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Frequency domain causality analysis of intra- and inter-regional return and volatility spillovers of South-East European (SEE) stock markets

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ABSTRACT

In this study the return spillovers and volatility spillovers between South-East European (SEE) stock markets are investigated as well as vis-à-vis regional and global stock markets (e.g. Europe, Japan, China and the US). By using Frequency Domain Causality approach, the evidence is found of significant spillover effects between markets. The results of study indicate both short-and long-run intra- and inter-regional return and volatility spillovers detected between South-East European (SEE) stock markets and the emerging and the mature markets around the globe, implying limited diversification benefits for international investor portfolios allocated to these markets. Thus, these results should be taken into account by portfolio managers, investors and policy makers before making any investment decision into region's stock markets. The policy makers and regulators of these markets should consider the nature and frequency of regional and global integration of their stock markets.

1. Introduction

In recent decades, the world has witnessed a dramatic increase in capital flows across nations. Indeed, with the advent of globalization and the development of new technologies, we are witnessing an increase in the integration of emerging markets into the global economy. In such economic integration of the emerging and developed markets, the onset of a crisis may have far-reaching consequences. In other words, with an increase in the correlation of the stock markets, the effect of an unexpected event on one of the markets may affect volatilities and returns in other markets. Increased financial integration among stock markets in the world motivates international investors to look for new investment opportunities in order to improve risk adjusted returns for their portfolios. Incentives for investing into international markets arise from lower correlations between asset returns as compared with that of the domestic assets (Grubel, 1968; Levy & Sarnat, 1970).

In the circumstances of ongoing economic and financial globalization, it is widely accepted that the growing integration between different markets has led to information spillovers from one market to another. The transmission of information between different markets can be done through returns as well as volatility. These are considered as the basis for the pricing of underlying assets and derivatives as well as risk management. In general, the calculation of the optimal hedge ratio and the weight of the portfolio, the evaluation of investment and leverage decisions and the determination of the cost of capital require better understanding of the volatility and its mode of transmission.

When volatility in the market triggers the volatility of other markets, it is called volatility spillovers. The importance is given to the return spillovers and volatility spillovers between different stock markets. Studying the return and volatility spillovers of stock markets in South-East Europe is not a coincidence. It offers an interesting case to study the transmission of return and volatility from developed markets to emerging markets and vice versa. Indeed, in recent years the countries of this European region have at first undertaken a series of financial reforms such as strengthening integration with international financial markets. Then, due to an increase in direct investment flows and trade with the European Union, the countries of South-East Europe experienced a fascinating economic integration. Evidence has shown that in particular period of time the entire region has overtaken the primate from East Asia in attracting flows of capital.

In this study, the return spillovers and volatility spillovers between South-East European (SEE) stock markets were investigated as well as vis-à-vis regional and global stock markets (e.g. Europe, Japan, China and the US) to find out how well the SEE stock markets are integrated with global markets. Integration is a matter of concern for both investors and policymakers, given the crucial implications for portfolio risk management and the potential spillover effects of economic policies. According to the 'modern portfolio theory', diversification increases the return for a given level of risk, or decreases the risk for a given return. It is well known that emerging markets are generally riskier than the most developed ones, especially measured by the volatility of returns. From the point of view of large investors, the answer to the following question could be a challenge: Is there any realistic benefit from international diversification and can they reduce the systematic risk by combining stocks from the most developed countries with emerging markets? Looking from that point of view our paper contributes to the financial integration literature by extending the geographical scope of existing empirical studies by including SEE countries in the portfolio with the most developed ones.

Thus, the short- and long-term return and volatility spillovers were examined between countries located in one region (intra-regional) and in different regions (inter-regional). To achieve this, firstly the return spillovers were modeled by using Frequency Domain Causality approach (further FDC), which is supposed to provide a more detailed explanation of causal influence over different frequencies developed by Breitung and Candelon (2006). Secondly, volatility spillovers were estimated by adopting two-step approach, where the first step involves estimation of time varying conditional variances using a GARCH (1) process. The second step involves using the

standardized residuals from the first step to estimate short-and long-term volatility spillovers by using FDC.

We contribute to the existing literature in many ways. First, the existing studies have largely focused on either advanced economies or emerging economies in Asia and Latin America (Do, Bhatti, & Konya, 2016; Guimarães-Filho & Hong, 2016; Mohammadi & Tan, 2015; Natarajan, Singh, & Priya, 2014; Ruch, 2013; Bhatti & Nguyen, 2012; amongst others). Thus, there is a dearth of research involving the interconnectedness of emerging markets in SEE with global equity markets. However, one of the realities of globalization is that shocks experienced in one financial market are transmitted to other markets, regardless of the linkage between the economies the markets are situated in (Aragó-Manzana & Fernandez-Izquidero, 2007). Further, conditional variance of domestic markets is affected not only by shocks from their own markets, but those that spill over from foreign markets as well (Jeong, 1999). Thus, this paper adds an important new dimension to the existing literature by examining the spillover and interaction between SEE stock markets and a broad range of international stock markets. Finally, permanent (long-term) and transitory (short-term) return and volatility spillovers were investigated between stock markets of SEE and mostly developed world stock markets from different parts of the world.

The article is organized as follows: Part 2 briefly introduces related literature, while Part 3 stipulates methodologies used in the study. Part 4 presents empirical results and finally, Part 5 offers concluding remarks and implications of the study for financial analysts, investors and policy makers.

2. Related literature

Regarding the sample of the countries analysed in our paper, Table 1 shows overview of the selected previous studies which analyse financial integration in CEE and SEE region. Majority of studies analysed co-movements of these markets and markets of developed countries, mostly the US, China, the UK, Germany and France. In the table studies are chronologically compiled, with the note that in most of the papers correlation has been proven, i.e. the existence of some degree of integration. Differences in findings can be interpreted as differences in the sample of countries, the analysed period and methodology which was used. As it can be seen in the table, SEE countries are not often analysed, especially Serbia and Croatia, which is one of the reasons for the selection of the sample in our research.

The seminal work on stock market integration relied to linear methodologies, namely using correlation coefficients and cointegration tests, such as Voronkova (2004), Kenourgios and Samitas (2011), Guidi and Ugur (2014). Nevertheless, the results show strong evidence of integration, mainly when CEE markets are concerned.

With the development of more complex models, the primacy in use is taken over by GARCH models (bi-variate, tri-variate and multivariate), since it enables deeper analysis and the possibility of time varying patterns. Analysis of Syriopoulos and Roumpis (2009) showed that the correlation is modest, as well as Égert and Kočenda (2011) showing a low systematic correlation between developed and emerging stock

Table 1. Overview of the selected previous studies which analyse financial integration in CEE and SEE.

Author(s)	Countries	Period	Models	Results
Voronkova (2004)	Czech Republic, Hungary, Poland	1993–2002	Gregory-Hansen cointegration test	Emerging CE markets have become increasingly integrated with the world markets
Égert and Kočenda (2007)	Czech Republic, Hungary, Poland	2003–2005	Granger causality tests	Signs of short-term spillover effects both in terms of stock returns and stock price volatility, but no long term relationships is established
Syriopoulos and Roumpis (2009)	Bulgaria, Croatia, Romania, Turkey, Cyprus, Greece	1998–2007	Multivariate GARCH model	Correlations with the mature markets is relatively modest
Beirne, Caporale, Schulze-Ghattas, and Spagnolo (2010)	Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Israel, Latvia, Poland, Romania, Slovakia, Slovenia, Turkey	1996–2008 (for emerging Europe region)	Tri-variate VAR-GARCH(1,1)-in-mean models	Spillovers in variance appear to play a key role in emerging Europe
Égert and Kočenda (2011)	Czech Republic, Hungary, Poland	2003–2006	Bi-variate GARCH	Very little systematic positive correlation during a trading day can be detected between the developed and emerging stock markets, or within the emerging group itself
Kenourgios and Samitas (2011)	Turkey, Romania, Bulgaria, Croatia, Serbia	2000–2009	Johansen and Gregory-Hansen cointegration tests and Monte Carlo simulation	Confirms existence of long run relationships within the region and globally
Horvath and Petrovski (2013)	Czech Republic, Hungary, Poland, Croatia, Macedonia, Serbia	2006–2011	Multivariate GARCH models	Degree of comovements is higher in Central Europe and with the exception of Croatia correlation between South East European and developed markets is essentially zero
Gjika and Horvath (2013)	Czech Republic, Hungary, Poland	2001–2011	Asymmetric dynamic conditional correlation multivariate GARCH model	Strong correlations, which increased over time, as these countries entered European Union
Guidi and Ugur (2014)	Bulgaria, Croatia, Romania, Slovenia, Turkey	2000–2013	Static and dynamic cointegration	Existence of time-varying cointegration and increasing conditional correlation from the onset of the financial crisis in September 2007 until May 2010
Okičić (2015)	Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia,	2005–2013	ARIMA and GARCH models	Confirmatory evidence of parsimonious approximations of

Table 1. Continued.

