ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA, 2017
VOL. 30, NO. 1, 381–393
https://doi.org/10.1080/1331677X.2017.1305774

Testing causal relation among central and eastern European equity markets: evidence from asymmetric causality test

Emrah Ismail Cevik[a], Turhan Korkmaz[b] and Emre Cevik[c]

[a]Department of Economics, Namık Kemal University, Tekirdag, Turkey; [b]Department of Business Administration, Mersin University, Mersin, Turkey; [c]Department of Econometrics, Marmara University, Istanbul, Turkey

ABSTRACT
The aim of this study is to analyse the presence of a causal link among financial markets of Central and Eastern Europe (CEE) countries by adopting an asymmetric causality test. The standard causality test results suggest a causal relation running from the Czech Republic to Poland. Also, the Poland stock market is found to be a Granger cause of Turkey stock markets. Asymmetric causality test results indicate only a causal link going from the Czech Republic to Hungary and Poland. In addition, the presence of financial integration between Germany and CEE equity markets cannot be determined.

ARTICLE HISTORY
Received 17 September 2015
Accepted 10 June 2016

KEYWORDS
Stock markets; financial integration; causality; CEE equity markets

JEL CLASSIFICATIONS
C32; G15; G11

1. Introduction

The issue of financial market integration has crucial importance in terms of both theoretical and practical aspects in the finance literature. Practically, international investors need information on financial market integration in order to determine the potential risks of their portfolio because one of the main principles of diversification is to construct a portfolio by using uncorrelated returns among financial markets. Theoretically, financial market integration that indicates the presence of strong information flows (or causality relation) among markets is related to market efficiency. The efficient market hypothesis suggests that prices in the stock markets fully reflect all available information and follow a random walk process. Hence prices in the stock markets cannot be predicted by implementing historical values or other variables. In that way, it can be said that evidence in favour of financial market integration suggests the lack of efficiency in financial markets because the presence of market integration implies a causality relation among financial markets. Moreover, policymakers can consider a dynamic relation among stock markets to construct optimal policies against contagion effects of financial crisis. Therefore, a large number of studies in the literature have examined the presence of a dynamic relation (e.g., integration, causality) among stock markets by adopting different econometrics methods.

CONTACT Emrah Ismail Cevik emrahic@yahoo.com
An earlier version of this paper was presented at the 49th Annual MBAA International Conference, Chicago, USA, 27 February–1 March 2013.

Empirical results in the literature suggest that interdependency among financial markets has significantly increased recently due to several factors, namely globalisation, bilateral trade, economic integration, financial liberalisation and advances in information processing technology. In this context, Pretorius (2002) empirically examined fundamentals of financial integration and found that bilateral trade and industrial production growth differential are important factors in explaining the interdependency. Demian (2011) stated that financial and economic factors are the main sources of integration among European stock markets. Furthermore, Ratanapakorn and Sharma (2002) indicated that strong economic integration, policy coordination and trade among relevant regions are reasons of increasing financial integration. Hatemi-J (2012a) emphasised the importance of financial integration for emerging countries in terms of economic growth and financial systems. In this context, it can be said that many emerging markets have opened up their financial markets to foreign investors for attracting foreign direct investment and capital to promote economic growth. In addition, financial market integration is important to develop the financial system to be able to make the flow of liquidity more efficient.

On the other hand, some studies in the literature determined that the most important pitfall of financial integration is contagion effects of global and local financial crisis (e.g., 1997 South-East Asian crisis, 1998 Russian crisis, 2008 global financial crisis). Ratanapakorn and Sharma (2002) explained how the reasons of financial crisis quickly spread to the other countries. The first factor is named common shocks in which sharp decrease or increase in the world interest rate, aggregate demand and commodity prices can cause increases in the stress level of the economy. Second, significant currency depreciation in one country experiencing a financial crisis may affect other countries through trade spill-overs due to the improved price competitiveness of the crisis country. Third, the occurrence of a crisis in one or more country may induce investors to rebalance their portfolios for risk management or other reasons. Fourth, a crisis in one country may trigger other financial markets to reassess their countries' circumstances.

The main objective of this study is to examine the presence of a causal link among financial markets of Central and Eastern Europe (CEE) countries, namely the Czech Republic, Hungary, Poland and Turkey. The paper contributes to this literature in several aspects. Firstly, studies in the literature generally examine the causality among stock markets of CEE by employing a standard causality test or multivariate GARCH models, but these testing procedures assume that the impact of a positive shock is the same as the impact of negative shock in absolute terms. However, Hatemi-J (2012b) indicated that this is a very restrictive assumption because investors tend to react more to negative news than positive news. Also, the presence of asymmetric information can cause an asymmetric causal link to be found between financial markets. This is particularly important for CEE stock markets because Caraiani (2012) found evidence in favour of nonlinear dependence in CEE stock market returns series. Therefore, the existence of a causal link among CEE countries by means of the asymmetric causality test proposed by Hatemi-J (2012b) is investigated in this study and, to the best of authors' knowledge, asymmetric causality test is adopted for the first time in the related field of literature for the case of CEE countries. Secondly, it is well known that the standard causality test procedure relies on some distributional assumptions (e.g., normality, homoscedasticity, etc.) but most of the financial series exhibit non-normality and ARCH effect and hence standard critical values cannot be used for testing causal relationships. Therefore, a bootstrap simulation approach is employed to obtain critical values in this study.

