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Year: 2020

Version: Accepted manuscript

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Please cite the original version:

Nikkinen, Jussi; Piljak, Vanja; Rothovius, Timo, (2020). Impact of the 2008–2009 financial crisis on the external and internal linkages of European frontier stock markets. *Global finance journal*. https://doi.org/10.1016/j.gfj.2019.100481

IMPACT OF THE 2008–2009 FINANCIAL CRISIS ON THE EXTERNAL AND INTERNAL LINKAGES OF EUROPEAN FRONTIER STOCK MARKETS

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Note: Accepted for publication in Global Finance Journal

Abstract

This study investigates the impact of the 2008–2009 financial crisis on (i) external linkages of European frontier stock markets (Croatia, Estonia, Romania, Slovakia and Slovenia) with the developed equity markets (the US, the UK, and Germany) and (ii) internal linkages within the frontier markets. The results demonstrate that both long- and short-run external linkages were strengthened during the crisis. The analysis of internal linkages reveals strong relationship only between the Croatian and Slovenian markets. However, the other frontier markets in the group were weakly linked, implying that European frontier stock markets may constitute a good alternative source of diversification benefits during crises periods.

JEL classification: F36; G11; G15

Keywords: Frontier market, Diversification benefits, Financial crisis

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1. Introduction

Interdependence among emerging and developed stock markets has become an important issue in the international portfolio diversification literature due to relevant implications for asset allocation management (see e.g., Graham et al., 2012). In addition, the financial crises over the past two decades have emphasized how important it is to examine stock market linkages in turbulent times, in order to identify markets that are able to provide diversification benefits during crises periods. Traditionally, investors looked for shelter by diversifying to emerging markets, and consequently, emerging markets finance has evolved into an important research topic in the recent years (Dimitriou et. al, 2013). Although many studies on international stock market linkages have focused on emerging markets in different regions, only limited research is conducted on the frontier markets (a subset of emerging markets characterized by thin trading activity, short history, and higher risk level). The frontier markets are becoming increasingly important for international investors because of their significant diversification potential, resulting from lower correlations with developed markets.

This study examines the impact of the 2008–2009 financial crisis on the external and internal linkages of European frontier stock markets (Croatia, Estonia, Romania, Slovakia and Slovenia). European frontier markets are of special research interest due to their accelerated economic growth. The external linkages refer to the linkages between European frontier stock markets and developed markets (the US, the UK, and Germany), while internal linkages refer to the linkages within the group of the frontier markets. We investigate long- and short-run dynamic linkages in the pre-crisis, crisis, and post-crisis period. Given the evidence in the literature that financial crises affect the strength of the stock market linkages, and consequently, level of the potential diversification opportunities (Yang et al., 2003; Syllignakis and Kouretas, 2011), it is important to investigate how the frontier markets are affected by the global financial crisis.

This study contributes to the existing literature in two ways. First, we examine external and internal linkages separately during the pre-crisis, crisis, and post-crisis period. Although most of the previous literature suggest that financial crisis enhances stock market integration (Yang et al., 2003), there still exists the question whether a financial crisis permanently or temporarily changes the level of stock market linkages. Our study provides new insights into this issue from the perspective of frontier markets. Second, by focusing on the European frontier markets as a special subset of emerging markets, on which very limited research has been conducted, we contribute to the body of emerging market literature. Other related studies mainly focus on the co-movement of frontier stock markets with major developed markets (e.g. Kiviaho et al., 2014), but they do not address the internal dynamics within the European frontier markets.

The remainder of the paper is organized as follows. Section 2 presents a brief overview of related literature. Section 3 describes the market environment and the data. The econometric analysis is given in Section 4. Section 5 reports the empirical results. Section 6 concludes.

2. Related literature on the European frontier markets

Most of the earlier literature on international stock market linkages has focused on the developed markets (e.g., Friedman and Shachmurove, 1997; Bessler and Yang, 2003), and more recently on the emerging markets (e.g., Syllignakis and Kouretas, 2011). In particular, research on equity linkages between emerging European and developed markets has focused on major emerging markets (Poland, Hungary, and the Czech Republic). The empirical findings are not consistent in all studies. Several studies provide evidence on the existence of long-run equilibrium of those markets with mature counterparts (e.g. Syriopoulos, 2007; Voronkova, 2004); while no long-run relationship is found in Gilmore et al. (2008). However, very limited research is conducted on a subset of the frontier markets in Europe. One of the few contributions to the literature on frontier markets, Syriopoulos (2011), investigates linkages among Balkan markets and developed stock markets. His

