LINKAGES BETWEEN THE STOCK MARKETS OF EASTERN EUROPE

TRENCA Ioan,[1] PETRIA Nicolae[2], DEZSI Eva[3]

[1] *"Babes-Bolyai" University, Cluj-Napoca, Romania,*
[2] *"Lucian Blaga", University, Sibiu, Roamania,*
[3] *"Babes-Bolyai" University, Cluj-Napoca, Romania,*

Abstract

This paper studies the relationship patterns between six Eastern European stock market: Czech Republic, Greece, Republic of Croatia, Hungary, Poland and Romania from 1997 until 2012. We employed a Constant Conditional Correlation model, and our results suggests that these linkages are highly volatile around the 97' and 07' crises. So in financial distress the markets become highly dependent, but overall they show signs only of mild interdependence. These results suggests that on the Eastern European markets contagion transmission is present, but also that these markets are not yet integrated.

Keywords: *CCC model, Market Linkages, Time varying correlations, Contagion.*

JEL classification: *G01, G15*

1. Introduction

In the last two decades a number of financial and monetary crises have ensued and propagated through capital markets, with regional and global consequences. In year 2007, again, with the most recent crisis, came to light the eternal question. What are the real linkage patterns reflecting between the

[1] *Professor, Ph.D., Faculty of Economics and Business Administration/Department of Finance, nic_petria@yahoo.co.uk*
[2] *Associate professor,Faculty of Economic Sciences, itrenca2011@yahoo.com*
[3] *Ph.D. student, Faculty of Economics and Business Administration/Department of Finance, dezsi_eva@yahoo.com*

markets, high degree of interdependence, independence with contagion or a mix between the two?

In the financial literature different sets of beliefs can be identified, in the first category there are those who believe that markets become more integrated, and so financial distress becomes a part of the equilibrium, as in Forbes and Rigobon (2002). In this case, before and after a shock, as the crisis in 2007, the linkages should not show significant variations, there is only interdependence, no contagion. According to this approach, Forbes and Rigobon (2002) define market integration in opposition to contagion. So, if two markets share a high degree of correlation during periods of stability, and after the shock the co-movement between them shows no significant increases, even if they are highly correlated one to another, this phenomenon can't be regarded as contagion, rather than interdependence.

The second view considers that markets become slowly integrated, but can never reach full integration, so in the case of a shock they show the signs of contagion from one market to another, as in Corsetti, Pericoli and Sbracia (2001). According to this view, if a shocks occurs, some comovements between markets are the implications of interdependence between them. This shock can be caused by global and regional factors, such as housing bubble, imprudent mortage lending, global financial imbalances, securitization, lack of transparency and shadow banking system, complex financial instruments with questionable risk management models or excessive leverage. So the rise of volatility of asset prices in one market can be expected to be correlated to the rise of volatility in other markets, due to the international transmission mechanism. But if contagion occurs, the degree of transmission is very high, above what can be predicted when the mechanism of international transmission is constant, and is it propagated by irrational investor behaviour and panic.

Regarding contagion, numerous definitions and opinions are expressed in the literature. Contagion is defined by Masson (1998) as a *'monsoonal effect'*, where he considers that major economic shifts in industrial countries can initiate crises in emerging countries, while '*spillovers*' are considered to be a consequence of the interdependence among countries. In his view, pure contagion is associated with changes in investors' expectations, that are not related to a country's macroeconomic fundamentals.

But Karolyi and Stulz (1996) don't agree with this view, they consider that market contagion can be defined indifferent if it is transmitted through macroeconomic fundamentals or not. Also Pritsker (2000) considers also the broader definition of contagion, namely the spread of a crisis from one state to another, with and without dependencies between markets.