CEE financial markets are the focus of this study because these countries are members of the European Union (EU) and they are aspiring to adopt the euro zone. Therefore, it can be expected that the presence of financial integration among these countries as a result of joining the EU entails substantial increase in capital, factor and product market integration among member states.

The rest of the paper is organised as follows. In Section 2, a brief literature review is presented on financial integration. Section 3 explains the general econometric framework for testing asymmetric causality. In Section 4, empirical results and discussions on their implications are presented. Section 5 concludes the study.

2. Literature review

Economic integration among countries and regions has significantly increased over the past decades and this phenomenon has given rise to increased attention of investors and academic scholars to the issue of financial integration among these markets around the world. Therefore, there are extended literatures that focus on the relation among financial markets. In this section, empirical studies are briefly summarised in the current literature.

The studies in the literature can be classified into three groups. The first group has generally employed a conventional cointegration test and standard causality test. For instance, Ratanapakorn and Sharma (2002) examined short-term and long-term relationships in five regional stock indices by using a VAR model and cointegration test for the pre-Asian crisis and Asian crisis. Their empirical findings showed that a local crisis such as the Gulf War, Japanese stock market decline and Mexican peso crisis did not affect the US market in terms of causal sense in the pre-Asian crisis. During the crisis periods, the European market was found to be a Granger cause of the US stock market. More importantly, they found that the Asian crisis spread not only to Latin American or Eastern Europe-Middle East markets but also to Europe and the US stock market. Egert and Kočenda (2007) investigated interrelations between three sock markets in Central and Eastern Europe (Hungary, Poland and the Czech Republic) and also examined the existence of the relationship between Western (Germany, France and the UK) and Central and Eastern European countries by adopting intraday data for the periods of 2003–2005. Although cointegration test results indicated the lack of long-run relationship among stock exchange markets, the presence of a short-term spill-over effect was detected in terms of returns and volatility. Onay (2006) examined the long-run financial integration of second round acceding and candidate countries, namely Bulgaria, Croatia, Romania and Turkey, with the US and EU stock markets. Johansen cointegration test results suggested the lack of long-run relationship between second round countries and the EU and US stock markets. However, the Granger causality test results indicated a causal link running from the EU and US stock markets to Croatian stock markets and also from Turkish stock market to Bulgarian stock market. Mandaci and Torun (2007) analysed stock market integration for Turkey, Brazil, Russia, Korea and Poland by applying cointegration and causality tests. Their empirical results showed the presence of short-run and long-run relationships between Brazil and Polish and Russian and Korean stock markets. Czerny and Koblas (2008) analysed stock market integration among developed and emerging European countries by adopting intraday data for the periods of 2003–2005. Cointegration and Granger causality test results suggested that the spill-over effect is very fast among stock markets where the strongest reaction occurs within one hour, with the first reaction detected often after only five minutes. Demian (2011) examined the effect of EU accession on financial market integration for new members of the EU such as the Czech Republic, Estonia, Hungary, Poland, Romania and Slovakia. While empirical evidence indicates the presence of a cointegration relationship among stock markets, the effects of EU accession are found to be very small. He also indicated that the main sources of integration among European stock markets are financial and economic factors. Gradojevic and Dobardzic (2013) analysed the presence of a causal link among five regional stock markets (Serbia, Croatia, Slovenia, Hungary and Germany) by employing a frequency domain causality test. Empirical results suggested that the Serbian stock market is affected by other markets except for Slovenia where a bidirectional causal link is detected between Serbian and Slovenian stock markets. Unlike these studies, Pretorius (2002) investigated determinants that lead to increased integration among emerging stock markets. Hence, the fundamental factors were classified as contagion effect, economic integration and stock market characteristics. Empirical results suggested that the bilateral trade and industrial production growth differential is found to be significant in explaining the correlation between the stock markets of two countries. Furthermore, Pretorius (2002) indicated that countries in the same region are more correlated than the countries in different regions.

