3. Influence of the EU Accession Process and the Global Crisis on the CEE Stock Markets: A Multivariate Correlation Analysis

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Abstract

The paper examines the long-term dynamics of four Central and Eastern European countries, namely the Czech Republic, Hungary, Poland and Romania between 2002 and 2012. The structure of the paper is twofold. In the first part, it examines the relationship between a set of macro financial variables, the main stock indices of Western Europe (MSCI EAFE indices, United Kingdom, Germany, Austria) and the stock market indices of four Central and Eastern European countries using a Vector Autoregressive model. The VAR model showed that during the global financial crisis there was an increased impact of the macroeconomic factors on the financial returns of the CEE countries. In the second part, the paper explores the conditional correlations of the index returns between Western Europe and the CEE countries using multivariate GARCH models.

By investigating the stock market co-movements of the countries that have recently joined the European Union with the developed European capital markets, we may see that the level of correlation across markets has significantly increased after joining the European Union.

During the 2008-2009 global financial crisis, the indices displayed a high conditional correlation indicating that the financial shocks had simultaneously hit all the regional Stock Exchanges. In the period after the crisis, the BEKK model showed evidence of the spillover effects generated by the sovereign debt crisis over the CEE countries.

Keywords: stock index returns, multivariate GARCH, conditional correlation, stepwise regression, Central and Eastern European countries

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1. Introduction

The relationship between macroeconomic variables and stock returns has been investigated by many studies assuming that macroeconomic changes are influential on stock prices through their effects on future cash flows and their discount rate.

According to the economic theory, the stock prices incorporate macroeconomic expectations, such as interest rate expectations, as well as sector specific risks. This means that, according to the Fama theory (1970), the relationship between macroeconomic variables and stock indices can be observed in terms of market efficiency. The degree of stock market efficiency depends on the speed and accuracy with which information is reflected in the stock prices. Although in theory there are three levels of market efficiency, the weak, semi-strong, and strong form, Campbell *et al*. (1997) notes that the strong form of market efficiency is not a realistic assumption.

A large body of literature and different methods were used in order to assess the degree to which the market efficiency of Central Eastern European (CEE) countries modified once they have joined the European Union. Most of the papers were focused on the Czech Republic, Hungary and Poland. On one hand, the accession process led to the strengthening of the financial integration. On the other hand, assuming that the integration of capital markets has become deeper after joining the European Union, what was the degree of correlation with the Western capital markets and how the pattern of correlation was affected by the financial crisis of 2008-2009?

We have studied the evolution of the conditional correlations between developed Western capital markets and four CEE capital markets, namely Hungary, the Czech Republic, Poland and Romania, as well as the impact of some macroeconomic indicators, which are strongly correlated with the stock markets indicators from the European developed markets.

Our results suggest that the international correlation linkages of the stock markets of the CEE countries varied over time, and that inter-linkages of both fundamentals and speculative bubbles strengthened during the market turbulences caused by the financial crisis of 2008.

Nevertheless, since the process of financial market integration is dynamic and difficult to measure, a wide range of empirical methods have been used in the literature to analyze the issue.

Since indices returns display fat tails and volatility clustering, we have fitted multivariate GARCH models, namely DVECH and BEKK in order to study the volatility spillovers across markets.

2. Literature Review

There is a large body of literature devoted to the study of financial market integration of developed countries, mainly focused on the correlation between the US and major European stock markets.

Karunanayeke *et al*. (2010) studied the correlation between the developed countries and the Asian emergent markets using a diagonal VECH model and found that both the Asian crisis and the global financial crisis of 2008-2009 led to the increase in volatilities and indicated a possible transmission channel of volatility from the US and the UK markets towards the Australian and Singapore markets.

Xiao and Dhesi (2010) used diagonal VECH, BEKK and Dynamic Conditional Correlation models to investigate the transmission of volatilities and time-varying conditional correlations between the developed capital markets (France, Germany, United States and United Kingdom) prior to the crisis. The authors concluded that France and Germany were very strongly correlated, while the UK acted as a volatility proxy between the USA and Europe.

Although multivariate GARCH models are usually used for analyzing the conditional correlation between different markets, they can also be used for studying the conditional correlation between macroeconomic indicators and the capital markets returns. De Goeij and Marquering (2004) extended the diagonal VECH model to incorporate asymmetric effects in covariances when residuals were of opposite sign. An asymmetric diagonal VECH model was used by de Goeij and Marquering (2009) to model the interaction between the stock and bond returns. The results showed that there was a contagion effect between them, more often when a negative shock hit the stock and bond markets.

In the last years, the Central and Eastern European capital markets have become intensely researched. Some researchers investigated the market efficiency by comparing the short-term and long-term relationships between the macroeconomic variables and stock exchange returns using VAR and VECM models (Horobet, Dumitrescu, 2009; Barbic, Condic, 2011; Kyzis, Pierdzioch, 2011; Al-Jafari *et al.*, 2011; Corradi *et al.*, 2012) while Büttner, Hayo, Neuenkirch, 2010 used GARCH models.