Author(s)	Countries	Period	Models	Results
	Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia			mean and volatility dynamics
Reboredo, Tiwari, and Albulescu (2015)	Czech Republic, Hungary, Poland, Romania	2000–2013	Static and dynamic copola functions with different forms of tail dependence	Evidence of time-varying average positive dependence was stronger between the Czech Republic, Hungary and Poland than between those countries and Romania
Dedi and Škorjanec (2017)	Croatia, Bosnia and Herzegovina, Serbia, Slovenia, Macedonia and Montenegro	2011–2017	MARMA and GARCH models	Evidence of significant co-movements of returns and volatility spillovers among selected markets
Latinović et al. (2018)	Serbia, Montenegro, Croatia	2005–2015	Multivariate GARCH	Evidence of regional spillover and transfer of volatility spillover between these markets and developed markets
Ferreira (2018)	Bosnia, Bulgaria, Czech Republic, Croatia, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia, Ukraine	2008–2017	DCCA and DMCA	Bosnian and Slovakia showed no evidence of correlation with any market, other markets show different level of integration

Source: Overview prepared by the authors.

markets. On the other hand, Horvath and Petrovski (2013) analysis shows a higher level of co-movement in CEE than in SEE markets, Gjika and Horvath (2013) indicate strong correlation that increases as the country approaches the European Union, Dedi and Škorjanec (2017) point out a significant co-movements among selected markets, Ferreira (2018) states different levels of integration among countries. In our study we used FDC approach to provide evidence of both return and/or volatility spillovers, since frequency domain analysis allows us to decompose the information content of causality analysis and test for permanent and transitory spillovers separately.

3. Methodology

Analyzing the existing studies on the return and/or volatility spillovers between stock markets, it is fair to conclude that most of them have employed conventional empirical methodologies such as correlation coefficient (Brooks & Del Negro, 2004), co-integration approach (Arouri, Jouini, & Nguyen, 2011), error correction models, copula theories (Aloui, Aïssa, & Nguyen, 2011; Samarakoon, 2011) and ARCH/GARCH models (Conrad & Lamla, 2010; Lin, Engle, & Ito, 1994; Theodossiou & Lee, 1993; Aloui et al., 2011; Dajčman & Festić, 2012). However, knowing the fact that these studies have contributed to our understanding of interactions between stock markets,

it is hard to say that they provide enough evidence about the frequency domain of co-movement in terms of both return and volatility. Thus, in this study we used FDC approach to provide evidence of both return and/or volatility spillovers, since frequency domain analysis allows us to decompose the information content of causality analysis and test for permanent and transitory spillovers separately. For this purpose, we use near-zero frequency to detect long-term return and volatility spillovers between stock markets and higher frequencies to identify short-term spillovers. More specifically, to model the volatility spillovers, first, a standard GARCH was used (1) to obtain standardized residuals and then use FDC approach to determine the volatility spillovers.

The traditional Granger causality test explained in Granger (1969) and carried out within VAR framework can have the ability to produce single one shot statistic regarding predictability at all frequencies. But, as indicated by Geweke (1982) and Hosoya (1991), such a traditional test does not take into consideration the prospect that the causal relationships could exhibit variations across different frequencies. Thus, Breitung and Candelon (2006, BC hereafter) developed an alternative test to obtain a more precise picture of the short, medium and long term Granger causality which is known as the frequency domain Granger causality test. In their proposed procedure, a bivariate vector autoregressive (VAR) approach is used which first can be generalized to a co-integrated system and a higher dimensional system and second can be used to disentangle short-term and long-term predictability.

By using BC approach, one can test the presence of Granger causality at any frequency (ω), which corresponds to the null hypothesis tested by Geweke, $M_{Y \to X}(\omega) = 0$, which states that Y does not Granger cause X, under the null hypothesis of

$$H_o : R(\omega)\beta = 0,$$

with $\beta = (\beta_1, ..., \beta_p)'$ and $R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & \ldots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \ldots & \sin(p\omega) \end{bmatrix}$.

To determine the outcome of this BC Granger causality tests for the frequency ω, we compare the computed value of test statistics to the table chi-square value at 5% level of significance with 2 degrees of freedom, which is 5.99.

4. Empirical results

In this section, the data used in this study will be described first and then empirical results of the study will be examined.

4.1. Data and preliminary analysis

In this study, the empirical analysis was conducted of the intra-and inter-regional return and volatility spillovers between SEE and international stock markets. For this purpose, return and volatility spillovers were examined between SEE stock markets and world stock markets, such as the US, Germany, China, Japan and the United Kingdom to see how well the SEE stock markets are integrated with global markets. Thus, data on stock prices from the SEE countries was used such as: Turkey (BIST
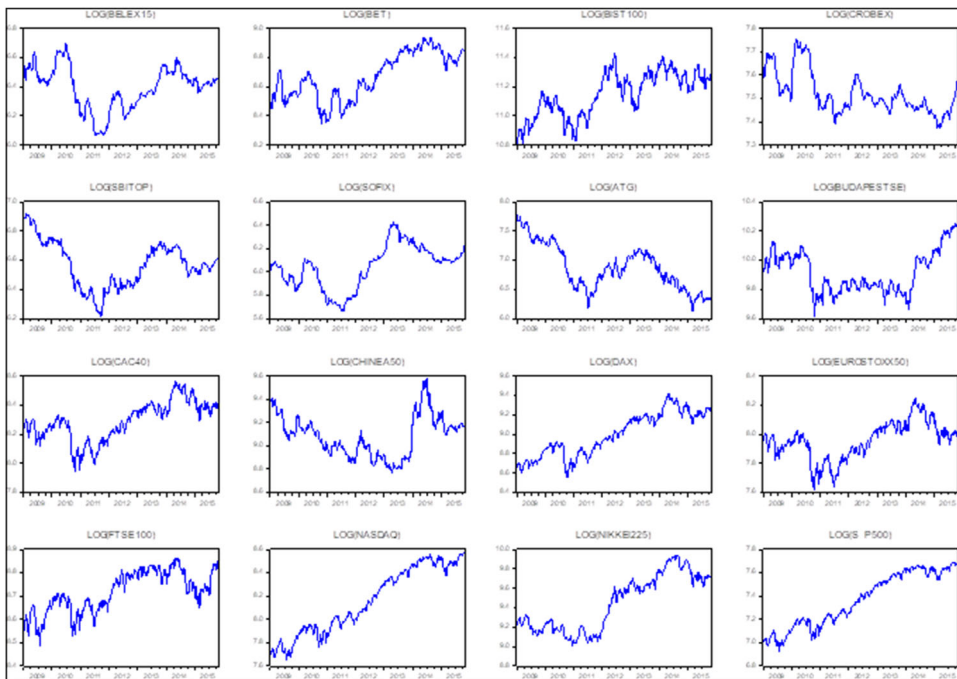
Figure 1. Stock indices during the year 2009 and 2015.
Source: DataStream.

100), Serbia (BELEX 15), Bulgaria (SOFIX), Croatia (CROBEX), Slovenia (SBITOP) and Romania (BET), as well as world stock markets of the United Kingdom (FTSE 100), the US (NASDAQ and S&P 500), France (CAC 40), Germany (DAX), Japan (Nikkei 225), China (China A50). We also include Austria (ATX), Hungary (BUX) as representatives of Central and Eastern European stock markets, and the euro area (Euro Stoxx 50) as a representative index.