empirical results are in line with Syriopoulos (2007) and Voronkova (2004) suggesting limited diversification benefits in the long-term, while the short-term benefits might still be feasible. Berger et al. (2011) document promising diversification potential of the frontier markets worldwide. Kiviaho et al. (2014) show that European frontier stock markets might be considered as significant source of diversification benefits (especially for short-term horizons) even during the financial crisis. As a consequence of the 2008–2009 financial crisis[1], there is a renewed interest in investigating how financial crisis may affect international stock market linkages. The study by Chudik and Fratzscher (2011) examines the effects of the recent 2008–2009 financial crisis on the developed stock markets and bigger emerging markets in different regions, while Kenourgios and Samitas (2011) investigate impact of the financial crisis on the time-varying correlation dynamics among the developed and the Balkan stock markets. Syllignakis and Kouretas (2011) document a significant impact of the 2008–2009 financial crisis on stock market linkages between seven emerging markets in Central and Eastern Europe and the US and German stock markets. Nikkinen et al. (2012) address the effects of the global financial crisis on the linkages between the Baltic and European developed stock markets. Samarakoon (2011) finds that linkages of frontier markets with the USA were affected by the global financial crisis, although the magnitude of the effect was small.

3. Market environment and data description

The sample is selected according to the Standard and Poor's classification of frontier markets and covers major European frontier markets included in the S&P Extended Frontier 150 Index.[2] The dataset consists of weekly stock price indices of Croatia (CROBEX), Romania (BET), Estonia (OMX Tallinn), Slovakia (SAX), Slovenia (SBI20), the United States (S&P 500), the United Kingdom (FTSE100), and Germany (CDAX). Following Syriopoulos (2011), we use stock price

[1] A comprehensive analysis of the responses of the U.S. and the European Monetary Union to the global financial crisis of 2008–2009 is provided by Kowalski and Shachmurove (2014). In addition, Lucey et al. (2018) provide the most recent overview of the effects of the global financial crisis on financial markets.

[2] Four European countries included in the Index are left out from the sample due to either short period of data availability (Ukraine and Bulgaria) or very small size of the market (Latvia and Lithuania).

indices denominated in the home currency of each respective country, in order to avoid potential distortion caused by the currency devaluations. The stock indices are transformed into daily rates of returns taking the natural logarithmic first difference of each stock price index. In order to alleviate the problem of non-synchronous trading, we use weekly returns.

The time period under study extends from September 19, 1997 to December 27, 2013. The starting date of our sample is determined by the earliest data available for the Romanian stock market. The sample period is divided into three sub-periods: pre-crisis (September 19, 1997 - July 27, 2007); crisis (August 3, 2007 - March 27, 2009); and post-crisis period (April 3, 2009 - December 27, 2013). The length of the crisis period is determined by official timelines provided by Federal Reserve Board of St. Louis (2009) and the Bank for International Settlements (BIS, 2009). According to their timelines, the crisis can be defined from August 1, 2007 until March 31, 2009. The same crisis period specification is provided in Dimitriou et al. (2013). All the index data used in the study are extracted from the Thomson Datastream database. The empirical analysis is conducted by using statistical softwares EViews and RATS.

Table 1 provides an overview of the main characteristics of the European frontier markets, including market capitalization, net inflows of foreign direct investments and annual GDP growth rates. These markets are characterized by a substantial variation in terms of market size, attractiveness to foreign investors and speed of economic development. The largest stock market prior to the crisis (at the end of 2007) was Croatia, with a market capitalization of 65.97 billion US dollars (USD), while the equity market of Estonia was the smallest with only 6.03 billion USD. During the crisis, market capitalization decreased remarkably in all markets. In addition, the economic growth differs across the markets. For instance, Estonia and Slovakia had fast economic growth from 1999 to 2006 (the annual GDP growth rate of Estonia changed from -0.27% in 1999 to 11.18% in 2006), whereas Slovenia and Croatia had slow, but relatively even growth (between 3%

and 5%). However, due to the financial crisis, all of the examined countries recorded negative GDP growth in 2009, after which most of the countries started to recover with positive GDP growth rates.

(Insert Table 1 about here)

The European frontier markets bear similarities in their rapid and successful transition from communist to capitalist systems, including a broad set of economic reforms to liberalize the financial sector and eliminate legal restrictions on foreign investments. Those restrictions were lifted mostly before year 2000 (see Table 2, Panel C), which in conjunction with privatization of state-owned enterprises and accession to the European Union significantly enhanced investment profiles of these markets. The descriptive statistics and unconditional correlations of the returns series in the pre-crisis, crisis and post-crisis periods are presented in Table 2 (Panels A and B). In the pre-crisis period, all frontier markets had higher average daily returns than the developed markets. During the crisis, the average returns of the frontier markets (except Slovakia) were lower compared to the developed markets. In the post-crisis period, Estonia and Romania had higher average returns than the developed markets, while Croatia, Slovakia and Slovenia recorded much lower returns. The correlations of the frontier and developed markets were very low in the pre-crisis period; but they have increased substantially during the crisis (for example, between Croatia and the US from 0.23 in the pre-crisis to 0.60 during the crisis period). The correlations within the group of the frontier markets are also drastically increased. In the post-crisis period, the correlations in general have decreased compared to the level during the crisis, but still remained higher than in the pre-crisis period.

