 1974 and December 1978, positive long term and short term links were found. These links, however, were stronger in the short term.

SOENNEN/HENNIGAR (1988) used the real effective exchange rate of the US dollar and stock prices. They found strong negative links between the changes of the US dollar and the changes of stock prices of US enterprises for the period 1980-1986. BAHMANI-OSKOOEE/SOHRABIAN (1992) applied the cointegration concept and Granger causality tests in order to study any potential links between foreign exchange rates and stock prices. They were also the first to research for a reverse relation. They applied monthly data for the period between July 1973 and December 1988 for the S&P 500 index and the effective exchange rate of the dollar, finding that both variables have an influence on each other. However, they were unable to find any long-term links.

After the Asian crisis, there were also various studies about the interdependence between foreign exchange and stock markets for Asian countries. Particularly important studies include that of ABDALLA/MURINDE (1997), who considered in their analysis South Korea, Pakistan, India and the Philippines by looking at the real effective exchange rates of these countries for the period from January 1985 to July 1994. Long-term links were tested using cointegration concept and short-term links with Granger causality tests. Only for India and the Philippines could long term links be found. Using an error correction model (ECM) for India and the Philippines implied for the former that the exchange rate indeed influences the stock market index; for the latter the reverse relation resulted. For South Korea and Pakistan, positive short term links have been found, where the exchange rate is causal – in the Granger sense – to the stock market index. AMARE/MOHSIN (2000) included nine Asian countries (Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan and Thailand) in their study. They employed the cointegration concept to examine potential long-term links between the two markets. Long-term links could be confirmed only for the Philippines and Singapore. The inclusion of the additional variable "interest rate" led to the result that for six of nine countries, long term links could be confirmed. GRANGER et al. (2000) considered Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan and Thailand by employing the cointegration concept and Granger causality tests. In order to filter out the shocks of the 1987 crash and the avian flu crisis in Asia, the time series were divided into three parts. They therefore used daily data of different time series' length (altogether from 3 January 1987 to 14 November 1997, i.e. 3,097 observations). Except for Japan, Singapore and Thailand significant links were found. These results effectively demonstrate that bi-directional links do exist. However, during the currency crisis – i.e., in the short-run – it holds that in most cases stock prices have an influence on exchange rates.

MUHAMMAD/RASHEED (2003) considered Bangladesh, India, Pakistan and Sri Lanka for the period from 1994 to 2000, also employing the cointegration concept and Granger causality tests. For India and Pakistan they could find neither short-term nor long-term links. However, for Bangladesh and Sri Lanka, bi-directional (positive) links could be confirmed. STAVÁREK (2004) examined the interdependence between the stock market index and the real effective exchange rates of four veteran EU members – Germany, France, Austria and the UK –, four new EU members – Poland, Slovakia, Czech Republic and Hungary – as well as the USA for the periods 1970 to 1992 and 1993 to 2003; he employed the cointegration concept, Vector ECM (VECM) and the Granger causality test. For the veteran EU member countries and the US, both long-term and short-term links were found, but the direction of causality is not uniform for all countries. Conversely, for the new members merely short term links resulted.

3. Theoretical Foundation

In the literature there are not many attempts to incorporate the stock market and foreign exchange market in a single model; the links between the two markets certainly exist, but they are not as obvious and unambigous as, for example, the link between the interest rate and the exchange rate. JARCHOW (1999) incorporates the stock market in a modified Mundell-Fleming model based on the idea of representing the stock price in the sense of Tobin's q and a variable price level. The ratio q consists of existing real capital p^A and newly produced real capital p. Hence, q can be interpreted as the real stock price.

The portfolio balance approach is a model which, besides the foreign exchange market, also incorporates the money market and the market of domestic and foreign securities (BRANSON, 1977). Market participants possess a wealth stock – with given stocks of nominal money, domestic bonds and foreign bonds – for which investors choose the preferred portfolio structure, namely based on (expected) returns of the alternative assets. The demand for domestic money, foreign securities or domestic securities depend both on domestic interest rate i and the yield on foreign bonds (i^f which is the foreign interest rate plus the expected devaluation rate). The asset markets included in this model are represented by the equations

$$M = w_1 \cdot \underset{(+)(-)(-)}{(W, i, i^f)}$$

$$B = w_2 \cdot \underset{(+)(+)(-)}{(W, i, i^f)}$$

$$e \cdot F = w_3 \cdot \underset{(+)(-)(+)}{(W, i, i^f)},$$

where,

$$W = M + B + eF$$

Total wealth W is the sum of money M, domestic bonds B, and foreign bonds eF (F is the stock of foreign bonds – denominated in foreign currency – in the country considered; e is the exchange rate in price notation). The signs given below the equations indicate the influence of the corresponding variables on the demand of M, B and eF, respectively. In an e-i-space, the equilibrium loci for foreign bonds (FF) and domestic bonds (BB) are both negatively sloped. The slope of the MM curve – portraying equilibrium in the money market – is positive. The securities considered in this model represent bonds with very short maturities. In a modified version of the portfolio balance approach, WELFENS (2007) includes the stock market instead of the domestic bonds market (for further Branson-type models, where beside the stock market also the oil market is incorporated as an additional asset market, see WELFENS (2008)). In this model, the supply side of the stock market is given as the product of the real stock market index P'/P and capital stock K. The demand for stocks (also for foreign bonds and money) depends on marginal utility of money, capital productivity, expected growth rate of the stock market price, and the sum of foreign bonds' interest rate and expected depreciation rate of the exchange rate. In an e-P' space, the KK curve and FF curve are both positively sloped and the MM curve is negatively sloped.

