Professor Aleksandar NAUMOSKI, PhD
E-mail: aleksandar@eccf.ukim.edu.mk
Professor Sasho ARSOV, PhD
E-mail: sarsov@eccf.ukim.edu.mk
Ss. Cyril and Methodius Universityin Skopje, Faculty of Economics
Professor Stevan GABER, PhD
E-mail: stevan.gaber@ugd.edu.mk
Goce Delcev University, Faculty of Economics
Vasilka GABER-NAUMOSKA, PhD
Public Revenue Office
E-mail: vasilka.gaber-naumoska@ujp.gov.mk

DIMINISHING INTER-LINKAGES OF THE SOUTH EAST EUROPEAN STOCK MARKETS

Abstract. *This paper investigates the level of relationship of the SEE stock markets in three analyzed periods: the pre-crisis, mid-crisis, and post-crisis period. We found that the relationships of the SEE markets with the benchmark developed markets, and among them, are not stable in the long-run. Using the VAR model, Granger cause causality, impulse response and variance decomposition, we came to the conclusion that while in the crisis period the SEE stock markets shows high interrelations among them and with the developed markets, the inter-linkages diminished after the crisis period. In the pre- and post-crisis period SEE markets have on average zero correlations, modest lead-lag interactions, small responses to other market shocks, and most of the variance is explained by their own shock. The opposite is true for the crisis period, when SEE markets have a significant adjusted effect, and each market responds to the impulses coming from most of the other markets. This suggests that in the period of instability and uncertainty SEE markets follow a common path, and in the calm periods with optimism and positive expectations the lead-lag relations of the SEE markets with the developed stock markets diminish.*

Keywords: *South East Europe, stock market integration, Granger cause causality, impulse response, variance decomposition.*

JEL classification: G01, C32, G15

1. Introduction

The stock markets of SEE countries are very volatile, which in certain periods show significant co-movements with the developed markets, but at other times there are large differences between them. Moreover, although research on inter-linkages among the SEE markets and the developed ones are scarce, they are an inexhaustible topic.

South East European countries established their organized capital markets in the years of the first half of the 1990s, after the fall of their communist regimes and the establishment of market economy, but they remained underdeveloped and uninteresting both for domestic and international investors in the following ten years. The real rise of the stock markets in these economies took place in the years before the global financial crisis of 2007/2008. Then, they realized a huge interest from international investors, who were looking for international diversification, which additionally attracted and opened prospects for earnings of the domestic investors. If beforehand the stock markets of SEE economies were not attractive enough for foreign investors because of the existence of barriers to foreign investors and they were being perceived as a major political risk, at the beginning of 2000s things have changed outright. SEE countries undertook major economic reforms and thus they have reduced political risk to a minimum and have fully opened to foreign investors, giving them special significance as well. Consequently, these countries experienced a large influx of foreign direct investments and portfolio investments, leading them to experience strong economic growth, and most of them thus liberalizing their financial markets. Moreover, they have entered into a maelstrom of the globalization of the world economy and the establishment of intensive relations in their national markets with other developed and less developed countries. Internalization of their economies has become more intense as a result of increased trade links, especially with the developed European countries after the EU enlargement with some SEE countries, leading to greater cooperation between the governments of this countries and the removal of barriers to achieve free flow of gods and services, as well as, financial, physical and to some extent, human capital. In that context, as a result of reduced capital barriers and increased liberalization of capital inflows, there has been a shift in the majority of this countries to the regime of flexible exchange rates, particularly because of the strong progress of the communication systems and information technology, reduced transaction cost, the entrance and even the dominance of European banking brands on their markets, with all of these factors leading to significant integration of the stock markets of SEE countries with the other SEE and especially with the developing countries.

In this paper at the focus is on how stock markets of South East Europe are inter-linked among themselves and with the developed stock markets. Is there a long term and stable relationship between these markets? Is there a stable inter-linkage among the SEE markets, as in the case of the developed markets? Is there stable long-run causality among the SEE markets as emerging markets? What is the response of the SEE emerging markets to the foreign shocks, and will they lead or follow the developed markets? This and other questions will be answered in the following analysis.

Therefore, in our analysis six SEE markets (Romania, Bulgaria, Croatia, Serbia, Slovenia, and Macedonia) were considered, all of them differing according

to their size. Their integration with global equity markets will be examined, especially those of the United States and Germany, in three different periods (before, during and after the crisis) in order to analyze the stability and long-term inter-linkages of these emerging markets with the developed markets.

2. Literature review

The level of financial integration for twenty five emerging stock markets, including SEE markets here, was examined by using a multivariate GARCH(1,1)-M return generating model for the period 1995-2005 (Chambet and Gibson, 2008). Interestingly, they found that these countries to a large extent are segmented and that the process of financial integration has been slowed down by the various financial crises that have struck these countries during the 1990s. In this paper, we also show that the level of integration of the SEE emerging stock markets is largely influenced by the great financial crisis. Another study provides analysis of the effect of the recent great financial crisis of 2007-2008 on global equity markets and their major components (Bartram and Bodnar, 2009), that we also try to analyze in this paper. They found that due to larger rises in 2007 the emerging markets drop more in 2008 than developed markets but in large part end up at the same level as the other markets. The global nature of the crisis is also apparent from the high correlations between markets and investment styles that further increased during the crisis. Here, in this paper we show that the results of the examination of the inter-linkages of the SEE stock markets with other markets according to other authors mainly defer according to the period of investigation that they have taken in the analysis. In general, those which covered the period before the great financial crisis of 2007/2008 show the existence of a great correlation and long-run relationship between the SEE and the developed stock markets (ex. Syriopoulos 2007). The studies which covered the period after the great financial crisis and the European debt crisis show the opposite (e.g. Guidi and Ugur, 2013). The second one shows that the correlation of SEE stock markets is nearly zero, and there is no long-run relationship between the SEE and the developed stock markets. Our paper fits in the later.