However, conventional cointegration and causality tests have been criticised for having low power to reject the null hypothesis when there are structural breaks in the series and hence the second group has focused on possible structural breaks in the cointegration relationship. In this context, Korkmaz, Zaman, and Cevik (2008) investigated the long-run cointegration relationship among the Turkish stock market, the stock markets of 17 EU member countries and the stock markets of Turkey's 10 largest trading partners via Johansen and Gregory-Hansen cointegration tests. Empirical findings suggested that Turkish stock market is cointegrated with the equity markets of 11 EU countries and the equity markets of seven countries with which Turkey has a high trade volume. Kenourgios and Samitas (2011) examined the long-run relationship among five Balkan emerging stock markets (Turkey, Romania, Bulgaria, Croatia and Serbia), the US and three developed European markets (the UK, Germany and Greece) by adopting a Gregory-Hansen cointegration test and multivariate GARCH model. They found evidence in favour of long-run relation among Balkan markets, and between Balkan and developed markets. Federova (2011) investigated contagion effects among Eastern European stock markets (Poland, Hungary and the Czech Republic) by means of a multivariate GARCH model and found that direct linkages between different stock market sectors significantly increased after EU accession in 2004. Onay and Unal (2012) examined the presence of long-run financial integration and extreme dependence between Turkey and Brazil stock markets. Although the Johansen cointegration test procedure fails to find financial integration between stock markets, the Gregory-Hansen cointegration test that allows structural breaks in the cointegration equation suggests the existence of long-run relationship between Turkey and Brazil. In addition, Onay and Unal (2012) suggest that time-varying correlations between Turkey and Brazil that is obtained from a DCC-GARCH model indicate strong relation for both systemic and local crisis periods.

The last group of studies examines the presence of nonlinear and asymmetric dynamic relationships among financial markets. Ozdemir and Cakan (2007) focused on nonlinearity in the financial markets when they examined the causal relation and hence nonlinear causality test is employed to investigate the dynamic relations between the major stock indices of the US, Japan, France and the UK. Empirical findings revealed the presence of a bidirectional causal relation between the US and the UK stock markets. Qiao, Li, and Wong (2011) investigated dynamic relations among stock markets of the US, Australia and New Zealand by employing regime-dependent impulse–response functions. Empirical results suggested the presence of two regimes in three stock markets and correlations among three markets are significantly higher in a bear regime than bull regime. Also, regime-dependent impulse–response functions implied that integration among the three stock markets is stronger and more persistent in the bear regime than in the bull regime. Hatemi-J (2012a) analysed the causality between the United Arab Emirates (UAE) and the US financial market by means of both symmetric and asymmetric causality tests. A standard symmetric causality test result indicates the lack of causal links between financial markets. On the other hand, asymmetric causality test results imply the existence of a causal link between the UAE and the US financial markets and these findings imply that the UAE financial market is integrated with the US financial market. It is also found that the causal link for the bear market is stronger than for the bull market. Cevik, Kirci-Cevik, and Gurkan (2012) examined the regime-dependent causality relation among the US, Germany and Turkish financial markets by using a Markov regime switching VAR (MS-VAR) model. They identified the regimes as bear and bull market and then employed causality test and impulse–response functions. Their empirical results are in line with Hatemi-J (2012a) because the causal link between financial markets for the countries in question is varied for the regimes. For instance, it was determined that a causal link runs from the US to Turkey in the bull market and from the US to Germany in the bear market. Nevertheless, a causal relation cannot be determined between Germany and Turkey in both regimes. Baumöhl (2013) examined the degree of stock market integration between CEE and G7 countries by using a multivariate asymmetric DCC-GARCH model. Empirical results suggested that the integration between CEE and G7 stock markets tends to increase over the sample period and the highest conditional correlation was observed at the end of the sample. The only Slovak stock market was found to be segmented and isolated from other CEE and G7 stock markets.

3. Econometric framework

3.1. Unit root tests

The existence of unit roots in the stock market indices are examined by adopting the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests in this study. However, Perron (1989) argued that conventional unit root tests have low power to reject the null hypothesis of non-stationarity when there is a structural break in the series. To overcome this problem, Perron (1989) modified the ADF test by adding dummy variables to account for structural breaks at known points in time. Zivot and Andrews (1992) suggested that structural breaks in the series may be endogenous and they extended Perron's methodology to allow for the endogenous estimation of the break date. Two alternative models proposed by Zivot and Andrews (hereafter ZA) are adopted to examine the presence of unit root with structural break in the stock market price series:

Model A:

$$\Delta p_t = \mu + \theta DU_t(\lambda) + \beta t + \alpha p_{t-1} + \sum_{j=1}^{k} c_j \Delta p_{t-j} + e_t \tag{1}$$

Model C:

$$\Delta p_t = \mu + \theta DU_t(\lambda) + \beta t + \gamma DT_t(\lambda) + \alpha p_{t-1} + \sum_{j=1}^{k} c_j \Delta p_{t-j} + e_t \quad (2)$$

where p_t indicates stock market price index, DU_t and DT_t are indicator variables for mean shift and trend shift for the possible structural break-date (TB) and they are described as follows;

$$DU_t = \begin{cases} 1 & if, t > TB \\ 0 & otherwise \end{cases} \quad DT_t = \begin{cases} t - TB & if, t > TB \\ 0 & otherwise \end{cases} \quad (3)$$

The null hypothesis of a unit root ($\alpha = 0$) can be tested against stationarity with structural breaks ($\alpha < 0$) in Equations 1 and 2. Every time points are considered as a potential structural break date in the ZA unit root test and the break date is determined according to the minimum one-sided t-statistic.

