Analysis of Interdependencies between Austrian and CEE Stock Markets

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Abstract
This study examines the short- and long-term linkages between eleven Central and Eastern European emerging stock markets and a developed one, i.e. Austrian stock market and assesses the impact of the formation of CEESEG on stock market linkages between Austria and CEE markets. The existence of more than one cointegration vectors signifies comovements and linkages for the CEE analyzed markets, indicating a stationary long-run relationship. No dramatic shock was detected in stock market dynamics after the expansion of Vienna Stock Exchange, but still the findings highlighted an increased integration between it and CEE markets in the second subperiod. In addition, the increasing response to the arrival of price innovations from Austria is registered only in the case of EU markets.

Keywords: price innovation, emerging stock markets, market linkages
JEL codes: G14, G15, O16, O57, F21

1. Introduction

In the last two decade the extent globalization progresses led to the increasing of co-movements among international equity markets, more precisely a high degree of interdependence among international stock markets, therefore national stock markets increasingly react to each other. Several factors that led to the existence of stronger links between stock markets are: growing international trade and investment flows, increasing policy coordination, abolition of capital controls in developed and emerging financial markets, the technological improvement in communications and trading systems, the development of new financial products, the development of global and multinational companies and organizations, the abolishment of foreign exchange controls etc. The importance of how markets influence one another is important in the determination of pricing, hedging, trading strategies and regulatory policy of financial markets, on the one hand and is important for governments, businesses and investors to manage the ripple effect of a global financial crisis, on the other hand.

The purpose of this paper is to investigate the dynamic linkages between several CEE emerging stock markets and one developed stock market, namely, the Austrian market (according to the FTSE Group). We conducted our research for several reasons. First, Vienna Stock Exchange represents some of the largest financial markets in the region in terms of liquidity and market capitalization. Second, the ten economies are closely interrelated in terms of trade relations and geographic proximity. Third, they are in the process of integrating into the European Union. Finally, Vienna Stock Exchange acquired a majority stake in the Budapest Stock Exchange in 2004 and in the stock exchanges of Ljubljana and Prague and thus building a strong alliance: Vienna – Budapest – Ljubljana – Prague. In addition it has established cooperation arrangements with several markets.

The Vienna Stock Exchange is the initiator and, just like the exchanges of Budapest, Ljubljana and Prague, a part of the CEE Stock Exchange Group (CEESEG). The four member exchanges of the Group account for around half of total market capitalization and about two-thirds of equity turnover in Central and Eastern Europe. CEESEG is thus the largest player of all exchanges in the region. From this, Wiener Börse AG is on the second place in the top of the market capitalisation in the CEE area, after Warsaw Stock Exchange. In 2004 an Austrian consortium acquired a majority stake of 68.8% in the Budapest Stock Exchange. Moreover, in 2008, the Vienna Stock Exchange acquired a majority

stake of 81.01% in the Ljubljana Stock Exchange that was followed by the acquisition of a 92.7% share in the Prague Stock Exchange. In addition, has entered into numerous cooperation agreements with regional exchanges, above all with Bucharest, Zagreb, Belgrade, Sofia, Sarajevo, Montenegro, Banja Luka and Macedonia.

The CEE emerging markets analyzed in this paper are those that joined the EU in 2004: Poland, Slovakia, Hungary, Slovenia and Czech Republic (these last three joined CEESEG in 2008), those that joined the EU in 2007: Romania and Bulgaria, the EU candidate countries: Republic of Macedonia and Republic of Croatia and some of those with which it has cooperation agreements, namely Serbia and Bosnia and Herzegovina. Firstly, we have chosen the markets that joined EU in 2004 along with the ones that joined EU in 2007 and the EU candidates to analyze the difference between three categories of European stock markets. Secondly, we have chosen the CEESEG markets to see if they previously had links with Vienna. The analysis interval is between January 1, 2004 and December 31, 2010 for all indices.

The main contribution of this paper is that it provides further evidence on stock market integration and correlations in several CEE emerging stock markets and a developed one, emphasizing new connections between Wiener Borse and other CEE exchanges. The results can be directly utilized by portfolio managers in planning portfolio diversification strategies in accordance with the expected future volatility and in risk measurement.

Our findings suggest that there exist small reaction from Central and Eastern European stock markets to the arrival of price innovations from Austria on the short run, while on the long run we find comovements and linkages for the analyzed markets. However, the CEE markets become gradually more integrated with the Austrian stock exchange, although no dramatic impact due to the formation of "CEE Stock Exchange Group"brand has been detected.

