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Causality between Regional Stock Markets: A Frequency Domain Approach

Summary: Using a data set from five regional stock exchanges (Serbia, Croatia, Slovenia, Hungary and Germany), this paper presents a frequency domain analysis of a causal relationship between the returns on the CROBEX, SBITOP, CETOP and DAX indices, and the return on the major Serbian stock exchange index, BELEX 15. We find evidence of a somewhat dominant effect of the CROBEX and CETOP stock indices on the BELEX 15 stock index across a range of frequencies. The results also indicate that the BELEX 15 index and the SBITOP index interact in a bi-directional causal fashion. Finally, the DAX index movements consistently drive the BELEX 15 index returns for cycle lengths between 3 and 11 days without any feedback effect.

Key words: Stock market indices, Causality, Frequency domain.

JEL: C58, G15.

The analysis of the co-movement of stock market returns represents a key issue in finance as it has important practical implications for asset allocation and investment management. Since the seminal work of Herbert G. Grubel (1968) on the benefits of international portfolio diversification (see also Haim Levy and Marshall Sarnat 1970; Tamir Agmon 1972) this topic has received a lot of attention in international finance. Typically, the co-movement of stock returns has been evaluated through the correlation coefficient while the evolving properties have been investigated either through a rolling window correlation coefficient (Robin Brooks and Marco Del Negro 2004) or by considering non-overlapping sample periods (Mervyn King and Sushil Wadhwani 1990; Wen Ling Lin, Robert F. Engle, and Takatoshi Ito 1994). It is also worth mentioning that the co-movement analysis should take into account the distinction between short- and long-term investors (Bertrand Candelon, Jan Piplack, and Stefan T. M. Straetmans 2008). From a portfolio diversification view, short-horizon investors are more interested in the co-movement of stock returns at higher frequencies, that is, short-term fluctuations, whereas long-term investors focus on the relationship at lower frequencies, i.e., long-term fluctuations. These considerations require a frequency domain analysis to obtain a better insight about the co-movement across various investment horizons (Brian A'Hearn and Ulrich Woitek 2001; Michael Pakko 2004).

By using a test for causality in the frequency domain from Jörg Breitung and Candelon (2006), this paper provides a deeper insight into the relationship between the returns on regional stock market indices in Croatia (CROBEX), Slovenia (SBI-

TOP), Hungary (CETOP) and Germany (DAX) relative to the returns on the BELEX 15 index in Serbia. The results suggest substantial causality interactions at various frequencies. The null hypothesis of no predictability (i.e., causality) from the CROBEX 15 index to the BELEX 15 index is rejected at frequencies that are lower than 10 days and higher than 4 days. In contrast, the null hypothesis of no causality from the BELEX 15 index to the CROBEX index is rejected over a narrow range of frequencies from 4 days to 6 days. Similar dominant influence on the BELEX 15 index is observed for the CETOP index, while the null hypothesis of no causality from the BELEX 15 index to the CETOP index is not rejected for all frequencies $\omega \in (0, \pi)$. Next, a bi-directional pattern of causality is documented between the BELEX 15 returns and the SBITOP returns. This pattern is remarkably stable and suggests significant economic ties between the investors in Serbian and Slovenian stock markets. Finally, the DAX index drives the BELEX index over the frequency range between 3 and 11 days, while the reverse causality is not found. To the authors' best knowledge, this is the first paper that studies causality in the frequency domain between the Serbian equity market and such a broad panel of other markets for the period after 2005.

The rest of the paper is organized as follows: Section 1 briefly reviews the relevant literature and Section 2 presents the equity index data. The methodology is explained in Section 3. Section 4 presents the results of our frequency domain tests, while the final section concludes the paper.