According to the World Bank, three definitions can be identified, namely:

- *Broad definition*: when contagion is defined as the general mechanism of transmission of shocks, but without making a difference between positive and negative shocks.
- *Restrictive definition*: this definition relays on the fundamental linkages between markets, and contagion is regarded to be everything that exceeds the excepted shocks prompted by the underlying fundamental linkages.
- *Very restrictive definition*: this definition considers that during tranquil periods the correlation structure between markets increases, while during crisis periods contagion is responsible for the increase of these.

Bekaert, Harvey and Ng (2005) consider that contagion can be described as an excess of correlation between markets, more than it can be explained by economic fundamentals.

Bekaert and Harvey (1995) state that stock markets are completely integrated if assets with a specific risk have the same expected rate of return, regardless of the market on which they are traded.

Serwa and Bohl (2005) investigate contagion between the European markets between 1997 and 2002. Their findings suggest significant increases in the cross-market interdependences, with the Central and Eastern European stock markets being similarly exposed to contagion, as they Western counterparts.

Egert and Kocenda (2005) study the interrelation during 2003 and 2005 between Western together with the Central and Eastern European. They find no integration, only short term transmission from one market to another.

The study of Bekaert et al. (2011) focuses on 55 countries, within 2007 and 2009. They consider the transmission effects in crises from the global financial sector and the US market to individual markets are very small. Instead, between domestic equity markets to individual domestic portfolios the effects of contagion are more perceptible. Also they confirm that investors are focused more on country-specific characteristics, so similar markets tend to behave similarly, while the global spread of crises is rejected.

Beirne and Gieck (2012) investigate in 60 countries the contagion effect within three asset classes: bonds, stock and currencies, between 1998 until 2011. Their finding suggests that the emerging equity markets are integrated at a higher level compared to the other asset classes. They also find a significant transmission channel from the US markets to the Central and Eastern European Markets.

Cocozza and Piselli (2011) investigate the linkages between the East and West European financial markets. The main result indicates that contagion is present in the system, with significant effects from emerging to advanced markets.

We defined interdependence as the long term average connection between the markets for the studied period .We assume that contagion between markets can be defined as extreme co-movement between markets, above the normal level of interdependencies in tranquil times, similar with the definition of Corsetti, Pericoli and Sbracia (2001) and Prisker (2000), while market integration is a form of extreme interdependence.

As one can observe, most of the studies focus on Eastern European markets together with transmission effects from or to another groups of markets. Also studies include different asset classes, without focusing only on the Eastern European stock markets. This is why in our study we choose these particular markets, for a period of 15 years, and with two different shocks.

The remainder of this paper proceeds as follows. In Section 2 we define CCC model shaped to our objectives. In Section 3 we apply the model to the selected data, while Section 4 concludes the paper.

2. Methodology

With the apparition of the ARCH model of Engle (1982), the GARCH model of Bollerslev (1986) and Taylor (1986), in the economic literature there was an outburst of models that were conceived for modelling the variance equation.

These models were specifically designed to capture the irregularities appearing in the evolution of stock markets, such as the phenomenon of volatility clustering, leptokurtosis and leverage effect.These models, as underlined by Bauwens, Laurent and Roumbouts (2006), are not fully efficient to capture and incorporate the transfers of shocks between markets. This is because a shock can be transported directly thought variance, or indirectly, thought the covariance structure. The before mentioned models, together with the ones directly derived from them are constructed to seize the direct effect, but if the shocks are transported by both of the channels, these become insufficient.