The rest of the paper proceeds as follows. Section II briefly surveys the major contributions of the literature review. Section III outlines briefly the development of Eastern European equity markets. Section IV explains our data set and the methodology used. Section V discusses the empirical results. Section VI brings the main conclusions.

2. Literature Review

In the literature there are numerous studies on stock market interdependence. However, depending on the data, methodology, and theoretical models used there is no clear resolution of the issue yet. Most of the studies on stock market interdependence have been done on geographical groups of markets. Coelho at al. (2007) demonstrate that global equity markets are increasingly interrelated. The results of Hu et al. (2008) support the preview study and indicate a dynamic relationship of world major stock markets over time.

Firstly, the relationship between the developed markets is widely examined, especially the relation between US and other developed markets. Ozdemir and Cakan (2007) find a significant bi-directional nonlinear Granger-causality relationship in the cases of US, Japan, France and the UK, highlighting the fact that the general belief of the US stock market is not affected by the other equity markets is not true. Ozdemir (2009) is examining the interdependence among the stock markets of Germany, Japan, the UK, and the USA and shows that there is an interconnection among the stock markets of these countries. Baur and Jung (2006) investigates the contemporaneous correlation and the spillover effects between the US and the German stock markets around the opening of the two markets and the main findings are: foreign daytime returns can significantly influence the domestic overnight returns; this holds for both the US and the German market; there is no evidence of spillovers from the previous daytime returns in the US to the DAX morning trading. Rezayat and Yavas (2006) examine the short-term linkages among U.S., U.K., France, Germany and Japan and the findings indicate that even though the interdependencies among the markets are significant, there is still room for international portfolio diversification and that the international market correlations change after an exogenous shock.

Secondly, the relationship between other developed markets than US is emphasized by Chong et al. (2008). They demonstrate that the next day market performance in Japan can be predicted by trading strategies using the signals from most of the G7 markets. Closely with EMU, Wälti (2010)

demonstrate on a panel of fifteen developed economies over the period 1975–2006 that the trade and the financial integration contribute to higher stock market return co movements. In addition, correlations between the respective returns of the United Kingdom, Sweden and Switzerland, and the EMU return have also increased after the introduction of the euro. Bley (2009) found that in Euro stock markets return behavior is changing and stock markets within the Euro zone are starting to drift apart. Morelli (2010) shows that degree of integration is found to exist between some E.U. countries, however it is evident that the hypothesis of full integration across all the European countries is not shown to hold. the Lucey and Muckley (2011) emphasize that European stock markets provide a superior long-term diversification opportunity relative to that provided by the Asian stock markets.

In the literature in the field the relations between developed and emerging markets and between emerging markets in an area is very large. Ozdemir et al. (2009) show that causality runs from the S&P500 to the stock prices of the 15 emerging markets but not vice versa.

An important place is occupied by studies on the CEE markets' linkages. In this sense, Serwa and Bohl (2005) find modest evidence of significant instabilities in cross-market linkages after the crises and the fact that Central and Eastern European stock markets are not more vulnerable to contagion than Western European markets.

Syriopoulos (2007) highlight the fact that in both a pre- and a post-EMU sub-period there is evidence of market co movements towards a stationary long-run equilibrium path and that Central European markets tend to display stronger linkages with their mature counterparts, whereas the US market holds a world leading influential role. Furthermore, Syllignakis and Kouretas (2010) reveal that the financial linkages between the CEE markets and the world markets increased with the beginning of the EU accession process. Syriopoulos and Roumpis (2009) support this idea that the Balkan stock markets are seen to exhibit time-varying correlations as a peer group, although correlations with the mature markets remain relatively modest. Also in this regard, Li and Majerowska (2008) demonstrate limited interactions among the markets; the emerging markets (Warsaw and Budapest) are weakly linked to the developed markets (Frankfurt and the U.S). Not least, Gilmore et al. (2005) found no robust co integration relationship between the UK, the German and Central European stock markets (Hungary, Poland, Czech Republic), over the period between July 1995 and February 2005. Égert and Kocenda (2010) find: a strong correlation between the German and French markets and also between these two markets and the UK stock market, very little systematic positive correlation between the developed and emerging stock markets, or within the emerging group itself and the fact that Hungary exhibits higher correlation with the developing markets and the emerging markets and its dynamics show an increasing trend.

