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Article

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Provided in Cooperation with:
Expert journal of finance

Reference: Horobet, Alexandra Integration of capital markets from Central and Eastern Europe.

Expert Journal of Finance (2014) 2, 1-9
 ISSN 2359-7712
Finance.ExpertJournals.com

Integration of Capital Markets from Central and Eastern Europe: Implications for EU Investors

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Our paper investigates the extent of capital market co-movements between three emerging markets– Czech Republic, Hungary and Poland – and three developed markets from the European Union - Austria, France and Germany. We test whether an increase in correlations between the six markets took place in recent years, as revealing higher integration of capital markets in the region. We find a statistically significant positive trend in cross-market correlations between 1999 and 2008, before the emergence of the global financial crisis. Movements in national stock markets are not fully synchronized, but increases in market volatilities lead to increases in cross-country correlations. There is a long-term relationship between some of these countries' capital markets, and information is transmitted from one market to the other. Our findings confirm previous studies and lead to the conclusion that stock markets from Central and Eastern Europe became more integrated with the developed markets in European Union.

***Keywords**: capital markets, co-integration, European Union*

***JEL classification**: F36*

1. Introduction

The increase in international economic integration in the past decades, fueled by the amplified trade and financial flows around the world changed the size and scope of benefits that investors may obtain from holding internationally diversified portfolios. Besides the positive effects of international financial markets' integrations, such as a better allocation of resources and improved mitigation of risks, negative effects are also present, observable at the level of increased and joint volatility of financial markets around the world. The extent of integration and its dynamics were investigated through the methods of price differences or co-movements of markets, through the responses to information arrivals, or through the fit of models of capital flows and portfolio allocations.

The classic result offered by Heston and Rouwenhorst (1994) that country factors are more important drivers of volatility and capital markets' co-movements than are industry factors seemed to raise a challenge to the asset management industry. Coupled with the widespread opinion that larger capital flows across countries and the global search of arbitrage opportunities by international investors to higher correlations of stock returns across economies, this had the potential of changing the anticipated benefits to

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Article History:
Received 12 February 2014 | Accepted 03 April 2014 | Available Online 07 April 2014

Cite Reference:
Horobeț, A., Belașcu, L., and Olaru, R.G., 2014. Integration of Capital Markets from Central and Eastern Europe: Implications for EU Investors. *Expert Journal of Finance*, 2, pp. 1-9

be obtained from international portfolio diversification. Nevertheless, starting from the well-known paper of Longin and Solnik (1995), the literature in the field failed to provide definitive conclusions on the matter. For example, Lee (2005) finds that conditional correlations between the US, Japan, and the Hong Kong stock markets were positive and increasing, Pascual (2002) finds evidence of increasing integration of the French stock market, but not of the British and German markets, while Rangvid (2000) also identifies a rise in the degree of convergence among European stock markets in the last two decades. On the other hand, Roll (1992) argues that stronger economic integration may lead to lower correlation of asset returns if the integration process is associated with higher industrial specialization, while Heston and Rouwenhurst (1994) identify the country effects – fiscal, monetary, legal and cultural differences – as better explanatory factors for the co-movement of stock markets. Tavares (2009) analyzes the impact of economic integration on cross-country co-movements of stock returns, in a large panel of developed and emerging countries, and finds that returns' correlations are pushed up by bilateral trade intensity, while the real exchange rate volatility, the asymmetry of output growth and the export dissimilarity between countries tend to decrease them. Bekaert and Hodrick (2006) use a risk-based factor model and conclude that no evidence of an upward trend in returns' correlation across countries is observable, except in the case of European stock markets.