These approaches emphasize stocks while flows are considered by REITZ et al. (2007). This flow-approach considers the aggregation of end-user order flows, which contain different information from different types of customers with respect to the expected fundamental value of the exchange rate. (A financial customer is much more engaged in exchange rate research than a commercial customer, as the latter only intends to hedge its money amounts resulting from exports or imports.) In particular, short-term deviations of the exchange rate from its fundamental value should be explained with this approach as traditional models do not offer satisfactory results.

ADLER/DUMAS (1984) capture the link between enterprise return and its exposure vis-à-vis relative exchange rate change in a single factor model which is given by the equation

$$r_i = a_i + b_i d + \varepsilon_i \quad (1)$$

The slope coefficient b_i expresses the exchange rate exposure of enterprise i (i = 1, ..., n), a_i denotes the constant and ε_i the error term (where $E(\varepsilon_i) = 0$ and $Var(\varepsilon_i) = \sigma^2$). The variable d represents exchange rate return and r_i the return of enterprise i.

BODNAR/WONG (2003) proposed an augmented market model (a two-factor model) which subdivides the risk exposure of enterprises into two components (factors): the overall market exposure – i.e., the risk an enterprise is exposed to the total stock market – and exchange rate exposure. The modified equation

$$r_{it} = a_i + b_i d_t + \beta_i r_{mt} + \varepsilon_{it} \quad (2)$$

can be estimated as usual by OLS. β_i now represents the "stock market risk", i.e. the beta-factor known from the standard Capital Asset Pricing Model (CAPM), with r_m expressing the stock market return and b_i representing the exchange rate exposure (see also ENTORF/JAMIN, 2007).

The factor models presented above presume that the variable exchange rate is the explanatory variable, and the variable stock price (at enterprise level) is the explained variable. Making some reflections about the linkage between the two variables lead to the realization that both variables can actually have an impact on each other at the macro level, as BAHMANI-OSKOOEE/SOHRABIAN (1992) for example have emphasized. Two possible channels will be explained through which links between the two markets can result.

The exchange rate has an impact on stock prices particularly on export-oriented enterprises. An increase of the exchange rate, i.e. a depreciation of the domestic currency, favours exports, therefore stock prices of enterprises should increase. Moreover, FROOT/STEIN (1991) emphasized particularly that foreign direct investments (FDI`s) are also influenced by real exchange rate as real devaluation of domestic currency stimulates net inflows – the latter in turn will affect trade balance in the medium term. The Froot-Stein model emphasizes the role of imperfect capital markets.

The influence of the stock (market) price on exchange rate can be taken into account through including transactions in the stock market in the money demand function. Referring to the 1920s onset of the Great Depression in the United States, FIELD (1984) emphasizes the importance of considering the significant impact of stock trading's value on the demand to hold cash balances. He asserts that the fact of having not recognized stock trading as a relevant argument in the demand for money (an expansion of the money supply could be misjudged as expansionary while it might be neutral or even restrictive, namely if rising turnover figures in asset markets fully absorb the additional liquidity) led indirectly to the Great Depression, as the nature of monetary policy was misjudged – it was less expensive than the FED thought. Hence, he incorporates the stock market in his augmented money demand function – namely, the transaction volume of stock markets multiplied by the stock price.

In a modern version of the Field argument, one may argue with respect to FDI that the demand for domestic money increases if foreign investors invest in domestic enterprises and raise the nominal amount of stock market transactions. On the one hand, stock price increases, on the other hand the interest rate increases as a consequence of increased money demand. Therefore capital inflows are additionally favoured, and domestic currency will appreciate under flexible exchange rate. In case of fixed exchange rate, stock market prices should consequently have no influence on exchange rates but may have an impact on foreign exchange reserves of the central bank, which is committed to preserving the current value of the exchange rate. If domestic currency appreciates, the central bank is obliged to perform foreign exchange interventions.

Obviously the exchange rate can have a strong impact on the stock price at the micro level. However, at the macro level the impact could be weaker or even non-existent, as a stock market index actually measures the performance of a "diversified portfolio". In other words, enterprises – weighted by their capital stock – of several industries are incorporated in a stock market index. The exchange rate should have a greater impact on a stock market index when more export-oriented enterprises are represented in the stock market index. Hence, the composition of a stock market index is a crucial hint when it comes to the question as to whether the exchange rate does indeed have a significant impact on the stock market index.