In contrast, Yang et al. (2006) find that both the long-run and short-run relationships are strengthened in the period of 1999–2002 compared with the period before the Russian crisis across the stock markets in the U.S., Germany and four Eastern European countries. Lucey and Voronkova (2008) examines the relationships between Russian and other equity markets before and after the 1998 crisis and point the fact that Russian equity market remained isolated from the influence by international markets in the long run and that while a structural break might have occurred in August 1998 this did not alter the nature of long-run relationships. In addition, Voronkova (2004) concludes that the emerging markets have become increasingly integrated with the world markets and shows the existence of long-run linkages between the UK, the German, and the French and Central European stock markets (Hungary, Poland, Czech Republic) using daily data for the period 1993–2002. Harrison and Moore (2009) find that there are spillover effects between the U.K. and Germany European equity markets, but they observe that these western equity markets influence Central and Eastern European with different degree. Büttner and Hayo (2010) demonstrate that the highest correlations exist between Hungary and Poland in foreign exchange and stock markets. Also related to Russian crisis, Schotman and Zalewska (2005) found that the Hungarian market was the most sensitive to the Asian and Russian crises, and the Czech market the least, an outcome that may be explained by the fact that the Hungarian market had the highest foreign share ownership level and the Czech market the lowest.

In terms of models used to test for integration in the stock markets, these are various. Some studies use the vector autoregression (VAR) (e.g. Steeley, 2005; Diamandis, 2009). Another studies use the VARIFMA model to demonstrate the linkage between markets (Ozdemir, 2009; Olgun and Ozdemir, 2008). A second generation of studies use ARCH/GARCH family of econometric models to

examine linkages and especially volatility and spillover of the stock markets (Cifarelli and Paladino, 2005; Fujii, 2005; Baur and Jung, 2006). A dominant approach in the literature is also, to apply the non-linear Granger-causality test for examining the dynamic relationship between stock market (Syriopoulos, 2007; Chan et al., 2008; Lim, 2009).

3. A Brief Review of Central and Eastern European stock markets

The transition from Central and Eastern Europe Economies is trying to construct modern viable financial markets. Sound, efficient and liquid financial markets is essential for all market participants. So, after the collapse of communist equity exchanges have been re-established in the region. Beginning with Ljubljana Stock Exchange, which was the first stock exchange that reopened in the area on March 29, 1990 and continuing with the other markets, by now these markets have displayed considerable growth in their size and in their degree of sophistication. The market capitalization of these markets is presented in Table 1.

Table1: Market capitalization of Stock Exchange in CEE, June 2011

Exchange	Value at month end (EUROm)
Athens Exchange	46 042.53
Bratislava Stock Exchange	3 901.78
Bucharest Stock Exchange	13 616.93
Bulgarian Stock Exchange	5 666.81
CEESEG - Budapest	22 350.23
CEESEG - Ljubljana	6 093.99
CEESEG - Prague	35 021.92
CEESEG - Vienna	90 912.78
Cyprus Stock Exchange	4 369.09
Warsaw Stock Exchange	145 444.45
Macedonian Stock Exchange	2 052.82
Zagreb Stock Exchange	27 887.8
Belgrade Stock Exchange	3 108.61
Sarajevo Stock Exchange	3 899.99

Sources: ***European Securities Exchange Statistics December 2010, ***Macedonian Stock Exchange, Monthly Statistical Bulletin, December 2010, ***Zagreb Stock Exchange, Monthly Report, December 2010, ***Sarajevo Stock Exchange, Statistical Report December 2010, ***Belgrade Stock Exchange, Monthly Statistical Bulletin, December 2010

The accession to the EU of these countries on May 1, 2004 and on January 1, 2007, gave a big boost to these markets, attracted more and more interest and in present they play an important role in the international financial environment. Stock markets in Central and Eastern Europe (CEE), especially those in Warsaw, Vienna, Athens and Prague, have the greater market capitalization in the area. The market capitalization of WSE in June 2011, represents 35,44% from the total market capitalization in the region, while CEESEGs' market capitalization is about 37,62% from the total market capitalization in the region, down from the previous semester. The financial system of all these countries largely remains bank-dominated and the stock exchanges are different integrated with the world financial markets. In addition, these markets are small compared to the stock exchanges of the largest OECD countries, in terms of listed companies, market capitalization and turnover value. Therefore, it may be sensitive to shifts in regional and worldwide portfolio adjustments of market participants, which mean it may be more volatile than well-established stock markets. So, since the contribution of these markets to internationally diversified portfolios has grown substantially, it is crucial to understand the relationship between CEE stock markets.

4. Data and methodology

4.1. Data description

The data consist of daily stock market indexes in local currency of twelve countries: Austria, Poland, Slovakia, Hungary, Slovenia, Czech Republic, Romania, Bulgaria, Republic of Macedonia, Republic of Croatia, Serbia and Bosnia and Herzegovina. The equity market indices are expressed in domestic currency in order to restrict their changes solely to stock price movements and to avoid potential distortions induced by exchange rate devaluations.