Lim and Brooks (2010) used a sample of 50 markets in order to reach the conclusion that the volatility, especially in the crisis, was negatively correlated with the GDP per capita. Also, the nonlinearities of the stock returns were measured using the Hurst coefficient (Caraiani, 2012) for assessing the multifractality in market returns and showed that the coefficient had higher values for the 2008-2009 crisis.

The correlations between the evolutions of the capital market returns were studied by diverse methods such as Generalized Spectral Test (Escanciano and Velasco, 2006, Todea, Lazar, 2012), cross-sectional dependence analysis (Harrison, Lupu, Lupu, 2010), non-linearity test (Karadigli, Donmez, 2012), Engle-Granger causality test for short-term relationships and long-term dependence with Johansen cointegration test (Nistor, Dumitriu, Stefanescu, 2012; Harrison, Moore, 2010) or with wavelet correlation analysis (Dajcman, Festic, Kavkler, 2012).

Horvath and Petrowski (2012) compared the stock market comovements from Western Europe, Central Europe and South Eastern Europe between 2006 and 2011 using diagonal VECH and BEKK models. The results indicated a higher correlation for Central Europe with the developed countries and that the crisis did not change the degree of financial market integration.

Égert and Kocenda (2011) analyzed the intraday 5 minutes tick comovements between a group of three developed countries, France, Germany and the United Kingdom, and three CEE countries, the Czech Republic, Hungary and Poland between 2003 and 2006 by using a Dynamic Conditional Correlation model. The results showed significant correlations between the developed capital markets and almost none with the CEE capital markets, except for Hungary, which displayed a trend for higher correlation.

Aslanidas and Savva (2011) measured the stock indices returns comovements between Hungary, the Czech Republic and Poland and the Euro zone index between 1999 and 2007 using VAR,
GJR-GARCH and STCC (smooth transition conditional correlation) models. They identified an increase in correlation for the three countries from 2006, and while in Hungary and Poland the transition was smoother, in the Czech Republic the financial integration was faster. Similar results were also identified by Novotny (2010), who analyzed the price jumps.

Guido and Gupta (2010) fitted a VAR and two multivariate GARCH models, a BEKK and a Dynamic Conditional Correlation for modeling the long term relationship between Germany and three CEE countries between 1999 and 2009. The Gregory-Hansen cointegration test showed evidence for cointegration in the series, with a break estimated for August 2002. The results also showed that the correlations increased after the Czech Republic, Hungary, and Poland joined the EU.

3. Data and Methodology

3.1. Data

We used weekly close prices of the main Western capital markets such as DAX (Germany), FTSE (UK) and ATX (Austria), as well as Morgan Stanley Capital International indices, namely European indices EAFE, the East-European emergent markets indices EMEE and the emergent market indices EM. In order to study the long-term dynamics of the CEE countries we employed the weekly close prices from the Czech Republic, Hungary and Poland. In addition to them we added Romania, in order to assess the impact of joining the European Union, given that Romania joined in January 2007, while the former three countries joined in May 2004. The data were retrieved from DataStream between July 2002 and June 2012.

We took the EAFE index[5] as a proxy for the capital markets of the developed countries. Weekly data of the macroeconomic factors were provided by FRED databases, namely the oil price (WTI), gold price on the London Metal Exchange, interest rate for the 3 months TBILL (TB3M) and 10 year maturity bonds (DG10Y) and the euro/USD exchange rate[6].

[5] The MSCI EAFE Index (Europe, Australasia, Far East) is a free float-adjusted market capitalization index that is designed to measure the equity market performance of developed markets, excluding the US and Canada. The MSCI EAFE Index consists of the following 22 developed market country indices: Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, and the United Kingdom.

[6] All time series were denominated in euro and stationarized using the first difference in logs.

3.2. Methodology

The vector autoregression model (VAR) is a well-known multivariate autoregressive model in which all variables are endogenous, thus allowing the value of variables to depend on more than its own lags and be able to capture more features of the data, especially the interdependencies between multiple time series. For a set of *n* time series of variables $y_t = (y_{1t}, y_{2t,} ..., y_{nt})'$, a VAR model of order p, VAR(p), can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t$$

where: the A_i's are *nxn* coefficient matrices and $u_t = (u_{1t}, u_{2t}, ..., u_{nt})'$ is an unobservable, i.i.d. zero mean error term.

In order to select the data for the VAR process, we proceeded to eliminate the colinearities from the time series using a stepwise regression procedure. For the VAR analysis we divided the data in 6 sub-periods depending on the main events that intuitively could have induced structural breaks into the returns, namely the pre-accession period, the EU accession, the outbreak of the 2008-2009 crisis and the onset of recession after the crisis. After we estimated the data, we applied the formal diagnosis tests to the fitted data, highlighting the variance decomposition to see how the weights of the asset returns have modified.

The short-term correlations between the stock indices returns were modeled with three multivariate GARCH methods: VAR, diagonal VECH and BEKK. A multivariate Garch model uses the fact that the contemporaneous shocks can be inter-correlated, thus allowing for the volatility spillovers, which is especially useful when one asset returns is leading the other, which is the case for financial series by modeling the conditional covariances between asset returns.