1. Literature Review

A growing body of literature that studies the co-movement of international stock prices has emerged recently (see King, Enrique Sentana, and Wadhwani 1994; Francois Longin and Bruno Solnik 1995; Andrew G. Karolyi and Rene Stulz 1996; Kirsten J. Forbes and Roberto Rigobon 2002; Brooks and Del Negro 2006; Eldin Dobardžić, Alma Dobardžić, and Edisa Brničanin forthcoming). Most of these studies have found that the co-movement of stock returns is not constant over time. For instance, Renatas Kizys and Christian Pierdzioch (2009) found evidence of increasing international co-movement of stock returns among the major developed countries since the mid-90s.

Within the context of the European markets, Theodore Syriopoulos (2007) highlights the fact that Central European markets (Poland, Czech Republic, Hungary, Slovakia) tend to display strong linkages with the U.S. and German markets. Furthermore, Manolis Syllignakis and Georgios Kouretas (2010) reveal that the financial linkages between the Central and Eastern European markets and the world markets increased with the beginning of the E.U. accession process. Syriopoulos and Efthimios Roumpis (2009) find that the Balkan stock markets exhibit time-varying correlations among themselves, but correlations with the mature markets are modest. Similarly, Hong Li and Ewa Majerowska (2008) show limited interactions between the emerging markets (Warsaw and Budapest) and the developed markets (Frankfurt and the U.S). With respect to the long-run interactions, Claire Gilmore, Brian Lucey, and Ginette McManus (2005) could not find any robust cointegration relationship between the U.K., German and Central European stock markets (Hungary, Poland, and Czech Republic). These findings are in line with the study of Balázs Égert and Evžen Kočenda (2007) who do not find any interactions between the Western European stock markets (France, Germany, and the U.K.) and the stock markets of Central and Eastern Europe (Czech Republic, Hungary and Poland). However, Svetlana Voronkova (2004) shows evidence of long-run relationships between the German and Polish stock indices as well as the German and Hungarian indices over the period from 1993 to 2002. Maruška Vizek and Tajana Dadić (2006) examine the integration between German equity markets, selected CEE equity markets and the Croatian equity market. Interestingly, no evidence of long-term relationship between the Croatian and German stock markets is found. In a related recent paper, Christiana Tudor (2011) presents evidence on time-varying interdependencies among six Central and Eastern European stock markets and the U.S. market. Our study complements the above articles that focus on the time domain and introduces a more robust frequency domain approach to testing for inter-market dependencies in both the short and the long-run. Aristeidis Samitas and Dimitris Kenourgios (2011) investigate the stock market integration in a number of Balkan countries and compare it to the integration among several developed markets (US, UK, Germany) in 2000-2006. Using several cointegration tests, the results support the existence of long-term relationships among Balkan stock markets and developed markets.

Quite recently, Roman Horvath and Dragan Petrovski (2013) examine international stock market comovements between Czech Republic, Hungary and Poland, and Croatia, Macedonia and Serbia for the 2006-2011 time period. They study time-varying co-movement (correlations) of the volatilities in the time domain and show that there is a zero correlation between Western stock markets and Serbian and Macedonian stock markets. In contrast to this paper, the focus of our paper is on frequency-varying causal effects across the stock market returns for a different time period (2005-2009) and, thus, our results are dominated by the financial crisis of 2007-2008 to a greater extent. Overall, the differences in research scope, methodology and sample years explain the seemingly conflicting results between our paper and Horvath and Petrovski (2013).

Despite its importance, frequency domain research is relatively scarce in the empirical finance literature (Kenneth Smith 2001; Nikola Gradojević 2012; Nuri Yildirim and Huseyin Tastan 2012). Clive Granger and Oscar Morgenstern (1970) were the first researchers to apply frequency domain methods to co-movements among equity markets. Also, Jimmy E. Hilliard (1979) estimated mean coherences among ten markets. He concluded that “intra-continental” prices moved together, with little “inter-continental” co-movements.