The stock indices that represent these ten markets are: The Austrian Traded *Index* (ATX) taken for the Austria's Wiener Börse, WIG-20 for Warsaw Stock Exchange, The Slovak Share Index (SAX) for Bratislava Stock Exchange, Budapest Stock Index (BUX) for Budapest Stock Exchange, SBI 20 for Ljubljana Stock Exchange, PX-50 Index for Prague Stock Exchange, Bucharest Exchange Trading (BET) for Bucharest Stock Exchange, SOFIX for Bulgarian Stock Exchange-Sofia, MBI10 Index for Macedonian Stock Exchange, CROBEX for Zagreb Stock Exchange, BIFX for The Sarajevo Stock Exchange and BELEXline taken for Belgrade Stock Exchange. The sample period is from January 1, 2004 to December 31, 2010, except for Serbia, which starts on October first, 2004. The data sets were collected from Global Financial Data.

4.2. Methodology

The daily returns are calculated as:

$$R_{it} = \ln\left({}^{P_t}/_{P_{t-1}}\right) \times 100 \quad (1)$$

Where R_{it} refers to the daily return; P_t refers to index price on day t; P_{t-1} refers to index price on day t-1.

The Granger-causality test requires that the data series are stationary, otherwise inference from the F-statistic might be spurious because the test statistics will have non-standard distributions. The null hypothesis of the augmented Dickey and Fuller (ADF) is non-stationarity. We performed the augmented Dickey-Fuller unit root tests on each series (the results are not given here but are available by the authors upon request) to determine whether they need to be transformed before models estimation. The tests reject the non-stationary null hypothesis for the stock price index at 1 %, 5 % and 10% significance level for all analyzed countries in the first difference. In addition, this result is reliable because the the Durbin-Watson statistics is near 2, and a value near 2 indicates non-autocorrelation. That means the series don't have autocorrelation problem.

The descriptive statistics of the daily returns for each analyzed stock index is shown in Table 2. The table below suggest that the Macedonian and Hungarian markets, offers, on average the highest return over the sample period (0,057% and 0,051%). The mean excess return is lower in Bulgaria and Slovenia. The analyzed markets exhibit higher volatility, as indicated by larger standard deviation values, but the highest risk is registered in Serbia, approximated by standard deviation of 16.9%. Most of the equity index series are negatively skewed (except from Bosnia and Croatia), the negative being found in Slovakia. This means that there is a higher probability for investors to get negative returns from Slovakia rather than positive returns. The kurtosis values of all indices returns are much larger than the value of normal distribution (the kurtosis of the normal distribution is 3), indicating that the returns indices have peaks relative to the normal distribution and the fact that big shocks are more likely to be present for this markets. The Jarque–Bera test rejects normality in all cases, in other words signifying that all indices exhibit significant departures from normality. These results are in line with the evidence of all previous studies in the literature, that daily stock returns are not normally distributed.

Table 2: Descriptive Statistics for National Stock Market Indices

	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Austria	0.031400	0.162042	1.685073	-0.371133	9.956718	3544.571	1738
Bosnia and Herzegovina	0.009922	-0.089303	1.467205	0.796601	9.831084	3161.229	1542
Bulgaria	-0.012185	0.043403	1.430477	-1.016156	11.82016	5939.594	1740

Cezech Rep.	0.034990	0.116298	1.692087	-0.587918	16.68946	13828.42	1758
Croatia	0.033286	0.041663	1.504874	0.039404	14.65605	9878.858	1745
Macedonia	0.057706	0.005174	1.650014	-0.193344	8.733088	2287.860	1663
Poland	0.030042	0.059938	1.656559	-0.242880	5.584414	507.3997	1761
Romania	0.044542	0.111376	1.792473	-0.732430	9.828300	3556.255	1750
Serbia	0.015418	0.011525	16.94371	-0.349878	779.7912	39573310	1574
Slovakia	0.015252	0.000000	1.217983	-1.621859	28.99008	49049.42	1716
Slovenia	-0.010532	0.009109	1.084726	-0.753357	14.55383	9588.133	1695
Hungary	0.051593	0.062015	1.803482	-0.080471	9.496193	3063.176	1741