To estimate return and volatility spillovers, weekly data was used over the period January 5, 2009 to September 09, 2015, thereby giving a total of 358 observations. We prefer to use weekly data, as indicated in Caporale and Spagnolo (2011) and Khalifa, Hammoudeh, and Otranto (2014), since weekly data allow us to deal with the problem of asynchronous trading as present in daily data and which can lead to biased results. As it is mentioned in Khalifa et al. (2014), another advantage of using weekly data is that it is beneficial in detecting the directions of temporal relationships following increased volatility and transmission of shocks to other markets.

Our preliminary analysis starts with the examination of the plots of logarithmic values of stock market prices presented in Figure 1. Visual inspection of all plots reveals that all stock prices display a significant plunge in August 2011. This sharp drop in stock prices were mainly due to the fears of contagion of the European sovereign debt crisis to Spain and Italy, concerns over both France's AAA rating at that time and the slow economic growth of the United States and its credit rating being downgraded. Following this sharp drop, most of stock prices increased until November 2014, since its stock market prices fell constantly after October 2010.
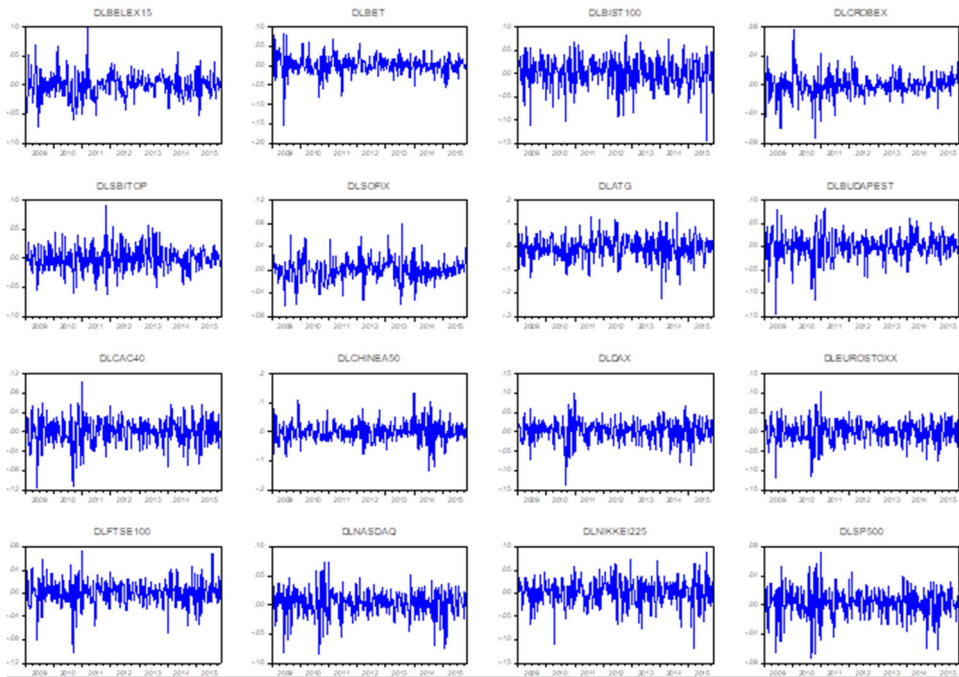
Figure 2. Returns of stock prices indices.
Source: DataStream, returns on stocks are calculated by authors.

Time series graphs of the returns series presented by Figure 2, which are calculated by taking the first differences of the logarithm of the two successive prices i.e. $r_t = \log\left(\frac{P_t}{P_{t-1}}\right)$, have been plotted which depict vividly how volatility has varied across time. The point worth noticing is that all series experience pronounced volatility clustering during the different periods, especially during European debt crises.

Based on the descriptive statistics presented in Table 2, some basic ideas can be outlined about the properties of the stock returns. First of all, series exhibit positive and negative mean returns. Japanese stock market returns have highest mean returns, but it has the negative skewness implying that large negative stock returns were more common than large positive stock returns. Moreover, Japanese stock returns have the excess kurtosis. ATX (Austrian stock indices) has the highest volatility with -0.38% mean returns and negative skewness and excess kurtosis. Serbian stock returns have a negative mean and positive skewness and excess kurtosis. Similarly, the US stock returns are slightly negatively skewed and have excess kurtosis. Based on the kurtosis values, it can be concluded that all stock return series are leptokurtic. Jarque-Bera test statistics for each return series indicate that all return series are not normally distributed. ARCH test cannot reject the hypothesis of time-varying conditional heteroskedasticity in the distributions of the above series. The above statistics reveal that all series are auto-correlated, heteroskedastic and not normally distributed. These time-series properties are consistent with the employment of GARCH models, but a final check is required on the stationary nature of the series.

Table 2. Descriptive statistics of stock returns.

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
BELEX15	−0.000267	0.000794	0.097849	−0.072746	0.02103	0.187388	4.869574	54.08199	0
BET	0.00097	0.001369	0.084053	−0.154484	0.024733	−0.75175	8.371508	462.8149	0
BIST100	0.001236	0.003519	0.083366	−0.143708	0.032854	−0.652716	4.23828	48.15769	0
CROBEX	−0.000127	−0.000428	0.076524	−0.072521	0.015747	−0.106807	6.26051	158.8137	0
SBITOP	−0.000844	−0.001298	0.092528	−0.063003	0.021098	0.210226	4.0711	19.69502	0.000053
SOFIX	0.000473	8.03E-05	0.080146	−0.06306	0.019513	0.113845	4.707073	44.1184	0
ATX	−0.003803	−0.000494	0.148692	−0.225438	0.05112	−0.369554	3.93467	21.12082	0.000026
BUX	0.000837	0.001242	0.082939	−0.144926	0.02798	−0.716256	6.164964	179.5277	0
CAC40	0.000403	0.003891	0.102376	−0.117869	0.028036	−0.468447	4.376821	41.25444	0
CHINAA50	−0.00056	−0.003393	0.13526	−0.136186	0.034064	0.23459	4.967724	60.86951	0
DAX	0.001656	0.00522	0.101666	−0.137974	0.028081	−0.576905	4.949839	76.35561	0
EUROSTOXX	9.68E-05	0.004035	0.103934	−0.11926	0.028833	−0.430197	4.21414	32.9394	0
FTSE100	0.000783	0.002899	0.072373	−0.102819	0.021397	−0.470696	5.298114	91.74227	0
NASDAQ	0.002443	0.00392	0.073276	−0.084747	0.023241	−0.546619	4.513732	51.86248	0
NIKKEI225	0.001419	0.003105	0.088073	−0.117658	0.028702	−0.477138	4.120839	32.23297	0
S&P500	0.001847	0.002844	0.071284	−0.074603	0.020108	−0.447658	4.599661	49.9875	0

Source: Author's calculations.

Table 3. Unconditional correlations.