The international transmission mechanism of stock market movements was examined using VAR methodology (Eun and Shim, 1989). In the period when they performed their analysis the SEE stock markets does not existed. Even than they found that innovations in the U.S. are rapidly transmitted to other markets in a clearly recognizable fashion, whereas no single foreign market can significantly explain the U.S. market movements. Actually, the emerging EU markets are strongly determined by mature stock markets (US is a represent od developed market) (Hanousek and Kocenda, 2011). In our paper, we provide similar results for the US – SEE stock market relationships.

Investigating the relationships between selected emerging European stock markets and Germany and the US as developed stock markets over the period of 1997-2003, a long-run relationship was discovered between these emerging markets and the developed stock markets (Syriopoulos, 2007). Interestingly, he documented that in the short-term period the US stock market has a stronger

impact on the emerging markets than the German market exerts on the European emerging stock markets. In a later study, exploring the time-varying co-movements, volatility implications and dynamic correlations of selected SEE countries and leading mature equity markets (the US and Germany) during the period of 1998-2007, discovered that SEE markets exhibit time-varying correlations as a peer group, although correlations with the mature markets remain relatively modest (Syriopoulos and Roumpis 2009).

The comovements among three stock markets in Central and Eastern Europe were analyzed using the intraday data and VAR methodology (Egert and Kocenda, 2007). They found signs of short-term spillover effects both in terms of stock returns and stock price volatility. Granger causality tests show the presence of bidirectional causality for returns as well as volatility series. The results based on a VAR framework indicate a more limited number of short-term relationships among the stock markets.

Using the Engle and Granger co-integration methodology Fonseca (Fonseca, 2008) examined the integration of the national stock markets of sixteen European countries using two indices: a European index and a World index. The founding is that both European and non-European international factors are necessary to explain the international integration of the national stock markets under analysis.

Another study investigated the integration among several SEE stock markets with the three developed European stock markets and the US (Samitas et al., 2011). They found a long-run co-integrated relationship which limits the portfolio diversification benefits in the region. Using both the Johansen co-integration test and Gregory-Hansen they found evidence of equity market integration among emerging SEE and developed equity markets. Also, (Kenourgios and Samitas, 2011) using the data for the period 2000-2009 and applying the Asymmetric Generalized Dynamic Conditional Correlation (AG-DCC) multivariate GARCH model (Cappiello et al., 2006) made a study in order to capture the impact of the 2007–2009 financial crisis on the time-varying correlation dynamics among the developed (US, UK, Germany, Greece) and the Balkan stock markets. Their results show that Balkan stock market dependence is heightened, supporting the herding behavior during the 2008 stock market crash period. Also, by applying the conventional, regime-switching cointegration tests and Monte Carlo simulation they provide evidence in favor of a long-run cointegrating relationship between the Balkan emerging markets within the region and globally.

Central and Eastern Europe (CEE) stock markets are small and illiquid, and these characteristics can hinder efficient capital raising and valuation (Korczak and Bohl, 2005). Another study of the regional integration of stock markets in South East Europe, show that the degree of market integration admits frequent

changes over the analyzed period (1996-2007), but in this study, it is not covered the crisis period (Guesmi and Nguyen, 2014).

In another paper, it is examined the relationships between Russian and other equity markets over the period of 1995-2004 (Lucey and Vavronkova, (2008). They pointed out that the Russian equity market remained isolated from the influence of 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.

The long-term linkages between seven Central and Eastern European (CEE) emerging stock markets and two developed stock markets (German and the US markets), was examined using recursive cointegration analysis (Syllignakis and Kouretas, 2010). They concluded that examined stock markets are partially integrated, while there is also evidence that the emerging stock markets of Central and Eastern Europe except for Estonia together with the German and the US stock markets, have a significant common permanent component, which drives this system of stock exchanges in the long run. Besides that, they also argue that the global financial crisis of 2007–2009 caused a slowdown in the convergence process.

Using tests that allow for endogenously determined breaks in cointegrating relationships and rolling cointegration analysis it was provided assessment of the dynamic process of convergence among four major European stock markets in the first euro-decade (Mylonidis and Kollias, 2010). In this study, they show that although some convergence has been taking place over time, it is very much an ongoing process. Also, they found evidence that the German and French markets appear to be the ones with a higher degree of convergence while the dominant position of Germany within the Eurozone seems to be (re)affirmed.

The international stock market co-movements between Western Europe vs. Central and South East Europe was investigated separately, and comparing these two groups (Horvath and Petrovski, 2013). They concluded that the degree of co-movements is much higher for CE markets than with WE markets. The correlation of SEE stock markets with developed markets is practically zero. Additionally, they did not conclude that the crisis altered the degree of stock market integration between this group of countries. These findings are also confirmed in our paper.

Using a variety of co-integration methodologies, it was investigated whether the stock markets of South East Europe (SEE) have become more integrated with the regional and global stock markets during the 2000s (Guidi and Ugur, 2013). They show that SEE stock markets have no long-run relationship with their mature counterparts.