Source: author's calculations

The impact of Wiener Borse acquisition in area and thus, the formation of CEESEG on the long-run linkages of the above mentioned market and the eleven emerging CEE is studied using cointegration methodology, and market behavior is analyzed estimating the models on two subperiod, 2004-2007 and 2008-2010 (based on the acquisition of a majority stake from Prague SE, Ljubljana SE and Budapest SE). A priori expectation is that the stock markets of interest are likely to be more integrated in the second subperiod, after building the strong alliance. This may be captured by an increase in the number of cointegrated vectors. So, we employ the maximum likelihood approach and two test statistics can be used for the hypothesis of the existence of r cointegrating vectors, namely:

$$\lambda_{trace}(r) = -2\log(Q) = -T\sum_{i=r+1}^{n}\log(1-\hat{\lambda}_i) \quad (2)$$

$$\lambda_{max}(r, r+1) = -2\log(Q) = -T\log(1-\hat{\lambda}_{r+1}) \quad (3)$$

where $i = r+1, \ldots, n$, are the $(n - r)$ smallest squared canonical correlations, $r = 0, 1, 2, \ldots, n-1$, and $\lambda_{trace}(r) = 0$, when all $\hat{\lambda}_i = 0$. The first trace test is testing the hypothesis that there are at most r distinct cointegrating vectors against a general alternative, while the second test is used to compare the null hypothesis of r cointegrating vectors against the alternative of $(r + 1)$ cointegrating vectors.

The causal relationship prescribes the direction of the impacts between two time series. In this sense, Granger causality measures are constructed to explore the causal relationship between two time series. The idea of Granger causality is a pretty simple one, namely that a time series Xt Granger-causes another time series Yt if Yt can be predicted better by using the past values of Xt than by using only the historical values of Yt.

In this article, we suppose that Yt and Xt are ATX and eleven CEE emerging stock market price index, respectively. Testing causal relations between the two series can be based on the following bivariate autoregression:

$$Y_t = \alpha_0 + \sum_{k=1}^{n}\alpha_k Y_{t-k} + \sum_{k=1}^{n}\beta_k X_{t-k} + u_t \quad (4)$$

$$X_t = \gamma_0 + \sum_{k=1}^{n}\gamma_k Y_{t-k} + \sum_{k=1}^{n}\theta_k X_{t-k} + u_t \quad (5)$$

Where, α_0 and γ_0 are constants, α_k, β_k, γ_k, θ_k are parameters, and u_t are uncorrelated disturbance terms with zero means and finite variances. The null hypothesis that Xt does not Granger-cause Yt is rejected if the α_k coefficients in the first equation are jointly significantly different from zero using a standard joint test. Critical is the choice of lags k, because insufficient lags yield autocorrelated errors (and incorrect test statistics), while too many lags reduce the power of the test. Similarly, Yt Granger-causes Xt, if the γ_k coefficients are jointly different from zero in the second equation. A bi-directional causality (or feedback) relation exists if both the α_k and γ_k coefficients are jointly different from zero. Ozdemir et al. (2009) used this test to show that causality runs from the S&P500 to the stock prices of the 15 emerging markets but not vice versa.

Finally, we use this test, within the framework of a vector autoregression (VAR) model, to examine the dynamics of interdependency between the Austrian and CEE countries. The most important advantage of VAR models is that they provide an opportunity to investigate the reaction of each national stock market to its own price shocks and the price innovations from Austria as well, the equation taking the following form:

$$R_{it} = \alpha_1 + \sum_{j=1}^{p} \beta_{ij} R_{i,t-j} + \sum_{j=1}^{p} \beta_{ij} R_{A,t-j} + \epsilon_{it} \quad (6)$$

where, R_{it} is the daily return of county i of CEE country on day t, R_A is daily returns on Austrian stock index respectively treated as endogenous variables. So, the return of national stock index is not only a function of its own lagged returns but also a function of lagged returns of Austrian stock market.

5. Empirical results

In order to determine if there are changes in correlation patterns after the extend of the group, we divide our sample into two sub-samples. The correlation matrix of national stock indices among the twelve analyzed markets for the divided sample is presented in Table 3a and 3b. It is evident from table 3a that the correlations of returns from the analyzed countries are significantly different from zero at the 1% level in the period 2004-2007. However, these correlation coefficients are not very large in magnitude, indicating weak (short-term) contemporaneous interactions between these markets. Indeed, the largest correlation coefficient takes the value of 0.271 for the Poland-Czech Republic pair, followed by the correlation coefficient of 0.079 for the Slovakia-Romania pair. Interestingly, in spite of the acquisition of a stake of 12.5% in the Budapest Stock Exchange made by Vienna Stock Exchange, Hungary exhibits an insignificant correlation with Austria. In addition, Wiener Borse has a small and positive pairwise correlations with five markets, while with the other six is registered a negative one.