At the macro level, capital (in) flows (e.g., due to investments in securities) can have a strong impact on the exchange rate as well. Investments in securities can be made either in bonds or in shares. Hence exchange rates are not only affected through foreign investments on domestic bonds but also through foreign investments on listed domestic enterprises. As the equity markets in emerging countries are relatively underdeveloped the effect of stock markets can be much higher than in highly developed capital markets. Moreover, emerging markets are quite interesting for investors, as high returns can often be obtained even though the risk is higher. According to the Capital Asset Pricing Model (CAPM), however, the investor is willing to bear a higher risk if he or she expects an enterprise return which is at least as high as its corresponding beta (SHARPE et al., 1995). Hence, the security market line (SML) can be used to assess shares and is thus quite a useful instrument in making decisions on investments. Another reason for investments in these countries is that emerging markets do not strongly correlate with highly developed stock markets. Hence, portfolios can further be diversified.

4. Data and Methods Employed

4. 1. Data and Countries

In the subsequent analysis, four accession countries (Poland, Czech Republic, Slovenia, and Hungary) and four cohesion countries (Ireland, Portugal, Spain, and Greece) are included in the analysis. Monthly (average) data (from Eurostat.; Index, 1995=100) of nominal stock market indices and nominal bilateral exchange rates (denominated as domestic currency per US dollar unit (for which time series data had to first be transformed) will be used. The time series applied to the accession countries are considered until June 2008, but the initial values of the time series vary for both country groups due to a lack of data (initial values depend on the countries included in the analysis, i.e. initial values correspond to the initial values available at the data source mentioned above). The introduction of the Euro poses an additionally strong restriction for the applied data of the cohesion countries concerning the data length. For this reason, cohesion countries are considered until December 1998 (Greece until December 2000). The initial values of the cohesion countries are given as follows: Greece: 09-1988; Ireland:12-1986; Portugal: 12-1992; Spain: 01-1987, and those of the accession countries: Poland: 04-1991; Slovenia: 01-1994; Czech Republic: 04-1994; Hungary: 01-1991.

4. 2. Methods Employed

For the further analysis, it is important to examine whether the time series applied fulfil the property of stationarity. An appropriate unit root test must be carried out, as this property decides whether long-term or short-term links between variables can be examined. The Augmented Dickey Fuller (ADF) test is a quite powerful test, and it will therefore be employed in this analysis. This test is based on the following regression:

$$\Delta y_t = \delta y_{t-1} + \sum_{j=1}^{m} \alpha_j \Delta y_{t-j} + u_t \,, \qquad (3)$$

where Δ represent the difference operator. The null hypothesis, y_t contains a unit root (i.e. $\delta = 0$), will be rejected if the t-value is less than the critical ADF value. Since autocorrelation of Δy_t is taken into account, the u_t must now fulfil the property of white-noise, otherwise the lag-length must be optimized until it does. The equation can adequately be estimated by OLS.

The links between distinct variables can be explored either in the short-term or in the long-term. The latter can be carried out by using the cointegration concept. The precondition for the employment of this approach is that all considered time series must be nonstationary and integrated of the same order. Cointegration means that time series have at least one common stochastic trend except for some temporarily deviations. According to ENGLE/GRANGER (1987), cointegration is defined as follows:

Let Y be a vector of k variables which are all integrated of order d. The components of Y are then cointegrated of order (d, c) in case of the existence of at least one linear combination z of these variables. The variable z is then integrated of order d-c ($d \geq c > 0$), i.e.

$$\beta' Y = z \sim I(d\text{-}c) \tag{4}$$

In other words, if the variables are integrated of order 1 – for economic variables this is often the case – then the residuals (resulting from the regression equations) must be of minor order, i.e. I(0) (ENGLE/GRANGER, 1987).

The vector β is denoted as cointegrating vector. The number of linear independent cointegrating vectors represents the cointegration rank r. In case of $r = k$ the system consists of k stationary variables – i.e., the cointegration concept cannot be employed. If $r = 0$, a long-term relationship does not exist due to a lack of at least one stationary linear combination for these variables – i.e., cointegration exists only in the case of $0 < r < k$ (ENDERS, 1995; KIRCHGÄSSNER/WOLTERS, 2007).

Both long-term and short-term links can also be explored simultaneously in case of the existence of a cointegrating relationship between the considered variables. In this case, an Error Correction Model (ECM) can be employed. In a two-variable case, a very simple two-step procedure could be carried out. The first step would be to regress each variable on the other if the property of nonstationarity for both variables is given, i.e.:

$$y_t = a_0 + b_0 x_t + z_t^y \tag{5}$$

$$x_t = a_1 + b_1 y_t + z_t^x \tag{6}$$

In the second step, the transformation into an ECM follows. According to the Granger representation theorem, an existing cointegration relationship always contains an equivalent ECM (and the reverse), and this can be expressed with the following equations:

$$\Delta y_t = \gamma_0^y - \gamma_y \underbrace{(y_{t-1} - a_0 - b_0 x_{t-1})}_{= z_{t-1}^y} + \sum_{j=1}^{n_x} a_{xj} \Delta x_{t-j} + \sum_{j=1}^{n_y} a_{yj} \Delta y_{t-j} + u_{yt} \tag{7}$$

$$\Delta x_t = \gamma_0^x + \gamma_x \underbrace{(y_{t-1} - a_1 - b_1 x_{t-1})}_{= z_{t-1}^x} + \sum_{j=1}^{n_x} b_{xj} \Delta x_{t-j} + \sum_{j=1}^{n_y} b_{yj} \Delta y_{t-j} + u_{xt} \tag{8}$$