The mean equation, in the simplest specification, in a multivariate case is

$$r_t = \mu + u_t$$

where: r_t is a multivariate return series and μ is the conditional mean vector, so that $\mathbb{E}(r_t/\Omega_{t-1}) = \mu$ and u_t is the shock of the return series at time *t*.

$$u_t = H_t^{0.5} v_t$$

where: $H_t^{0.5}$ is the conditional variance-covariance matrix, so that $var(r_t/\Omega_{t-1}) = H_t$. Since many empirical analyses indicated that the shocks fitted with multivariate Gaussian distribution failed to capture the kurtosis in the return series, we used a multivariate Student distribution for the shocks.

In the VECH model proposed by Bollerslev, Engle, and Wooldridge (1988), every conditional variance and covariance is a function of all lagged conditional variances and covariances, as well as lagged squared returns and cross-products of returns, so that the number of parameters equals $(p+q)\times(N(N+1)/2)^2+N(N+1)/2$, which is too large. For example, a simple Garch (1,1) model with three assets has six equations for the variances and each equation has 12 coefficients, plus a constant and three equations for the mean, meaning that at least 78 parameters have to be estimated.

Numerical methods used to find the parameter values fail when dealing with over-parameterized models. This is the reason why there is necessary to impose restrictions on the VECH model. We searched for models that can allow interaction between variances, but small enough not to produce spurious conditional correlations.

The diagonal VECH model (Bollerslev *et al*., 1988) diagonalizes the VECH model, so that the variances for two assets are written as:

$$h_{11t} = c_{10} + \alpha_{11}\varepsilon_{1t-1}^2 + \beta_{11}h_{11t-1}$$
$$h_{12t} = c_{20} + \alpha_{22}\varepsilon_{1t-1}\varepsilon_{2t-1} + \beta_{22}h_{12t-1}$$
$$h_{22t} = c_{30} + \alpha_{33}\varepsilon_{2t-1}^2 + \beta_{33}h_{22t-1}$$

The equation for each variance looks like a univariate Garch, while the covariance is also written as a Garch model depending on itself and on the cross-product of the errors (Enders, 2010).

If in a VECH model we set $\alpha_{ij} = \beta_{ij} = 0$, it means that the non-diagonal terms such as $\alpha_{12}\varepsilon_{1t-1}\varepsilon_{2t-1}$, $\alpha_{13}\varepsilon_{2t-1}^2$, $\beta_{12}h_{12t-1}, \beta_{13}h_{22t-1}$ which are in the VECH model in the equation of the first variance (h_{11t}) are equal to zero, then there will be no interaction between the variances. However, the diagonal VECH model, even if it has fewer parameters to estimate, $(p+q+1)(N(N+1)/2)$, is not realistic, since it does not take into account the interactions between different conditional variances and covariances. The solution is to impose different restrictions on the DVECH model in order to ensure that the variances are positive semi-definite.

The BEKK model (Baba, Engle, Kraft and Kroner, 1995) ensures that the conditional variances are positive, which may not be the case in the diagonal VECH model. The model allows for volatility spillovers, so that the shock in the variance of one variable influences the others. Since the model has a large number of parameters, the convergence may fail; also, since the parameters show up in equations in a nonlinear fashion, the interpretation proves to be difficult.

The BEKK specification is

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}'A + B'H_{t-1}B$$

where: A and B are parameter matrices with dimension *nxn* and C is an upper triangular matrix of the parameters. While the original model is more general, in practice the BEKK models are of order 1. The BEKK models can be difficult to estimate especially with many assets; this is the reason why we have chosen not to estimate more than six assets. The convergence was achieved with good t-values of the parameters, but the convergence failed for more assets.

As in the case of diagonal VECH, there are a scalar and a diagonal version of the BEKK model. The diagonal form assumes that the A_{kj} and B_{kj} are diagonal, while the most restricted version is the scalar BEKK, where $A = aI$ and $B = bI$ and *a* and *b* are scalars. Since the diagonal BEKK model assumes the matrices A and B are diagonal, thus makes it possible for H_t to be positive definite for all *t*. The number of parameters for diagonal BEKK decreases to $(p+q)KN+N(N+1)/2$, but it is still large and the interpretation of the parameter is not easy (Silvennoinen and Terasvirta, 2008).

To analyze the degree of co-movements across the markets, we estimated and plotted the conditional correlations between each pair wise of indices, according to the formula:

$$\rho_{xy,t}=\frac{h_{xy,t}}{\sqrt{h_{xx,t}h_{yy,t}}}$$

4. Empirical Results

Since the VAR model is atheoretical, we have selected the variables for the VAR model using the stepwise procedure. The following regressors were used: on one hand, we used stock indices returns as Germany stock index (DAX), UK stock index (FTSE), Austria stock index (ATX), Morgan Stanley Capital International (MSCI) index for European market (EAFE), MSCI index for emergent East-European markets (EMEE), MSCI index for emergent markets and, on the other hand, we used the following macroeconomic data: gold price on the London Metal Exchange, interest rate on 3 months US Tbill (TB3M), 10 year maturity US bonds (DG10Y), the spread between long and short term interest rate (SPREAD), as well as the following exchange rates: EUR/USD, EUR/RON, EUR/CZK, EUR/HUF, EUR/PLZ.