Using the multivariate GARCH-BEKK model (Popa et al., 2015) examined the returns and volatility dynamics to explain the shock spillovers between post-communist Eastern Europe stock markets and developed markets, and found that shocks are not persistent and disappear quickly, especially in the case of the small EE markets.

Generally, different studies are not consistent regarding the results of the relationship among South Eastern Europe stock markets and developed markets. The differences come from the time period analyzed, the sample of countries taken and the methodology used. Among them, the most important is the time period analyzed, since the analysis that include the period before the global financial crisis are contradictory with those covering the period after the crisis. The existence of mutual interactions among the SEE market is conformed in the short-run, but the stable relationship on a long-run is contradictory issue depending of the period taken in the analysis.

3. Data

In our analysis, we use the time series of the daily stock market indices in terms of local currencies. As an approximation for the events on national markets in the SEE region we have taken the data series of the major stock market indices of respective countries, BELEX15 for Serbia, CROBEX for Croatia, MBI10 for Macedonia, SBITOP Index for Slovenia, BET Index for Romania, and SOFIX for Bulgaria. Germany and the USA are representatives of a developed market. German Index DAX30 is chosen as a representative for the Euro area. Additionally, the USA S&P 500 is an approximation for the global stock market and a market from which the initial shocks came during the great financial crisis. We have covered a time period of 11 years, starting from January 2005 to November 2015, divided in three sub-periods. The first sub-period is the pre-crisis period from January 2005 to the end of June 2007; the second is the crisis period from July 2007 to September 2012; and the third is the post-crisis period from October 2012 to November 2015. The crisis period covers the two crises: the global financial crisis of 2007, and the European sovereign debt crisis, having taken place in the European Union since the end of 2009. By dividing the period in these three parts, we are able to investigate the changes in the mutual relationships of the markets before, during and after the crises, or better stated, in a stable and in a distressed period.

The stock market indices are transformed into continuously compounded daily rates of returnR_t^i, defined as:

$$R_t^i = ln\left(\frac{P_t^i}{P_{t-1}^i}\right) \quad (1)$$

where, P_t^i is a stock market index of market *i* at time *t*. Dividends are not included since they are relatively unimportant on a daily basis, and the changes of the prices on such short period are mainly affected by the arrival of information.

4. Methodology used in the analysis

In order to investigate the linkages and mutual relationships among the SEE emerging market and their relationship with the developed markets we employed the correlation analysis as a first insight, and then we go further with the VAR model and Granger causality testing.

4.1. Vector autoregressive model (VAR)

Vector autoregressive models (VAR) were popularized by the work of Sims (1980) as a natural generalization of the univariate autoregressive models. It is commonly used for investigating systems of interrelated time series and for analysis of dynamic impact of random shocks on the system of variables. Using VAR we can explore the dynamic interrelationship between the different market returns. Here, each market returns R_t^i are treated as endogenous variables in the system as a function of the lagged values of the own returns and of the lagged values of the other market returns. The simplest case that can be entertained is a bivariate VAR, where there two variables are the market returns of country 1 and 2 i.e. R_t^1 and R_t^2, each of whose current values depend on different combinations of the previous *j* values of both variables and error terms

$$R_t^1 = \alpha_1 + \sum_{j=1}^{k} \beta_{1j} R_{t-j}^1 + \sum_{j=1}^{k} \delta_{1j} R_{t-j}^2 + u_{1t} \quad (2)$$

$$R_t^2 = \alpha_2 + \sum_{j=1}^{k} \beta_{2j} R_{t-j}^1 + \sum_{j=1}^{k} \delta_{2j} R_{t-j}^2 + u_{2t} \quad (3)$$

WhereR_{t-j}= $(R^1, R^2)_{t-j}$, is the *j*th length variable of R_t, and it is assumed that each u_{1t} and u_{2t} are uncorrelated white noise error terms.

The VAR model of *n*-markets can be expressed as:

$$R_t = C + \sum_{j=1}^{k} A_j R_{t-j} + u_t \quad (4)$$

where $R_t$is a $n \times 1$ column vector of daily rates of return of the n stock markets, *C* and A_j are, respectively, $n \times 1$ and $n \times n$ matrices of coefficients, *k* is the lag length, and u_t is a $n \times 1$ column vector of error terms. The *xy*-th component of A_j measures the direct effect that a change in the return to the *y*-th market will have on the return of the *x*-th market in the *j* period.

Using the estimated VAR model we can explore the causality among the stationary variables with the help of Granger cause causality test (Granger, 1969). If a market return X_{t-1} is statistically significant independent variable in relation to market return Y_t than market return X_{t-1} affects causality on market return Y_t in Granger sense. We can implement this in the equation (4). Since the coefficients in equation (4) contain complicated cross-equation feedbacks and are difficult to describe intuitively, it is better to analyze the model's reaction to typical random shocks. By successive substitutions of the right-hand side of equation (4), we can obtain a moving average representation as follow:

$$R_t = C' + \sum_{j=1}^{m} B_j u_{t-j} \quad (5)$$

Where each B_s is an $n \times n$ matrix. The $B_{xy,s}$ are called the impulse response functions, which show the response of the *x*-th market in the *j* period after a unit

random shock in the *y*-th market, other things remaining constant. The decomposition of variance

$$\frac{\sum B_{xy,j}^2}{\alpha_{x,j}^2} \tag{6}$$

can reveal how much variance of market *x* is determined by the innovations of market *y* in the *j* period.