The parameters γ_y and γ_x give information about long-term links (speed of adjustment toward the long-term equilibrium) between the variables y_t and x_t. If at least one of these parameters is significantly different from zero, a long-term link then exists between the considered variables. The parameters a_{xj}, a_{yj}, b_{xj} and b_{yj} represent short-term links. Furthermore, if the parameter γ_y (γ_x), and at least one a_{xj} (b_{yj}) is significantly different from zero – b_{yj} (a_{xj}) is not significantly different from zero – the variable x_t (y_t) is said to Granger cause y_t (x_t). The advantage of this approach is that the information lost through differentiating the data in level can be taken into account in differenced data.

A problem arises in this context with testing the property of stationarity of the residuals, as the common unit root tests are thought to be employed for realised but not generated time series. The critical values of the ADF test are therefore not valid, and other critical values must be considered (MACKINNON, 1991). Furthermore, in case of more variables, two problems can emerge. On the one hand, multiple cointegration relations can exist, and on the other hand, the endogenous variable cannot be fixed a priori. If a cointegrating relation for the considered n variables exists, each variable should be exchangeable as an endogenous and exogenous variable and also be significantly different from zero. Often, however, exactly this anomalous feature emerges. Therefore a more powerful test is needed. The Johansen approach, based on a VAR, can overcome these problems. The starting-point is the following VAR without a deterministic trend (JOHANSEN, 1988):

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + U_t \qquad (9)$$

The variables are I(1), and they may be cointegrated. Subtraction of both sides with Y_{t-1} and rearrangement of (9) leads to the Vector Error Correction Model (VECM)

$$\Delta Y_t = -\Pi Y_{t-1} + A_1^* \Delta Y_{t-1} + A_2^* \Delta Y_{t-2} + \ldots + A_{p-1}^* \Delta Y_{t-p+1} + U_t , \qquad (10)$$

with

$$\Pi = I - \sum_{j=1}^{p} A_j \text{ and } A_j^* = -\sum_{i=j+1}^{p} A_i , \quad j = 1, 2, \ldots, p-1$$

The matrix I denotes the identity matrix and Π contains the long-term links between the included variables. Tests for cointegration can be carried out through examining the rank of the matrix Π (i.e., testing whether the eigenvalues λ_i are significant different from zero). The number of significant eigenvalues is equivalent to the rank of the matrix Π (LÜTKEPOHL/KRÄTZIG, 2004). The idea is the same as in the case of the ADF test. The difference is that unit root is tested in a multi-equation case.

Considering the eigenvalues, two tests can be generated:

- $Tr(r) = \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i)$ (trace-test)

with the hypothesis

H_0: the number of positive eigenvalues is at most r vs. H_1: there are more than r (r < k) positive eigenvalues.

- $\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$ (λ_{max}-test)

However, the hypotheses of the λ_{max}-test are constructed as follows:

H_0: the number of positive eigenvalues is exactly r vs. H_1: there are exactly r + 1 positive eigenvalues.

The sequences of tests start with r = 0 and end when the null hypothesis cannot be rejected any more. The cointegration rank is then equivalent to the value at which the null hypothesis could not be rejected (BROOKS, 2003). The null hypothesis will be rejected if the value of the test statistic is larger then the critical value.

If the attempt of detection of any long-term links between variables fails, an alternative would be to ascertain whether at least short-term links can be found. Short-term links can be explored by employing VAR models for variables, which has been induced to stationarity. In a VAR model, the dependence of a variable to itself is considered up to the lag p and to other variables as well (SIMS, 1980). A VAR without deterministic trend is given in (9), where in this case – short-term links are explored – all variables must be stationary. These models can easily be estimated by OLS. The correct specification of the model can be checked with the usual instruments, i.e. checking whether the residuals fulfil the property of white-noise or may be serially autocorrelated (e.g., using the Q statistics for each single equation).

Finally, the interdependencies should adequately be specified. The VAR process is not able to specify which variable is exogenous and which one is endogenous. Hence, Granger-causality tests will be employed. A variable, say x_t, is said to Granger-cause the other variable, say y_t, if the inclusion of x_t improves the forecast of y_t and vice versa. If both variables Granger cause each other, a feedback relationship is given.

Considering

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \sum_{i=1}^{p} \begin{pmatrix} \alpha_{11,i} & \alpha_{12,i} \\ \alpha_{21,i} & \alpha_{22,i} \end{pmatrix} \begin{pmatrix} x_{t-i} \\ y_{t-i} \end{pmatrix} + u_t \qquad (11)$$

then in a bivariate VAR x_t Granger causes y_t if $\alpha_{21,i} \neq 0$ for at least one i (i = 1, 2, ..., p) and $\alpha_{12,i} = 0$ ($\forall i = 1,...,p$) and y_t Granger causes x_t if $\alpha_{12,i} \neq 0$ for at least one i (i = 1,.. , p) and $\alpha_{21,i} = 0$ ($\forall i = 1,...,p$).