(Insert Table 2 about here)

4. Econometric framework of analysis

In order to analyze long- and short-run relationships between the investigated stock markets, we employ a cointegrated vector autoregression (VAR) framework (Engle and Granger, 1987), including cointegration analysis, Granger causality test (Granger, 1969), impulse response analysis and forecast error variance decomposition. Long-run relationships among European frontier stock markets and developed markets are examined by using Johansen (1991) procedure to test for the presence and number of cointegrating vectors. Before testing whether the stock price series are cointegrated, it should be verified that each series is non-stationary. The stationarity of time-series is examined by conducting the augmented Dickey-Fuller (Dickey and Fuller, 1981) unit root test in logarithms and first differences. The unit root test results, presented in Table 3, show that there is a unit root in each of stock price indices in all three sub-periods, but no unit root in their first differences (i.e., the equity index returns are stationary) at the 5% significance level.

(Insert Table 3 about here)

The existence of cointegrating vectors implies the use of a vector error-correction model (VECM), proposed by Engle and Granger (1987), to examine long- and short-run linkages among investigated stock markets. We estimate a VECM for each sub-period under study. Let X_t denotes a vector that includes p non-stationary variables (stock price indices). In case that p time series are cointegrated, a VECM with $k - 1$ lags is of the following form:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \qquad (1)$$

where Δ is the difference operator ($\Delta X_t = X_t - X_{t-1}$), X_t is a (p x 1) vector of prices, Π is a coefficient matrix ($\Pi = \alpha\beta'$), the matrix α contains short-run adjustment parameters towards long-run relationship and the matrix β contains long-run coefficients, while Γ_i is a matrix defining the short-

run adjustments to changes in the variables. The number of cointegrating vectors r (linearly independent columns in Π) is determined by the rank of Π. The impact of the crisis on the long-run stock price relationship is examined by comparing the number of cointegrating vectors in the pre-crisis and crisis periods (see, Yang et al., 2003). In this study, p (number of markets) is equal to 8. The appropriate lag length of the VAR system is determined by applying the modified likelihood ratio test. Lag length of seven is chosen for the pre-crisis and crisis periods, while three lags are selected for the post-crisis period. The short-run causal linkages between different pairs of markets are investigated by Granger causality test, which provides insights into lead-lag relationships between stock markets examined. Further analysis is conducted by applying generalized impulse response analysis, developed by Pesaran and Shin (1998), since these generalized impulse responses do not depend on the order of the variables. Finally, the forecast error variance decomposition is used to detect the fraction of the variation in one stock market explained by a variation in other stock markets in the system.

5. Empirical results

The results of the cointegration analysis for all three sub-periods are reported in Table 4. The cointegration specification includes a constant term, but no trend in the cointegration vector. We report results from the trace test for cointegration, with the critical values tabulated in Osterwald-Lenum (1992). According to the λ_{trace} test, the null hypothesis that investigated markets are not cointegrated (r = 0) is rejected in all three sub-periods, since the λ_{trace} statistic exceeds the critical value at the 5% significance level. The λ_{trace} test indicates presence of two cointegrating vectors in the pre-crisis and post-crisis periods, while during the crisis period the number of cointegrating vectors is equal to seven. These results suggest that the long-run linkages between frontier and developed markets were strengthened during the crisis period.

(Insert Table 4 about here)

The results from the Granger causality tests are presented in Table 5. Each column shows the values of F-statistics testing the marginal effect of inclusion of lagged returns of the market in the row (affecting market) on the market in the column (affected market). In the pre-crisis period, the frontier markets were not affected by the developed markets, with the exception of Croatia (affected by the UK at 10% significance level) and Slovakia (affected by Germany at 5 % level). During the crisis period, the Estonian and Romanian markets were affected by the US market, while the other frontier markets showed no signs of significant causality relations with the developed markets. In the post-crisis period, the Romanian and Croatian markets were influenced by the US market (at 10% level). In addition, the UK market started to be influential for the Croatian, Estonian, and Slovenian markets. The causality relationships within the frontier markets group vary considerably across countries and across sub-periods. For instance, Slovenia was the most influential market in pre-crisis period, affecting all other frontier markets except Slovakia; while in post-crisis period Slovenia was affecting only Estonia.

(Insert Table 5 about here)

In order to quantify the interdependences among the stock markets investigated, variance decomposition analysis is used. Table 6 shows results of 1-week and 4-weeks ahead forecast error variances of each frontier market's stock index return series in pre-crisis, crisis, and post-crisis periods. In pre-crisis period, the most of the forecast error variance of each frontier market is attributable to the market itself (ranging from 83.9% in Slovenia to 98.7% in Slovakia for 1-week window). The results indicate that the developed markets have only minor impact on returns of the frontier markets in pre-crisis period. For instance, the greatest impact of appeared to be in the case of

Croatia, where the US market returns explain 11% of the forecast variance of returns one week ahead.