It was only a step toward the apparition of the MGARCH (Multivariate General AutoRegressive Conditional Heteroskedasticity) models. See Bauwens, Luc and Roumbouts (2006), together with Silvennoinen and Terasvirta (2008), for a classification of the MGARCH models. In our study we choose to implement the CCC model of Bollerslev (1990) from the MGARCH model class. Our intuition is based on the covariace equation from the CCC model, which is time varying, but with a constant correlation structure between the markets that constitute the system. This is necessary because we want a picture of an 'average' degree of dependencies, together with a varying system. We consider a vector y_t that consists of N markets, and it is defined according equation (1), in a VAR model, where A_k is a (kxk) coefficient matrix and M a kx1 the mean vector. We define ε_t as the normalized error vector such as in equation (4), that the covariance matrix is defined according to the CCC model as in equation (5). The time varying component of H_t is given by variance equation D_t, specified in (6)-(8). We presume that D_t follows the dynamics described in (6), namely a GJR-GARCH model proposed by Nelson (1991). while the correlation matrix, R is constant over time. In the case of the CCC, the correlation matrix R needs to be positive and definite, but not the full variance and covariane matrix, H_t .

$$y_t = \mathrm{M} + \sum_{i-1}^{k} A_k \cdot y_{t-i} + e_t \tag{1}$$

$$e_t = \left[e_{CZ,t} \quad e_{GR,t} \quad e_{HR,t} \quad e_{HU,t} \quad e_{PL,t} \quad e_{RO,t} \right]^T \tag{2}$$

$$e_t \mid I_{t-1} \sim \mathrm{N}\left(0, \mathrm{H}_t\right) \tag{3}$$

$$\varepsilon_t = e_t \cdot D_t^{-1} = \left(y_t - \mathrm{M} + \sum_{i-1}^{k} A_k \cdot y_{t-i} \right) \cdot D_t^{-1} \tag{4}$$

$$\mathrm{H}_t = D_t \cdot R \cdot D_t \tag{5}$$

$$\sigma_{i,t}^2 = \varpi_i + \alpha_i \cdot \varepsilon_{i,t-1}^2 + \gamma \cdot \varepsilon_{i,t-1}^2 \cdot I\left(\varepsilon_{i,t-1} < 0\right) + \beta_i \cdot \sigma_{i,t-1}^2 \tag{6}$$

with $i = \overline{1,n}$.

$$\sigma_{ij,t} = \rho_{ij} \cdot \sigma_{i,t} \cdot \sigma_{j,t} \quad \forall i, j = \overline{1,n}, \quad i \neq j. \tag{7}$$

$$D_t = diagonal(\sigma_{1,t}, \sigma_{2,t}, \ldots, \sigma_{n,t}) \quad (8)$$

$$H_t = \begin{bmatrix} \sigma_{1,t}^2 & \sigma_{12,t} & \cdots & \sigma_{1n,t} \\ \sigma_{21,t} & \sigma_{2,t}^2 & \cdots & \sigma_{2n,t} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{n1,t} & \sigma_{n2,t} & \cdots & \sigma_{n,t}^2 \end{bmatrix} = D_t \cdot \begin{bmatrix} 1 & \rho_{1,2} & \cdots & \rho_{1,n} \\ \rho_{2,1} & 1 & \cdots & \vdots \\ \vdots & \vdots & \ddots & \rho_{1,n-1} \\ \rho_{n,1} & \cdots & \rho_{n-1,1} & 1 \end{bmatrix} \cdot D_t \quad (9)$$

3. The Data and Results

This section describes the data used for the analysis, it provides descriptive statistics and the final results of our model. We collected daily closing returns for six stock market indexes from Datastream database. The sample includes the period between the 19th of September 1997 to the 1st of March 2012, with a total sample size of 3370 observations. The data covers 15 years, and allows to capture also the Asia crisis from 1997, as the recent financial crisis which began in 2007. The fact that we included in our sample two shocks allows us to observe the behaviour of the correlation structure in several different phases, while it increases the robustness of the estimates. Daily closing prices for six stock market indexes were used, namely PX from *Czech Republic (used from now on as CZ), ATHEX from Greece (used as GR), CROBEX from the Republic of Croatia (used as HR), BUX from Hungary (used as HU), WIG from Poland (used as PL), and BET from Romania (used as RO). We only retained these countries from EE (Eastern Europe), because we wanted an extensive sample size, while the other indexes from the EE region didn't qualify*.