In this test the significance of lags of the considered variables is examined by using F-tests in order to ascertain whether the whole parameters of the lags are insignificant or at least one parameter is significantly different from zero. Therefore variables must fulfil the property of stationarity.

5. Empirical Results

5. 1. Unit Root Test

The first step in the analysis consists of testing time series to determine whether they fulfil the property of non-stationarity as it is a requirement for the employment of the cointegration concept. Therefore, the ADF test will be employed in level and in first differences. For the sake of clarity, the presentation of the results will be divided into two groups, the group of cohesion countries, and the group of accession countries.

The ADF test critical values depend on selected lag length; for this reason, the optimal lag length must be determined somehow. In a univariate autoregressive process, the number of lag p is chosen, for example, by the Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion (SBC). Furthermore, the lag length is augmented if significant serial autocorrelation for the residuals is indicated (tested by Q statistics). In this analysis, both the multivariate AIC (MAIC) and the multivariate SBC (MSBC) are employed. The variable SP expresses the nominal stock market index and EXR the nominal exchange rate. DSP and DEXR express the differenced variables of SP and EXR, respectively.

Cohesion Countries

The results show that except for the exchange rate in case of Ireland, both stock market indices and exchange rates are nonstationary for all considered time series. Hence, the requirement of employing the cointegration concept is not fulfilled for Ireland. A VAR in first differences must therefore be employed.

Tab. 1a: Results of ADF test.

Country	**Variable**	**t-Stat.**	**Test critical values**
Ireland	SP	0.7125	1% -3.4768
	DSP	-3.1375	5% -2.8818
	EXR	-3.2895	10% -2.5777
	DEXR	-5.9077	
Portugal	SP	-0.9946	1% -3.5285
	DSP	-4.7437	5% -2.9042
	EXR	-2.3184	10% -2.5896
	DEXR	-6.0621	
Spain	SP	0.4635	1% -3.4775
	DSP	-6.2969	5% -2.8821
	EXR	-0.6409	10% -2.5778
	DEXR	-8.3412	
Greece	SP	-1.3650	1% -3.4775
	DSP	-3.8481	5% -2.8821
	EXR	0.5620	10% -2.5778
	DEXR	-8.5979	
Null Hypothesis: … has a unit root			

Accession Countries

Obviously all time series are I(1) according to the ADF test, i.e. stationarity will be induced after first differences. All accession countries included in the analysis can therefore be taken into account for testing long-term links between the two variables.

Tab. 1b: Results of ADF test.

Country	Variable	t-Stat.	Test critical values	
Poland	SP	-0.3558	1%	-3.4627
	DSP	-11.7245	5%	-2.8757
	EXR	-2.0019	10%	-2.5744
	DEXR	-10.1764		
Slovenia	SP	1.9228	1%	-3.4731
	DSP	-8.7503	5%	-2.8802
	EXR	-1.3872	10%	-2.5768
	DEXR	-8.4053		
Czech Rep.	SP	-0.0969	1%	-3.4699
	DSP	-9.5093	5%	-2.8788
	EXR	-0.1042	10%	-2.5761
	DEXR	-9.4750		
Hungary	SP	-1.1418	1%	-3.4632
	DSP	-3.0379	5%	-2.8759
	EXR	-1.7570	10%	-2.5745
	DEXR	-11.4651		
Null Hypothesis: … has a unit root				

5. 2 Long Term Links

In the second part of the analysis, the cointegration concept is employed. In a two-variable case the Engle-Granger two-step approach could be employed. Obviously, the Johansen approach is a more sophisticated approach and at the same time it is more pleasant in implementation even in a two-variable case. The transformation into a Vector Error Correction Model (VECM) leads to a quasi VAR anyway.

As the results of the Johansen approach depend on selected lag order of the VAR, the optimal lag has to be determined by an appropriate information criterion. In this analysis, the multivariate AIC will be employed. Nevertheless, the lag length may need to be augmented if serial autocorrelation does not disappear.

Tab. 2a and 2b show that except for Poland, stock market indices and exchange rates are not cointegrated for any of the countries, as the critical values are not exceeded by the test statistic values; in other words, there are no long term links for seven of the eight countries under consideration.

Tab. 2a: Results of the Cointegration test (cohesion countries)

Country					
Ireland	Lags	–	Statistic	Critical Value	Prob.**
	None			–	
	At most	1			
Portugal	Lags	5	Statistic	Critical Value	Prob.**
	None		13.2342	15.4947	0.1065
	At most	1	0.2063	3.8415	0.6497
Spain	Lags	6	Statistic	Critical Value	Prob.**
	None		11.4983	15.4947	0.1826
	At most	1	1.6909	3.8415	0.1935
Greece	Lags	2	Statistic	Critical Value	Prob.**
	None		7.0238	15.4947	0.5749
	At most	1	0.0011	3.8415	0.9735
**MacKinnon-Haugh-Michelis (1999) p-values					

Tab. 2b: Results of the Cointegration test (accession countries)