	BELEX 15	BET	BIST100	CROBEX	SBITOP	SOFIX	ATX	BUDAPEST	CAC40	CHINAA50	DAX	EUROSTOXX	FTSE100	NASDAQ	NIKKEI225	SP500
Panel A: Unconditional correlations of returns series																
BELEX15	1															
BET	0,32	1														
BIST100	0,10*	0,33	1													
CROBEX	0,37	0,47	0,19	1												
SBITOP	0,27	0,37	0,17	0,34	1											
SOFIX	0,23	0,21	0,02*	0,18	0,20	1,00										
ATX	0,21	0,17	0,06*	0,13	0,16	0,08*	1									
BUDAPEST	0,20	0,52	0,42	0,31	0,27	0,17	0,07*	1								
CAC40	0,22	0,54	0,48	0,40	0,25	0,17	0,16	0,57	1							
CHINAA50	0,12	0,10*	0,10*	0,00*	0,07*	0,08*	0,15	0,05*	0,04*	1						
DAX	0,19	0,47	0,45	0,36	0,25	0,20	0,20	0,51	0,92	0,06*	1					
EUROSTOXX	0,20	0,52	0,48	0,38	0,25	0,17	0,16	0,57	0,98	0,05*	0,94	1				
FTSE100	0,20	0,51	0,46	0,38	0,21	0,15	0,11	0,51	0,87	0,05*	0,82	0,84	1			
NASDAQ	0,18	0,47	0,38	0,40	0,20	0,16	0,11	0,44	0,76	0,08*	0,76	0,75	0,81	1		
NIKKEI225	0,22	0,40	0,33	0,31	0,24	0,14	0,14	0,34	0,60	0,07*	0,58	0,58	0,57	0,55	1	
SP500	0,19	0,49	0,41	0,43	0,22	0,17	0,10*	0,48	0,81	0,07*	0,79	0,80	0,85	0,95	0,55	1
Panel B: Unconditional correlations of return volatilities																
BELEX15	1															
BET	0,27	1														
BIST100	0,08*	0,32	1													
CROBEX	0,31	0,42	0,18	1												
SBITOP	0,26	0,34	0,19	0,36	1											
SOFIX	0,18	0,20	0,04*	0,16	0,22	1										
ATX	0,18	0,14	0,06*	0,13	0,15	0,10*	1									
BUDAPEST	0,15	0,47	0,42	0,30	0,26	0,17	0,08*	1								
CAC40	0,19	0,50	0,48	0,37	0,24	0,17	0,16	0,54	1							
CHINAA50	0,12	0,07*	0,11	0,00*	0,07*	0,07*	0,13	0,05*	0,03*	1						
DAX	0,14	0,45	0,46	0,33	0,23	0,20	0,18	0,49	0,91	0,05*	1					
EUROSTOXX	0,17	0,48	0,48	0,35	0,24	0,17	0,16	0,55	0,98	0,05*	0,93	1				
FTSE100	0,18	0,47	0,47	0,37	0,21	0,14	0,12	0,50	0,85	0,03*	0,81	0,82	1			
NASDAQ	0,12	0,43	0,38	0,37	0,20	0,14	0,11	0,40	0,74	0,06*	0,73	0,73	0,78	1		
NIKKEI225	0,21	0,40	0,34	0,32	0,25	0,15	0,14	0,35	0,61	0,08*	0,58	0,58	0,57	0,55	1	
SP500	0,13	0,44	0,42	0,39	0,28	0,15	0,11	0,43	0,78	0,06*	0,76	0,77	0,82	0,94	0,56	1

*shows insignificant unconditional correlations at 5% level of significance.
Source: Author's calculations.

Table 3 gives unconditional correlations for both returns and return volatilities as well.

When we examine the correlations between stock returns (Panel A in Table 2), it is found that all pairwise return correlations are positive with the highest correlations between developed country stock market returns (e.g. the correlation between the SP 500 and FTSE 100 is 0.85), while there is no correlation between CROBEX and China A50. In general, the return correlations between SEE countries and world's developed markets are relatively higher than the correlations between the returns of SEE countries implying that inter-regional integration is stronger than intra-regional integration.

The return volatility correlations (Panel B in Table 2) also yield similar results. Again, there is a relatively high correlation between the return volatilities of developed stock markets than that of SEE countries. Also, return volatility correlations of SEE countries with the developed countries are higher than with that of SEE countries themselves implying again that SEE countries integration to world markets through volatility is more significant than intra-regional integration.

4.2. Frequency domain analysis[1]

In this section, the linkages in the stock markets are analyzed first in their distribution's first moment to test the presence of return spillover and then continue with testing the presence of volatility spillovers by using the results of both traditional time domain and frequency domain Granger causality tests. Upon spillover analysis in frequency domain, a distinction will be made between short term (transitory) and long term (permanent) return and volatility spillovers, since short term spillovers are captured by higher frequency components of the spectra, while long term spillovers correspond to lower frequency components, or trend relations. Thus, we carry out the short term causality tests at a frequency of $\omega = 2.5$ which corresponds to a periodicity of 2 to 3 weeks and long term causality at a frequency of $= 0.5$ which corresponds to a periodicity of 12 to 13 weeks. For the ease of analysis, we will explain the results related to the Serbian stock market in Table 4 in details and then try to summarize the results for other SEE countries.

Since any evidence of co-integration between stock returns could not be provided, traditional time domain causality tests were carried out within the bivariate VAR models using stock returns, and the Breitung and Candelon (2006) frequency domain tests to specify if there exists a bidirectional or unidirectional Granger causality between stock returns at different frequencies. Table 4 presents the results of returns and volatility spillover tests for Serbia.

Traditional Granger causality test results in Table 4 indicate significant bidirectional and unidirectional Granger causal relationships between stock returns. Most of the unidirectional Granger causalities are running from other stock market returns to Serbian stock returns, except from unidirectional Granger causality from Serbian stock returns to that of Austria. Also, bidirectional Granger Causalities exist between returns of Serbian stock market and returns of Romania, Croatia, United Kingdom stock markets. No Granger causality is established between Serbia and Turkey,

Table 4. The results of returns and volatility spillover tests-Serbia.

	Frequency domain			Frequency domain		
	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5
BET≠>BELEX15[b]	0.0000(13)*	✓	✓	0.0180(18)*	✓	✗
BELEX15≠>BET	0.0345(13)*	✗	✓	0.5420(18)	✗	✗
BIST100≠>BELEX15	0.0502(3)	✓	✗	0.1051(3)	✗	✗
BELEX15≠>BIST100	0.0881(3)	✗	✗	0.1766(3)	✓	✓
CROBEX≠>BELEX15	0.0005(9)*	✓	✓	0.04253(3)*	✗	✓
BELEX15≠>CROBEX	0.0019(9)*	✗	✓	0.5890(3)	✗	✗
SBITOP≠>BELEX15	0.2871(13)	✓	✓	0.1726(12)	✗	✗
BELEX15≠>SBITOP	0.21659(13)	✗	✗	0.2833(12)	✗	✗
SOFIX≠>BELEX15	0.2721(9)	✗	✗	0.3551(8)	✗	✗
BELEX15≠>SOFIX	0.06381(9)	✗	✗	0.1269(8)	✗	✗
ATX≠>BELEX15	0.1577(12)	✓	✗	0.4456(9)	✓	✗
BELEX15≠>ATX	0.0001(12)*	✗	✗	0.0003(9)*	✗	✗
BUX≠>BELEX15	0.0003(11)*	✓	✓	0.0921(26)	✗	✗
BELEX15≠>BUX	0.0767(11)	✗	✓	0.9767(26)	✗	✗
CAC40≠>BELEX15	0.0000(9)*	✓	✗	0.0835(19)	✗	✓
BELEX15≠>CAC40	0.2654(9)	✗	✗	0.2169(19)	✗	✗
DAX≠>BELEX15	0.0038(9)*	✓	✓	0.1712(16)	✗	✗
BELEX15≠>DAX	0.1417(2)	✗	✗	0.1071(16)	✗	✗
Eurostoxx50≠>BELEX15	0.0026(3)*	✗	✓	0.0221(19)*	✓	✗
BELEX15≠>Eurostoxx50	0.0660(3)	✗	✗	0.14750(19)	✓	✗
FTSE100≠>BELEX15	0.0024(7)*	✓	✗	0.0193(3)*	✗	✗
BELEX15≠>FTSE100	0.3092(1)*	✗	✗	0.3731(3)	✓	✗
NASDAQ≠>BELEX15	0.0000(11)*	✓	✓	0.0176(18)*	✓	✗
BELEX15≠>NASDAQ	0.1080(11)	✗	✗	0.6719(18)	✗	✗
S&P500≠>BELEX15	0.0000(11)	✓	✓	0.0038(3)*	✗	✗
BELEX15≠>S&P500	0.1777(11)	✗	✗	0.7177(3)	✗	✗
NIKKIEI225≠>BELEX15	0.2105(12)*	✓	✗	0.0724(3)*	✓	✓
BELEX15≠>NIKKIEI225	0.4468(12)	✗	✗	0.4135(3)	✗	✗
ChinaA50≠>BELEX15	0.4445(12)	✗	✗	0.6163(11)	✗	✗
BELEX15≠>ChinaA50	0.0940(12)	✓	✗	0.0295(11)*	✗	✗

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BET≠>BELEX15 denotes the null hypothesis: H_0: Stock Market Return of Romania Doesn't Granger Cause Stock Market Return of Serbia. (return).
[b]BET≠>BELEX15 denotes the null hypothesis: H_0: The Volatility of Stock Market Returns of Romania Doesn't Granger Cause the volatility of Stock Market Returns of Serbia. (volatility).
Source: Author's calculations.