2. Data

This study uses recent daily closing index prices of five regional stock markets - Serbia, Slovenia, Croatia, Hungary and Germany - covering the period from October 4, 2005 to August 18, 2009. The returns (ROI) for the five stock exchanges are calculated for the following indices:

- BELEX 15 index for Serbia,
- CROBEX index for Croatia,
- CETOP index for Hungary,
- SBITOP index for Slovenia, and
- DAX index for Germany.

The data set is very interesting because regional indices reached their highest historical values in 2008, and, then, dropped substantially in 2009, due to the world economic crisis. In our estimations, we use the ROI values for each pair of indices for which the frequency domain causality is investigated. Table 1 shows the summary data for the five markets. As can be seen from the table, the capital market of Serbia has the smallest market capitalization, and the value is close to the market capitalization of Slovenia. On the other side, the capitalization of Croatian stock market has almost three times higher value relative to the Serbian market and it is slightly smaller than the Hungarian stock market, a member of the European Union since 2004. German stock market is the most developed capital market in the sample, which is confirmed by its large market capitalization.

Table 1 Data Summary

Country	Stock Exchange (SE)	Domestic market capitalization (in USD millions)*	The number of listed companies
1. Serbia	Belgrade SE	11 490.5	1084
2. Croatia	Zagreb SE	26 619.0	254
4. Hungary	Budapest SE	30 036.6	43
5. Slovenia	Ljubljana SE	12 140.9	-
6. Germany	Frankfurt SE	1 292 355.3	363

Note: * Data are for 2009.

Source: World Federation of Exchanges.

Descriptive statistics for the returns on stock indices are given in Table 2. They include the mean, standard deviation, skewness and kurtosis. Table 2 reveals that all stock markets except Slovenian and German offer negative returns, but, it is important to stress that all mean returns are statistically insignificant. In addition, according to the standard deviation values, Ljubljana and Frankfurt stock exchanges are the least risky, while the CETOP index shows the highest volatility.

The distribution of Serbian stock market returns is significantly positively skewed, which indicates a higher frequency of small losses and a few substantial gains over the sample years. The only other market with the positive skewness value is German. The negativity of the skewness coefficient is generally perceived as a sign of non-linearity and increased risk of the dynamics of a stock market. Such markets are Croatian, Hungarian and Slovenian as their return distributions exhibit negative skewness. i.e., a higher frequency of small gains and a few substantial losses over the sample years. Noteworthy, all of the presented skewness coefficients indicate asymmetric distributions of returns.

Kurtosis provides a measure of the "thickness" of the tails of a distribution relative to the normal distribution. For the normal distribution, kurtosis is usually equal to three. All daily stock returns have excess kurtosis, which means that they have a thicker tail and a higher peak than a normal distribution. As the BELEX 15 index shows the highest kurtosis, it can be concluded that extreme market movements over the sample period were most frequent in the Belgrade stock exchange.

Table 2 Descriptive Statistics of Daily Returns

Index	No. obs.	Mean	Std. dev.	Skewness	Kurtosis
BELEX 15	957	-0.00047 (0.00059)	0.01844	0.19990 (0.0791)	9.01582 (0.1583)
CROBEX	910	-0.00011 (0.00061)	0.01845	-0.21067 (0.0812)	8.85074 (0.1624)
CETOP	941	-0.00026 (0.00072)	0.02213	-0.75504 (0.0798)	7.93881 (0.1597)
SBITOP	896	0.00019 (0.00051)	0.01547	-0.52237 (0.0818)	7.23700 (0.1636)
DAX	957	0.00002 (0.00053)	0.01647	0.21088 (0.0791)	7.66124 (0.1583)

Note: Standard errors are given in the parentheses.

Source: Authors' calculations.