Country					
Poland	Lags	4	Statistic	Critical Value	Prob.**
	None		**17.8659**	15.4947	0.0216
	At most	1	0.0570	3.8415	0.8112
Czech Rep.	Lags	2	Statistic	Critical Value	Prob.**
	None		5.3659	15.4947	0.7688
	At most		0.8128	3.8415	0.3673
Slovenia	Lags	2	Statistic	Critical Value	Prob.**
	None		6.7315	15.4947	0.6091
	At most		0.0435	3.8415	0.8347
Hungary	Lags	3	Statistic	Critical Value	Prob.**
	None		6.9283	15.4947	0.5860
	At most	1	0.1633	3.8415	0.6861
**MacKinnon-Haugh-Michelis (1999) p-values					

5. 3. Short term links

In the next step short term links are explored. An appropriate approach for this purpose is a bivariate VAR(p). A VAR process presumes that all variables depend on each other, i.e. there is no exogenous variable given. A suitable property of this approach is that, on one hand, the own endogenous structure of a variable is considered; on the other hand, interdependence to the other variables is also taken into account up to the lag p.

Cohesion Countries

The results show that for Ireland significant links between the nominal stock market index and the nominal exchange rate can be confirmed until the second lag. Obviously the direction of causation is from stock market index (DSP) to exchange rate (DEXR). For Spain and Greece, significant links can be confirmed, while for Greece a feedback relationship seems to exist. Conversely, the stock market index and the exchange rate for Portugal do not depend on each other. An explanation for this could be the small number of observations included in the analysis (73 observations). It would be desirable to have a time series length of at least ten years as monthly data are used. The data length may be one explanation for the lack of significance interdependence between the exchange rate and stock market index in Portugal.

From the VAR analysis, we can conclude that for the cohesion countries, three of the four countries considered are interrelated where the foreign exchange market seems to be influenced by the stock market. For Greece, a bi-directional link seems to exist. In order to ensure whether DSP or DEXR can be regarded as the exogenous variable – especially for Greece, as a lack of clarity remains – Granger causality tests must be employed.

Tab. 3a.1: Results of VAR estimation for Ireland

Ireland	DEXR	DSP
Constant	0.2193 [0.8697]	1.0268 [1.6816]
DEXR(-1)	0.3236 [3.2927]	0.1406 [0.5909]
DEXR(-2)	-0.2511 [-2.4509]	0.4228 [1.7043]
DEXR(-3)	0.1986 [1.8360]	-0.0828 [-0.3160]
DEXR(-4)	-0.1523 [-1.3820]	0.1051 [0.3939]
DEXR(-5)	0.0342 [0.3072]	0.3031 [1.1229]
DEXR(-6)	-0.0391 [-0.3579]	0.0161 [0.0608]
DEXR(-7)	-0.0736 [-0.6814]	0.3772 [1.4422]
DEXR(-8)	0.0445 [0.4273]	-0.2713 [-1.0757]
DEXR(-9)	0.1295 [1.3706]	0.2492 [1.0890]
DSP(-1)	0.0855 [**2.2058**]	0.4807 [5.1217]
DSP(-2)	-0.0965 [**-2.2197**]	-0.4156 [-3.9469]
DSP(-3)	0.0564 [1.2503]	0.2214 [2.0259]
DSP(-4)	-0.0186 [-0.4000]	-0.0570 [-0.5063]
DSP(-5)	0.0340 [0.6911]	-0.0699 [-0.5871]
DSP(-6)	-0.0620 [-1.1911]	-0.3022 [-2.3978]
DSP(-7)	0.0336 [0.6217]	0.0537 [0.4106]
DSP(-8)	-0.0895 [-1.6853]	-0.1961 [-1.5254]
DSP(-9)	-0.0888 [-1.6853]	0.3906 [3.1613]
R-squared	0.2853	0.3726
Adj. R-squared	0.1744	0.2752

Note. t-statistics in [ ]

Tab. 3a.2: Results of VAR estimation for Portugal

Portugal	DEXR	DSP
Constant	0.1192 [0.4104]	1.6797 [1.1943]
DEXR(-1)	0.2747 [2.1891]	0.0735 [0.1210]
DSP(-1)	0.0161 [0.6321]	0.3726 [3.0263]
R-squared	0.1003	0.1431
Adj. R-squared	0.0738	0.1179

Tab. 3a.3: Results of VAR estimation for Spain

Spain	DEXR	DSP
Constant	0.4704 [2.6694]	1.3903 [1.8770]
DEXR(-1)	0.3303 [3.9449]	0.0323 [0.0918]
DEXR(-2)	-0.0359 [-0.4242]	-0.1302 [-0.3662]
DSP(-1)	0.0079 [0.4172]	0.4760 [5.9731]
DSP(-2)	-0.0527 [**-2.6164**]	-0.3928 [-4.6434]
R-squared	0.1556	0.2423
Adj. R-squared	0.1308	0.2200