Slovenia, Bulgaria and China stock markets. Thus, the results of traditional Granger causality suggest that there are significant return spillovers mostly from world stock market to Serbian stock market.

Even though the traditional time domain Granger causality test results indicate the significant spillovers between the stock markets by providing only one statistics across all frequencies, with the help of the spectral-causality approach of Breitung and Candelon (2006), it can be determined whether these spillovers are transitory or permanent. We investigate long-term spillovers among stock market using $\omega = 0.05$ to analyze the short-term spillovers and compute test statistics at higher frequencies of $\omega = 2.5$. Table 4 also reports the results of these tests for Serbia.

The results show also several cases where the traditional causality tests are insignificant, but the frequency domain causality tests suggest the presence of causality dynamics; that is, significant return spillovers at different frequencies. For instance, the time domain tests could conclude no spillover between Serbia and Turkey, Slovenia, Bulgaria, and China, whereas in fact, there are significant both long term and short term spillovers between these markets. Also, the results of frequency domain test support the main conclusion of the traditional Granger causality tests of the presence of significant return spillovers between world stock market. Therefore, the results support the argument that analyzing linkages at different frequencies could provide more information and better results than simply relying on simple summary statistics. Moreover, they provide much clearer and more accurate details of the directions and strengths of causalities between stock returns at different frequencies. Further, they provide evidence suggesting that these spillovers are mostly permanent.

After providing evidence of significant return spillovers between stock markets, volatility spillovers are also analyzed. As emerging markets develop further and exhibit higher co-movement with the mature markets, they automatically become more responsive to the volatility of stock markets elsewhere in the world. The investigation of volatility spillovers between stock markets is an important topic, which contributes to our knowledge about global financial interconnectedness. Based on the evidence of significant volatility spillovers between stock markets, we can present a general pattern to volatility transmission. It is also the fact that volatility could be transmitted between the markets where returns either are statistically uncorrelated or exhibit no causality in mean. This information can be used by the academics and practitioners to understand and forecast the volatilities in the global markets. The knowledge of the timing and direction of transmission can be used to facilitate the investment and hedge positions in response to foreign information shocks. As it is indicated in many studies such as Kumar (2016), volatility is considered as a latent variable, thus it is obtained by estimating GARCH (1) model. By using the volatility estimates, we develop bivariate VAR models to carry out the traditional Granger causality tests. Table 3 presents also the results of volatility spillovers tests.

The results of volatility spillovers test in Table 4 show first that there are significant intra-and inter-regional spillover effects in volatility for Serbia. Secondly, similar to the return spillover tests, cases are detected where the traditional Granger causality tests fail to capture the causality between the stock returns, when in fact causality is present at different frequencies. Moreover, like most of the return spillovers, the

results mostly indicate that volatility spillovers are permanent (long-term). On the other hand, unlike the return spillovers, both traditional and frequency domain Granger tests results indicate less volatility spillovers than return spillovers implying that Serbia's interactions with intra-and inter-regional stock markets are taking place mostly through return spillovers. Also, the results of volatility spillovers indicate that intra-regional volatility spillovers are more significant than that of inter-regional.

Based on these results, it can be argued that Serbian stock market has integrated into the world's stock markets both through returns and volatilities of returns, mostly through return spillovers and permanent nature. Thus, it should be clearly understood that Serbian stock market seems to be vulnerable to long-term shock originated from world's important stock markets. These results should be considered as important inputs for the identification of the factors underlying the transfer of national financial disturbances to Serbian market. Also, understanding the direction and time frame of return and volatility spillovers between Serbian and the world stock markets is helpful for institutional and individual investors to engage in effective risk management and superior asset allocation. The more information about spillover characteristics of stock markets Serbian policy makers and regulators obtain the better prudential policies they will adopt. For economic policy makers it would help a lot in predicting with a certain time lag the next stage of the business cycle and adopt it in their present measures of fiscal and monetary policy.

Table 5 presents the results of return and volatility spillovers for Romanian stock market respectively. Both results indicate that there are significant intra-and inter-regional return and volatility spillovers for Romania and most of these spillovers are permanent in nature. But, there is no indication of return spillovers between Romania and China and Japan and no volatility indication between Romania and China. Interestingly, Romanian stock market does not have any linkages with Slovenian stock market through either spillover. Specifically, there are uni-directional returns and volatility spillovers from Germany to Romania, while there are bi-directional return spillover between Romania and Euro area stocks and France. There is also a bi-directional volatility spillover between Romania and Euro area stocks. Based on this results, it can be concluded that there are intra- and inter- regional investment opportunities for investing in Romanian stock markets, particularly from China and Slovenia.

The results of return and volatility spillovers tests for Turkey are given in Table 6.

The results of Turkey indicate that most of the return spillover are taking place in the short-term; in other words, they are temporary or transitory. Interestingly, the results of return spillovers indicate that there are no return spillovers between Turkey and the US and between Turkey and Bulgaria. Also, all significant return spillover are uni-directional and mostly running from Turkish stock market.

The results of volatility spillovers test also provide some evidence of volatility spillovers both uni-and bi-directional and mostly of permanent nature. There are no volatility spillovers between Turkey and both Slovenia and Bulgaria considering the intra-regional volatility spillovers. Regarding the inter-regional spillovers, there is no volatility spillovers between Turkey and Euro area stocks and between Turkey and the USA (S&P 500). There are also bi-directional volatility spillovers between Turkey

Table 5. The results of return and volatility spillover tests-Romania.

	Traditional (lag)[a],*	Frequency domain		Traditional (lag)[a],*	Frequency domain	
		Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5		Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5
BELEX15≠>BET[b]	0.0345(13)*	×	×	0.5420(18)	×	×
BET≠>BELEX15	0.0000(13)*	✓	✓	0.0180(18)*	×	×
BIST100≠>BET	0.0415(15)*	✓	×	0.0926(15)	✓	×
BET≠>BIST100	0.4879(15)	×	×	0.5086(15)	×	×
CROBEX≠>BET	0.7124(3)	×	×	0.7156(8)	✓	×
BET≠>CROBEX	0.0101(3)*	✓	×	0.0015(8)*	✓	×
SBITOP≠>BET	0.8431(3)	×	×	0.7382(3)	×	×
BET≠>SBITOP	0.3998(3)	×	×	0.1910(3)	×	×
SOFIX≠>BET	0.9665 (3)	×	×	0.7406(10)	×	×
BET≠>SOFIX	0.0522 (3)	✓	×	0.2254(10)	×	×
ATX≠>BET	0.9878(3)	×	×	0.3061(11)	×	×
BET≠>ATX	0.0000(3)*	✓	✓	0.0000(11)*	✓	×
BUX≠>BET	0.0883(18)*	✓	×	0.0490(17)*	✓	×
BET≠>BUX	0.1771(18)	×	×	0.2860(17)	×	×
CAC40≠>BET	0.0107(3)*	✓	✓	0.0962(17)	✓	×
BET≠>CAC40	0.6353(3)	✓	×	0.4810(17)	✓	×
DAX≠>BET	0.0514(3)	✓	×	0.3355(15)	✓	×
BET≠>DAX	0.2423(3)	×	×	0.7281(15)	×	×
Eurostoxx50≠>BET	0.1556(13)	✓	×	0.0226(17)*	✓	×
BET≠ Eurostoxx50	0.5489(13)	✓	×	0.4155(17)	✓	✓
FTSE100≠>BET	0.0128(3)*	×	×	0.0114(3)*	✓	×
BET≠>FTSE100	0.6423(3)	✓	×	0.2447(3)	✓	×
NASDAQ≠>BET	0.0545(3)	✓	✓	0.1808(16)	×	×
BET≠>NASDAQ	0.3060(3)	×	×	0.7468(16)	✓	×
S&P500≠>BET	0.0388(3)*	✓	✓	0.1417(17)	×	✓
BET≠ S&P500	0.2553(3)	×	×	0.7410(17)	✓	×
NIKKIEI225≠>BET	0.6931(3)	×	×	0.3462(18)	×	×
BET≠ NIKKIEI225	0.8346(3)	×	×	0.2966(18)	✓	×
ChinaA50≠>BET	0.6775(2)	×	×	0.8177(3)	×	×
BET≠>ChinaA50	0.2635(2)	×	×	0.3814(3)	×	×

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BELEX15≠>BET denotes the null hypothesis: H₀: Stock Market Return of Serbia Doesn't Granger Cause Stock Market Return of Romania (return).
[b]BELEX15≠>BET denotes the null hypothesis: H₀: the Volatility of Stock Market Returns of Serbia Doesn't Granger Cause the volatility of Stock Market Returns of Romania (volatility).
Source: Author's calculations.