Table 3a: Pairwise Correlation Matrix for National Stock Market Indexes, 2004-2007

	AU	BA	BG	CZ	HR	MK	PL	RO	RS	SK	SI	HU
AU	1.00											
BA	-0.08	1.00										
BG	-0.01	-0.05	1.00									
CZ	0.06	0.03	-0.03	1.00								
HR	0.04	-0.07	0.05	0.04	1.00							
MK	0.05	-0.01	-0.01	0.01	0.04	1.00						
PL	0.03	-0.03	0.01	0.27	0.03	-0.02	1.00					
RO	-0.01	-0.04	0.02	0.02	0.06	0.07	0.05	1.00				
RS	-0.09	-0.01	0.01	-0.03	-0.01	-0.03	0.05	-0.04	1.00			
SK	-0.02	0.08	0.06	-0.01	0.02	0.07	0.02	0.08	0.01	1.00		
SI	0.07	-0.02	-0.01	0.01	0.07	0.02	-0.02	0.07	-0.05	0.01	1.00	
HU	-0.01	0.03	0.03	-0.03	0.01	-0.05	-0.07	0.01	-0.03	0.01	-0.01	1.0

Source: author's calculations

The values of pairwise correlation matrix of national stock indices among the analyzed countries for the second subperiod are presented in Table 3b. So, is noticeable that the correlation coefficients among stock returns generally increased between the earlier subsample and the later one. The highest correlation coefficient takes the value of 0.322 for the Poland-Austria pair. The correlation coefficients between Austrian market and the others are also higher in the second subperiod, with the exception of Czech Republic and Hungary, and further previously negative correlations turn to positive. This finding provides some evidence of stronger financial integration among these markets over time due both to EU accession of Eastern and Central European countries and group expansion.

Table 3b: Pairwise Correlation Matrix for National Stock Market Indexes, 2008-2010

	AU	BA	BG	CZ	HR	MK	PL	RO	RS	SK	SI	HU
AU	1.00											
BA	0.05	1.00										
BG	0.18	0.07	1.00									
CZ	0.03	0.06	0.15	1.00								
HR	0.07	-0.02	0.18	0.02	1.00							
MK	0.10	0.07	0.12	0.12	0.19	1.00						
PL	0.32	-0.02	0.19	0.02	0.08	0.08	1.00					
RO	0.09	0.18	0.05	0.11	-0.06	0.05	0.12	1.00				
RS	0.21	0.14	0.22	0.17	0.07	0.13	0.15	-0.03	1.00			
SK	0.05	0.02	0.05	0.02	-0.01	0.06	0.03	0.04	0.05	1.00		
SI	0.08	-0.01	0.09	0.06	0.10	0.22	0.14	0.06	0.09	-0.01	1.00	
HU	-0.02	-0.02	-0.04	-0.01	0.01	-0.02	0.02	-0.03	0.02	-0.02	-0.04	1.00

Source: author's calculations

Johansen's maximum likelihood method is used to examine whether or not the ATX price index and stock price index series of each CEE emerging market are cointegrated. The number of lags is from 1 to 4 for both subperiods, suggested by AIC, and in addition the order that the stock indices enter the VAR model is based on their market capitalization. A vector error cointegration model is estimated for each sub-period under study to consider the series jointly presented in Table 4. Two alternative model versions are compared and contrasted: a model with intercept but no trend in the cointegrating vector and the test VAR and a model with intercept and trend in the cointegrating vector but no trend in the VAR.

Table 4: Johansen–Juselius likelihood cointegration tests

	Eigenvalue		Trace		Critical Value at 95%	
2004-2007	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
r=0	0.122817	0.132585	436.2261	491.8653	334.9837	374.9076
r<=1	0.083666	0.095878	333.3599	380.2084	285.1425	322.0692
r<=2	0.071765	0.072766	264.7712	301.0879	239.2354	273.1889
r<=3	0.064364	0.071479	206.3123	241.7814	197.3709	228.2979
2008-2010	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
r=0	0.133822	0.136373	449.5408	483.7339	334.9837	374.9076
r<=1	0.109753	0.115696	349.9810	382.1304	285.1425	322.0692
r<=2	0.078773	0.078820	269.4151	296.9230	239.2354	273.1889
r<=3	0.072384	0.072783	212.5554	240.0275	197.3709	228.2979
r<=4	0.062010	0.064513	160.4849	187.6591	159.5297	187.4701