Tab. 3a.4: Results of VAR estimation for Greece

Greece	DEXR	DSP
Constant	0.3719 [1.3522]	4.6308 [2.0124]
DEXR(-1)	0.3125 [3.0411]	-0.6183 [-0.7192]
DEXR(-2)	-0.146005 [-1.3449]	-0.1392 [-0.1532]
DEXR(-3)	0.1019 [0.9593]	0.6011 [0.6761]
DEXR(-4)	-0.2281 [-2.1588]	-0.8151 [-0.9220]
DEXR(-5)	0.0284 [0.2794]	0.2385 [0.2805]
DEXR(-6)	0.0130 [0.1281]	-2.4684 **[-2.8991]**
DEXR(-7)	-0.1111 [-1.0113]	0.0960 [0.1045]
DEXR(-8)	0.1650 [1.4721]	-0.3674 [-0.3917]
DEXR(-9)	-0.6719 [-1.7562]	-0.2897 [-0.3091]
DEXR(-10)	0.1269 [1.1226]	0.5066 [0.5357]
DEXR(-11)	-0.1869 [-1.6666]	-0.6081 [-0.6481]
DEXR(-12)	0.1246 [1.1849]	-0.8881 [-1.0091]
DSP(-1)	0.0030 [0.2575]	0.3343 [3.4354]
DSP(-2)	-0.0042 [-0.3546]	0.0460 [0.4629]
DSP(-3)	0.0119 [0.9971]	-0.0093 [-0.0931]
DSP(-4)	-0.0166 [-1.3265]	0.2274 [2.1688]
DSP(-5)	-0.0186 [-1.4020]	-0.3381 [-3.0454]
DSP(-6)	0.0166 [1.2173]	-0.0310 [-0.2713]
DSP(-7)	-0.0010 [-0.0770]	0.1905 [1.6784]
DSP(-8)	0.0241 [1.8345]	0.0316 [0.2871]
DSP(-9)	-0.0281 **[-2.1219]**	0.0861 [0.7760]
DSP(-10)	0.0119 [0.8544]	-0.0538 [-0.4613]
DSP(-11)	0.0274 [1.9270]	-0.3269 [-2.7499]
DSP(-12)	0.0404 **[2.8277]**	0.1915 [1.6028]
R-squared	0.4025	0.3399
Adj. R-squared	0.2721	0.1959

Granger causality tests show that the hypothesis "DSP does not Granger cause DEXR" can be rejected for three of four countries, i.e. Ireland (can be rejected at 5.7% significance level), Spain, and Greece. The reverse direction cannot be confirmed for any of the cohesion countries. The selected lag length is equivalent to the lag length of the VAR model as it is intended to ascertain whether the interdependent links confirmed with the VAR approach can be specified with respect to the direction of causation.

Tab. 3a.5: Results of Granger causality tests for the cohesion countries

Country			
	Null Hypothesis:	F-Statistic	Probability
Ireland Lags: 2	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	2.9305 1.1458	**0.0567** 0.3210
Portugal Lags: 1	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	0.3995 0.0147	0.5295 0.9040
Spain Lags: 2	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	3.5551 0.0674	**0.0313** 0.9348
Greece Lags: 12	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	3.2995 1.2089	**0.0004** 0.2860

Accession Countries

The results of the VAR model for the accession countries are similar to those of the cohesion countries. Absolute changes of exchange rates and stock market indices show significant interdependence for Hungary and Slovenia. For the Czech Republic, exchange rate and stock market indices seem to be independent. For Poland, a VECM is employed as long-term links could be confirmed. From the VECM, short-term links become obvious. As in the equation of DEXR, both the adjustment parameter and the parameter of DSP in t–2 are significant. It can thus be concluded that the stock market index Granger causes the exchange rate (i.e. SP→EXR). In case of the other countries, Granger causality tests confirm that there is a significant link between stock market and foreign exchange market for Slovenia, where SP→EXR.

Tab. 3b.1: Results of VECM estimation for Poland

Poland		
Cointegrating Eq.:		
EXR(-1)	1	
SP(-1)	0.7030 [3.7432]	
Constant	-296.6521	
Error Correction:	DEXR	DSP
CointEq.	-0.0071 [**-4.1854**]	0.0063 [0.5642]
DEXR(-1)	0.3088 [4.1702]	0.7094 [1.4679]
DEXR(-2)	-0.2456 [-3.1263]	0.4111 [0.8019]
DEXR(-3)	0.0350 [0.4557]	-0.0909 [-0.1814]
DEXR(-4)	-0.1133 [-1.5644]	0.7011 [1.4831]
DSP(-1)	0.0041 [0.3559]	0.1721 [2.2964]
DSP(-2)	0.0303 [**2.6010**]	0.1052 [1.3830]
DSP(-3)	0.0115 [0.9069]	-0.0407 [-0.4930]
DSP(-4)	0.0079 [0.6378]	-0.0257 [-0.3192]
C	0.0719 [0.3153]	1.8182 [1.2214]
R-squared	0.2333	0.0683
Adj. R-squared	0.1968	0.0240

Note. t-statistics in [ ]

For Hungary a significant impact of stock market on the foreign exchange market can only be confirmed at 10% (exactly at 7%) significance level. The reason for the weaker links between the two markets in comparison to the cohesion countries may be based upon the fact that financial markets (especially stock markets) in Eastern Europe are still underdeveloped as confirmed in the analysis of KÖKE/SCHRÖDER (2003). Moreover, HOLTEMÖLLER (2005) confirmed that many accession countries – inter alia the accession countries considered in this analysis – exhibit a very low monetary integration. As a measurement of monetary integration, the interest rate spreads of the countries considered vis-à-vis the Euro interest rate and country specific risk premium volatility were used. An important reason in this context could also be the fact that the currencies of these countries – except for Poland – do not float freely but within currency bands (managed floating). For this reason, “true” links may become blurred.