In addition, the linkages within the frontier markets group are rather weak. The strongest relationship is observed between Croatia and Slovenia, where the proportion of the Slovenian market forecast error variance (at 1-week window) explained by Croatian returns is 5.7%. During the crisis period, there is a substantial increase in the percentage of the frontier markets' forecast error variance that is collectively attributable to innovations in the returns of the developed markets. The greatest change is observed for Romania (from 6.8% in pre-crisis to 66% during the crisis), followed by Croatia (from 13.9% to 55.7%) and Slovenia (from 10.3% to 40%). The Estonian and Slovakian market show minor change in the behavior during the crisis (corresponding percentage is changed from 12.3% to 17.4% for Estonia and from 0.7% to 8.7% for Slovakia). In the post-crisis period, the corresponding percentage in all frontier markets decreased compared to the crisis period; but stayed on higher level (21.1% for Croatia, 37.4% for Romania, and 15.5% for Estonia) than in the pre-crisis period. The Slovenian and Slovakian markets are exceptions from this pattern, since the corresponding percentage in the post-crisis period returned to approximately same level as in the pre-crisis period. The linkages within the frontier markets group are still rather weak in the crisis and post-crisis period, with the exception of the Slovenian market, where the proportion of the Slovenian market forecast error variance explained by Croatian returns is 20.7% in the crisis and 9.9% in the post-crisis period.

Generalized impulse response functions provide information about responsiveness of each market to shocks coming from the other markets in the VAR system. The responsiveness is determined by the speed with which shocks in a particular market are transmitted to the other markets. The plots of the time path of impulse responses of each frontier stock market to one standard error shock of the US market in the pre-crisis, crisis and post-crisis period are shown in

Figure 1.[3] The speed and size of response vary across countries, but the common pattern is that the size of response has increased during the crisis period in all frontier markets.

(Insert Table 6 and Figure 1 about here)

6. Conclusions

We examine the impact of the 2008–2009 financial crisis on (i) external linkages of European frontier stock markets (Croatia, Estonia, Romania, Slovakia and Slovenia) with the three developed stock markets (the US, the UK, and Germany), and (ii) internal linkages within the frontier markets. Emphasis has been placed on assessing the strength of the linkages in the pre-crisis, crisis and post-crisis period. The results support the presence of cointegration relationships among investigated stock markets in all three sub-periods, indicating that they share a long-run equilibrium. During the crisis period, the cointegration relationships became more evident (increase in the number of cointegrating vectors), implying a significant impact of the global financial crisis on strengthening the long-term external linkages of the European frontier markets. Further evidence from the variance decomposition indicates that short-run external linkages of the examined frontier markets were also strengthened during the crisis. In the post-crisis period, the strengthening effect continued for Croatia, Estonia and Romania; while the strength of external linkages in the case of Slovenia and Slovakia returned approximately to the level in the pre-crisis period.

The results for internal linkages within the frontier markets group reveal very low level of mutual interdependence among the group members in all three sub-periods. In particular, relatively strong linkages are observed only between the Croatian and Slovenian markets; which may be explained by their historical links and geographic proximity, as they are adjacent countries which were parts of the same country (the former Yugoslavia) for more than 40 years and have strong

[3] The graphs of the impulse responses of frontier markets to one standard error shock originating from the UK and German market are not shown here; they are available upon request.

economic relations. The remaining frontier markets in the group are weakly linked, implying that European frontier stock markets might be considered as an alternative for potential diversification benefits during the crises periods. Overall, our study provides new insights into the field of stock market co-movement dynamics, given our evidence from the frontier markets perspective.

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Table 1. Market indicators for European frontier stock markets