Central and Eastern Europe is a new stock market region among other emerging markets, as all these markets started to operate at the beginning of 1990s. The attention of international investors towards the region was fuelled by its high returns and low correlations with other developed and emerging markets, but the effective benefits of diversification received mixed results in the existing literature. Gilmore and McManus (2002) found that there is no long-term relationship between major markets in Central Europe, after conducting a co-integration test on stock returns from these markets, while the Granger causality test they employed showed that no causality is present between these markets and the US markets, but evidenced causation between Hungary and Poland. The lack of benefits for portfolio investors from holding assets in these markets is also documented by Shachmurove (2001), although his findings might be affected by the short period of time chosen. Egert and Kocenda (2007) analyze co-movements among three stock markets in Central and Eastern Europe (Hungary, Poland and Czech Republic) and the interdependence between them and Western European markets (Germany, France, and United Kingdom), using intraday price data. They find no signs of robust cointegration relationships between stock indices in a bivariate or multivariate framework, but discover short-term spillover effects both in terms of stock returns and stock price volatility. Patev et al. (2006) evaluate the degree of market integration between the US stock market and Central and Eastern European markets, through the use of cointegration, Granger causality and variance decomposition tests, by studying the long-run and short-run convergence among stock prices in Hungarian, Polish, Russian, Czech and US markets. They find that CEE markets are segmented, but during crisis times there is an increase in co-movements between markets, which leads to a sharp decrease in the diversification benefits for an American investor allocating his funds in the region's stocks. At the same time, the intensity of co-movements between markets decreased after the crisis, which restores the diversification opportunities in Central and Eastern European markets.

The current research continues previous attempts to investigate capital market linkages between Central and Eastern European countries, including Romania, and between them and Western Europe countries, developed by Horobet et al. (2006), Lupu et al. (2006), Horobet et al. (2007), and Horobet and Lupu (2009). The authors examined the significance of benefits available for international asset allocators given the higher presumed correlations between these markets and an intense process of information transmission between stock exchanges in terms of returns and volatilities. Their results indicate that the markets react rather quickly to the information included in the returns on the other markets, and that this flow of information takes place in both directions, from the developed markets to the emerging ones, and vice versa. At the same time, investors on emerging markets seem to take into account information from the other emerging markets in the region. Nevertheless, the results cannot definitely indicate whether there is a direct transmission of information from one market to another or a common reaction of all markets to some other information relevant to them, either on a European or global level.

2. Data and research methodology

2.1 Data sources and description

We employ daily logarithmic return data for stock market indices from six European Union countries – Austria, Czech Republic, France, Germany, Hungary and Poland – over ten years, starting in January 4, 1999 and ending in December 31, 2008. Of them, three are developed markets – Austria, France and Germany – and three are emerging markets – Czech Republic, Hungary and Poland. The sample of

countries was constructed in such a way as to allow the maximum number of comparative data following the introduction of the euro in 1999. All indices values were collected from Datastream and are Morgan Stanley Capital International (MSCI) indices for these countries. The indices are denominated in euro for the entire sample of countries. A brief description of the data is presented in Table 1.

Table 1. *Descriptive statistics of stock market returns*

	Austria	**Czech Rep.**	**France**	**Germany**	**Hungary**	**Poland**
Mean (%)	-0.002	0.062	-0.006	-0.009	0.008	0.012
Median (%)	0.011	0.080	0.013	0.039	0.025	0.010
Maximum (%)	12.759	16.550	13.149	11.125	17.410	10.870
Minimum (%)	-11.164	-16.350	-11.301	-8.666	-19.110	-11.850
Standard deviation	1.411	1.731	1.522	1.598	1.973	1.948
Skewness	-0.254	-0.315	0.045	0.045	-0.168	-0.221
Kurtosis	17.373	13.312	10.923	7.720	13.518	6.060
Jarque-Bera	22475.68	11599.26	6821.791	2421.35	12034.91	1038.53
Probability	0.000	0.000	0.000	0.000	0.000	0.000

Over the 1999-2008 period, all emerging markets – Czech Republic, Hungary and Poland – offered investors average daily positive returns, ranging between 0.008% for Hungary and 0.062% for Czech Republic, while all developed markets recorded average daily negative returns, ranging from -0.009% for Germany and -0.002% for Austria. At the same time, the volatility of all emerging markets, as measured by the standard deviation of daily returns, was higher as compared to the volatility of developed markets: the Hungarian market volatility was the highest (1.973%), while the Austrian market volatility was the lowest (1.411%). The returns were positively skewed for France and Germany and negatively skewed for Austria, Czech Republic, Hungary and Poland. All returns show non-normal leptokurtic distributions, as indicated by the values of kurtosis and Jarque-Bera normality test.