Table 6. The results of return and volatility spillover tests-Turkey.

	Frequency domain			Frequency domain		
	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5
BELEX15≠>BIST100[b]	0.0881(3)	X	X	0.1766(3)	✓	✓
BIST100≠>BELEX15	0.0502(3)	✓	X	0.1051(3)	X	X
BET≠>BIST100	0.4879(15)	X	X	0.5086(15)	✓	X
BIST100≠>BET	0.0415(15)*	✓	X	0.0926(15)	X	X
CROBEX≠>BIST100	0.6952(15)	X	X	0.5057(15)	X	✓
BIST100≠>CROBEX	0.4192(15)	X	✓	0.5385(15)	X	X
SBITOP≠>BIST100	0.0211(15)*	✓	X	0.4019(10)	X	X
BIST100≠>SBITOP	0.3065(15)	X	X	0.2581(10)	X	X
SOFIX≠>BIST100	0.4376(19)	X	X	0.6005(3)	X	X
BIST100≠>SOFIX	0.6961(19)	X	X	0.1953(3)	X	X
ATX≠>BIST100	0.3972(3)	X	✓	0.4576(3)	X	X
BIST100≠>ATX	0.0000(3)*	✓	X	0.0000(3)*	✓	X
BUX≠>BIST100	0.5784(3)	X	X	0.4444(3)	✓	X
BIST100≠>BUX	0.3044(3)	X	X	0.2627(10)	X	X
CAC40≠>BIST100	0.5880(15)	X	X	0.2175(3)	✓	✓
BIST100≠>CAC40	0.4582(15)	X	✓	0.3863(3)	✓	X
DAX≠>BIST100	0.1170(15)	X	X	0.1993(14)	✓	X
BIST100≠>DAX	0.0776(15)	X	✓	0.0440(14)*	X	✓
Eurostoxx50≠>BIST100	0.4980(15)	X	X	0.5451(14)	X	X
BIST100≠>Eurostoxx50	0.3929(15)	X	✓	0.4051(14)	X	X
FTSE100≠>BIST100	0.3087(15)*	X	✓	0.3151(14)	✓	✓
BIST100≠> FTSE100	0.0208(15)*	X	✓	0.0130(14)*	X	✓
NASDAQ≠>BIST100	0.2370(3)	X	X	0.0496(14)*	X	✓
BIST100≠>NASDAQ	0.1076(3)	X	X	0.3710(14)	X	X
BIST100≠>NASDAQ	0.2889(3)	X	X	0.0911(14)	X	X
S&P500≠>BIST100	0.3519(3)	X	X	0.1913(14)	X	X
BIST100≠>S&P500	0.0405(3)	X	X	0.2144(15)	X	X
NIKKIEI225≠>BIST100	0.4200(3)	X	X	0.3320 (15)	X	✓
BIST100≠> NIKKIEI225	0.4708(17)	X	X	0.2426(17)	X	X
ChinaA50≠>BIST100	0.0567(17)	✓	X	0.0136(17)*	X	✓

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BELEX15≠>BIST100 denotes the null hypothesis: H_0: Stock Market Return of Serbia Doesn't Granger Cause Stock Market Return of Turkey (return).
Source: Author's calculations.

and France. Therefore, there are also intra- and inter-regional opportunities for investors from Bulgaria and the United States to invest in Turkey.

Table 7 presents the results of return and volatility spillovers tests for Croatia.

The results of return spillovers tests indicate that most of the significant return spillover between Croatia and other markets are intra-regional spillovers and they are permanent. The results, however, show that there are return spillovers between Croatia and Hungary and Austria as well; but, no indication of return spillovers between Croatia and other world stock markets implying that in terms of return spillovers, Croatian stock market is the least connected market to world markets.

On the other hand, when it comes to the volatility spillovers, Croatian stock market seems to be more isolated. There are only few intra-regional volatility spillovers from Croatia to Serbia and Turkey in the short-term and from Romania to Croatia in the long-term. Again, the results also show that there are volatility spillovers between Croatia and Hungary and Austria. Finally, there are bi-directional volatility spillovers between Croatia and Euro area stocks in the long-term. Investors from the world leading markets can exploit benefits of portfolio diversification investing in Croatian stock market.

The results of return and volatility spillovers tests for Slovenia are given in Table 8.

Regarding the intra-regional return spillovers, the results of the study provide evidence of long-term permanent return spillover between Slovenia and almost all other SEE markets except for Romania. And also, the results indicate significant return spillover between Slovenian and other inter-regional stock markets especially in Europe, except for China, Japan and USA (Nasdaq). There are uni-directional return spillovers from Slovenia to Serbia, Turkey, Bulgaria and Croatia in the long-term. Moreover, there are bi-directional return spillovers between Slovenia and Austria. On the other hand, there are uni-directional return spillovers from almost all European stock market to Slovenian stock market.

In terms of volatility spillovers, except for Bulgaria and Romania, there is no evidence of significant volatility spillovers between most of SEE stock markets and Slovenian stock market neither in the short nor in the long-term. There are short-term uni-directional volatility spillovers from Bulgaria to Slovenia. There is a uni-directional volatility spillover from Slovenia to Austria in both short-and long-term. Finally, almost all significant volatility spillovers regarding the inter-regional spillovers are from developed markets to Slovenia especially in the European region. Based on the results, it seems that investing in Slovenian stock market is not a good option for the investors from the world developed markets, but could be profitable for some regional investors (Table 9).

Bulgaria is linked in terms of returns to the intra-regional stock markets except for Turkey (Table 9). There are uni-directional long-term (permanent) return spillovers from Serbia, Croatia, Romania and Slovenia to Bulgaria. Regarding the inter-regional return spillovers, Bulgaria is also linked in terms of returns to the inter-regional stock markets except for China and Japan and these linkages are mostly in the long-term and they are permanent. Specifically, there are a uni-directional return spillovers from Germany, Hungary, France, the United Kingdom, the USA and Euro area stocks to Bulgaria. But, there are some short-term (transitory) return spillovers between

Table 7. The results of return and volatility spillover tests-Croatia.