5. Empirical results

5.1. Dynamics of the stock market indices and returns in eight markets

The period before the great financial crisis is characterized with accelerating growth of all stock market indices, especially SEE markets. From Figure 1 it can be seen that the all markets recorded upward trend until the third quarter of 2007. For the emerging SEE markets this is historically high. After that, there is a downward trend in all cases which is present until the beginning of 2009. Until than the trends are common for all markets, those of SEE, as well as for developed markets. Starting from the beginning of 2009 different markets have specific trends, where the developed markets show upward movement and had reached the previous level that they have before the crisis and they even gone beyond that, but the most of SEE markets in this period continuously goes down. This is a first impression that the inter-linkages among the markets are lost after the crisis period.

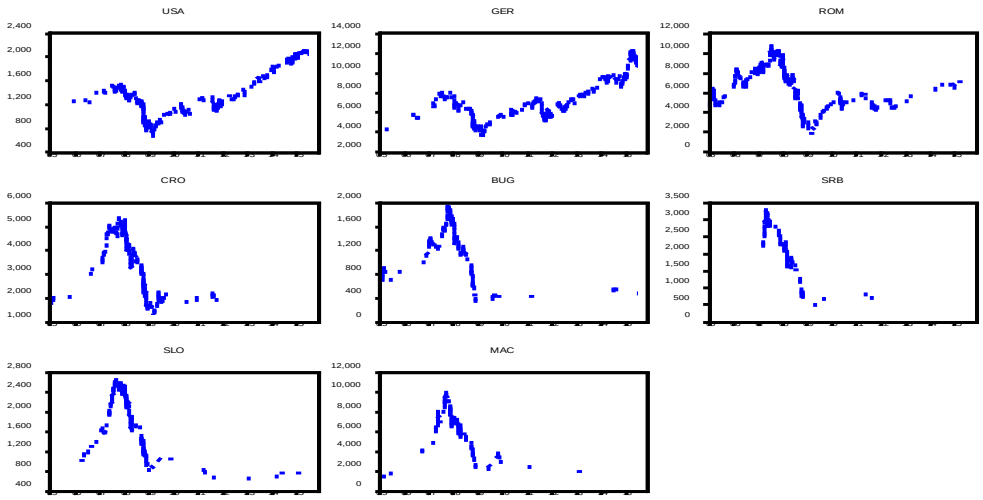


Figure 1. Dynamics of the stock market indices in eight markets

Considering the dynamics of the daily log returns, it is evident the great volatility in the crisis period that is common for all markets especially in the year 2008. Table 1 shows the descriptive statistics for all stock markets returns. The

means of all sample returns are quite small while the standard deviations are significantly high. The stock market returns are not normally distributed that is typical for stock markets returns.

5.2. Correlation analysis as a first test of the inter-linkages of the SEE markets

The first signal of the inter-linkages among the SEE markets between themselves and with the developed markets can be perceived by the correlation matrix of their daily returns. The results are presented in Table 2 for the three analyzed periods. A few main conclusions can be extracted. *Firstly*, there is a generally high correlation among the two developed markets – the USA and Germany - in the three analyzed periods; *Secondly*, all of the SEE markets have a low correlation with the developed markets in the pre- and post-crisis periods, on average 0.03 and 0.09 respectively; *Thirdly*, there is a low correlation between the SEE markets themselves in the pre- and post-crisis period, on average 0.06 and 0.08 respectively; and *Fourthly*, the pared value of all of the correlation coefficients sharply increases in the crisis period, where it amounts on average to 0.32 among the SEE markets themselves, and among the SEE markets and developed markets it amounts on average to 0.23. The results of the correlation analysis present an interesting common finding that the interrelationship among the SEE market themselves and among the SEE emerging markets with developed markets increased in the crisis period and decreased dramatically after the crisis.

Table 1. Descriptive statistics of the daily stock market returns for the whole analyzed period

	USA	GER	ROM	CRO	SRB	BUG	SLO	MAC
Mean	0.020%	0.034%	0.016%	0.002%	-0.018%	-0.013%	-0.016%	0.021%
St. Dev.	1.26%	1.39%	1.65%	1.24%	1.34%	1.24%	1.18%	1.36%
Kurtosis	11.21	6.34	9.41	17.80	14.80	10.41	7.01	10.20
Skewness	-0.33	0.01	-0.75	0.00	0.20	-0.88	-0.46	0.04
Jarque-Bera	14551	4642	10469	36580	23540	12879	5091	12005

Table 2. Correlation of the daily stock market returns

	USA			GER			SRB			ROM			MAC			CRO			BUG		
	pre	mid	post	pre	mid	post	pre	mid	post	pre	mid	post	pre	mid	post	pre	mid	post	pre	mid	post
GER	0.47	0.66	0.54																		
SRB	-0.02	0.08	0.00	0.01	0.17	0.02															
ROM	0.04	0.28	0.17	0.09	0.47	0.18	0.09	0.28	0.05												
MAC	0.01	0.08	-0.01	-0.03	0.16	0.00	-0.01	0.32	0.07	0.06	0.22	0.08									
CRO	0.03	0.38	0.15	0.11	0.51	0.17	0.07	0.26	0.08	0.15	0.53	0.13	0.05	0.24	0.03						
BUG	-0.04	0.07	0.02	-0.06	0.23	0.09	0.03	0.35	0.07	0.09	0.37	0.05	0.00	0.23	0.10	0.00	0.35	0.07			
SLO	0.05	0.12	0.12	0.12	0.24	0.13	0.04	0.34	0.10	0.18	0.39	0.22	-0.07	0.28	0.01	0.14	0.33	0.17	0.09	0.38	0.06

5.3. Results of the VAR model

At the beginning we provide formal authentication of the stationarity of the time series using the Augmented Dickey – Fuller test. Actually, the key insight of this test is that testing for non- stationarity is equivalent to testing for the existence

of unit roots. We rejected the null hypothesis of unit root and we can conclude that all eight series are stationary in the three analyzed periods.