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Market capitalization (billions of US dollars)																
Croatia	4.24	3.19	2.58	2.74	3.31	3.97	6.12	10.95	12.91	29.00	65.97	26.79	25.63	24.91	21.79	21.55
Estonia	1.10	0.51	1.78	1.84	1.48	2.42	3.79	6.20	3.49	5.96	6.03	1.95	2.65	2.26	1.61	2.33
Romania	0.62	1.01	0.87	1.06	2.12	4.56	5.58	11.78	20.58	32.78	44.92	19.92	30.32	32.38	21.19	15.92
Slovakia	1.82	0.96	1.06	1.21	1.55	1.90	2.77	4.41	4.39	5.57	6.97	5.07	4.67	4.14	4.73	4.61
Slovenia	1.62	2.45	2.18	2.54	2.83	4.60	7.13	9.67	7.89	15.18	28.96	11.77	11.76	9.42	6.32	6.47
Market capitalization (percent of GDP)																
Croatia	18.06	12.70	11.19	12.75	14.39	14.98	17.94	26.72	28.82	58.17	111.22	38.32	40.41	42.31	35.27	36.40
Estonia	21.79	9.27	31.34	32.52	23.75	33.17	38.49	51.55	25.13	35.91	28.23	8.29	13.90	11.95	7.15	10.41
Romania	1.77	2.41	2.45	2.88	5.28	9.95	9.38	15.61	20.81	26.73	26.53	9.95	18.82	19.69	11.16	8.26
Slovakia	6.75	3.29	3.53	4.24	5.14	5.50	6.06	7.87	7.16	8.07	8.27	5.15	5.33	4.76	4.94	5.05
Slovenia	7.95	11.26	9.77	12.80	13.92	19.96	24.55	28.69	22.09	38.97	61.21	21.54	23.93	20.09	12.58	14.29
Foreign direct investment, net inflows (billions of US dollars)																
Croatia	0.54	0.94	1.45	1.10	1.58	1.09	2.04	1.07	1.78	3.45	4.99	6.01	2.95	0.78	1.28	1.39
Estonia	0.26	0.58	0.30	0.38	0.54	0.28	0.91	0.96	2.94	1.78	2.72	1.74	1.75	2.05	0.52	1.64
Romania	1.21	2.03	1.04	1.03	1.15	1.14	1.84	6.44	6.48	11.39	9.92	13.88	6.31	3.20	2.55	2.02
Slovakia	0.17	0.56	0.35	2.05	NA	4.10	0.55	3.03	2.41	4.16	3.36	3.23	1.61	2.11	3.65	1.52
Slovenia	0.33	0.21	0.10	0.13	0.50	1.65	0.30	0.83	0.54	0.64	1.53	1.93	-0.57	0.63	0.81	-0.22
GDP growth (annual %)																
Croatia	6.54	1.97	-1.04	3.75	3.65	4.87	5.31	4.12	4.27	4.93	5.05	2.40	-5.80	-1.40	-0.92	-1.97
Estonia	11.73	6.80	-0.27	9.55	7.66	8.01	7.23	8.25	10.15	11.18	7.11	-5.12	-14.08	2.56	9.55	3.93
Romania	-6.10	-4.78	-1.2	2.10	5.70	5.10	5.19	8.40	4.17	7.90	6.00	9.42	-8.50	-1.64	3.04	3.10
Slovakia	4.44	4.36	0.03	1.37	3.48	4.58	4.77	5.03	6.66	8.50	10.58	6.17	-6.20	4.18	3.00	1.8
Slovenia	4.95	3.51	5.32	4.38	2.85	3.97	2.83	4.28	4.49	5.80	6.79	3.49	-7.80	1.37	0.70	-2.50

Source: World Development Indicators (WDI) Database available on the World Bank's website. (http://databank.worldbank.org/data/databases.aspx)

Table 2.

Panel A: Descriptive statistics

	USA	UK	Germany	Croatia	Estonia	Romania	Slovakia	Slovenia
Pre-crisis								
Mean	0.0008	0.0004	0.0008	0.0027	0.0014	0.0044	0.0016	0.0035
Median	0.0016	0.0021	0.0033	0.0027	0.0027	0.0027	0.0003	0.0024
Maximum	0.0749	0.1006	0.1121	0.1658	0.1911	0.2448	0.1884	0.0835
Minimum	-0.1233	-0.0886	-0.1260	-0.2672	-0.2485	-0.2139	-0.0972	-0.1191
Standard Deviation	0.0235	0.0224	0.0299	0.0396	0.0412	0.0440	0.0300	0.0199
Skewness	-0.5269	-0.2074	-0.2817	-0.5612	-1.2520	0.1199	0.6645	-0.2175
Kurtosis	5.7824	4.5883	4.5169	9.7178	12.5898	6.9079	6.9989	7.1043
Observations	514	514	514	514	514	514	514	514
Crisis								
Mean	-0.0066	-0.0053	-0.0076	-0.0142	-0.0143	-0.0163	-0.0039	-0.0135
Median	-0.0040	-0.0028	-0.0078	-0.0124	-0.0120	-0.0137	-0.0003	-0.0085
Maximum	0.1135	0.1258	0.1401	0.1361	0.0900	0.1054	0.0512	0.0804
Minimum	-0.2008	-0.2363	-0.2404	-0.2948	-0.1541	-0.3152	-0.1011	-0.1830
Standard Deviation	0.0438	0.0451	0.0491	0.0548	0.0414	0.0624	0.0217	0.0410
Skewness	-0.6069	-1.1982	-0.9946	-1.6684	-0.8368	-1.6188	-1.6679	-1.4470
Kurtosis	6.9887	10.6223	8.5608	10.4688	5.2751	9.0292	8.4443	7.8172
Observations	87	87	87	87	87	87	87	87
Post-crisis								
Mean	0.0032	0.0022	0.0027	0.0008	0.0042	0.0039	-0.0017	-0.0014
Median	0.0036	0.0031	0.0052	-0.0002	0.0016	0.0030	0.0003	-0.0033
Maximum	0.0712	0.0723	0.0973	0.1419	0.1596	0.1036	0.1224	0.0925
Minimum	-0.0746	-0.1028	-0.1378	-0.0921	-0.0805	-0.1544	-0.1515	-0.0630
Standard Deviation	0.0225	0.0223	0.0282	0.0240	0.0299	0.0321	0.0256	0.0233
Skewness	-0.2692	-0.4810	-0.6880	0.9065	1.1873	-0.4709	-1.2780	0.3782
Kurtosis	4.1499	5.3041	5.8735	9.4590	8.4438	6.2857	11.3635	3.9524
Observations	247	247	247	247	247	247	247	247