2.2 Research methodology

We investigate the degree of capital market integration between the emerging and developed markets in Europe, as well as its implication for international investors on three levels, from simple to advanced: (1) analysis of cross-market correlations and identification of trends in correlations; (2) analysis of the link between correlations and market volatilities; and (3) investigation of information transmission between markets.

The analysis of cross-market correlations aims at observing the evolution of average and rolling correlations with a 60-day window (approximately three months of observations) between pairs of countries and types of countries (developed against developed, emerging against emerging, and developed against emerging), as well as identifying statistically significant trends in correlations. In case of higher market integrations one should observe significant positive trends in cross-market correlations.

Several studies have focused on volatility transmission across markets and their results showed that there is a "volatility contagion" across markets. Moreover, when markets become more volatile they also tend to become more synchronized, which would be bad news for international investors, since the benefits of international diversification are needed most in times of high volatility. We conduct an econometric estimation of the link between correlations and volatilities, estimating the following model:

$$Corr_t^{C1/C2} = \alpha_t + \gamma_1 Vol_t^{C1} + \gamma_2 Vol_t^{C2} + \varepsilon_t \quad (1)$$

where $Corr_t^{C1/C2}$ denotes the correlations between country 1 (C_1) and country 2 (C_2), Vol_t^{C1} and Vol_t^{C2} indicate the volatilities of daily returns of countries 1 and 2, respectively. α_t is the constant of the regression and ε_t is the error term.

In order to estimate the parameters of this model we first apply the Solnik et al. (1996) approach, by using daily "innovations" in rolling correlations and volatilities. When working with moving averages, a 60-day moving average includes a 59-day overlap between two successive estimations in correlations and volatilities, which leads to strong autocorrelation that cannot be easily handled by standard statistical adjustment. Our approach is to use the residuals in rolling correlations and in both markets rolling volatilities, obtained through the estimation of the following model:

$$y_t = c + y_{t-1} + e_t \quad (2)$$

where y_t is the variable value at moment t, y_{t-1} is the one-day lagged value of the variable, and e_t are the residuals in the regression.

The third level of analysis uses a Granger causality test to identify the direction of information transmission from one market to the other and to determine the leading and lagging markets in EU. We test causal relations between indices based on the following vector autoregression framework (VAR):

$$Y_t = \alpha_0 + \sum_{k=1}^{n} \alpha_k Y_{t-k} + \sum_{k=1}^{n} \beta_k X_{t-k} + \varepsilon_{y,t} \quad (3)$$

$$X_t = \phi_0 + \sum_{k=1}^{n} \phi_k Y_{t-k} + \sum_{k=1}^{n} \theta_k X_{t-k} + \varepsilon_{x,t} \quad (4)$$

where α_0 and ϕ_0 are constants, α_k, β_k, ϕ_k and θ_k are parameters and $\varepsilon_{y,t}$ and $\varepsilon_{x,t}$ are uncorrelated disturbance terms with zero mean and finite variances. The null hypothesis that X_t does not Granger-cause Y_t is rejected if the α_k coefficients in equation (3) are jointly significantly different from zero using a standard joint test. Similarly, Y_t Granger-causes X_t if the coefficients α_k are jointly different from zero. The appropriate formulation of the Granger-causality analysis may need to incorporate an error correction term into the test if variables are cointegrated. Granger (1988) shows that causality tests might reach incorrect conclusions if they fail to account for a cointegration relationship. It is possible that the time series share a common stochastic trend even when all series contain a stochastic trend. For this reason, we also investigate Granger causality in the bivariate vector error correction framework (VEC):

$$\Delta Y_t = \alpha_0 + \delta EC_{t-1} + \sum_{k=1}^{n} \alpha_k \Delta Y_{t-k} + \sum_{k=1}^{n} \beta_k \Delta X_{t-k} + \varepsilon_{y,t} \quad (5)$$

$$\Delta X_t = \phi_0 + \delta EC_{t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{t-k} + \sum_{k=1}^{n} \theta_k \Delta X_{t-k} + \varepsilon_{x,t} \quad (6)$$

where EC_{t-1} is an error-correction term derived from the long-run cointegrating relationship.