The assessment of the number of lags was conducted using the information criteria AIC and SBC. According to them, for the first period 2005-2007 and for the third period 2012 to 2015 we use one lag (VAR (1) model), while in the second period from 2007 to 2012 we use three lags (VAR (3) model). In many other papers higher number of lags is being used, which we think is inappropriate for the stock markets analysis. Namely, equity markets are dominated by investors who are sensitive and take rapid intervention after each information. Thus, Eun and Shim (1989) found that the price changes from one market are transmitted within 48 hours to the other markets. It further gives us confirmation that the choice of one to three lags is the most appropriate when analyzing stock markets returns. The results of the lag exclusion test confirmed this, and we experimented with the same test and found that the higher number of lags is insignificant. Indeed, the application of high lag numbers cannot be supported for at least two reasons. First, it's not a legitimacy that is established and which must be respected and therefore is completely adaptable to the phenomenon under study. Second, it is unlikely that the shock of the one stock market will be extended beyond three days.

The stability of the model is confirmed. Figure 2 presents graph of the roots using a complex coordinate system. It can be seen that all inverse roots of autoregressive polynomials in all periods lie within the unit circle in the complex plane.

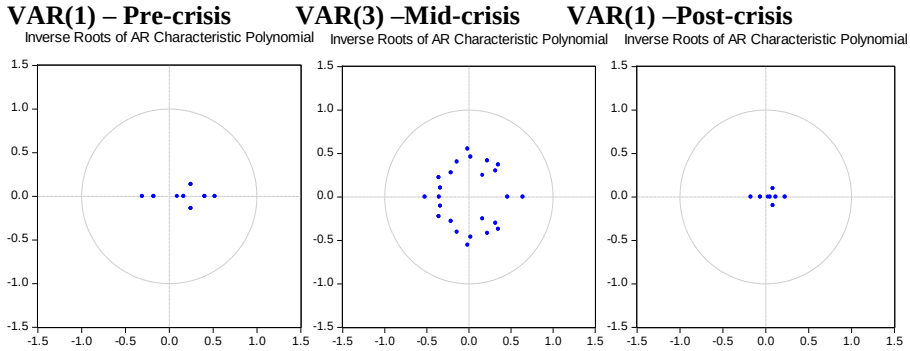


Figure 2. Roots of Characteristic Polynomial

The results from the estimated VAR (1) model for the pre- and post- crisis period and VAR (3) for the mid-crisis periods are presented in Table 3, Table 4 and Table 5 respectively. Findings are interesting for analysis.We present only the significant lagged variables with significance level of 5%. In the pre- crisis period it is evident that each dependent variable have significant adjusted (partial) effect only from its own lagged variable, except for Slovenia and Croatia where one lag USA return USA(-1) also has significant adjusted effect. In the crisis period each

country market has relations with the most of the other markets, and where USA lagged variables have positive significant partial effect on all six emerging markets. This confirms our initial thesis for the existence of spillover effect of the shocks coming from the US on the other markets in the world and the existence of increased linkage of the emerging markets with the developed markets that occurred with this crisis.Stock market indexes of the two developed market, US and Germany, after the resolution of the debt crisis has not only returned to the old levels, but also drastically went above it. But the emerging markets in this period remained illiquid and with the low trading volume compared to that in the pre-crisis period, consequently, in five of them there is evident continuous decline. Therefore, in the post crisis period there is significant loses of the inter-link between the emerging markets, and USA for most of them still have significant partial effect.

Table 3. Estimation of the VAR(1) model for the pre-crisis period

USA		GER		ROM		CRO		BUG		SRB		SLO		MAC	
Const.	0.001	Const.	0.001	Const.	0.001	Const.	0.002	Const.	0.001	Const.	0.002	Const.	0.002	Const.	0.001
BUG(-1)	-0.100	USA(-1)	0.600	GER(-1)	0.255	USA(-1)	0.265	BUG(-1)	0.236	SRB(-1)	0.341	USA(-1)	0.302	SRB(-1)	0.119
		GER(-1)	-0.279			CRO(-1)	0.164					ROM(-1)	0.080	MAC(-1)	0.582
												SLO(-1)	0.151		
Adjusted R^2	-0.001	0.110		0.054		0.056		0.081		0.119		0.089		0.336	