3. Methodology

The test for causality in the frequency domain by Breitung and Candelon (2006) originates from John Geweke (1982) and Yuzo Hosoya (1991). Let $z_t = [x_t, y_t]'$ be a two-dimensional time series vector with t = 1,...,T. It is assumed that z_t has a finite-order VAR representation:

$$\Theta(L)z_t = \varepsilon_t, \tag{1}$$

where $\Theta(\mathrm{L}) = I - \Theta_1 L - \ldots - \Theta_p L^p$ is a 2×2 lag polynomial with $L^k z_t = z_{t-k}$. It is assumed that the vector ε_t is white noise with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t\varepsilon_t') = \Sigma$, where Σ is a positive definite matrix. Next, let G be the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$, such that $E(\eta_t\eta_t') = I$ and $\eta_t = G\varepsilon_t$. The system is assumed to be stationary, implying the following MA representation:

$$\begin{aligned} z_t = \Phi(L)\varepsilon_t &= \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \\ = \Psi(L)\eta_t &= \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \end{bmatrix} \end{aligned} \tag{2}$$

where $\Phi(L) = \Theta(L)^{-1}$ and $\Psi(L) = \Phi(L)^{-1}G^{-1}$. Using this representation, the spectral density of x_t can be expressed as:

$$f_x(\omega) = \frac{1}{2\pi}\left\{\left|\Psi_{11}(e^{-i\omega})\right|^2 + \left|\Psi_{12}(e^{-i\omega})\right|^2\right\} \tag{3}$$

The measure of causality suggested by Geweke (1982) and Hosoya (1991) is defined as:

$$M_{y\to x}(\omega) = \log \frac{2\pi f_x(\omega)}{\left|\Psi_{11}(e^{-i\omega})\right|^2} \tag{4}$$

$$= \log\left[1 + \frac{\left|\Psi_{12}(e^{-i\omega})\right|^2}{\left|\Psi_{11}(e^{-i\omega})\right|^2}\right] \tag{5}$$

This measure is zero if $\left|\Psi_{12}(e^{-i\omega})\right| = 0$ in which case it is said that *y* does not cause *x* at frequency *ω*. To test the hypothesis that *y* does not cause *x* at frequency *ω* the following null hypothesis is used:

$$M_{y\to x}(\omega) = 0 \tag{6}$$

Feng Yao and Hosoya (2000) estimate $M_{y\to x}(\omega) = 0$ by replacing $\left|\Psi_{11}(e^{-i\omega})\right|$ and $\left|\Psi_{12}(e^{-i\omega})\right|$ from Equation (5) with estimates obtained from the fitted VAR. However, this approach is appropriate $\left|\Psi_{12}(e^{-i\omega})\right|$ just complicated non-linear function of the VAR parameters. Breitung and Candelon (2006) resolve this problem by showing that the null hypothesis $M_{y\to x}(\omega) = 0$ is equivalent to a linear restriction on the VAR coefficients. First, they use $\Psi(L) = \Theta(L)^{-1}G^{-1}$ and $\Psi_{12}(L) = -\frac{g^{22}\Theta_{12}(L)}{|\Theta(L)|}$ (where g^{22} is the lower diagonal element of G^{-1} and $|\Theta(L)|$ is the determinant of $\Theta(L)$) to express the null hypothesis as:

$$\left|\Theta_{12}(e^{-i\omega})\right| = \left|\sum_{k=1}^{p}\theta_{12,k}\cos(k\omega) - \sum_{k=1}^{p}\theta_{12,k}\sin(k\omega)i\right| = 0, \tag{7}$$

where $\theta_{12,k}$ is the (1,2)-element of Θ_k. Thus, a necessary and sufficient set of conditions for $\left|\Theta_{12}(e^{-i\omega})\right| = 0$ is:

$$\sum_{k=1}^{p} \theta_{12,k}\cos(k\omega) = 0, \tag{8}$$

$$\sum_{k=1}^{p} \theta_{12,k}\sin(k\omega) = 0, \tag{9}$$

The notation can be simplified by letting $a_j = \theta_{11,j}$ and $\beta_j = \theta_{12,j}$. Then, the VAR equation for x_t can be written as:

$$x_t = a_1 x_{t-1} + ... + a_p x_{t-p} + \beta_1 y_{t-1} + ... + \beta_p y_{t-p} + \varepsilon_{1t}. \quad (10)$$