Summary statistics of the returns of the market indices can be found for the returns can be found in Table 1.

Table 1: Summary Statistics of the Stock Market Indices

	CZ	GR	HR	HU	PL	RO
Mean	0.0002	-0.0002	0.0001	0.0002	0.0002	0.0004
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.1236	0.1343	0.1747	0.1362	0.0789	0.1154
Minimum	-0.1619	-0.1021	-0.1338	-0.1803	-0.1029	-0.1312
Std. Dev.	0.0150	0.0181	0.0170	0.0187	0.0149	0.0183
Skewness	-0.4464	-0.0116	0.0549	-0.5794	-0.3547	-0.2652

Kurtosis	13.8647	6.8834	16.9627	13.1819	6.7725	9.5071
JB	18662.47	2368.40	30618.03	16491.60	2314.04	6693.71
Note:	The Jarque-Bera (JB) test is a goodness-of-fit statistical test of whether the sample data has the skewness and kurtosis of a normal distribution.					

Source: (Own processing)

According to the statistical properties of the returns, most of the indices depart from normality, with mostly negative skewness and excess kurtosis. We can observe that the time series exhibit fat tail phenomenon. In Table 2. the coefficients of the unconditional correlations can be found.

Table 2: Unconditional correlations of returns

	CZ	**GR**	**HR**	**HU**	**PL**	**RO**
CZ	1					
GR	0.4416 (30.2044) [0.0000]	1				
HR	0.3409 (22.2550) [0.0000]	0.2468 (15.6284) [0.0000]	1			
HU	0.5214 (37.5069) [0.0000]	0.3577 (23.5130) [0.0000]	0.3112 (20.0985) [0.0000]	1		
PL	0.5303 (38.3870) [0.0000]	0.4055 (27.2287) [0.0000]	0.3147 (20.3508) [0.0000]	0.5530 (40.7362) [0.0000]	1	
RO	0.3371 (21.9788) [0.0000]	0.2349 (14.8298) [0.0000]	0.2217 (13.9568) [0.0000]	0.2441 (15.4464) [0.0000]	0.2443 (15.4610) [0.0000]	1
Note	Where ( ) signifies T-Statistics and [ ] the corresponding P value.					

Source: (Own processing).

These show a medium degree of dependence between the EE markets, with coefficients between the interval [0.222; 0.553]. The highest dependencies can be found within HU, CZ and PL, with correlation coefficients above 0.5. These dependencies can also be introduced by the fact that all three are part of the Visegrád Group, with more similar economies that the other studied markets. Romania in overall shows a week dependence with the markets, being a young markets, it is not yet fully integrated with the EE market group.

The first step in applying the CCC model was the filtration of the mean equation of the returns, by applying a VAR with 4 lags as in equation (1). The significant estimates lags can be found in Table 4. In the second step the variance equation was modelled with the GJR-GARCH model, according to equation (6). The parameter β represents the volatility persistence, while parameter α measures the response of the volatility to market shocks. The asymmetry coefficient expresses the effects of bad news on the evolution of the volatility ($\varepsilon_t < 0$). So good news impact volatility with α, while the bad news with $\alpha + \gamma$. As observed, the coefficient $\gamma \neq 0$ in every market, so the volatility has distinctive reactions to good and bad news. Also the asymmetry coefficient $\gamma < 0$, whish shows that the volatility rises more in times of financial distress, as in tranquil times. Together with the volatility parameters we estimated the elements of the correlation matrix. The results are reported din Table 5., while Figure 1. represents the distinctive estimates for the correlation coefficients. From the parameters we can observe that the volatility tends to respond to shocks from moderated to fast. The highest α, is in Romania, almost double to the ones in *Croatia* and *Poland*, but similar to *Hungary*.