The unit root tests (ADF and PP) indicated that all series were I(1), except for SPREAD, which was I(0). The MSCI indices, EAFE, EMEE, and EM are collinear, which exclude them to be used at the same time in the stepwise regression.

Table 1 presents the result of the stepwise regressions, with each of the three MSCI indices being used in different regressions for the reasons stated above.

The results indicate that the index returns are significant for the other countries, except BUX for BET and BET for BUX and WIG, meaning that for the whole period, July 2002-June 2012, all three stock exchanges, Prague, Budapest and Warsaw, are correlated, except for the Bucharest Stock Exchange which shows a lower correlation with the other three. Although the results may indicate that the indices of the four countries (BUX, PX, WIG and BET) are correlated with their own exchange rates, the degree of correlation will be analyzed later with a multivariate Garch.

The Vienna stock index (ATX) is a significant regressor for BUX, PX and BET, and less for WIG, which can be explained by the fact that the Polish Stock Exchange is a serious regional competitor for Vienna. The Warsaw Stock Exchange is higher correlated with the Frankfurt Exchange (DAX), while Prague is more influenced by the UK Exchange (FTSE).

The capital markets from Hungary, Poland and Romania are correlated with the MSCI emergent market index (EM); gold returns influence WIG and BET, and oil returns influence only WIG, TB3M influence only PX and SPREAD affects only BET. The last row of the table presents the results of the regression for EAFE, used to compare them.

Table 1

The Results of the Stepwise Regression for Regressors (Own Calculations)

Indices	Currency	BUX	PX	WIG	BET	ATX	DAX	FTSE	EM	EAFE	MSCI	EMEE	GOLD	OIL	TB3M	DG10Y	SPREAD	adj.R2
BUX1	HUF	-	PX	WIG		ATX			EM	-	-	-						0.75
BUX2	HUF	-	PX	WIG		ATX			-	EAFE	-	-						0.75
BUX3	HUF	-	PX	WIG		ATX			-	-	MSCI	-						0.75
PX1	CZK	BUX	-	WIG	BET	ATX		FTSE*		-	-	-			TB3M			0.74
PX2	CZK	BUX	-	WIG	BET	ATX		FTSE*	-	-	-	-			TB3M			0.74
PX3	CZK	BUX	-	WIG	BET	ATX		FTSE*	-	-	-	-			TB3M			0.74
WIG1	PLZ	BUX	PX	-		ATX	DAX	FTSE*	EM	-	-	-	GOLD					0.71
WIG2	PLZ	BUX	PX	-			DAX	FTSE*	-		-	-	GOLD	OIL				0.70
WIG3	PLZ	BUX	PX	-			DAX	FTSE*	-	-		-	GOLD	OIL				0.70
BET1	RON		PX	WIG	-	ATX			EM*	-	-		GOLD				SPREAD	0.47
BET2	RON		PX	WIG	-	ATX			-	-	-		GOLD*				SPREAD	0.46
BET3	RON		PX	WIG	-	ATX			-	-			GOLD*				SPREAD	0.46
EAFE	EUR	BUX	PX	WIG	BET	-	-	-	-	-	-	-			TB3M	DG10Y		0.82

**Weak significance of the regressor with p-value in the interval 0.05-0.10.*

The preliminary results of the multivariate regressions were used to build VAR models for each stock index, and for each model we divided the sample into six periods according to previous results from literature and to the structural shocks identified in the data.

1. July 2002-April 2004; pre-accession period of the Czech Republic, Hungary and Poland,
2. May 2004-December 2006: post-accession period of the Czech Republic, Hungary, Poland and pre-accession phase of Romania
3. January 2007-August 2008: post-accession period of Romania and preceding the financial crisis
4. September 2008 – February 2009: full-blown global financial crisis
5. March 2009 – April 2011: economic adjustment period after the crisis
6. March 2011-June 2012: the Czech Republic economy is in recession according to World Bank and the sovereign debt crisis is escalated.

We fitted 24 VAR, for each of the four indices on six sub-periods. The effects of the shocks to index returns were analyzed by using variance decomposition. The results for each index returns are presented in Tables 2-5.