Table 4. Estimation of the VAR(3) model for the mid-crisis period

USA		GER		ROM		CRO		BUG		SRB		SLO		MAC	
Const.	5.2E-05	Const.	-1E-05	Const.	0.000	Const.	0.000	Const.	-0.001	Const.	-0.001	Const.	-0.001	Const.	0.000
USA(-1)	-0.209	USA(-1)	0.397	USA(-1)	0.459	USA(-1)	0.318	USA(-1)	0.352	USA(-1)	0.317	USA(-1)	0.292	USA(-1)	0.165
GER(-1)	0.120	USA(-2)	0.140	USA(-3)	0.107	USA(-2)	0.124	CRO(-1)	0.118	GER(-1)	-0.084	CRO(-1)	0.185	USA(-3)	0.090
CRO(-1)	-0.086	USA(-3)	0.097			GER(-1)	-0.093	BUG(-1)	0.083	GER(-3)	-0.084	BUG(-2)	0.115	ROM(-2)	-0.058
BUG(-2)	0.071	GER(-1)	-0.246			ROM(-3)	-0.065	BUG(-2)	0.128	ROM(-2)	-0.063	SRB(-3)	-0.046	CRO(-1)	0.204
BUG(-3)	0.114	GER(-2)	-0.088			CRO(-2)	-0.084	BUG(-3)	0.065	CRO(-1)	0.140	SLO(-1)	0.095	CRO(-2)	0.124
		GER(-3)	-0.099			CRO(-3)	0.071	SLO(-1)	-0.121	BUG(-2)	0.077	SLO(-2)	-0.068	BUG(-2)	0.094
		CRO(-1)	-0.099			BUG(-1)	-0.063	MAC(-1)	-0.056	SRB(-1)	0.247	MAC(-3)	0.079	MAC(-1)	0.284
		CRO(-2)	-0.106			BUG(-2)	0.131			SRB(-3)	-0.084			MAC(-2)	-0.175
		BUG(-3)	0.111							MAC(-3)	0.065				
		SRB(-2)	0.083												
Adjusted R^2	0.038	0.086		0.111		0.102		0.196		0.218		0.226		0.219	

Table 5. Estimation of the VAR(1) model for the post-crisis period

USA		GER		ROM		CRO		BUG		SRB		SLO		MAC	
Const.	0.001	Const.	0.000	Const.	0.000	Const.	-9E-05	Const.	0.000	Const.	0.000	Const.	-5E-07	Const.	-8E-05
ROM(-1)	-0.128	USA(-1)	0.345	USA(-1)	0.208	USA(-1)	0.073			USA(-1)	0.075	USA(-1)	0.203	BUG(-1)	0.050
		GER(-1)	-0.138							ROM(-1)	0.073	SRB(-1)	0.109	SRB(-1)	0.066
										SRB(-1)	0.155			MAC(-1)	0.211
Adjusted R^2	0.009	0.035		0.053		0.010		-0.001		0.034		0.057		0.053	

It can be seen that none of the six SEE emerging markets plays important role among the analyzed indexes. Maybe we can say that some important role had Croatia and Bulgaria during the crisis period, but not in all cases. Since USA has significant positive partial effect in all countries, through the whole analyzed period, we can conclude that the investors in this selected SEE counties were under the influence of the happening in the USA. One day lagged USA returns are almost always statistically significant. This is consistent with our assumption that the development of the USA stock market affects the development of the SEE markets. Besides SEE countries are geographically close and has more economics interrelations with Germany, surprisingly German stock market has no significant effect on the SEE markets. This suggests that SEE markets are more integrated with USA market than with the Euro-zone market. Also SEE markets show moderate relationship among themselves in the mid-crisis period, especially the influence of Croatia and Bulgaria to the other markets, but in the aftermath of the crisis the inter-linkage among them completely disappeared. In the following section we will instigate the hypothesis of the causality of the markets. Especially we will investigate the relationship between the cause of the shock of USA markets and its effect on the SEE countries.

The adjusted $R^2$of the VAR models are low, which indicate that there are other factors which can explain the stock markets returns of this selected markets than the own and other market lagged returns. We did not detected serial correlation in the residuals using the Breusch–Godfrey LM test for serial correlation at 5% significance level for the both VAR(1) and at 1% significance level for the VAR(3) model. We performed the White Heteroskedasticity test for the residuals of the estimated VAR models, where at 1% significance level the residual homoscedasticity is rejected i.e. the results show that the residuals are heterogeneous in the three models. And, the error terms are obviously not normally distributed, which is typical for the stock market returns.

5.4. Causal relations among the analyses markets

Linkages among the developed markets represented by USA and Germany and the selected SEE emerging markets are further analyzed with the VAR Granger causality test. Here we investigate the *chronological ordering of movements in the series* (Brooks, 2014, p.31). Results that are significant at 5% show only modest evidence of lead-lag interactions between the markets in the pre- and after- crisis period, and more lead-lag relations in the mid-crisis period. This suggests that in a period of instability and uncertainty investors follow common path, and in the calm periods with optimism and positive expectations the lead-lag relations diminish. In the pre-crisis period we can identify only five causalities that are significant at 5% level. USA market leads in the three of them. In the crisis period there are large more causality relations among the markets. USA is a leading market for all other markets, and in the regional level Croatia and Bulgaria

seems to be leaders that are followed by the others. This finding is the same with the findings of the previous VAR results for the crisis period. The smallest markets in this sample (Macedonia and Slovenia) it seems that only follows the other bigger markets. In post-crisis period USA remains a leading market but not with the same intensity as in the crisis period and not in all cases. The findings are obvious, since the great financial crisis started in the USA and the eyes of the investors in all markets in the world were focused on the USA government measures for fighting with the crisis. Here, maybe we would have expected a leading part from Germany, since its measures for solving the debt crisis were the most important.