3.2. Asymmetric causality test

In this study, the asymmetric causality test which was proposed by Hatemi-J (2012b) is employed to determine upside and downside causal links among stock markets of CEE countries. Qiao et al. (2011) and Cevik et al. (2012) showed that dynamic relations among financial markets are varied due to stock market regimes (bear and bull market periods). This can be expected because investors tend to react more to negative shocks than to positive ones even in cases when the size of the shock is the same in absolute terms. These findings imply the presence of asymmetric relations among financial markets and standard causality tests do not take into account the potential asymmetric property of the underlying data. In this context, it is assumed that the positive and negative shocks may have different causal impacts in the asymmetric causality test. In order to explain the asymmetric causality relation between two integrated variables such as y_{1t} and y_{2t}, the variables are first defined as the following random walk process:

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{10} + \sum_{i=1}^{t} \varepsilon_{1i} \quad (4)$$

$$y_{2t} = y_{2t-1} + \varepsilon_{1t} = y_{20} + \sum_{i=1}^{t} \varepsilon_{2i} \quad (5)$$

where $t = 1, 2, \ldots, T$, the constants y_{10} and y_{20} are the initial values and the variables ε_{1i} and ε_{2i} imply white noise residuals. Positive and negative shocks can be defined respectively as the $\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0)$, $\varepsilon_{1i}^{-} = \min(\varepsilon_{1i}, 0)$, and $\varepsilon_{2i}^{-} = \min(\varepsilon_{2i}, 0)$.

Therefore, residuals can be defined sum of positive and negative shocks as $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$ and $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$. Due to this definition, y_{1t} and y_{2t} can be defined as follows:

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{10} + \sum_{i=1}^{t} \varepsilon_{1i}^{+} + \sum_{i=1}^{t} \varepsilon_{1i}^{-} \quad (6)$$

$$y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{20} + \sum_{i=1}^{t} \varepsilon^{+}_{2i} + \sum_{i=1}^{t} \varepsilon^{-}_{2i} \tag{7}$$

Finally, the positive and negative shocks of each variable can be defined in a cumulative form as $y^{+}_{1t} = \sum_{i=1}^{t} \varepsilon^{+}_{1i}$, $y^{-}_{1t} = \sum_{i=1}^{t} \varepsilon^{-}_{1i}$, $y^{+}_{2t} = \sum_{i=1}^{t} \varepsilon^{+}_{2i}$, and $y^{-}_{2t} = \sum_{i=1}^{t} \varepsilon^{-}_{2i}$. Note that, by construction, each positive as well as negative shock has a permanent impact on the underlying variable. The next step is to test the causal relationship between these components. Note that only the case of testing for a causal relationship is defined between positive cumulative shocks and the vector $y^{-}_{t} = \left(y^{-}_{1}, y^{-}_{2}\right)$is used for testing causality between negative cumulative shocks. Assuming that $y^{+}_{t} = \left(y^{+}_{1}, y^{+}_{2}\right)$, the test for causality can be employed by using the following vector autoregressive model of order p, VAR (p):

$$y^{+}_{t} = v + A_{1}y^{+}_{t-1} + \cdots + A_{p}y^{+}_{t-p} + u^{+}_{t} \tag{8}$$

where y^{+}_{t} is the 2×1 vector of variables, v is the 2×1 vector of intercepts, and u^{+}_{t} is a 2×1 vector of residuals terms. The matrix A_r is a 2×2 matrix of parameters for lag order r ($r = 1,\ldots, p$).

Note that Hatemi-J (2012b) considered the Toda–Yamamoto principle (Toda & Yamamoto, 1995) to the conduct asymmetric causality test procedure. In this context, the Toda–Yamamoto test procedure consists of three steps. In the first step, maximum order of integration of variables ($d_{\max}$) should be determined by using unit root tests. In the second step, optimal lag lengths of the VAR system (r) should be determined via model information criterions and then the VAR system with ($r + d_{\max}$)th order should be estimated. In the final step, a standard Wald test with an asymptotic χ^2 distribution is employed for testing the presence of a causal link between the variables.

As in Hatemi-J (2012a, 2012b), model information criterion is considered which is proposed by Hatemi-J (2003) in order to select the optimal lag lengths. The null hypothesis of there is no causality among variables can be tested by Wald restriction for the autoregressive parameters. Wald test statistic has an asymmetric χ^2 distribution in which the number of degrees of freedom is equal to the number of restrictions. However, most financial series exhibit non-normality and ARCH effects and hence bootstrap simulation procedure is employed with 10,000 replications to determine critical values.

4. Data and empirical results

In this study, monthly stock market price indexes are employed for the Czech Republic, Hungary, Poland, Turkey and Germany covering the period from January 1995 to June 2014 for a total of 234 observations. Stock price index that is measured in US dollars is obtained from MSCI-Barra database which represents all share indices for the local stock market. The logarithmic forms of stock market price index series are used in the empirical analysis. Figure 1 presents the log of price index series and positive and negative cumulative sums of log of price index.