Table 2

Variance Decomposition for the Czech Republic Index Returns (PX) for Each Sub-period

DL_PX	S.E.	DL_PX	DL_CZK	DL_ATX	DL_BUX	DL_BET	DL_WIG	DL_FTSE	DL_TB3M
VAR1	0.02726	80.79539	4.83975	1.78262	3.55378	0.95188	4.92077	0.50467	2.65115
VAR2	0.03001	89.75951	0.91561	1.69647	0.86250	1.48179	1.04060	0.42197	3.82155
VAR3	0.02649	81.90108	8.83793	0.15722	0.79952	2.82616	1.30653	1.94986	2.22170
VAR4	0.19728	45.20643	9.38003	6.75780	14.76873	5.32772	9.29763	4.14068	5.12098
VAR5	0.04030	85.08869	0.90077	0.83774	5.06829	4.74786	0.66461	1.05130	1.64074
VAR6	0.04313	65.24510	5.17534	0.98949	5.95573	3.64657	5.79230	5.80045	7.39502

Table 3

Variance Decomposition for Hungary Index Returns (BUX) for Each Sub-period

DL_BUX	S.E.	DL_BUX	DL_HUF	DL_ATX	DL_PX	DL_WIG	DL_EM
VAR1	0.03004	88.30922	1.81320	5.04834	3.05562	1.50868	0.26495
VAR2	0.03989	92.31994	2.54709	1.24489	1.83123	1.65756	0.39928
VAR3	0.03375	89.29864	1.23904	2.76232	2.22542	0.75733	3.71724
VAR4	0.14319	66.34674	15.18921	13.06824	1.64453	2.36872	1.38256
VAR5	0.05363	84.34938	3.29565	1.49313	2.36274	0.26272	8.23639
VAR6	0.05428	86.61101	1.15565	0.54035	2.46574	5.70833	3.51893

Table 4

Variance Decomposition for Polish Index Returns (WIG) for Each Sub-period

DL_WIG	S.E.	DL_WIG	DL_PLZ	DL_ATX	DL_BUX	DL_PX	DL_EM	DL_DAX	DL_GOLD
VAR1	0.03529	87.50642	0.76869	0.28865	1.68528	2.00829	0.88139	1.02635	5.83494
VAR2	0.03773	91.28458	0.74766	4.82657	0.98730	0.38866	0.70660	0.11841	0.94021
VAR3	0.03887	80.53909	1.05247	1.94462	0.10778	2.99577	4.99178	5.51630	2.85219
VAR4	0.15110	48.81417	19.09637	13.35118	2.98235	11.45023	2.81238	0.43046	1.06285
VAR5	0.04556	81.86252	3.57411	2.80531	0.71176	1.02308	5.19137	1.32450	3.50737
VAR6	0.04662	73.97243	3.77315	5.22892	1.62433	3.02652	5.65196	4.12805	2.59465

Table 5

Variance Decomposition for Romanian Index Returns (BET) for Each Sub-period

DL_BET	S.E.	DL_BET	DL_RON	DL_ATX	DL_PX	DL_WIG	DL_GOLD	D_SPREAD
VAR1	0.030343	84.38536	1.72350	1.76109	7.62942	1.68673	0.69178	2.12212
VAR2	0.039367	91.63797	0.89126	1.30775	1.21951	0.60514	0.26093	4.07744
VAR3	0.047874	78.83484	1.50335	3.97175	4.14702	3.12748	2.63918	5.77639
VAR4	0.139842	40.61371	30.48732	9.69745	4.94819	3.48948	5.02560	5.73825
VAR5	0.048170	91.63488	3.54832	1.21828	0.42585	0.13992	1.69572	1.33703
VAR6	0.037415	78.17312	0.52752	7.70130	4.52390	5.46227	2.96381	0.64808

Analyzing the variance decomposition results we may conclude that the influence of their own shocks is significantly reduced during the crisis period, denoted with VAR4 as being VAR fitted for the fourth sub-period, when the influence of the exchange rate, shocks from neighboring countries and macroeconomic variables is heavily increased.

We may see that the PX index has a behavior similar to a crisis for the sixth period (VAR6), with the reduction in importance of its own shocks and a higher sensitivity to exogenous factors, although slightly higher than during the global financial crisis.

The weight of its own shocks was higher for the post-accession period for all three CEE countries (May 2004-December 2006), including for Romania. The shock transmitted by exogenous factors during the crisis was the highest for Romania, but also the reversion after the crisis was steeper in the case of the Bucharest Stock Exchange. The shocks dissipated quickly, indicating a fast absorption of the information in the market.

Since the normality tests for VAR (Lutkepohl, 1991) indicated that the residuals were not normal and since the residuals were also heteroskedastic, we fitted the index returns within a multivariate GARCH framework for explicitly taking into account the volatility spillovers across countries.

In order to study the conditional correlations of the stock returns with the macroeconomic data, we fitted up to six assets in every model, since empirically the models fitted with more assets had convergence problems. In every multivariate GARCH model fitted, either diagonal VECH or BEKK, we included the four countries indices and a mix of macroeconomic data.

We compared the results by information criteria AIC and concluded that the BEKK models produced better results. We also investigated the fit of the models by plotting the quantile-quantile of the standardized residuals. The results showed that the fat tails were not captured adequately. The problem was partially addressed by using a Student distribution of the errors.

The results, not presented here, showed that the gold price, TB3M and DG10Y did not have any significant correlation with the four CEE index returns.

The conditional correlations between the index returns of the Czech Republic (PX), Hungary (BUX) and Poland (WIG) are presented in Figure 1 in the Annex.