Table 2.

Panel B: Correlation coefficients of stock market returns

	USA	UK	Germany	Croatia	Estonia	Romania	Slovakia
Pre-crisis							
UK	0.72						
Germany	0.73	0.78					
Croatia	0.23	0.26	0.26				
Estonia	0.14	0.20	0.25	0.12			
Romania	0.03	-0.01	0.03	0.06	0.12		
Slovakia	0.06	0.12	0.05	0.06	0.07	0.03	
Slovenia	0.09	0.12	0.13	0.22	0.14	0.17	0.03
Crisis							
UK	0.88						
Germany	0.89	0.94					
Croatia	0.60	0.61	0.68				
Estonia	0.42	0.46	0.51	0.65			
Romania	0.54	0.55	0.63	0.66	0.52		
Slovakia	0.09	0.07	0.08	0.25	0.21	0.16	
Slovenia	0.56	0.62	0.63	0.70	0.61	0.60	0.23
Post-crisis							
UK	0.88						
Germany	0.86	0.87					
Croatia	0.49	0.44	0.41				
Estonia	0.31	0.35	0.34	0.40			
Romania	0.55	0.54	0.58	0.47	0.38		
Slovakia	0.04	0.02	0.05	0.11	0.17	0.14	
Slovenia	0.28	0.25	0.29	0.38	0.15	0.34	0.06

Panel C: Stock markets highlights and relevant dates in financial liberalization process

Country	Index	Stock exchange	Stock market established	Removal of restrictions
Croatia	CROBEX	Zagreb	1991	1998
Estonia	OMX Tallinn	Tallinn	1995	1996
Romania	BET	Bucharest	1995	1998
Slovakia	SAX	Bratislava	1991	1998
Slovenia	SBI 20	Ljubljana	1989	1999

Notes: Estonia, Slovenia and Slovakia joined the EU in 2004; Romania joined in 2007; while Croatia joined in January 2014.

*Sources: National stock exchanges, Bekaert and Harvey (2002)**

*Bekaert, G., & Harvey, C. R. (2002). Chronology of important financial, economic and political events in emerging markets. (http:// www.duke.edu/_charvey/chronology.htm).

Table 3. Unit root tests

	Pre-crisis		Crisis		Post-crisis	
	level	first difference	level	first difference	level	first difference
USA	-1.49	-25.82***	-0.25	-9.95***	-0.60	-16.92***
UK	-1.51	-23.80***	-0.54	-10.83***	-2.40	-16.29***
Germany	-0.93	-21.16***	-0.23	-10.26***	-1.37	-16.65***
Croatia	5.43	-20.71***	0.05	-8.36***	-2.67	-14.06***
Estonia	1.29	-11.09***	-1.14	-7.48***	-1.90	-9.04***
Romania	2.57	-19.59***	-0.41	-9.59***	1.27	-15.61***
Slovakia	-0.05	-9.53***	1.16	-8.40***	-1.65	-17.98***
Slovenia	5.01	-7.05***	0.10	-9.80***	-1.11	-16.02***

Note: The unit root test is the Augmented Dickey-Fuller test. *** denotes statistical significance at the 1% level.

Table 4. Trace tests for the number of cointegrating vectors

Number of cointegrating vectors		λ_{trace} test			Critical value (5%)
H_o	H_1	Pre-crisis	Crisis	Post-crisis	
$r = 0$	$r > 0$	198.76	486.36	186.47	156.00
$r \leq 1$	$r > 1$	132.85	340.06	130.25	124.24
$r \leq 2$	$r > 2$	83.27	222.03	84.26	94.15
$r \leq 3$	$r > 3$	54.16	144.33	50.10	68.52
$r \leq 4$	$r > 4$	35.58	85.66	31.30	47.21
$r \leq 5$	$r > 5$	21.53	43.75	18.89	29.68
$r \leq 6$	$r > 6$	8.88	16.86	7.92	15.41
$r \leq 7$	$r = 8$	3.19	0.64	0.01	3.76

Note: The number of cointegrating vectors (r) is tested using the trace test with a constant, but no linear trend in the cointegrating vector. H_o (H_1) refers to null (alternative) hypothesis of the number of cointegrating vectors. Critical values are tabulated in Osterwald-Lenum (1992).