3. Results

3.1 Analysis of cross-market correlations

Table 2 shows the correlations of daily returns over the 1999-2008 period between all markets. The values of correlation coefficients vary between 0.387 for Germany and Poland and 0.858 for France and Germany. Correlations are higher for developed markets and lower between developed markets and emerging markets, on one hand, and between emerging markets, on the other hand. It is interesting to observe the evolution of correlations in time, as previous research suggests that as markets become more integrated this should be observable through higher correlations between them.

Table 2. *Cross-market correlations of daily returns, 1999-2008*

	Austria	**Czech Rep.**	**France**	**Germany**	**Hungary**	**Poland**
Austria	1					
Czech Rep.	0.4467	1				
France	0.5360	0.4651	1			
Germany	0.4830	0.4085	0.8578			
Hungary	0.4853	0.5266	0.4816	0.4440	1	
Poland	0.4138	0.4864	0.4355	0.4068	0.5461	1

Table 3 presents the average values of cross-market correlations, calculated for pairs of all markets, but also for pairs of the three developed markets (DM to DM), for pairs of the three emerging markets (EM to EM), and for pairs of developed and emerging markets (DM to EM), for each year in the period under analysis and also for the entire 1999-2008 period. As we may observe, the average correlations are higher for developed markets as compared to correlations between emerging markets and correlations between developed and emerging markets, and they all increase between 1999 and 2008. Over the entire period, the average correlations of daily returns increase from 0.558 to 0.817 for pairs of developed markets, from 0.359 to 0.665 for pairs of emerging markets, and from 0.318 to 0.662 for pairs of developed and emerging markets. When we consider the increase in the average correlations from 1999 to 2008, the highest increase

– 108.17% – is observable in correlations between emerging markets and developed markets, followed by the increase in correlations between emerging markets – 85.23%. This may suggest a more intense process of market integration involving emerging and developed markets in Europe, fueled by these countries' accession to the European Union.

Table 3. *Average annual cross-market correlations of daily returns, 1999-2008*

Average correlation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	1999-2008
All markets	0.374	0.364	0.385	0.421	0.307	0.405	0.476	0.588	0.632	0.693	0.495
DM to DM	0.558	0.446	0.498	0.542	0.401	0.646	0.648	0.746	0.833	0.817	0.626
EM to EM	0.359	0.395	0.490	0.456	0.416	0.369	0.602	0.644	0.568	0.665	0.520
DM to EM	0.318	0.326	0.312	0.369	0.239	0.336	0.377	0.515	0.587	0.662	0.443

Aiming at improving the view over the increases in correlations between markets, we analyzed monthly correlations of daily returns in all markets, also for the entire period. The first observation is that all correlations display high volatility in time, which is higher in the case of emerging countries' correlations. Second, the correlation between France and Germany is the highest over the entire period, but also the most stable, compared to all other market pairs' correlations. This finding confirms previous results that indicate more synchronization in market movements for the countries that are part of an economic convergence process. As all stock market correlations fluctuate widely over time, a stable trend is not easy to identify in any of the correlations' graphs. In order to identify the presence of a trend in the correlation series, we regressed the time series of correlations on a constant and time index using ordinary least squares. Table 4 presents the values of the time coefficients resulted from the regressions where the dependent variable is the rolling 60-day window correlation, as well as their annualized values. All coefficients are positive and statistically significant, which suggests that correlations between all market pairs increased over the period under analysis. The highest increase is observable in the correlation between Austria and Germany – an annual 5.25% increase, which represents an increase of 52.5% over the ten year period. The smallest increase takes place in the correlation between Czech Republic and Hungary, with an annualized value of 1.58% or 15.8% for the entire period. Still, one should cautiously interpret the simple trend line in correlations, though, as fitting a straight line through a moving average leads to econometric problems (auto-correlated residuals) that make the estimate of the slope subject to errors.