The descriptive statistics for the stock index returns series are presented in Table 1. The monthly mean of all stock index return series varies between 0.367 percent and 0.683 percent. The highest mean return is obtained from Turkish stock market. The Poland stock

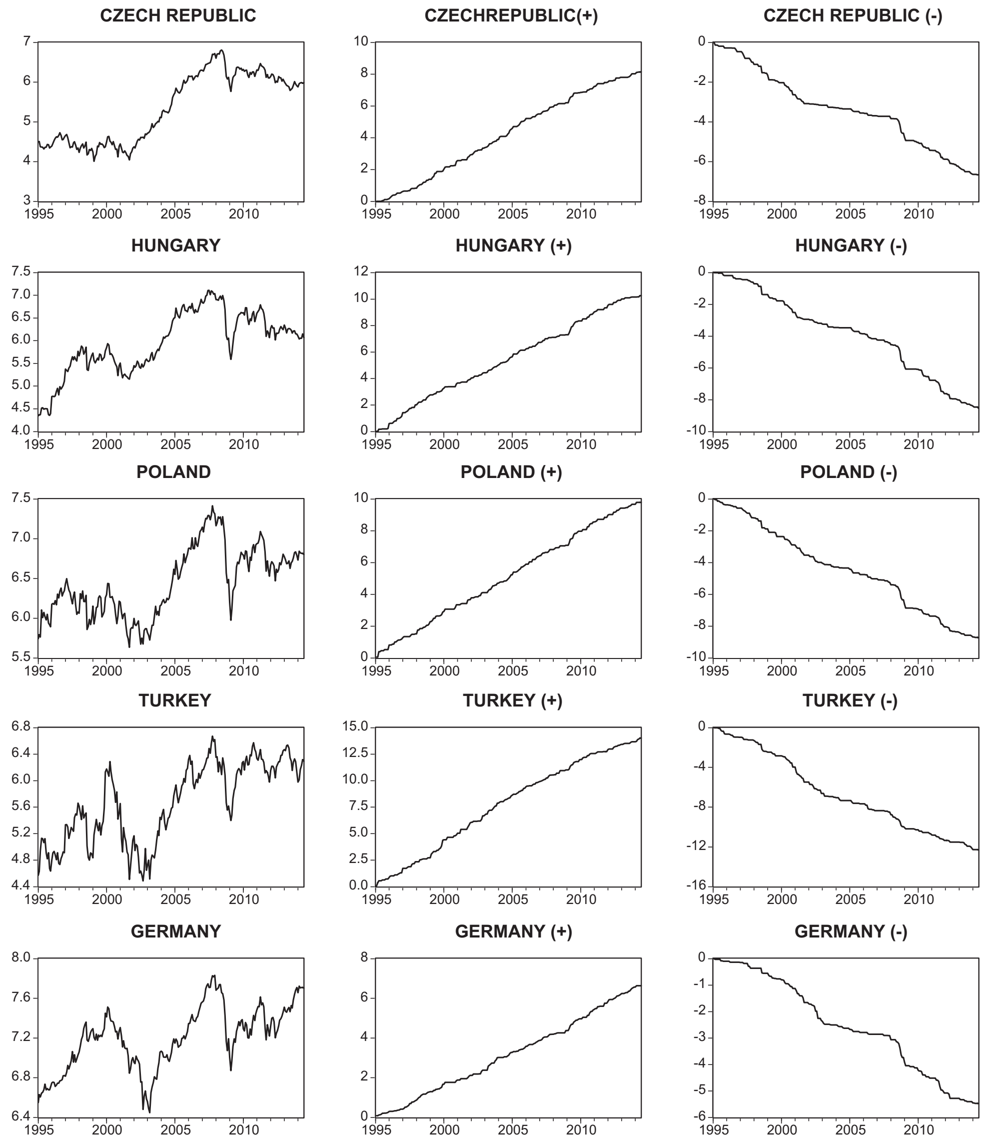

Figure 1. Log of Price Index and Positive and Negative Cumulative Sums. Source: MSCI-Barra and authors' calculation.
Note: (+) indicates positive cumulative sums and (–) indicates negative cumulative sums.

Table 1. Descriptive Statistics for Returns Series.

Countries	*n*	Mean (%)	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Czech Republic	234	0.589	26.295	−34.877	8.414	−0.608	4.895
Hungary	234	0.626	37.950	−56.826	11.223	−1.049	7.318
Poland	234	0.367	33.931	−42.980	10.570	−0.474	4.885
Turkey	234	0.683	54.408	−53.177	14.835	−0.286	4.658
Germany	234	0.484	20.204	−27.908	6.939	−0.914	5.145

Source: Authors' calculation.

market, on the other hand, yields the lowest mean returns during the sample periods. Minimum returns for all stock markets are observed generally during the crisis periods such as 1998 Russian crisis, 2001 Turkey crisis and 2007–2008 global financial crisis. Furthermore, Turkish stock return series exhibit higher volatility according to standard deviation statistics. Also all return series reveal the evidence of strong skewness and excess kurtosis, which indicates that they are leptokurtic.

The correlations among stock returns series are presented in Table 2. It can be seen that all correlation coefficients are found to be significant at 1% level of significance. On the other hand, the highest correlation is found between Hungary and Poland. In addition, results in Table 2 imply that correlation between Turkey and Poland and Turkey and the Czech Republic is lower than 0.5. Finally, the Hungarian and Poland stock markets have highest correlation coefficient with German stock market in which correlation coefficient is determined as 0.652 and 0.658, respectively.