The hypothesis $M_{y \to x}(\omega) = 0$ is equivalent to the linear restriction:

$$H_0 : R(\omega)\beta = 0, \quad (11)$$

where $\beta = \left[\beta_1, ..., \beta_p\right]'$ and:

$$R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & ... & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & ... & \sin(p\omega) \end{bmatrix} \quad (12)$$

The ordinary F statistic for (11) is approximately distributed as $F(2, T-2p)$ for $\omega \in (0, \pi)$.

4. Results

This section reports the results of causality tests in the frequency domain for two bivariate systems. Both the Augmented Dickey-Fuller (David A. Dickey and Wayne A. Fuller 1979) (Table 3) and Phillips-Perron (Peter Phillips and Pierre Perron 1988) (Table 4) tests reject the null hypothesis of a unit root in all time series at the 1% and 5 % significance level (p-value = 0.000).

Table 3 ADF Unit Root Tests for Five Stock Market Indices

Market index	ADF t-value	Critical value of t (1%)	Critical value of t (5%)
BELEX 15	-15.08551	-2.56135	-1.94112
CROBEX	-15.37924	-2.56447	-1.94141
SBI TOP	-16.97904	-2.56152	-1.94123
CETOP	-17.45813	-2.56199	-1.94225
DAX	-19.46879	-2.56220	-1.94343

Source: Authors' calculations.

Table 4 Phillips-Perron Unit Root Tests for Five Stock Market Indices

Market index	Phillips-Perron t-value	Critical value of t (1%)	Critical value of t (5%)
BELEX 15	-20.42169	-3.43707	-2.86439
CROBEX	-26.44681	-3.43758	-2.86467
SBI TOP	-25.30626	-3.43770	-2.86475
CETOP	-28.04427	-3.43749	-2.86458
DAX	-32.11159	-3.43696	-2.56835

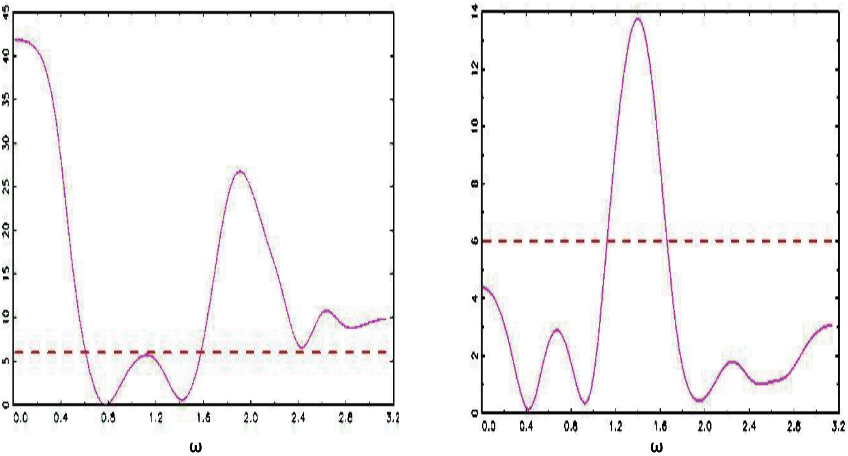
Source: Authors' calculations.

Our data is sampled at a daily frequency and, given that all the returns are stationary at such a frequency, it is expected that they will also be stationary at lower ("smoother") frequencies. However, if there are monthly or other lower frequency additive components where these components have trending elements, then the overall dynamics at the monthly or lower frequencies may not necessarily be stationary. For such reasons, as suggested by a referee, we performed unit root tests at bi-weekly (10 days) and monthly (20 days) frequencies. At lower frequencies, the sample size shrinks substantially (to roughly 90 and 45 observations, for the respective frequencies) and, due to the weak power of the Dickey Fuller in small samples, we relied primarily on the Phillips-Perron unit root test. The results in general confirmed multiscale stationarity of returns for all stock market indices.