	Frequency domain				Frequency domain		
	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5	
BELEX15≠>CROBEX[b]	0.0019(9)*	✓	x	0.5890(3)	x	x	
CROBEX≠>BELEX15	0.0005(9)*	✓	✓	0.04253(3)*	x	✓	
BET≠>CROBEX	0.0101(3)*	✓	x	0.0015(8)*	✓	x	
CROBEX≠>BET	0.7124(3)	x	x	0.7156(8)	x	x	
BIST100≠>CROBEX	0.4192(15)	x	✓	0.5385(15)	x	x	
CROBEX≠>BIST100	0.6952(15)	x	x	0.5057(15)	x	✓	
SBITOP≠>CROBEX	0.0856(3)	✓	✓	0.0569(3)	x	x	
CROBEX≠>SBITOP	0.2400(3)	x	x	0.1170(3)	x	x	
SOFIX≠>CROBEX	0.8454 (3)	x	x	0.2922(8)	x	x	
CROBEX≠>SOFIX	0.0283(3)*	✓	x	0.0832(8)	x	x	
ATX≠>CROBEX	0.9376(3)	x	x	0.2361(17)	x	x	
CROBEX≠>ATX	0.0002(3)*	✓	✓	0.0037(17)	✓	✓	
BUX≠>CROBEX	0.0160(3)*	x	✓	0.3925(10)	x	x	
CROBEX≠>BUX	0.1520(3)	x	x	0.8898(10)	x	x	
CAC40≠>CROBEX	0.7075(3)	x	x	0.5122(8)	x	x	
CROBEX≠>CAC40	0.1524(3)	x	x	0.8899(8)	x	x	
DAX≠>CROBEX	0.7835(3)	x	x	0.8809(3)	x	x	
CROBEX≠>DAX	0.1254(3)	x	x	0.3376(3)	x	x	
Eurostoxx50≠>CROBEX	0.8115(3)	x	x	0.7488(3)	✓	x	
CROBEX≠> Eurostoxx50	0.1447 (3)	x	x	0.4133(3)	✓	x	
FTSE100≠>CROBEX	0.3614(3)	x	x	0.1442(8)	✓	✓	
CROBEX≠> FTSE100	0.3570(3)	x	x	0.9350(8)	✓	x	
NASDAQ≠>CROBEX	0.8063(3)	x	x	0.1076(8)	x	x	
CROBEX≠>NASDAQ	0.2394(3)	x	x	0.6885(8)	x	x	
S&P500≠>CROBEX	0.8097(3)	x	x	0.5193(1)	x	x	
CROBEX≠> S&P500	0.2825(3)	x	x	0.5979(1)	x	x	
NIKKIEI225≠>CROBEX	0.3833(3)	x	x	0.3371(3)	x	x	
CROBEX≠>NIKKIEI225	0.8933(3)	x	x	0.8082(3)	x	x	
ChinaA50≠>CROBEX	0.9676(3)	x	x	0.9783(3)	✓	x	
CROBEX≠>ChinaA50	0.8768(3)	x	x	0.7475(3)	x	x	

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BELEX15≠>CROBEX denotes the null hypothesis: H_0; Stock Market Return of Serbia a Doesn't Granger Cause Stock Market Return of Croatia (return).
[b]BELEX15≠>CROBEX denotes the null hypothesis: H_0; the Volatility of Stock Market Returns of Serbia Doesn't Granger Cause the volatility of Stock Market Returns of Croatia. (volatility).
Source: Author's calculations.

Table 8. The results of return and volatility spillover tests-Slovenia.

		Frequency domain				Frequency domain	
	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5	Traditional (lag)[a],*	Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5
BELEX15≠>SBITOP[b]	0.21659(13)	×	×	0.2833(12)	×	×
SBITOP≠>BELEX15	0.2871(13)	√	×	0.1726(12)	×	×
BET≠>SBITOP	0.3998(3)	×	×	0.1910(3)	×	×
SBITOP≠>BET	0.8431(3)	×	×	0.7382(3)	×	×
BIST100≠>SBITOP	0.3065(15)	×	×	0.2581(10)	×	×
SBITOP≠>BIST100	0.0211(15)*	√	×	0.4019(10)	×	×
CROBEX≠>SBITOP	0.2400(3)	×	×	0.0832(8)	×	×
SBITOP≠>CROBEX	0.0856(3)	√	×	0.2922(8)	×	×
SOFIX≠>SBITOP	0.7408(3)	√	×	0.4631(3)	×	√
SBITOP≠>SOFIX	0.0579(3)	√	×	0.7408(3)	×	×
ATX≠>SBITOP	0.1273(12)	√	×	0.0642(11)	×	×
SBITOP≠>ATX	0.0523(12)	√	√	0.0285(11)*	√	√
BUX≠>SBITOP	0.0921(11)	√	×	0.0518(10)	×	×
SBITOP≠>BUX	0.5451(11)	×	×	0.6555(10)	×	×
CAC40≠>SBITOP	0.0117(13)*	√	×	0.0018(3)*	√	×
SBITOP≠>CAC40	0.3326(13)	×	×	0.9848(3)	×	×
DAX≠>SBITOP	0.0011(3)*	√	√	0.0031(16)*	√	√
SBITOP≠>DAX	0.9283(3)	×	×	0.8301(16)	×	×
Eurostoxx50≠>SBITOP	0.0012(3)*	√	√	0.0008(12)*	√	√
SBITOP≠>Eurostoxx50	0.88684(3)	√	×	0.5811(12)	×	×
FTSE100≠>SBITOP	0.1318(24)	√	×	0.0040(5)*	√	√
SBITOP≠>FTSE100	0.1789(24)	×	×	0.9907(5)	×	×
NASDAQ≠>SBITOP	0.0696(15)	×	×	0.0594(3)	×	×
SBITOP≠>NASDAQ	0.3891(15)	×	×	0.9977(3)	×	×
S&P500≠>SBITOP	0.0148(15)*	√	×	0.0102(3)	×	×
SBITOP≠>S&P500	0.8481(15)	×	×	0.9955(3)	×	×
NIKKIEI225≠>SBITOP	0.3100(13)	×	×	0.3362(3)	×	×
SBITOP≠>NIKKIEI225	0.6752(13)	×	×	0.5846(3)	×	×
ChinaA50≠>SBITOP	0.9502(13)	×	×	0.2707(3)	×	×
SBITOP≠>ChinaA50	0.3607(13)	×	×	0.0690(3)	×	×

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BELEX15≠>SBITOP denotes the null hypothesis: H_0: Stock Market Return of Serbia Doesn't Granger Cause Stock Market Return of Slovenia (return).
[b]BELEX15≠>SBITOP denotes the null hypothesis: H_0: the Volatility of Stock Market Returns of Serbia Doesn't Granger Cause the volatility of Stock Market Returns of Slovenia (volatility).
Source: Author's calculations.

Table 9. The results of return and volatility spillover tests-Bulgaria.

	Traditional (lag)[a],*	Frequency domain		Traditional (lag)[a],*	Frequency domain	
		Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5		Long-run (permanent) ω = 0.05	Short-run (transitory) ω = 2.5
BELEX15≠>SOFIX[b]	0.06381(9)	✓	×	0.12698(8)	×	×
SOFIX≠>BELEX15	0.2721(9)	×	×	0.3551(8)	×	×
BET≠>SOFIX	0.0522 (3)	✓	×	0.2254(10)	×	×
SOFIX≠>BET	0.9665 (3)	×	×	0.7406(10)	×	×
BIST100≠>SOFIX	0.6961(19)	×	×	0.1953(3)	×	×
SOFIX≠>BIST100	0.4376(19)	×	×	0.6005(3)	×	×
CROBEX≠>SOFIX	0.0283(3)*	✓	×	0.0832(8)	×	×
SOFIX≠>CROBEX	0.8454 (3)	✓	×	0.2922(8)	×	×
SOFIX≠>SBITOP	0.7408(3)	×	×	0.7408(3)	×	×
SBITOP≠>SOFIX	0.0579(3)	✓	×	0.4631(3)	×	×
ATX≠>SOFIX	0.1733 (3)	×	×	0.4338(8)	×	×
SOFIX≠>ATX	0.0038 (3)*	✓	✓	0.0010(8)*	✓	✓
BUX≠>SOFIX	0.0443(3)*	✓	×	0.1357(3)	×	×
SOFIX≠>BUX	0.1470(3)	×	×	0.3048(3)	×	×
CAC40≠>SOFIX	0.0007(3)*	✓	×	0.0007(3)*	✓	×
SOFIX≠>CAC40	0.1286 (3)	×	×	0.1666(2)	×	×
DAX≠>SOFIX	0.0257(5)*	✓	×	0.0041(3)*	✓	×
SOFIX≠>DAX	0.0656(5)	×	×	0.1242(3)	×	×
Eurostoxx50≠>SOFIX	0.0010(3)*	✓	×	0.0009(3)*	✓	×
SOFIX≠>Eurostoxx50	0.0865 (3)	×	×	0.1598(3)	×	×
FTSE100≠>SOFIX	0.0068(3)*	✓	×	0.0032(3)*	✓	×
SOFIX≠>FTSE100	0.5801(3)	×	×	0.5732(3)	✓	✓
NASDAQ≠>SOFIX	0.0175(3)*	✓	×	0.0147(3)*	✓	✓
SOFIX≠>NASDAQ	0.8444(3)	×	×	0.8523(3)	✓	✓
S&P500≠>SOFIX	0.0080(3)*	✓	×	0.0220(10)	×	✓
SOFIX ≠>S&P500	0.7279(2)	×	×	0.7442(10)	✓	✓
NIKKIEI225≠>SOFIX	0.1683(3)	×	×	0.1714(8)	×	×
SOFIX ≠>NIKKIEI225	0.2528(3)	×	×	0.1792(8)	✓	×
ChinaA50≠>SOFIX	0.2689(3)	×	×	0.2724(3)	×	×
SOFIX≠>ChinaA50	0.2439 (3)	×	×	0.3372(3)	×	×