Testing unit roots of the stock market price index series is the first step of the econometric analysis by means of the ADF and PP unit root tests and tests results are presented in Table 3. The null hypothesis of a unit root for all series in levels cannot be rejected. On the other hand, when the first differences of the series are considered, the null hypothesis is rejected for all series at 1% significance level.

As well known in the literature, linear unit root tests have a lack of power when there are structural breaks in the series. Therefore, we now turn to the examination of unit root process with structural break for the series via ZA test and test results are presented in Table 4. Again the null hypothesis of unit root cannot be rejected in levels and these results are consistent with ADF and PP tests results. All unit root tests results suggest that all stock market price index series are stationary when first differences are taken and this finding implies that maximum order of integration of variables (d_{max}) is one.

Then, causality relationship among CEE countries is examined by adopting asymmetric causality test proposed by Hatemi-J (2012b) and the results are presented in Table 5.

Table 2. Correlations among Stock Returns Series.

Countries	Czech Republic	Hungary	Poland	Turkey	Germany
Czech Republic	1.000				
Hungary	0.699***	1.000			
Poland	0.689***	0.763***	1.000		
Turkey	0.421***	0.536***	0.467***	1.000	
Germany	0.543***	0.652***	0.658***	0.522***	1.000

Note: ***indicates significant correlation coefficient at the 1% level.
Source: Authors' calculation.

Table 3. Unit Root Test Results.

	Level		First Differences	
Countries	ADF	PP	ADF	PP
Czech Republic	−1.218	−1.301	−13.727***	−13.705***
Hungary	−1.881	−2.008	−13.888***	−13.895***
Poland	−2.528	−2.517	−15.465***	−15.472***
Turkey	−3.014	−3.203	−15.141***	−15.141***
Germany	−2.347	−2.637	−14.245***	−14.262***

Note: The optimal number of lags is selected according to the Schwarz BIC.
***indicates that the series in question is stationary at the 1% significance level.
Source: Authors' calculation.

Table 4. Zivot–Andrews Structural Break Test Results.

	Test Statistics		Break Periods	
Countries	Model A	Model C	Model A	Model C
Czech Republic	−3.078	−3.206	2003M08	2004M08
Hungary	−3.240	−3.781	2008M08	2004M08
Poland	−4.096	−4.017	2004M09	2004M09
Turkey	−3.962	−4.004	2004M06	2000M11
Germany	−3.043	−3.037	2001M02	2000M04

Note: −4.58, −4.80 and −5.43 are critical values for Model A at 10, 5 and 1% significance levels respectively. −4.820, −5.08 and −5.57 are critical values for Model C at 10, 5 and 1% significance levels respectively. ***, ** and *indicate that the series in question is stationary at the 1, 5 and 10% significance level, respectively.
Source: Authors' calculation.

Table 5. Hatemi-J Asymmetric Causality Test Results among CEE Equity Markets.

Causality Direction	Test Value	VAR order	CV 1%	CV 5%
Czech Republic → Hungary	3.113	1	6.663	3.960
Czech Republic$^+$ → Hungary$^+$	5.040**	1	6.945	3.822
Czech Republic$^-$ → Hungary$^-$	0.718	1	8.254	3.916
Hungary → Czech Republic	0.003	1	6.453	3.747
Hungary$^+$ → Czech Republic$^+$	0.156	1	7.313	3.955
Hungary$^-$ → Czech Republic$^-$	0.074	1	9.310	4.128
Czech Republic → Poland	5.679**	1	6.699	3.976
Czech Republic$^+$ → Poland$^+$	5.083**	1	7.294	3.894
Czech Republic$^-$ → Poland$^-$	3.318	1	7.558	3.998
Poland → Czech Republic	0.056	1	6.408	3.697
Poland$^+$ → Czech Republic$^+$	0.305	1	6.599	3.806
Poland$^-$ → Czech Republic$^-$	0.182	1	8.222	4.092
Czech Republic → Turkey	0.308	1	6.852	3.983
Czech Republic$^+$ → Turkey$^+$	0.119	1	7.012	3.993
Czech Republic$^-$ → Turkey$^-$	0.526	1	8.412	4.162
Turkey → Czech Republic	0.155	1	6.671	3.831
Turkey$^+$ → Czech Republic$^+$	1.084	1	7.194	3.928
Turkey$^-$ → Czech Republic$^-$	1.535	1	7.964	3.963
Hungary → Poland	1.666	1	6.902	3.979
Hungary$^+$ → Poland$^+$	0.001	1	7.106	3.761
Hungary$^-$ → Poland$^-$	1.272	1	8.306	4.016
Poland → Hungary	0.523	1	7.106	3.934
Poland$^+$ → Hungary$^+$	1.271	1	6.924	3.873
Poland$^-$ → Hungary$^-$	0.040	1	8.391	4.000
Hungary → Turkey	2.482	1	6.538	3.826
Hungary$^+$ → Turkey$^+$	0.082	1	7.102	3.913
Hungary$^-$ → Turkey$^-$	1.964	1	9.015	4.090
Turkey → Hungary	0.021	1	6.884	3.838
Turkey$^+$ → Hungary$^+$	0.129	1	7.031	3.972
Turkey$^-$ → Hungary$^-$	0.004	1	8.359	3.933
Poland → Turkey	4.837**	1	6.879	3.761
Poland$^+$ → Turkey$^+$	2.352	1	7.129	4.043
Poland$^-$ → Turkey$^-$	1.652	1	8.003	4.041
Turkey → Poland	2.238	1	6.743	3.824
Turkey$^+$ → Poland$^+$	0.165	1	7.136	3.943
Turkey$^-$ → Poland$^-$	0.556	1	8.164	4.090