Table 3: VAR model estimates

	μ	**CZ**	**GR**	**HR**	**HU**	**PL**	**RO**	R^2
CZ		2	2	4	1/4	1	-	0.0333
GR		-	1	-	1	-	-	0.0199
HR		2	-	3	1/2	2/3	-	0.0236
HU		-	-	1	2/3/4	-	-	0.0201
PL		2	-	1	1/4	-	2	0.0219
RO		3	-	-	-	1	1 /3	0.0429
Note	Statistical significance is denoted by the presence of a lag at 5%.							

Source: (Own processing).

Table 4: GJR-GARCH model estimates

	CZ	GR	HR	HU	PL	RO
ϖ	6.6248E-06*	2.6538E-06*	2.4284E-06***	1.1309E-05	2.5050E-06*	1.5102E-05**
α	0.1565*	0.1405*	0.0968*	0.1821***	0.1023*	0.2487*
γ	-0.0888**	-0.0762**	-0.0247	-0.1198	-0.0614**	-0.0869*
β	0.8548*	0.8966*	0.9138*	0.8464*	0.9180*	0.7616**
Note	Denotes significance at *** - 10%, ** - 5% * -1% level.					

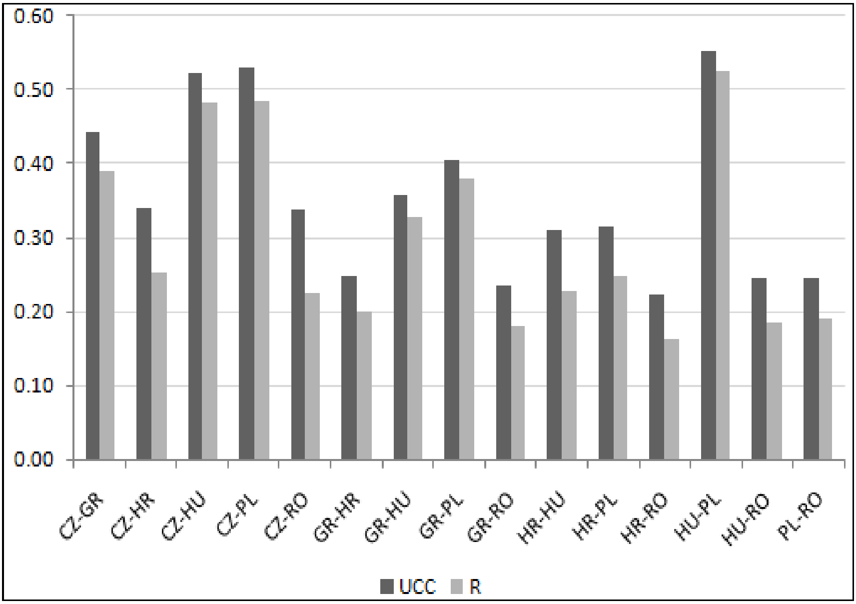
Source: (Own processing).

Table 5: Unconditional Correlations of the CCC model: R matrix

	CZ	GR	HR	HU	PL	RO
CZ	1					
GR	0.3894 (0.0251) [15.4946]	1				
HR	0.2519 (0.0256) [9.8492]	0.1995 (0.0248) [8.0359]	1			
HU	0.4815 (0.0251) [19.2128]	0.3280 (0.0241) [13.5869]	0.2274 (0.0259) [8.7726]	1		
PL	0.4838 (0.0260) [18.6087]	0.3794 (0.0240) [15.8311]	0.2474 (0.0227) [10.9090]	0.5256 (0.0270) [194336]	1	
RO	0.2249 (0.0268) [8.4064]	0.1805 (0.0226) [7.9920]	0.1621 (0.0243) [6.6737]	0.1849 (0.0274) [6.7446]	0.1899 (0.0325) [5.8453]	1
Note	Where ( ) signifies T-Statistics and [ ] the corresponding P value.					