Source: author's calculations

The null hypothesis that the seven stock markets are not cointegrated (r=0) against the alternative of one or more cointegrating vectors (r>0) is rejected, since the probability of both models statistic exceeds the critical value at the 5% significance level. Based on that, all variables were found statistically significant at the 5% level of significance and contribute to the long-run relationship. The statistics suggest the following: in both subperiods, the trace test indicates that there are at most three cointegrating equations in model 3 and at most four cointegrating equations in model 4, since the trace and maxim eigenvalue statistic exceeds the critical value at the 5% significance level. So, the large number of cointegration vectors signifies a high probability of existence of a long-run relationship between the CEE analyzed markets, moreover this long term relationship increasing in the second period. For an international investor, these findings may indicate that potential long-term benefits associated with portfolio diversification to the CEE markets may be rather limited. Not least, because

in the null cointegration relationship is recorded an upward trend in the second sub-period, this means there exist an increased integration among the markets under study. Moreover, the results reported in Table 4 show a higher degree of integration than those reported by Gilmore et al. (2005) and Syllignakis and Kouretas (2010) for a group of CEE and several mature equity markets. This more favorable outcome may be due to the extended time period used in the present analysis or to the extended number of CEE stock markets that we include in our sample.

As the evidence of cointegration guarantees some significant Granger causalities in the system, it is useful to examine, firstly the short-term causal linkages, and secondly the innovation accounting implications. The results for Granger-causality test is given in Table 5, but only for the influence of Austrian market and the coefficients which passed the test (5%). The empirical results from the Granger-causality tests highlight that the Austrian market exerts a strong impact only on Romanian and Slovenian markets, in both sub-periods. The situation is different in the second sub-period, where this test supports the increasing role of the Austrian market, as short-run channels of causality run from changes in the Austrian market, and exerts a strong impact on the following markets: Bosnia and Herzegovina, Czech Republic, Poland, Romania and Slovenia. Put differently, not only stock returns in Austria Granger-cause stock returns in the three CEE markets, but the several CEE countries (Bulgaria, Republic of Croatia, Macedonia, Poland, Serbia, Slovenia and Hungary) also influence stock returns in Austria in the second sub-period. The fact that Wiener Borse doesn't exert higher influence on this area may be firstly due to the fact that these markets react to stimulus coming from the leading markets, like U.S or Germany (Syriopoulos, 2007). Secondly, Syllignakis and Kouretas (2010) note that the global financial crisis of 2007–2009 caused a slowdown in the convergence process. Finally, Egert and Kocenda (2010) found very little systematic positive correlation between the developed and emerging stock markets, or within the emerging group itself, the strongest correlation being detected between the developed markets.

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Table 5: Pairwise Granger-causality tests

Null Hypothesis:	2004-2007		2008-2010		Null Hypothesis:
	F-Statistic	Probability	F-Statistic	Probability	
Austria ‡> Romania	8.59039	1.8E-06	42.7058	3.2E-32	Austria ‡> Czech Rep.
Austria ‡> Macedonia	2.38573	0.04967	41.2437	3.3E-31	Austria ‡> Romania
Austria ‡> Slovenia	4.10443	0.00264	5.16338	0.00042	Austria ‡> Slovenia
			6.68847	2.7E-05	Austria ‡> Bosnia
			3.57005	0.00680	Austria ‡> Poland

Source: author's calculations

The decomposition of forecast error variance of each market provides a quantitative measure of the short-run dynamic interdependences of the CEE emerging stock markets and Austrian stock market. In this study, we attempt Choleski decomposition to orthogonalise the shocks method. So, in Table 6 are studied the variance decomposition results of 1-day, 5-day and 10-day horizon ahead forecast error variances of each stock market.

Table 6 suggests that in all countries by day 5 or 10 ahead, the behavior has settled down to a steady state, where a smaller percentage of the error variance in the series of all indices is attributable to own shocks. Furthermore, in all analyzed countries, the national market price innovations account for more of the error variance while Austrian price innovations account for less of the forecast error variance. In addition, only Czech, Polish, Romanian, Slovenian and Hungarian markets registered a greater influence in the second sub-period than in the first one. This might be due to the acquisition of three stock exchanges by Wiener Borse. Austrian influence on all the analyzed states is very small, almost inexistent. On the basis that about 0,1-7% of the variation in the returns of analyzed indices is caused by shocks to Austrian market, indeed the extent of influence of the developed market on the returns of the emerging markets in CEE is small, indicating a weak integration of the emerging markets with the developed one in the area. In this sense, Syriopoulos (2007) highlighted that market movements, predominantly in the US rather than in the neighboring CE markets, drive fluctuations in the individual CE stock markets. In addition, Li and Majerowska (2008) highlighted the fact that the

emerging markets are weakly linked to the developed markets and that the Balkan equity markets exhibit significant dynamic correlations as a peer group. Not least, the test emphasizes the fact that Austrian stock market exerts greater influence only over EU Member States.