Table 4. *Trends in rolling cross-market correlations*

Correlation	Trend	Trend (annualized)	T-statistic	Correlation	Trend	Trend (annualized)	T-statistic
Austria/France	0.000208	0.0499	47.713	France/Poland	0.000148	0.0355	47.458
Austria/Germany	0.000219	0.0525	48.702	Germany/Czech Rep.	6.59E-05	0.0158	16.221
Austria/Czech Rep.	0.000210	0.0504	49.567	Germany/Hungary	7.23E-05	0.0173	13.654
Austria/Hungary	0.000179	0.0429	40.056	Germany/Poland	0.000159	0.0381	49.280
Austria/Poland	0.000210	0.0504	48.723	Czech Rep./Hungary	7.37E-05	0.0176	17.561
France/Germany	7.50E-05	0.0180	55.048	Czech Rep/Poland	0.000130	0.0312	29.738
France/Czech Rep.	7.50E-05	0.0180	55.048	Hungary/Poland	0.000157	0.0376	43.347
France/Hungary	7.45E-05	0.0178	15.286				

In order to work out the auto-correlated residuals issue, we tested for the presence of trends in monthly correlations. The results are presented in Table 5 and they confirm the trend tests performed using rolling correlations. Although only thirteen out of fifteen coefficients are statistically significant at the 5% level – we find no significant trend of the correlations between France and Czech Republic, Germany and Czech Republic and Hungary and Czech Republic -, all of them are positive, indicating that correlations between the six markets have gone up during the past ten years. The highest value of the trend coefficient is found in the case of Austria and Germany – the correlation between these two markets increased annually by an average of 5.49% (the result is similar to the one identified by using rolling correlations) – and the smallest value is found in the case of Germany and Hungary – only an annual average increase of 1.93%.

Table 5. *Trends in monthly cross-market correlations*

Correlation	Trend	Trend (annualized)	T-statistic	Correlation	Trend	Trend (annualized)	T-statistic
Austria/France	0.0041	0.0487	6.3101	France/Poland	0.0032	0.0381	6.2938
Austria/Germany	0.0046	0.0549	7.0137	Germany/Czech Rep.	0.0004	0.0053	0.7200
Austria/Czech Rep.	0.0032	0.0387	4.9887	Germany/Hungary	0.0016	0.0193	2.3231
Austria/Hungary	0.0034	0.0405	5.4104	Germany/Poland	0.0033	0.0400	6.6023
Austria/Poland	0.0039	0.0468	6.2212	Czech Rep./Hungary	0.0009	0.0107	1.4204
France/Germany	0.0018	0.0214	7.3581	Czech Rep/Poland	0.0021	0.0256	3.5063
France/Czech Rep.	0.0004	0.0043	0.5949	Hungary/Poland	0.0031	0.0376	5.5351
France/Hungary	0.0017	0.0203	2.5844				

3.2 Analysis of links between volatility and correlation

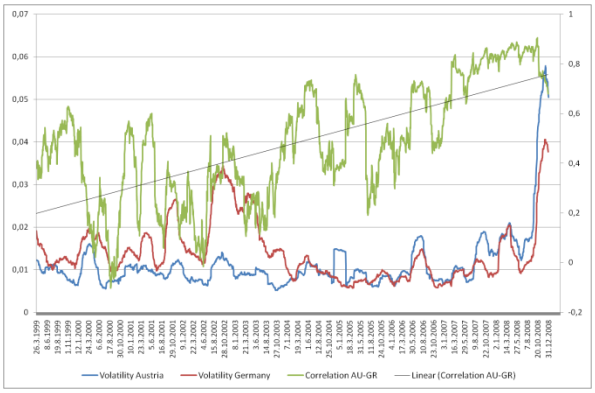
The Figures 1a-c below plots the rolling correlations between daily returns and the rolling standard deviations of daily returns, for three pairs of countries. We observe that movements in national stock markets are not fully synchronized, but a short look at the graphs shows that correlations tend to be high in periods of high market volatility, as measured by the standard deviation of stock market returns. The graphs of all country pairs show that both market volatilities tend to move together and that correlation tends to follow movements in market volatility. As Solnik et al. (1996) draw attention to, if correlation remained constant over time, the covariance between two markets would increase in line with the product of the two markets' standard deviations. In our case, the correlations increase when the market volatilities increase, which means the covariance increases more than market volatilities.