Note: '+' and '−' indicate upside and downside causality relations, respectively. *, ** and *** indicate the existence of causal link at the 1, 5 and 10% level, respectively.
Source: Authors' calculation.

According to the standard causality test results, causal relationship is determined at 5% level of significance in which direction of causal link is running from the Czech Republic to Poland and from Poland to Turkey.

Table 6. Hatemi-J Asymmetric Causality Test Results between Germany and CEE Equity Markets.

Causality Direction	Test Value	VAR order	CV 1%	CV 5%
Germany → Czech Republic	0.703	1	6.753	3.915
Germany$^+$ → Czech Republic$^+$	1.989	1	7.532	3.975
Germany$^-$ → Czech Republic$^-$	1.324	1	7.955	3.813
Czech Republic → Germany	2.838	1	7.291	3.988
Czech Republic$^+$ → Germany$^+$	2.911	1	7.125	3.995
Czech Republic$^-$ → Germany$^-$	1.035	1	8.628	4.218
Germany → Hungary	2.820	1	7.007	3.910
Germany$^+$ → Hungary$^+$	1.841	1	6.847	3.862
Germany$^-$ → Hungary$^-$	3.421	1	8.281	3.945
Hungary → Germany	0.293	1	6.992	4.011
Hungary$^+$ → Germany$^+$	0.000	1	7.058	3.901
Hungary$^-$ → Germany$^-$	0.529	1	8.098	3.906
Germany → Poland	0.870	1	7.001	4.067
Germany$^+$ → Poland$^+$	0.044	1	6.874	3.935
Germany$^-$ → Poland$^-$	3.493	1	7.822	3.875
Poland → Germany	1.677	1	6.808	3.899
Poland$^+$ → Germany$^+$	0.658	1	6.609	3.983
Poland$^-$ → Germany$^-$	1.727	1	7.135	3.879
Germany →Turkey	2.040	1	6.739	3.857
Germany$^+$ →Turkey$^+$	0.386	1	6.732	3.897
Germany$^-$ →Turkey$^-$	1.530	1	7.201	3.928
Turkey → Germany	0.216	1	6.723	3.900
Turkey$^+$ → Germany$^+$	0.152	1	7.062	3.938
Turkey$^-$ → Germany$^-$	0.065	1	7.302	4.077

Note: '+' and '–' indicate upside and downside causality relations, respectively. *, ** and *** indicates the existence of a causal link at the 1, 5 and 10% level, respectively.
Source: Authors' calculation.

On the other hand, when we look at the asymmetric causality test results, the Czech Republic stock market is found to be Granger cause of Hungary and Poland stock markets in upside regime at 5% significance level. This finding is interesting because standard causality test results indicate lack of causality relation between the Czech Republic and Hungary. However, evidence is determined in favour of causal link running from the Czech Republic to Hungary in upside market regime.

Finally, existence of financial integration between Germany and CEE countries is examined because Germany is the main trade partner of the countries in question. It is also important for causality testing procedure because a common problem in investigating the causal interrelationships is the possibly of obtaining spurious results due to the effects of common third factors or because there are confounding variables. This is important since a spurious causal relationship between two variables, X and Y, can arise when a common third factor, Z, that causes both X and Y is not included in the model (Hsiao, 1982). In this context, finding evidence in favour of a causal relation running from Germany to CEE countries may lead to find spurious causal relationship among CEE stock markets because Germany stock market may be a common third factor.

The asymmetric causality test results are presented in Table 6. The null hypothesis of German stock market Granger causes CEE countries stock markets at conventional significance level cannot be rejected. In addition, asymmetric causality test results indicate the lack of causal link between Germany stock market and stock markets of CEE countries.

5. Conclusions

Issue of financial market integration is important for investors and academic scholars and hence there is a growing literature that focuses on to examine the presence of financial market integration over the past decades. In this context, the presence of (or lack of) financial market integration among CEE equity markets is analysed by adopting asymmetric causality test proposed by Hatemi-J (2012b) and to the best of authors' knowledge; asymmetric causality test is applied for the first time in the related field of literature for the case of CEE equity markets.