According to the AIC criterion, a VAR (3) model was selected for both systems. As in Breitung and Candelon (2006), to assess the statistical significance of the causal relationship between stock market index returns, the causality measure for the frequency ω is compared to the 5% critical value of a χ^2-distribution with 2 degrees of freedom (5.99).

Figure 1 presents the causality measure between the BELEX 15 daily stock returns and the CROBEX index returns for all frequencies $\omega \in (0,\pi)$ along with the 5% critical value (5.99) that is represented with a horizontal dashed line. The left panel shows that the null hypothesis of no causality is rejected for $\omega < 0.6$, corresponding to frequencies less than 10 days. Also, for the values of $\omega > 1.6$, the null hypothesis is rejected, corresponding to frequencies greater than 4 days. The conclusion is that changes of the CROBEX index affect the changes of the BELEX 15 index, at both high and low frequencies. The right panel shows that the null hypothesis of no causality is rejected when $\omega \in [1.1, 1.7]$ corresponding to a frequency range between 4 and 6 days. Therefore, the impact of the BELEX 15 index on the CROBEX index exists in a narrow range of frequencies while the impact of the CROBEX index on the BELEX 15 index is dominant and present over a wider range of frequencies.

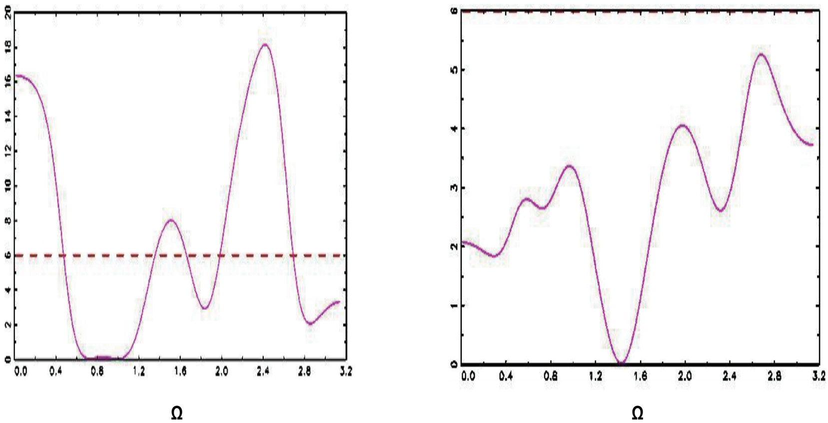
Figure 2 shows the χ^2 statistics for the stock returns of the BELEX 15 stock index and the CETOP index. The left panel shows that the null hypothesis of no causality is rejected for $\omega < 0.5$, corresponding to frequencies of less than 13 days, as well as for values $\omega \in [1.4, 1.6]$, corresponding to a frequency range between 4 and 5 days. The null hypothesis is also rejected when $\omega \in [2.0, 2.7]$, which corresponds to a frequency range between 2 and 3 days. It can be concluded that the CETOP stock index affects changes of the BELEX 15 index dominantly at low frequencies, but also at certain intervals of higher frequencies. The right panel shows that the null hypothesis of no causality is not rejected. Therefore, the BELEX 15 index has no effect on the CETOP stock index, while the CETOP index has a significant impact on the BELEX 15 index.



Note: The values of the χ^2 test statistic are given by a solid line. The 5% critical value (5.99) is given by a horizontal dashed line. The null hypotheses are: 1) that CROBEX returns do not cause BELEX 15 returns at frequency ω (left), and 2) that BELEX 15 returns do not cause CROBEX returns at frequency ω (right).

Source*:* Authors' calculations.