The pair-wise linkages between SEE markets for the three respective periods are also examined using the VAR Granger cause causality. The results with 5% level of significance are shown in Figure 3, Figure 4 and Figure 5. It is evident that in the pre-crisis and post-crisis period there is no significant effect from one to another market. In the mid-crisis period there is a mass influential effect, most of them in the both direction among the analyzed markets. In the mid-crisis period the developed USA and German market have significant effect on all other markets. All of the emerging markets are caused by USA and Germany in a Granger sense. Among the emerging markets, here also it seems that Croatia and Bulgaria has significant effect on the other SEE emerging markets and leads these markets.

Figure 3. Pre-crisis pair-wise linkages

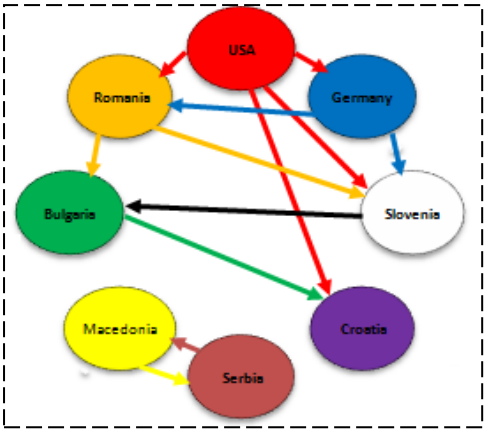


Figure 4. Mid-crisis pair-wise linkages

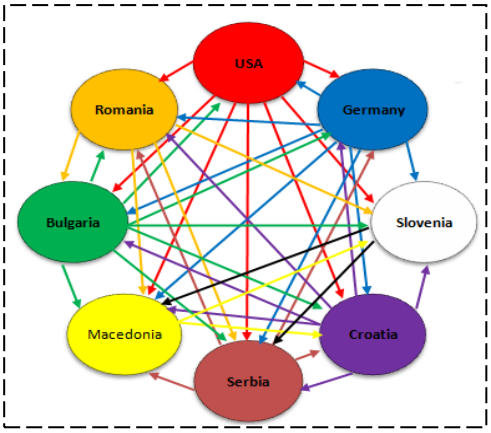
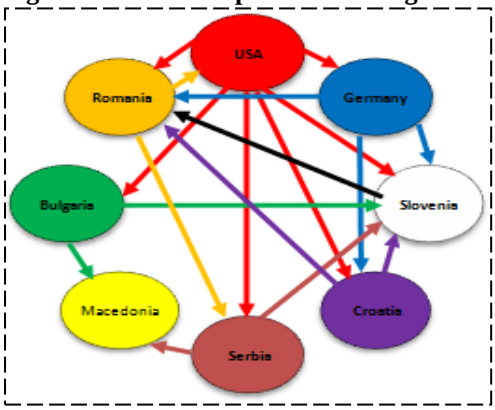


Figure 5. Post-crisis pair-wise linkages



It can be concluded that in the stable periods there is no strong causality among the markets in a Granger sense. But, in the periods of instability, there are strong causalities in the Granger sense where the big markets lead the small markets. The movements in the

bigger markets are found to Grangee-cause i.e. they lead the movements in the smaller markets in the periods of instability. The effect is proportional with the size of the markets, the bigger the market the greater the significance influence and vice versa. The smallest markets (Macedonia and Slovenia) have almost no influence on the bigger markets in the three analyzed periods. In the periods of stable markets, the Granger-cause causality diminishes significantly.

5.5. Impulse response

We examined the responses of each of the selected markets on impulses coming from itself and from the other market for the three periods separately, for the estimated models VAR(1) for the pre- and post-crisis, VAR(3) for the crisis period. The ordering of the markets was according to their market capitalization, as we have concluded from the VAR results and GCC that the bigger markets leads and the smaller markets follow. So, we determined this Cholesky Ordering: USA GER ROM CRO BUG SRB SLO MAC. The results show that in the pre- and in the post- crisis period the convergence needs on average almost4-5days to be completed, butin the crisis period the convergence is almost complete in 6-7 days for different markets. The responses to the shocks are small in the pre-crisis and diminish in the post-crisis period, except for the response of the markets to its own shocks. Generally, all markets have the greatest responses to own innovations in the three periods. The crisis period shows that each market responds to the impulses coming from the most of the other markets shocks, where the greatest shocks in all cases come from their own innovations, and second greatest impulse comes from the USA market. In the post-crisis period the impulses come only from their own innovations, even USA market innovation has no impulse on SEE markets as it was in the crisis period and in some markets in the pre-crisis period.

USA market in the three periods responds only to the shocks coming from its own innovation on the first day and diminishes after that.

German market responds to its own innovations and almost equally from the shocks coming from USA on the first and the second day in the three analyzed periods. No other shock seems to be relevant.

Romanian market has the biggest shock coming from its own innovations, and secondly but not with the same intensity as its own, comes from USA and Germany. The intensity is grater on the first and diminishes after the second day.

The biggest shock to Croatian market comes from its own innovation and USA and German market. Most of the transmission is complete in two days. In the pre-crisis periods the most relevant shock is those coming from its own innovation on the first day, and USA (second day) and German (firs day) shocks. In the crisis period its own, USA and German shocks, from the first and second day, have relevant responses. In the post crisis period, no other markets, except its own innovation, have effect on Croatian market.

For the Bulgarian market only its own innovation is relevant in the pre- and post-crisis period. In the crisis period the impulses from the first day coming from USA, Germany, Romania and Croatia are also relevant. Also, impulses coming from USA, Croatia and Slovenia, besides its own, have greatest effect on it. In the post-crisis period only the own innovations are relevant.