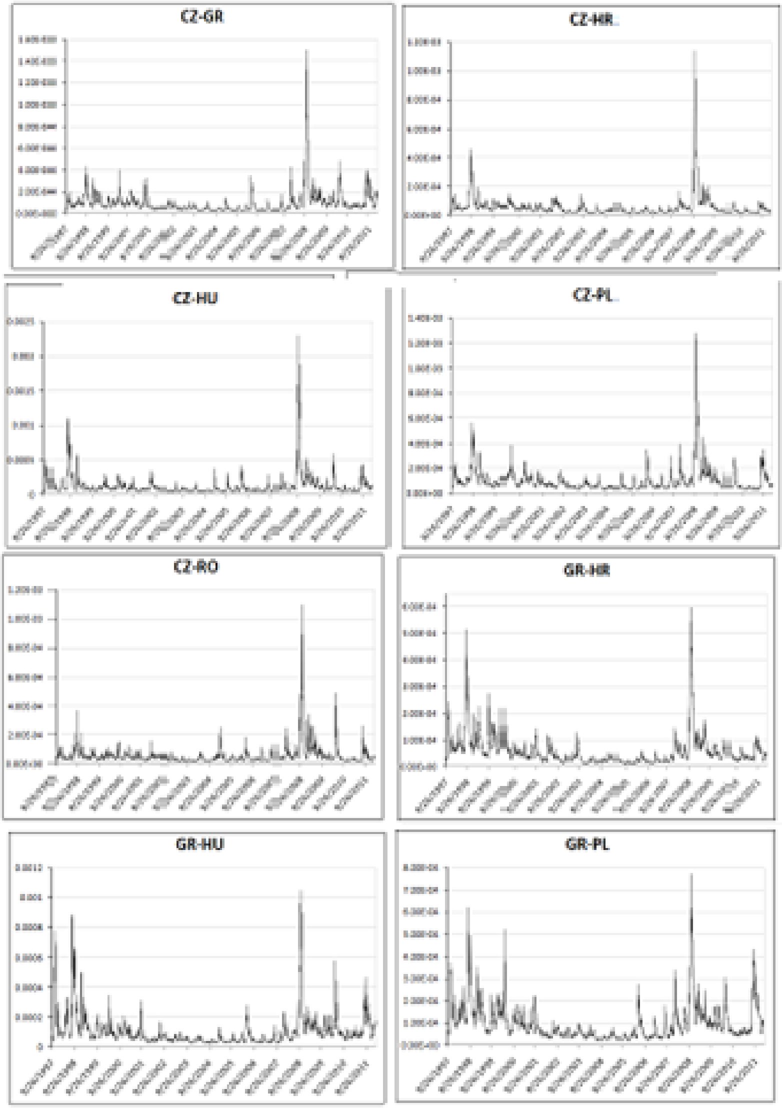
Source: (Own processing).