Table 5. F-tests for Granger causality

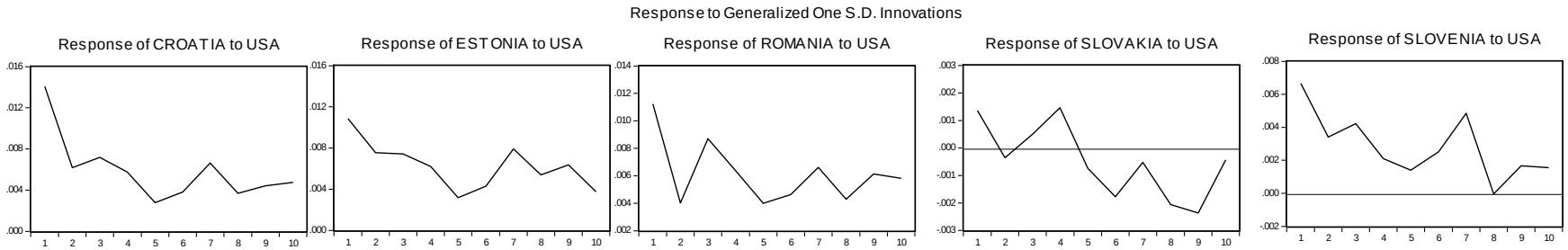
	Affected markets				
Affecting market	Croatia	Estonia	Romania	Slovakia	Slovenia
Pre-crisis period					
USA	1.10	0.37	1.15	1.12	0.67
UK	1.96*	1.21	1.64	0.95	0.95
Germany	0.62	0.97	0.30	2.05**	1.03
Croatia	1.64	2.67**	1.70	0.72	1.36
Estonia	2.43**	2.34**	1.00	0.57	4.17***
Romania	2.82***	1.26	0.69	1.58	0.88
Slovakia	0.99	1.40	0.72	1.67	1.63
Slovenia	3.42***	1.98*	2.29**	0.66	3.45***
Crisis period					
USA	1.44	2.47**	2.08*	1.03	0.97
UK	1.15	0.97	1.56	0.27	1.29
Germany	0.56	1.37	0.20	0.49	0.42
Croatia	2.10*	1.32	1.63	0.39	1.64
Estonia	0.42	1.06	0.65	0.42	0.12
Romania	0.46	0.64	0.34	1.27	1.10
Slovakia	0.87	3.11**	0.75	0.67	1.12
Slovenia	0.78	1.56	0.51	0.49	0.71
Post-crisis period					
USA	2.24*	2.02	2.62*	1.12	0.54
UK	4.36***	3.36**	2.07	1.81	2.14*
Germany	1.04	0.25	0.72	1.93	1.21
Croatia	1.27	0.10	0.60	0.54	0.47
Estonia	1.60	1.04	1.21	0.53	0.12
Romania	1.30	1.85	0.58	2.60*	0.14
Slovakia	2.85**	5.49***	0.27	4.14***	0.20
Slovenia	0.54	2.27*	0.19	1.98	0.61