Table 6: Forecast Error Variance Decomposition of Daily Market Returns

Country	Horizon (days)	Percentage of forecast error variance by innovations in:			
		2004-2007		2008-2010	
		Own innovation	Austrian innovation	Own innovation	Austrian innovation
Bosnia and Herzegovina	1	98.05122	0.471787	97.97958	0.012085
	5	94.16392	1.151770	86.71860	0.341274
	10	92.53903	1.230853	83.15710	0.511826
Bulgaria	1	99.35649	0.024474	95.99732	0.326184
	5	92.01791	0.962671	78.71844	0.770703
	10	90.73529	1.137567	77.23785	0.957591
Czech Republic	1	92.76927	0.656086	99.99582	0.000456
	5	86.07034	1.055067	66.07993	6.111770
	10	85.59103	1.122823	59.34946	5.543363
Croatia	1	99.67890	0.177844	99.39342	0.347138
	5	90.48614	1.094497	88.12350	1.099815
	10	87.31470	1.261638	87.32408	1.141515
Macedonia	1	98.10381	0.079743	95.44694	0.031775
	5	92.31782	0.953514	78.62394	0.636639
	10	91.24700	0.958140	77.26261	0.770500
Poland	1	100.0000	0.000000	100.0000	0.000000
	5	86.19424	0.167932	80.41331	1.769798
	10	84.56732	0.251970	79.51600	1.878475
Romania	1	99.34375	0.070157	95.70215	0.270071
	5	88.74603	3.299620	76.23076	7.251052
	10	86.86827	3.308051	71.41000	7.280130
Serbia	1	95.25026	3.724040	97.29752	0.123577
	5	91.25554	4.023550	74.47381	0.610681
	10	91.44388	3.739336	70.64925	2.253873
Slovakia	1	98.84617	0.195128	99.11138	0.079595
	5	90.81358	1.022188	93.06609	0.503688
	10	90.09272	1.065418	92.39380	0.751619
Slovenia	1	98.54747	0.886688	97.02274	0.039986
	5	90.82008	1.507386	76.38812	2.294382
	10	90.02476	1.505767	75.56234	2.322568
Hungary	1	99.48326	0.003123	99.57299	0.078744
	5	94.87787	0.715826	94.94713	0.649661
	10	94.22648	0.722212	94.25855	0.809064

Source: author's calculations

6. Conclusion

As several CEE states have joined the EU recently, several are candidates, the increasing in globalization process and along with the fact that Austria is interested in expanding in the region by setting up the basis of a collaboration or an acquisition, the examination of dynamic interdependencies of stock markets remains an important issue. In this paper, we analyzed possible interdependences between eleven emerging stock markets in Central and Eastern Europe and the Austrian stock market.

To investigate the short- and long-run linkages between the equity markets under study we employ three econometric models. The tests for cointegration using the Johansen procedure support

the presence of twelve cointegrating vectors between the CEE emerging in the two subperiods, indicating a robust long-term (statistical) relationship between these markets. Granger causal relationships have also been identified between the CEE emerging and the developed one, as short-run channels of causality run from changes in the Austrian market, and exert a stronger impact on the analyzed markets in the second subperiod.

The extent of the linkages is weak, as the variance decompositions by orthogonalised approaches demonstrate limited interactions between any pair of the emerging and the developed market under study. The implication of the low level of the linkages is that expected returns of the investment in the emerging stock markets would be determined mainly by the country-specific risk factors (Li and Majerowska, 2008). Only five countries appear more sensitive to shocks from the more mature market in the second subperiod than in the first one, therefore not being able to find any dramatic impact due to the CEESEG cooperation.

We found that the national market price innovations account for more of the error variance while Austrian price innovations account for less of the forecast error variance. This support the highlight of Syriopoulos (2007) that, the CEE stock markets tend to display stronger linkages with their mature counterparts rather than with the other CEE neighbors'. However, the linkages between Austrian and CEE stock markets are anticipated to strengthen, as a result of overcoming the crisis, as the euro area and EU expansion, as the implementation of several medium to long-term harmonization projects by CEESEG. These results lead to the argument that investor can benefit, at least in the short run, from diversifying into the Central and Eastern European equity markets.

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