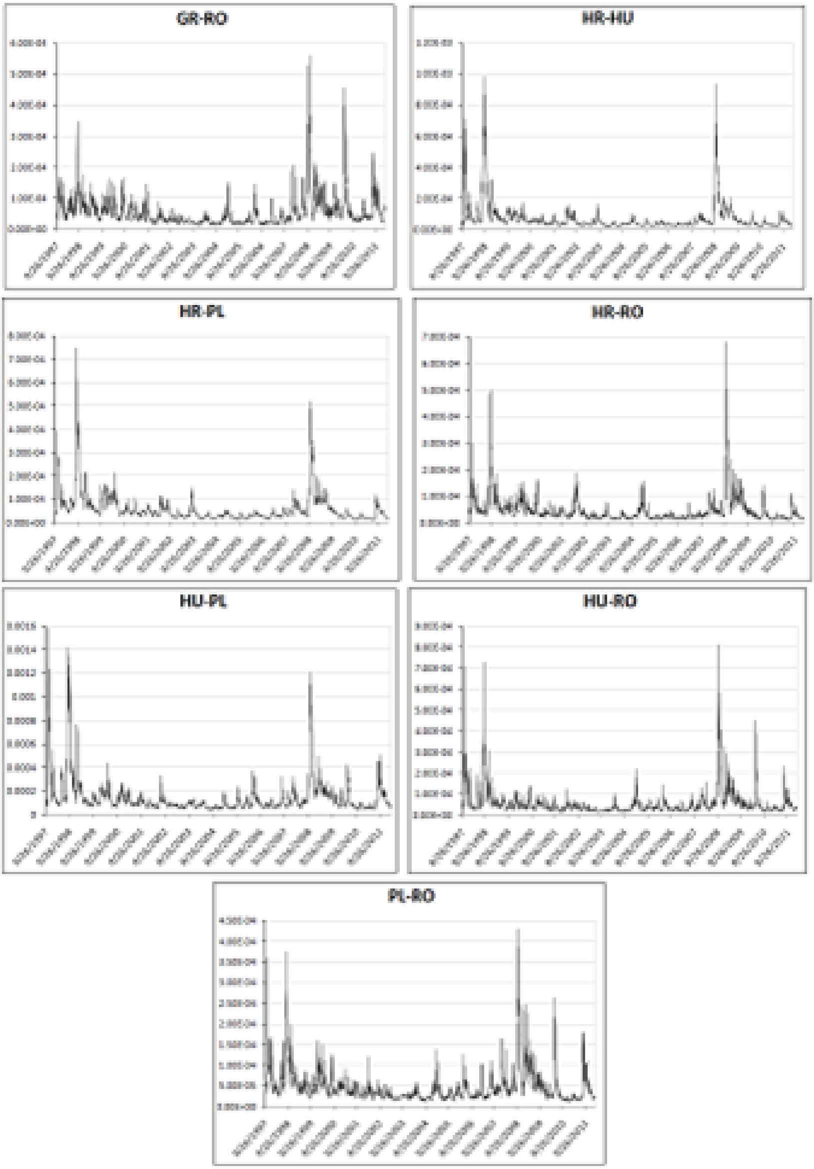
Figure 1: Estimates of the Unconditional Correlation Coefficients (UCC) and Correlation Coefficients from CCC (R)



Comparing the results of the correlation coefficients from the CCC model (Table 5.), with the UCC - unconditional correlation coefficients (Table 2.), the most important difference that stands out is that the coefficients obtained from the model are significantly lover than the original estimates from the UCC. The parameters are over estimated in the UCC from 5% to 50%. But even with the differences, the values still express mild interdependence between the EE markets. The final step of our methodology consist of calculation the elements of H_t . For each series we obtained 3764 covariance estimates, reported in Figure 2. These represent the joint evolution of market pairs from the Eastern European countries. The most important conclusion is that in all the markets heavy reactions are noticeable during the shocks included in the sample. During the crisis from 1997 and 2007, all the interdependencies between the markets rose to elevated levels. In the covariance series we can observe the presence of the two shocks, with a moderate rise in 1999, together with a severe one in 2007. These show that not all the markets from the EE were affected identical by the Asian crisis, while the interdependencies to the financial crisis are corresponding.

Figure 2: Time-varying Covariance series - H_t




GR-RO
HR-HU
HR-PL
HR-RO
HU-PL
HU-RO
PL-RO

Source: (Own processing).

2. Conclusions

We investigated the interdependencies in a homogenous group of markers, from the point of view of economic development, but also which are located in the same region, namely Eastern Europe. We choose only these markets because we wanted to capture the linkages only between them, as their reactions to shocks. We defined market interdependence as the long term average correlation between the markets for the studied period. Contagion was defined as extreme co-movement, above the normal level of interdependence, while market integration was considered a form of extreme interdependence.

Our study main results indicate that the Eastern European markets are not yet integrated, mildly interdependent, with contagion transmission from one market to another.

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