The conditional correlations between the Czech Republic (PX), Hungary (BUX), Poland (WIG) and Romania (BET) are shown in Figure 2, while Figure 3 shows the conditional correlation between the four CEE countries and the EAFE index

The significance level taken for correlation was 0.4, while the values over 0.9 are interpreted either as crisis pervading all markets at the same time or as spurious correlation. There are empirical evidences that all multivariate GARCH produces such spurious correlation from time to time (Fuss and Gluck, 2012). Since both DVECH and diagonal BEKK models produced the same high correlation and the high conditional correlation results corroborated with the market information at that moment, we concluded that the correlations were not spurious and they added to the fact of market integration.

From the analysis of the conditional correlation we may see that although they are dynamic, they exhibit patterns of long-term memory or long clusters of dynamic volatility. Also, the plots show how the asset returns respond dynamically to external factors.

The evolution of the correlations between BUX, PX, and WIG shows that their capital markets had a significant correlation even before joining the EU, with an average of 0.5 and after May 2004, the correlation increased up to an average correlation of 0.6, the highest correlation being registered between WIG and BUX (see Figure 1). The level of correlation between these three CEE countries increases up to an average level of 0.7 before the crisis, with a temporary decrease in correlation between 2009 and 2011, and reverting back to higher correlation around 0.75 after May 2011. Also, we noticed that before joining the EU, the correlation with the EAFE was insignificant, and shortly after that the correlation became significant (see Figure 3).

In what regards the Romanian capital market, the conditional correlation with the Czech Republic, Hungary and Poland has become significant only after joining the EU. The correlation of BET with EAFE has become significant only with the onset of the global financial crisis.

As a general pattern of the CEE capital markets, we could see a consistent trend of increasing correlation in the period preceding the crisis, followed by a sharp decrease during the crisis and a reversion to a slightly higher correlation after the crisis.

We noticed that the Austrian index (ATX) is highly correlated with BUX and PX, while the correlation with the Warsaw Exchange is more reduced and the Bucharest Stock Exchange shows a low correlation, around 0.4, barely significant, with ATX in the pre-accession period, after which the correlation is around 0.5.

Although the oil price was correlated with the EAFE index, the correlation had a jump after the outbreak of the crisis in 2008 and it increased significantly after the crisis has ended, as seen in Figure 4. The BET index correlation with OIL surged during the financial crisis and subsided afterwards. The pattern is similar to the other regional stock exchanges.

Similarly to oil price, the euro-dollar exchange rate had a jump in correlation during the financial crisis with all the regional Stock Exchanges, but during the economic recovery period after the crisis the correlation become insignificant and remained so until May 2011,when it started to correlate again, a behavior that might be explained by the escalation of the sovereign debt crisis. The BET index is inversely correlated with EUR/RON exchange rate.

5. Conclusions

The paper studies the evolution of the index returns of four Central Eastern European countries, before and after joining the European Union, as well as before the global financial crisis and after that. The analysis covers a 10 year period, between 2002 and 2012, and it was divided into six sub-periods for providing a better understanding of the shocks to the index returns.

The calendar for joining the European Union was different: May 2004 for the Czech Republic, Hungary and Poland and January 2007 for Romania. The four countries were selected in order to assess the co-movements of their stock index returns. In the first step, the analysis was performed with a Vector Autoregression model and the influence of the shocks was assessed with the decomposition of variance. The presence of heteroskedasticity in residuals suggested the use of multivariate GARCH to take into account the fat tails and volatility clustering in the data. In this respect, we used two multivariate GARCH models, a diagonal VECH and a diagonal BEKK, which were fitted with a multivariate Student t distribution of the errors.

The effect of shocks to the index returns was measured by performing variance decomposition and impulse response. The variance decomposition for the six sub-periods showed that the influence of the index returns' own shocks was considerably reduced during crisis, when the shocks of other variables was increased, such as exchange rate and neighboring stock exchange indices.

In the case of the Czech Republic, which was officially declared in recession after May 2011, we saw that the behavior of the stock returns was similar to the behavior during the financial crisis of 2008-2009, when the returns were very sensitive to exogenous factors. The shock transmitted by external factors during the crisis was the highest for the Bucharest Stock Exchange in comparison to the other three CEE countries, and it also had the sharpest recovery after the crisis.

The pattern identified for the CEE countries by the VAR models was also registered by the diagonal VECH and diagonal BEKK models, which showed a high increase during the financial crisis of 2008-2009 in the conditional correlations for all four indices, followed by a decrease in correlation after the crisis ended.

In the period after the crisis, the BEKK model showed evidence of the transmission of the shock waves of sovereign debt crisis over the whole region.

The results indicate that, although before joining the European Union there were no conditional correlations between the stock market indices of the Czech, Hungarian and Polish capital markets with the main Western European indices, after joining the European Union the conditional correlations had become significant.

The Romanian capital market correlation grew significantly with the other three CEE countries only with a few months before joining the EU, and stayed on an increasing trend afterwards. The BET index became correlated with the EAFE index only at the onset of the global financial crisis.