Table 6 reports the results of parameter estimates from equation (1). All volatility coefficients are statistically significant, with a few exceptions: for the Austria-France correlation, the French market volatility is not significant; for the Austria-Germany correlation, the Austrian market volatility is not significant; and for the France-Germany correlation, the French market is not significant. All coefficients that are statistically significant are positive, which indicates that increases in market volatilities lead to increases in cross-country correlations. The two volatilities have some multi-colinearity, so separating their effects on correlations is difficult. Still, including only one of the volatilities in the regression significantly reduces the adjusted R^2.

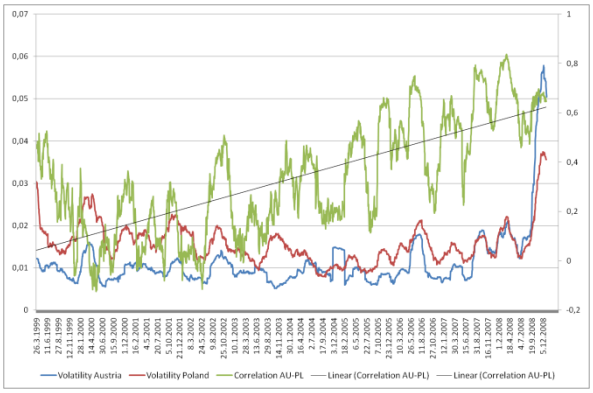
3.3 Results of Granger causality tests

First, we test the series for stationarity using the Augmented Dickey-Fuller and the Phillips-Perron tests. The results, reported in Table 7, strongly confirm at the standard 1% significance level that the series are not stationary in levels, but are stationary in first differences. We conclude that the series are difference-stationary processes.

a. Austria and Germany



b. Austria and Poland



c. Hungary and Poland

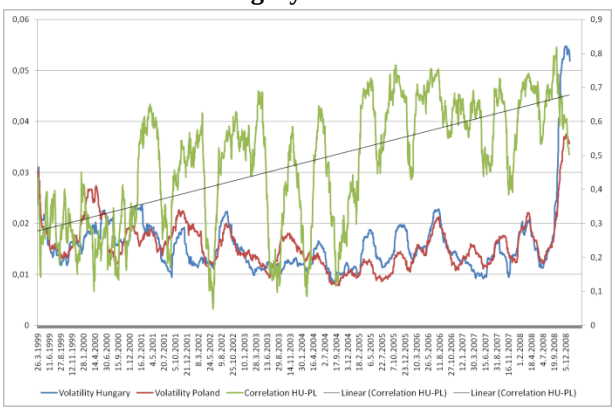


Figure 1. *Rolling correlation and volatilities of daily returns, 1999-2008*

Table 6. *Links between correlations and volatilities, 1999-2008 – Regression results*

Correlation	1st volatility	2nd volatility	Adjusted R^2 (%)	Correlation	1st volatility	2nd volatility	Adjusted R^2 (%)
Austria/France	8.930*	-0.603	1.968	France/Poland	9.545*	14.872*	8.646
Austria/Germany	-0.943	15.401*	4.973	Germany/Czech Rep.	17.263*	15.262*	14.847
Austria/Czech Rep.	9.604*	11.053*	6.298	Germany/Hungary	12.771*	4.702*	4.709
Austria/Hungary	10.926*	13.470*	10.697	Germany/Poland	11.198*	12.369*	6.950
Austria/Poland	7.144*	16.916*	7.824	Czech Rep./Hungary	10.833*	18.180*	16.136
France/Germany	1.042***	7.636*	12.559	Czech Rep/Poland	5.812*	19.349*	9.967
France/Czech Rep.	12.909*	14.894*	13.340	Hungary/Poland	11.141*	16.916*	15.645
France/Hungary	1.042*	7.636*	12.559				

Note: 1st volatility column indicates the coefficient for the volatility of the first country mentioned in the first column of the table, and the 2nd volatility column indicates the coefficient for the second country volatility. Namely, for the Austria-France line, 1st volatility refers to the Austrian market volatility and 2nd volatility refers to French market volatility. *, ** and *** denote statistical significance of coefficients at 1%, 5% and 10% level.