Figure 1 Causality Tests (CROBEX to BELEX 15 Returns) (Left Panel) Causality tests (BELEX 15 to CROBEX Returns) (Right Panel)

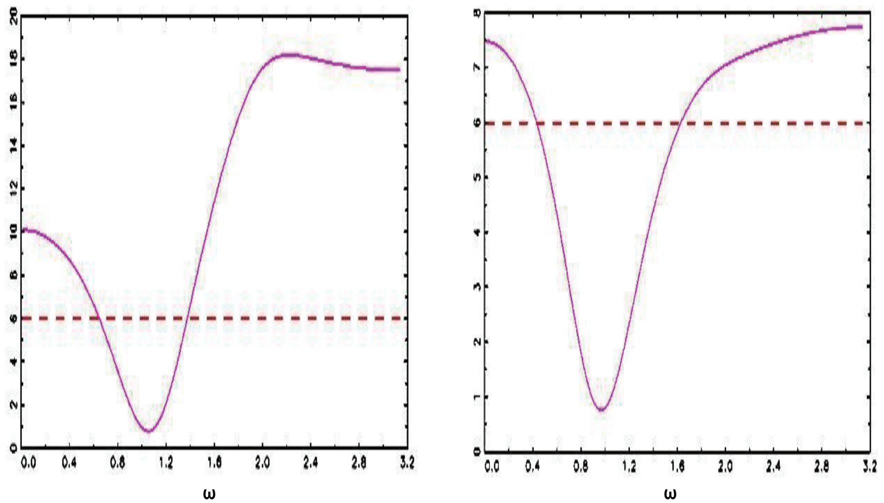


Note: The values of the χ^2 test statistic are given by a solid line. The 5% critical value (5.99) is given by a horizontal dashed line. The null hypotheses are: 1) that CETOP returns do not cause BELEX 15 returns at frequency ω (left), and 2) that BELEX 15 returns do not cause CETOP returns at frequency ω (right).

Source*:* Authors' calculations.

Figure 2 Causality Tests (CETOP to BELEX 15 Returns) (Left Panel) Causality Tests (BELEX 15 to CETOP Returns) (Right Panel)

Figure 3 shows the test statistic for the causality between the BELEX 15 stock returns and the SBITOP index returns. The left panel shows that the null hypothesis of no causality is rejected for ω<0.7, i.e., for frequencies lower than 9 days. In addition, for the values of ω>1.4, the null hypothesis is rejected, which are the frequencies higher than 5 days. The conclusion is that changes of the SBITOP index affect the changes of the BELEX 15 index, at high and low frequencies. The right panel of Figure 3 shows that the null hypothesis of no causality is rejected for ω<0.4 (frequencies lower than 16 days) and ω>1.6 (frequencies greater than 4 days). Hence, the SBITOP index is affected by the BELEX 15 index in a fashion similar to that in the left panel of Figure 3, which can be roughly interpreted as a bi-directional causality at high and low frequencies.

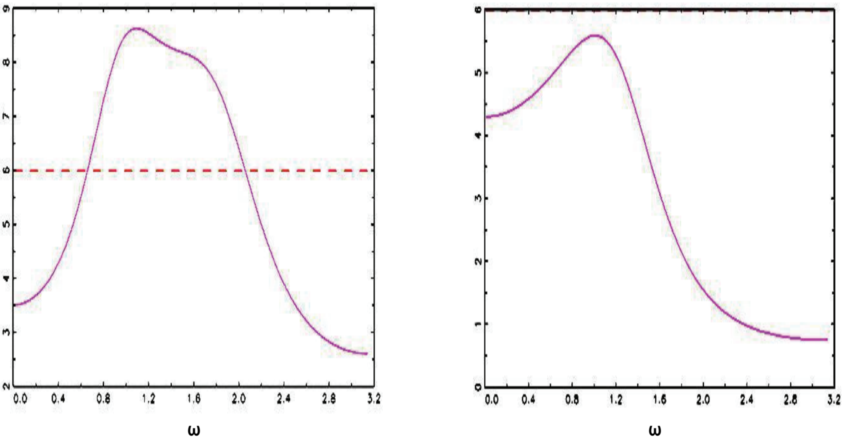


Note: The values of the χ^2 test statistic are given by a solid line. The 5% critical value (5.99) is given by a horizontal dashed line. The null hypotheses are: 1) that SBITOP returns do not cause BELEX 15 returns at frequency ω (left), and 2) that BELEX 15 returns do not cause SBITOP returns at frequency ω (right).