The volatility spillovers across the regional stock markets are circumscribed by the jumps in correlation of about or more than 0.9. The jumps corresponded to the uncertainties in the international capital markets and were correlated with the negative news that had hit simultaneously all the capital markets. The end of the crisis was marked by a reversion process to a specific dynamic for each CEE stock market.

The policy implications of our study highlights the fragility of the Romanian capital markets in the presence of adverse financial shocks, therefore requiring active measures for its strenghtening. The accession of Romania to the European Union increased the interconnection with the regional capital markets. The speculative inflows made the Romanian capital market more sensitive to the financial shocks and weakened its resilience. Compared with other CEE stockmarkets, the Romanian capital market had the most volatile dynamics during the 2008 financial crisis. The short-term investment flows may negatively impact its long-term development because volatility spillover may have destabilizing effects on the domestic investors.

Annex

Figure 1

Conditional Correlations between BUX, PX and WIG (Diagonal BEKK)

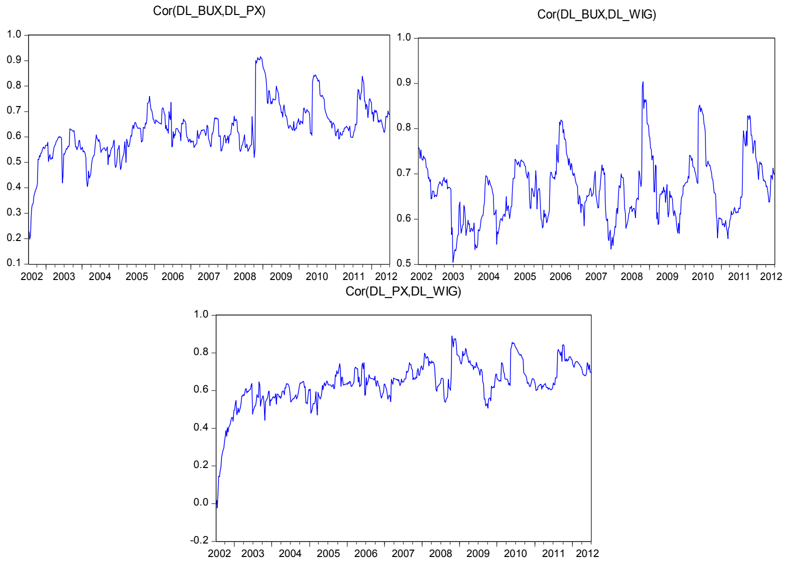


Figure 2

Conditional Correlations between BET and BUX, PX, WIG (Diagonal BEKK)

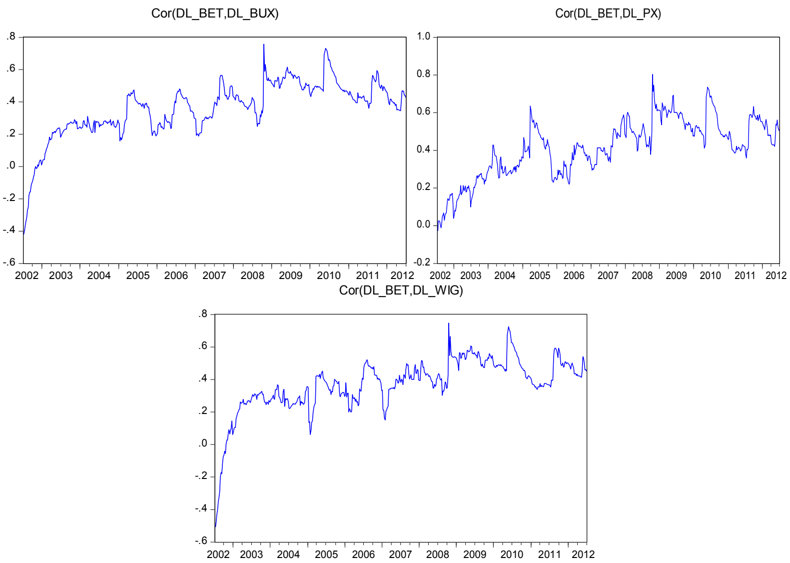


Figure 3

Conditional Correlations between EAFE and BET, BUX, PX, WIG (Diagonal BEKK)