In the case of the Serbian market it can be seen that the responses to the shocks in the pre- and post- crisis period is very small, except for the responses of this market to its own innovations and they die down after the second day. But in the crisis period the shocks coming from USA, Romania, Croatia and Bulgaria onthe first three days are relevant. The USA shock on the second day is even greater from its own. The complete convergence here lasts almost 5 days.

Slovenian market, before the crisis, is affected by its own innovation, and from the shocks coming from USA on the second day. In the post-crisis period, only its own innovations are relevant. During the crisis period, besides its own innovation, it also responds the shocks coming from USA, Croatia, Romania, Bulgaria and Serbia on the first day and shocks coming from USA and Croatia coming from the second day.

External shocks are not relevant for the Macedonian market in the pre- and post-crisis period. It responds only to its own innovation. But in the turbulent period it seems its investors follow the foreign shocks. Here, in the crisis period the responses to its own shocks are the greatest. Besides, the impulses coming from USA, Germany, Romania, Croatia and Serbia on the first and the second day have greatest effect. The complete convergence in this market takes almost 10 days.

5.6. Variance decomposition

With the impulse response analysis, we saw the effects of different days separately, which sometimes is a great problem. Since the effect of one innovation or one shock in one market can be prolong in more days that are needed by all investors to react on the other markets, than a better tool is to see the variance decomposition as some kind of cumulative effect. We provide variance decomposition for the three analyzed periods. The results from the impulse response graphs show us that the most of the transmission occurs in the first two days and after the fifth day the effects are marginal. That's why we allow ten days for impulse response to fully exhaust the effect of the shocks and will discuss the variance decomposition on the fifth day when the transmission is sure to be almost completed.

Interestingly, while the percentage of the errors in the SEE markets that is attributable to own shocks is between 90-95% in the pre-crisis, and more than 95% in the post-crisis period, this percent drops down to 65-75% in the mid-crisis period. The rest part in the crisis period can be explained mostly by USA (approximately 20%) in all SEE countries. Neither single SEE market, nor Germany what is interesting, appears as a significant in explanation of the variation of returns of the other SEE markets. Here, we can also conclude that the inter-

linkages among SEE markets are weak in the stable periods, and rise to a small extent in the instable periods.

The percentage of errors that is attributable to own shocks in the case of USA is almost 100% in the three periods.

As we concluded above in the impulse response analysis for the German market that it responds to its own innovations and almost equally from the shocks coming from USA, here we confirm this finding. In the pre-crisis period the proportion of the German variance is due to own innovations in 60%, and USA shocks explain even 38% of German variance. In the crisis period, the most of the German variance is explain by USA shocks of 52%, a 45% by its own innovations. In the post crisis period own shocks took the greatest part of 68% and USA explains 31%. The existence of great and constant inter-linkages among the developed markets is obvious. The opposite can be concluded for the emerging SEE markets.

The influence of USA market in explaining of Romanian market variance increased from 5% in the pre-crisis on 20% in the crisis period, and then drops to 8% in the post crisis period. German market explains 4% and 7% in the pre-crisis and in the crisis period respectively. The influence of the remaining SEE markets is negligible. This means that the percentage of the errors that is attributable to own shocks is 89%, 71% and 90% in the three respective periods.

For the Croatia market, the great part of the variance in the pre- and post-crisis period is explained by its own innovations 90% and 95% respectively, and USA has somewhat significant part of 5% and 4% respectively. No other market is significant in these two periods. In the crisis period the variations of returns are explained 60% by its own innovation, USA has increased to 23%, Germany with 6% and Romania with 8%.

The variations of Bulgarian stock market return in a small amount are explained by Romanian market innovations in the pre-crisis period of 3% and 4% in the crisis period. In the crisis period USA explains 16% and Croatia 3%. As with other markets, the percentage of the errors that is attributable to its own shocks is 92% in the pre-, 74% in the crisis and even 98% in the post- crisis period.

Its own shock caused the variance in the Serbian market returns with 94% and 97% in the pre- and post-crisis period. No other market has relevance in explanation of it variance in these periods. This percent falls to 76% in the crisis period, and at the same time USA explains 14%, Romania 2%, Croatia 3% and Bulgaria 4% of the variation of Serbia's returns.

When we look at the Slovenian market we can see great similarities with Serbian case. Here, its own shocks attribute a little less, 88%, 66% and 89% in the three respective periods. USA market attributes with 7%, 20% and 6% respectively. Among the other market, we can mention Romania with 3%, 5% and 2%.

Macedonian market is the smallest among the sixth SEE analyzed market, and the conclusions are similar as for the other five. Here, also the main part of the errors is attributable to its own shocks with even 93% and 97% in the pre- and post-crisis period, and this percentage falls to 77% in the crisis period. In the pre-crisis period a very small part of 3% is explained by Serbia. In the crisis period Serbia explains only 2%, and other markets that have significance in explanation are USA with 9% and Croatia with 7%. Others are marginal.

6.Conclusion

We investigated the inter-linkages of the SEE stock markets (Romania, Bulgaria, Croatia, Serbia, Slovenia and Macedonia) with the developed stock markets (USA and Germany). We divided the analyzed period in three segments, pre-crisis period, mid-crisis and post–crisis period. The pre- and post- crisis period shows similarities in that SEE markets do not show inter-linkages among them and with the developed market. They present a great interrelationships and mutual co-movements during the crisis period that diminished after that. Thus, exploring the short and long-term relationships, we found that SEE markets do not show long-term stable relationship with the developed markets.

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