Table 7. *Unit root tests results*

	Log levels			
	ADF		PP	
	Constant	Trend and constant	Constant	Trend and constant
AU_IND	-0.73	1.31	-0.76	1.31
CZ_IND	-0.91	-1.33	-0.92	-1.38
FR_IND	-1.49	-1.49	-1.24	-1.23
GR_IND	-1.35	-1.38	-1.28	-1.30
HU_IND	-1.25	-0.79	-1.28	-0.68
PL_IND	-1.45	-1.04	-1.47	-1.09
ΔAU_IND	-51.18 ***	-51.25 ***	-51.21 ***	-51.25 ***
ΔCZ_IND	-38.52 ***	-38.52 ***	-49.83 ***	-49.82 ***
ΔFR_IND	-53.27 ***	-53.28 ***	-53.92 ***	-53.96 ***
ΔGR_IND	-52.36 ***	-52.35 ***	-52.42 ***	-52.42 ***
ΔHU_IND	-24.23 ***	-24.25 ***	-46.26 ***	-46.27 ***
ΔPL_IND	-50.30 ***	-50.31 ***	-1.47 ***	-1.09 ***

Note: ADF and PP are Augmented Dickey-Fuller and Phillips-Perron unit root tests. Test equations include either an intercept or an intercept and a trend. The lag length is chosen using the Schwarz information criterion for the ADF test, and the Newly West kernel estimator for the PP test. *** denote the rejection of the null hypothesis at the 1% levels.

We use the multivariate Ljung-Box test based on the residuals obtained from the maximum likelihood estimation of VEC models given in equations (5) and (6) to determine the lengths of lags in the VAR model. Table 8 reports the Johansen cointegrating trace statistics.

Table 8. *Results of cointegration test*

		Austria	Czech Republic	France	Greece	Hungary
Austria	r = 0					
	r ≤ 1					
Czech Republic	r = 0	32.88 ***				
	r ≤ 1	4.78 **				
France	r = 0	2.30	3.36			
	r ≤ 1	0.60	0.86			
Greece	r = 0	5.75	2.48	9.27		
	r ≤ 1	1.73	0.67	1.62		
Hungary	r = 0	23.81 ***	13.47 *	3.17	4.93	
	r ≤ 1	0.78	3.00 *	1.39	2.27	
Poland	r = 0	21.83 ***	7.30	3.72	4.90	10.36
	r ≤ 1	1.32	1.46	1.54	1.90	1.97

Note: This table reports the results of the one-sided test of the null hypothesis that the stock indices of the countries under consideration are cointegrated. Reported critical values are Osterwald-Lenum (1992) critical values.

The results in Table 8 indicate that the null hypothesis of no cointegration is rejected for the pairs Czech Republic – Austria, Hungary – Austria, Hungary – the Czech Republic and Poland – Austria. Consequently, Granger-causality tests between the stock indices of these countries are performed in the VEC model. The remaining pairs do not incorporate cointegrating relations, therefore the Granger-causality test is performed correctly in a VAR framework.