Source: Authors' calculations.

Figure 3 Causality Tests (SBITOP to BELEX 15 Returns) (Left Panel) Causality Tests (BELEX 15 to SBITOP Returns) (Right Panel)

In the end, we examined the interactions between the Frankfurt stock exchange and the Belgrade stock exchange (Figure 4). The left panel shows that the null hypothesis of no causality from the DAX index returns to the BELEX 15 index returns is rejected for ω∈[0.6, 2.1], which represent frequencies with a wave length between 3 and 11 days. The right panel shows the absence of any causality from the BELEX 15 index to the DAX index, which is expected given the size of the two markets. Typically, small, regional markets are heavily dependent on the influx of investors from large, developed markets.



Note: The values of the χ^2 test statistic are given by a solid line. The 5% critical value (5.99) is given by a horizontal dashed line. The null hypotheses are: 1) that DAX returns do not cause BELEX 15 returns at frequency ω (left), and 2) that BELEX 15 returns do not cause DAX returns at frequency ω (right).

Source*:* Authors' calculations.

Figure 4 Causality Tests (DAX to BELEX 15 Returns) (Left Panel) Causality Tests (BELEX 15 to DAX Returns) (Right Panel)

5. Conclusions

The goal of this paper is to investigate the nature of the causality relationship between selected regional stock market indices. A test for causality in the frequency domain by Breitung and Candelon (2006) evaluates the existence of causality at a given frequency. The results show which of the two observed indexes has a dominant impact on the other (and vice-versa). This is important because the test can disentangle short-run and long-run causality and, thus, has broad implications for equity investors operating at different investment horizons.

The results show that the BELEX 15 index is occasionally driven by other markets, except for the SBITOP index, where the causality is bi-directional across the spectrum of frequencies. Although some reverse causality for the 4 to 6-day horizons is observed, the impact of the CROBEX index on the BELEX 15 stock index is dominant for a wide range of frequencies. This result has implications for investors who trade in the short term and can utilize the predictability of the CROBEX index by using the BELEX 15 stock index. On the other hand, monitoring changes in the CROBEX stock index is important for investors who invest in the BELEX 15 across a range of trading horizons.

The CETOP stock index affects the BELEX 15 index mainly at low frequencies, but also at certain intervals of high frequencies, while the BELEX 15 index has no effect on the CETOP index. The impact of the SBITOP index on the BELEX 15 index is slightly more dominant in relation to the impact of the BELEX 15 index on the SBITOP index, but, in general, they drive each other at low frequencies as well as at high frequencies. The causality tests also show the absence of any impact of the BELEX 15 stock index on the DAX stock capital index, which is the expected result.

In conclusion, it is worth emphasizing that public policymakers and regulators may also be interested in the presented evidence on the degree of integration of regional equity exchanges. The empirical results presented in this paper also support the view that international investors have opportunities for long-term portfolio diversification by purchasing shares in the markets that this paper has included. However, such approach requires care because greater integration implies fewer opportunities for portfolio diversification within the E.U. area. This brings emphasis on diversification by industry sectors or by smaller regions. From the policy perspective, financial integration not only increases competition and market efficiency (Gradojević, Vladimir Djaković, and Goran Andjelić 2010), but it also makes individual European markets increasingly interdependent and subject to spillover effects resulting from endogenous and exogenous shocks.

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