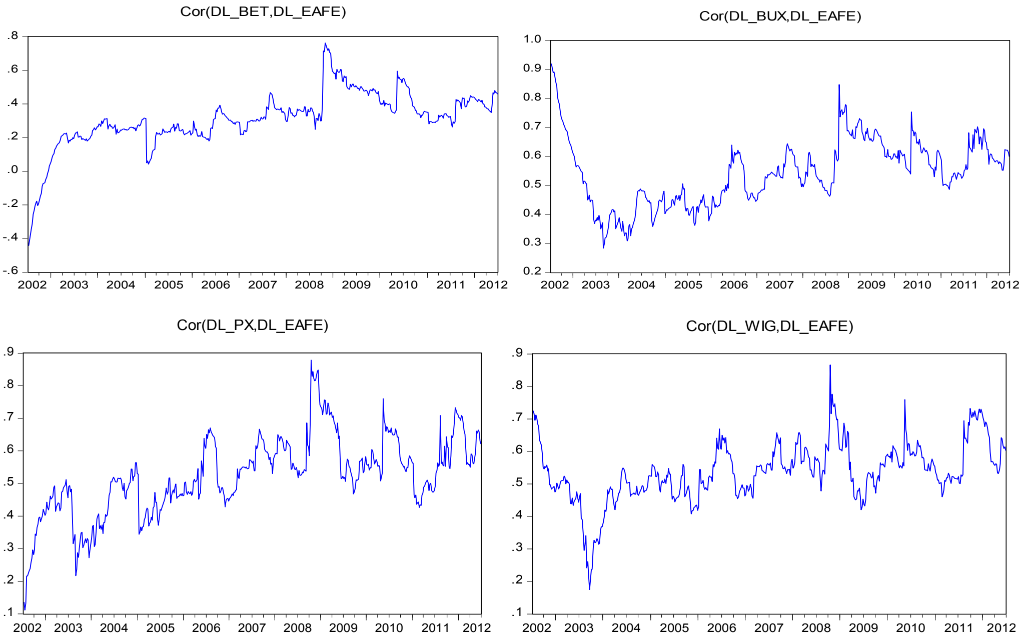


Figure 4

Conditional Correlations between EAFE, BET and OIL (Diagonal BEKK)

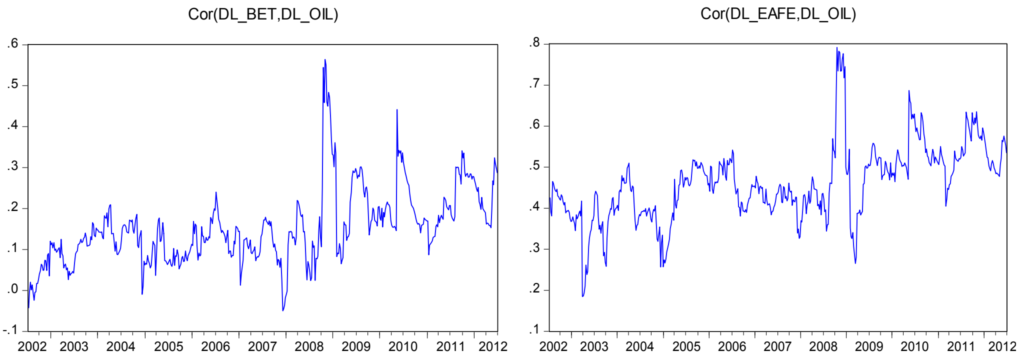
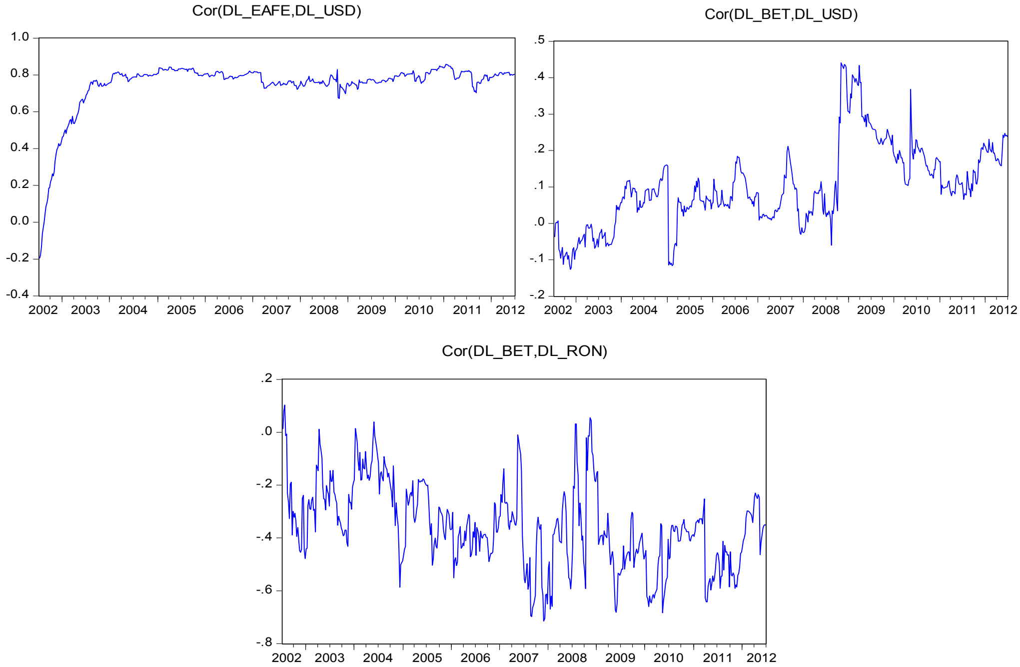


Figure 5

Conditional Correlations between EAFE, BET and USD (Diagonal BEKK)



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