Tab. 3b.2: Results of VAR estimation for Slovenia

Slovenia	DEXR	DSP
Constant	0.3320 [1.1182]	1.8974 [2.5173]
DEXR(-1)	0.3320 [4.7664]	-0.0654 [-0.3436]
DSP(-1)	-0.0700 [**-2.2303**]	0.3042 [3.8168]
R-squared	0.1575	0.0890
Adj. R-squared	0.1464	0.0770

Tab. 3b.3: Results of VAR estimation for Czech Rep.

Czech Rep.	DEXR	DSP
Constant	-0.2183 [-0.9565]	0.7170 [0.9616]
DEXR(-1)	0.2890 [3.8422]	0.0390 [0.1588]
DSP(-1)	0.0064 [0.2875]	0.3153 [4.3665]
R-squared	0.0836	0.1050
Adj. R-squared	0.0724	0.0940

Tab. 3b.3: Results of VAR estimation for Hungary.

Hungary	DEXR	DSP
Constant	0.1650 [0.6080]	5.6226 [1.6571]
DEXR(-1)	0.2726 [3.7638]	1.6353 [1.8062]
DEXR(-2)	-0.0832 [-1.1378]	-0.3223 [-0.3526]
DSP(-1)	0.0030 [0.5008]	0.1823 [2.4706]
DSP(-2)	0.0126 [**2.1595**]	-0.0547 [-0.7472]
R-squared	0.0921	0.0393
Adj. R-squared	0.0738	0.0201

Tab. 3b.4: Results of Granger causality tests for the accession countries

Country			
	Null Hypothesis:	F-Statistic	Probability
Czech Rep. Lags: 1	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	0.0827 0.0253	0.7740 0.8740
Slovenia Lags: 1	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	4.9744 0.1181	**0.0272** 0.7316
Hungary Lags: 2	DSP does not Granger Cause DEXR DEXR does not Granger Cause DSP	2.7010 1.6446	**0.0696** 0.1957

Nevertheless, the results of both country groups are quite surprising in comparison with previous research on this aspect. Moreover, the results are not in consensus with part of traditional theory as exchange rate is assumed to influence stock price. It is also astonishing that the results do not show bi-directional links but an unambigous direction of causation from stock market to foreign exchange market. The arising question is now how to explain this result.

The unusual and a priori unexpected results of unidirectional causality link from SP to EXR could be explained with high capital inflows (i.e., portfolio investments and FDI) in these countries during their catching up process. For investors, it is quite attractive to invest in these countries as high marginal product of capital can be expected. Another explanation could be based upon capital market liberalization. It certainly facilitates cross border investments, and this can lead to an increasing movement of capital across countries. Hence, financial market integration could be one reason with respect to facilitation of cross border investments. Under these circumstances, a unidirectional causation from stock market to foreign exchange market is possible. Indeed, these countries experienced much FDI during this time, but not simultaneously. (Hungary and the Czech Republic, for instance, attracted high FDI inflows relative to GDP in early 1990s, but Poland later.) This could also be a reason for the different results within the accession countries. If there are strong portfolio adjustments, the exchange rate could also be affected. Furthermore, capital market liberalization could induce increasing speculations on stock markets and foreign exchange markets, which also may have an impact on the interdependence between these two markets. The results support the assumptions made in the Dornbusch model, for example, that short-term deviations from the long-term equilibrium are mainly caused by the fact that financial market prices are flexible and prices of goods are sticky in the short-term (DORNBUSCH, 1976).

6. Concluding Remarks

In this analysis, four cohesion countries (Ireland, Portugal, Spain, Greece) and four accession countries (Poland, Czech Rep., Slovenia, Hungary) have been considered in order to examine any potential links between nominal stock market index and nominal exchange rate. For this purpose, monthly data were used, where the cohesion countries were taken into account until the introduction of the Euro. The cointegration concept was employed for testing on long-term links and the VAR approach for short-term links. Finally, Granger causality tests were employed for determination of the exogenous and endogenous variable. The results show that for six countries, significant links exist between the stock market index and foreign exchange rate, where for Poland both long-term and short-term links exist. An unambigous result with respect to the direction of causation, from stock market index to the foreign exchange market is a surprise. It could be partly explained by high incipient capital inflows. Comparable analyses for emerging Asian countries showed different results. The results of the analysis presented could largely be explained by high capital inflows – through FDI inflows and portfolio investments – in these countries. Increased financial market integration in Europe could be another reason, as it implies free trade and free movement of capital – with higher capital inflows anticipated, markets will react. This fact could have strengthened the “latent” links between the two markets.

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