Table 9. *Pairwise Granger-causality tests*

Lags	**5**	**10**	**15**	**Lags**	**5**	**10**	**15**
CZ_IND → AU_IND	6.85***	3.84***	2.79***	PL_IND → CZ_IND	8.72***	5.73***	4.05***
AU_IND → CZ_IND	4.80***	3.90***	4.00***	CZ_IND → PL_IND	2.24**	1.94***	1.42
FR_IND → AU_IND	2.82**	2.49***	1.82**	GR_IND → FR_IND	8.65***	6.65***	3.34***
AU_IND → FR_IND	2.55**	2.32**	1.58*	FR_IND → GR_IND	2.25**	4.29***	3.37***
GR_IND → AU_IND	4.15***	2.96***	2.01**	HU_IND → FR_IND	0.96	1.99**	1.57
AU_IND → GR_IND	2.92**	1.92**	1.70**	FR_IND → HU_IND	1.26	1.41	1.06
HU_IND → AU_IND	6.76***	4.62***	4.04***	PL_IND → FR_IND	1.17	1.21.2013	1.08
AU_IND → HU_IND	5.40***	4.78***	3.39***	FR_IND → PL_IND	5.03***	4.15***	4.04***
PL_IND → AU_IND	6.16***	3.61***	2.68***	HU_IND → GR_IND	1.41	1.33	1.37
AU_IND → PL_IND	4.65***	2.66***	2.04**	GR_IND → HU_IND	5.12***	2.25	1.70**
FR_IND → CZ_IND	1.44	1.83*	1.67**	PL_IND → GR_IND	0.86	1.11	0.87
CZ_IND → FR_IND	1.72	1.11	1.00	GR_IND → PL_IND	10.96***	5.87	4.71***
GR_IND → CZ_IND	3.27***	2.04**	1.79**	PL_IND → HU_IND	1.59	1.42	1.39*
CZ_IND → GR_IND	2.17*	1.43	1.37	HU_IND → PL_IND	5.15***	3.64	3.47***
HU_IND → CZ_IND	11.33***	6.81***	6.91***				
CZ_IND → HU_IND	4.00***	2.83***	2.62***				

Note: *, ** and *** denote statistical significance of causal links at the 10%, 5% and 1% significance levels.

The results in Table 9 suggest that Austria is integrated with all other countries under consideration, in the sense that the Austrian stock index Granger-causes and is Granger-caused by all other stock indices. Similarly, the Czech market appears to influence and be influenced by the other stock markets except France. We also observe unidirectional influences from the Hungarian, French and German indices to the Polish index and from the German index to the Hungarian index. In addition, the German and French markets exhibit reciprocal effects.

4. Conclusions

We investigate the extent of capital market co-movements between three emerging markets from the European Union – Czech Republic, Hungary and Poland – and three developed markets from the European Union, namely Austria, France and Germany. Since the general perception, also supported by empirical evidence, is that an integration process should be observable at the level of higher correlations between countries' capital markets, we test whether such an increase in correlations between the six markets above took place in the recent years. Although correlations are highly unstable and fluctuate widely in time, we find that there is an observable and statistically significant positive trend in cross-market correlations between 1999 and 2008, with an increase in correlations over the ten year period ranging from 15.8% to 52.5%. We also find that correlations between the three emerging markets and the three developed markets increased on average between 1999 and 2008, more than the increase observable in the correlations between

developed markets only and emerging markets only, which may indicate a higher integration of these capital markets.

At the same time, we observe that movements in national stock markets are not fully synchronized, but correlations tend to be high in periods of high market volatility, as measured by the standard deviation of stock market returns. Regressing the rolling correlations on markets rolling volatilities, we find that almost all coefficients are statistically significant and positive, which indicates that increases in market volatilities lead to increases in cross-country correlations during the ten years under analysis. Our findings confirm previous studies and lead to the conclusion that stock markets from Central and Eastern Europe became more integrated with the developed markets in European Union, as revealed by the evolution of correlations between these markets.

Granger causality tests offer more insight into the links between these capital markets. The hypothesis of no-cointegration, or of a no long-term relationship between markets is rejected for the pairs Czech Republic – Austria, Hungary – Austria, Hungary – Czech Republic and Poland – Austria. The remaining pairs do not incorporate cointegrating relations. The results of Granger causality tests indicate that Austria Austria is integrated with all other countries under consideration, in the sense that the Austrian stock index Granger-causes and is Granger-caused by all other stock indices. Similarly, the Czech market appears to influence and be influenced by the other stock markets except France. We also observe unidirectional influences from the Hungarian, French and German indices to the Polish index and from the German index to the Hungarian index. In addition, the German and French markets exhibit reciprocal effects.

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