The standard causality test results suggest the presence of a causal link which is running from the Czech Republic to Poland and from Poland to Turkey at 5% significance level. On the other hand; the asymmetric causality test results indicate that the stock market of Czech Republic Granger causes Hungary stock market in upside regime at 5% significance level. The importance of this finding is that standard causality test results indicate lack of a causal relation between the Czech Republic and Hungary. In addition, the Czech Republic stock market Granger causes Poland stock market in upside at 5% significance level. Finally, the presence of a causality relation between Germany and CEE equity markets cannot be determined.

Results of this study suggest the presence of potential benefits for investment in CEE stock markets because limited numbers of causal relations among financial markets are observed and this implies the existence of diversification opportunities for international investors. Note that these results are consistent with empirical results of Middleton, Fifield, and Power (2008). Similarly, substantial benefits of investing in CEE stock markets are observed by Middleton et al. (2008). Therefore, these findings can be considered for the international investors in their portfolio constructing decisions. Furthermore, the asymmetric relation among stock markets can be examined by means of time-varying causality test in the future studies.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Baumöhl, E. (2013). *Stock market integration between the CEE-4 and the G7 markets: Asymmetric DCC and smooth transition approach*(MPRA Paper No. 43834). Retrieved from July 10, 2014, from https://mpra.ub.uni-muenchen.de/id/eprint/43834

Caraiani, P. (2012). Nonlinear dynamics in CEE stock markets indices. *Economics Letters, 114*, 329–331.

Cevik, E. I., Kirci-Cevik, N., & Gurkan, S. (2012). Analyzing the relationship between stock markets of the US, Germany and Turkey with MS-VAR Model. *Journal of BRSA Banking and Financial Markets, 6*, 133–155.

Czerny, A., & Koblas, M. (2008). Stock markets integration and the speed of information transmission. *Czech Journal of Journal of Economics and Finance, 58*, 2–20.

Demian, C.-V. (2011). Cointegration in Central and East European markets in light of EU accession. *Journal of International Financial Markets, Institutions & Money, 21*, 144–155.

Egert, B., & Kočenda, E. (2007). Interdependence between Eastern and Western European stock markets: Evidence from intraday data. *Economic Systems, 31*, 184–203.

Federova, E. (2011). *Transfer of financial risk in emerging Eastern European stock markets: a sectoral perspective*. (BOFIT Discussion Papers 24). Retrieved April 5, 2012, from https://helda.helsinki.fi/bof/bitstream/handle/1234567898238/169458.pdf?sequence=1
Gradojevic, N., & Dobardzic, E. (2013). Causality between regional stock markets: A frequency domain approach. *Panoeconomicus, 60*, 633–647.
Hatemi-J, A. (2003). A new method to choose optimal lag order in stable and unstable VAR models. *Applied Economics Letters, 10*, 135–137.
Hatemi-J, A. (2012a). Is the UAE stock market integrated with the USA stock market? New evidence from asymmetric causality testing. *Research in International Business and Finance, 26*, 273–280.
Hatemi-J, A. (2012b). Asymmetric causality tests with an application. *Empirical Economics, 43*, 447–456.
Hsiao, C. (1982). Autoregressive modeling and causal ordering of economic variables. *Journal of Economic Dynamics and Control, 4*, 243–259.
Kenourgios, D., & Samitas, A. (2011). Equity market integration in emerging Balkan markets. *Research in International Business and Finance, 25*, 296–307.
Korkmaz, T., Zaman, S., & Cevik, E. I. (2008). The integration relationship between ISE and the countries which have a high trade volume with Turkey and European Union equity markets. *Zonguldak Karaelmas University Journal of Social Sciences, 4*, 19–44.
Mandaci, P. E., & Torun, E. (2007). Testing integration between the major emerging markets. *Central Bank Review, 1*, 1–12.
Middleton, C. A. J., Fifield, S. G. M., & Power, D. M. (2008). An investigation of the benefits of portfolio investment in Central and Eastern European stock markets. *Research in International Business and Finance, 22*, 162–174.
Onay, C. (2006). A co-integration analysis approach to European Union integration: The case of acceding and candidate countries. *European Integration Online Papers, 10*, 2–11.
Onay, C., & Unal, G. (2012). Cointegration and extreme value analyses of Bovespa and Istanbul Stock Exchange. *Czech Journal of Economics and Finance, 62*, 66–91.
Ozdemir, Z. A., & Cakan, E. (2007). Non-linear dynamic linkages in the international stock markets. *Physica A: Statistical Mechanics and its Applications, 377*, 173–180.
Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica, 57*, 1361–1401.
Pretorius, E. (2002). Economic determinants of emerging stock market interdependence. *Emerging Markets Review, 3*, 84–105.
Qiao, Z., Li, Y., & Wong, W.-K. (2011). Regime-dependent relationships among the stock markets of the US, Australia and New Zealand: A Markov-switching VAR approach. *Applied Financial Economics, 21*, 1831–1841.
Ratanapakorn, O., & Sharma, S. C. (2002). Interrelationships among regional stock indices. *Review of Financial Economics, 11*, 91–108.
Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics, 66*, 225–250.
Zivot, E., & Andrews, W. K. D. (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business and Economic Statistics, 10*, 251–270.