Notes: [a]the number in parenthesis indicates the optimal lag length.
*denotes the rejection of the no causality at 5% level of significance.
[b]BELEX15≠>SOFIX denotes the null hypothesis: H_0: Stock Market Return of Serbia Doesn't Granger Cause Stock Market Return of Bulgaria (return).
[b]BELEX15≠>SOFIX denotes the null hypothesis: H_0: the Volatility of Stock Market Returns of Serbia Doesn't Granger Cause the volatility of Stock Market Returns of Bulgaria (volatility).
Source: Author's calculations.

Bulgaria and Austria and Germany. There are both short-and long-term return spill-overs from Bulgaria to Austria and short-term return spillovers to Germany.

The results of volatility spillovers tests show that there is not much evidence of Bulgaria's intra-regional integration through volatility spillovers. Except for Slovenia, there are no volatility spillovers between Bulgaria and any country in the SEE region. Particularly, there is a uni-directional volatility spillover from Slovenia to Bulgaria. On the other hand, there are evidence of both short-and long-term inter-regional volatility spillovers mostly shocks caused by Bulgaria except for France, since there is uni-directional long-run volatility spillover from France to Bulgaria and no indication of volatility spillovers between Bulgaria and China. Specifically, there are both short-and long-term volatility spillovers from Bulgaria to Germany, the United Kingdom, the US (S&P 500). Also, there are long-run volatility spillovers from Bulgaria to the US (Nasdaq), Austria and Japan. Finally, there are bi-directional short-run volatility spillovers between Bulgaria and United Kingdom and USA(S&P500). Thus, we can conclude that Bulgaria's stock market's intra-regional integration occurs mostly through return spillovers, while its inter-regional integration takes place thorough both return and volatility spillovers. This result implies that only Chinese investors can benefit from investing in Bulgarian stock market.

To sum up, almost all SEE countries are intra-regionally linked in terms of returns and show no sign of return spillovers with China and Japan except for Turkey. Turkey has seemed to be well integrated into international financial markets compared to other countries in the region, since Turkey has liberalized its external financial accounts earlier than other nations in the sample. On the other hand, their inter-regional integration takes place in terms of both return and volatility spillover. Particularly, Serbia has an intra-regional linkage mostly in terms of permanent return spillovers and an inter-regional linkage in long-term volatility spillovers. Romania has almost the similar structure except for most of its inter-regional link-age in terms of long-term volatility spillovers are related to European markets. Turkey has strong intra-regional integration in terms of transitory return spillover, but, its inter-regional linkage is mostly through volatility spillovers. Thus, Turkey's stock market seems to be mostly affected by shocks originated from major world stock markets because of huge foreign investment. Croatia has strong intra-regional linkages in terms of return spillover and inter-regional linkages in term of volatility spillovers. Slovenia is linked to both intra-and inter-regional markets mostly in terms of return spillover. However, Slovenian stock market is affected by shocks mostly originated from European stock markets. Bulgaria is linked to the world stock markets in terms of long-term return spillover and not showing any sign of linkage in terms of return spillover with SEE countries except for Slovenia. On the other hand, Bulgaria is linked to both intra and inter-regional stock market mostly in terms of permanent volatility spillovers implying that stock market of Bulgaria is open to both intra-and inter-regional permanent volatility shocks. Based on these results, it can be concluded that information about the macroeconomic state of the SEE countries is transmitted to the pricing process of the SEE markets. Also, infor-mation about intra-and inter-regional and global risk affects volatility of the stock markets in SEE region.

Although, up to our best knowledge there is no recent study in which the sample of countries fully coincides with ours, the results largely correspond with the results of previous analyses. In terms of the existence of a certain degree of co-movements and integration between the stock markets of the developed countries and the SEE region, similar findings have studies by Kenourgios and Samitas (2011), Horvath and Petrovski (2013), Guidi and Ugur (2014), Okičić (2015), Dedi and Škorjanec (2017), Latinović, Bogojevic Arsic, and Bulajic (2018) and Ferreira (2018).

Therefore, the implication of the relatively high level of the linkages is that expected returns of the investment in stock markets in SEE countries would be determined not only by the country-specific risk factors but also global factors and developments. Based on the results of the study, the presence of potential benefits for intra- and inter-regional portfolio diversification into the stock markets in South East Europe can be discussed.

5. Conclusion

Our research has implications for risk management, asset pricing and economic policies. Although the SEE countries are considered by international investors to be a homogenous group, the financial markets of these countries display different degrees of integration.

In this study, short-term (transitory) and long-term (permanent) intra-and inter-regional returns and volatility spillovers of stock markets in South Eastern Europe (SEE) are examined by using frequency domain causality approach. According to the results of the study, all SEE countries in the sample are linked to intra-and inter-regional stock markets in terms of both returns and volatility. That is, the stock markets in the SEE region are interrelated either by their returns and/or their volatilities. Because of these interdependencies, to explain particularly the changes in volatility in one market, both intra-and inter-regional markets have to be taken into account.

Moreover, the results indicate that intra-regional linkages in terms of both return and volatility spillovers are less common than those of inter-regional linkages. In other words, the findings of the study indicate a relatively not limited degree of both intra-and inter-regional integration of stock markets in SEE region. Finally, the results of the study suggest that one can treat the SEE countries as a homogenous group, since SEE countries stock market intra-and inter-regional integration seem to have some common features.

The results of the study provide several useful implications for policy makers, portfolio managers and institutional and private investors seeking to diversify their portfolios and to hedge market risk. From the point of view of portfolio diversification, due to long-term linkages, the international investors should understand that they would have limited diversification benefits for portfolios allocated to these markets. In other words, there are not so many opportunities for investors to diversify their portfolios allocated into this region. However, it should be understood that investors can still find significant diversification possibilities investing into some stock markets in the region. To guarantee sufficiently diversified portfolios, they permanently have to monitor and assess changes in these countries' both intra-and inter-regional

market linkages. An important issue in this context is whether or not return and volatility spillovers are of permanent or only of transitory nature.

Understanding the nature and the implications of the intra-and inter-regional linkages of SEE countries, policy makers could develop better economic policies on stock markets, especially stressing the importance of the need for greater policy coordination between the SEE countries. Finally, it can help economic policy makers a lot in designing proper fiscal and monetary policy measures in reaction to external shocks on global financial market. Effective and sound policy measures require a solid understanding of the intra-and inter-regional return and volatility spillovers in stock markets.

Limitation of the study is that it is not clear if there are any diversification benefits in the region, since there are long-term spillovers, which are permanent. The limitations of our study provide impetus for future research. The future research should tend to designing optimal portfolio and considering hedging ratios based on the short-and long-run spillovers and the conditional volatilities from MGARCH models. In that way it would be possible to determine whether there are any diversification benefits in the region.

Note

1. To examine the time series properties of stock prices, we first carried out unit root tests whether or not stock prices are level or first difference stationary by using the Augmented Dickey-Fuller (Dickey & Fuller, 1981); the Elliott, Rothenberg, and Stock (1996); Elliott (1999) GLS augmented Dickey-Fuller; the Phillips and Perron (1988) and the Kwiatkowski, Phillips, Schmidt, and Shin (1992) KPSS tests as well as break point unit root tests. These tests unanimously reveal that all return series are integrated of order zero, i.e. I(0).

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