Note: *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

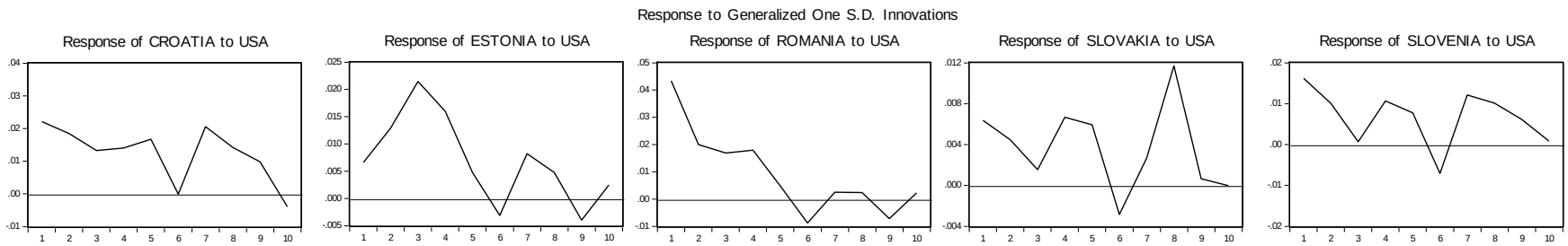
Table 6. Variance decomposition

Country	Percentage of forecast error variance in							
Period (weeks)	USA	UK	Germany	Croatia	Estonia	Romania	Slovakia	Slovenia
Croatia								
Pre-crisis (1)	11.07	2.73	0.13	86.07	0.00	0.00	0.00	0.00
Pre-crisis (4)	15.20	3.53	0.29	76.16	1.40	1.74	0.81	0.87
Crisis (1)	26.03	29.69	0.04	44.24	0.00	0.00	0.00	0.00
Crisis (4)	30.29	26.55	1.22	23.80	0.53	5.37	7.95	4.29
Post-crisis (1)	20.75	0.26	0.12	78.87	0.00	0.00	0.00	0.00
Post-crisis (4)	13.98	7.22	0.27	74.06	0.48	1.44	1.75	0.80
Estonia								
Pre-crisis (1)	8.41	0.63	3.35	0.09	86.54	0.00	0.00	0.98
Pre-crisis (4)	15.57	2.40	3.45	1.19	73.17	2.35	0.44	1.43
Crisis (1)	6.61	10.48	0.32	2.82	65.68	0.00	0.00	14.09
Crisis (4)	38.32	13.80	2.46	4.72	19.16	10.73	5.65	5.16
Post-crisis (1)	7.48	7.98	0.05	2.67	81.75	0.00	0.00	0.07
Post-crisis (4)	5.62	27.53	0.14	2.21	51.63	1.05	7.53	4.29
Romania								
Pre-crisis (1)	5.44	0.66	0.71	0.93	0.52	88.05	0.00	3.69
Pre-crisis (4)	9.38	3.97	0.67	1.29	0.60	79.85	0.08	4.16
Crisis (1)	59.53	5.58	0.95	4.95	1.00	27.55	0.00	0.44
Crisis (4)	48.46	8.16	1.08	3.99	4.82	23.92	7.99	1.58
Post-crisis (1)	32.74	3.74	1.01	3.83	0.63	56.82	0.00	1.23
Post-crisis (4)	29.95	10.05	3.32	3.23	3.02	48.30	0.57	1.56
Slovakia								
Pre-crisis (1)	0.20	0.57	0.00	0.49	0.04	0.00	98.70	0.00
Pre-crisis (4)	0.43	1.06	0.16	1.47	0.40	1.87	94.31	0.30
Crisis (1)	7.98	0.36	0.36	10.82	0.82	2.11	74.04	3.51
Crisis (4)	13.83	5.98	3.57	9.22	1.79	7.65	54.28	3.68
Post-crisis (1)	0.44	0.07	0.01	0.00	0.36	0.29	98.83	0.00
Post-crisis (4)	2.39	2.60	2.75	0.12	2.30	4.83	82.38	2.63
Slovenia								
Pre-crisis (1)	7.97	1.83	0.50	5.75	0.00	0.00	0.00	83.95
Pre-crisis (4)	11.65	2.08	0.78	6.65	0.42	0.35	1.21	76.86
Crisis (1)	29.19	10.80	0.03	20.75	0.00	0.00	0.00	39.23
Crisis (4)	27.94	13.15	2.06	11.29	0.73	7.75	13.44	23.64
Post-crisis (1)	8.44	0.30	0.57	9.98	0.00	0.00	0.00	80.71
Post-crisis (4)	7.20	2.29	2.04	8.47	0.21	0.15	0.21	79.43

Panel A: Pre-crisis period



Panel B: Crisis period



Panel C: Post-crisis period

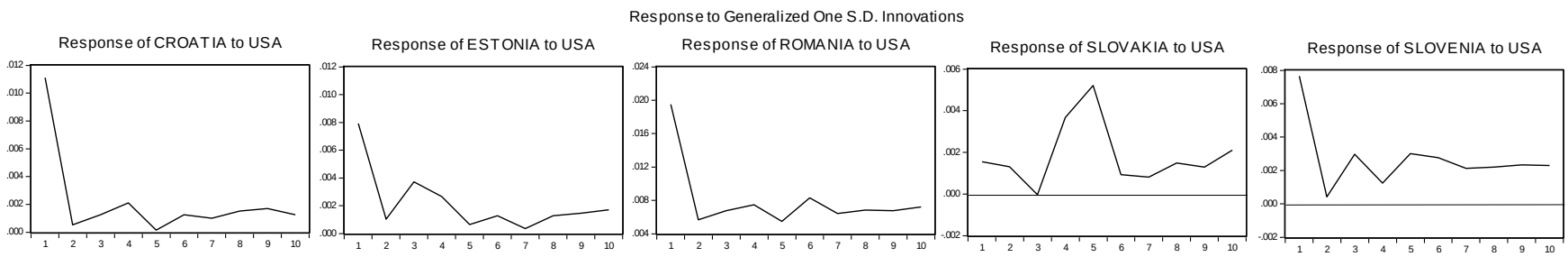


Figure 1. Impulse response function in the pre-crisis (Panel A), crisis (Panel B), and post-crisis period (Panel C).