GLOBALIZATION EFFECTS ON CONTAGION RISKS IN FINANCIAL MARKETS

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Abstract: Financial globalization has opened international capital markets to investors and companies worldwide. However, the global financial crisis also caused massive stock price volatility due in part to global availability of market information. We explore ten EU member states (France, Germany, the United Kingdom, Belgium, Bulgaria, Romania, Greece, Portugal, Ireland, and Spain), and the USA. The explored period is March 3, 2003 to June 30, 2016, and includes the effects of the global financial crisis of 2008. The purpose of the article is to determine whether there is a contagion effect between the Bulgarian stock market and the other examined stock markets during the crisis period and whether these markets are efficient. We apply an augmented Dickey-Fuller test, DCC-GARCH model, autoregressive (AR) models, TGARCH model, and descriptive statistics. Our results show that a contagion between the Bulgarian capital market and the eight capital markets examined did exist during the global financial crisis of 2008. We register the strongest contagion effects from the U.S. and German capital markets on the Bulgarian capital market. The Bulgarian capital market is relatively integrated with the stock markets of Germany and the United State, which serves as an explanation of why the Bulgarian capital market was exposed to financial contagion effects from the U.S. capital market and the capital markets of EU member states during the crisis. We register statistically significant AR (1) for UK, Greece, Ireland, Portugal, Romania, and Bulgaria, and we can define these global capital markets as inefficient.

Keywords: efficient market hypothesis; capital markets; dynamic conditional correlations; financial contagion; globalization

JEL Classification: C22; G01; G14; G15; F65

1. Introduction

Financial crises are a severe phenomenon found in both developed and emerging countries. The 2008 financial crisis caused big volatility in stock price, which poses a challenge to the efficient market hypothesis (EMH), according to which stock prices should always show a full reflection of all available and relevant information and follow a random walk process. The global financial crisis of undoubtedly 2008 affected the efficiency of the global capital markets, financial activities, and macroeconomic conditions. "Contagion" became the catchword for such phenomena and is now widely being used to describe the spread of financial disturbances from one country to another (Dimitriou and Kenourgios, 2014). After the crisis of 2008, the European and U.S. stock markets underwent large depreciation and high stock market volatility. To examine the extent of independence and contagion between these capital markets before, during, and after the crisis, we apply the DCC-GARCH model (Erdas, 2019).

In this article, we aim to determine whether there were contagion effects between the capital markets of France (CAC 40), Germany (DAX), The United Kingdom (FTSE 100), Belgium (BEL- 20), Bulgaria (SOFIX), Romania (BET), Greece (ATHEX20), Portugal (PSI-20), Ireland (ISEQ-20), Spain (IBEX35), and USA (DJIA) during the crisis period and whether these markets are efficient. We apply a bivariate dynamic conditional correlation-generalized autoregressive conditional heteroscedasticity (DCC-GARCH) model to estimate the rate of dynamic correlation between the explored stock returns. Additionally, we use daily returns of the examined indices to estimate market efficiency, applying the AR (1) model (Granger, 1969).

Matteo and Gunardi (2018) studied some of the most important market anomalies in France, Germany, Italy, and Spain stock exchange indexes in the first decade of the new millennium (2001-2010) by using statistical methods: the GARCH model and the OLS regression. The analysis doesn't show strong proof of comprehensive calendar anomalies and some of these effects are country-specific. Stefanova (2019) claims that overcoming ever-increasing macroeconomic, institutional, technological, climatic, etc. challenges, complexities, and risks facing the economies and stock markets of the Western Balkan countries requires an integrated approach for active co-operation and involvement of national, regional and international stakeholders (market and institutional ones) to successfully move from status of peripheral/frontier to emerging stock markets in the Western Balkans in the medium to long term. Cristi and Cosmin (2018) intended to identify key studies with the main objective of analysis of the integration of financial systems. The results of the studies are heterogeneous—on the one hand, integration of financial systems is indicated, and, on the other hand, a high degree of heterogeneity is integrated. Recent studies also prove that financial markets show strong mutual correlation, by applying the methods and models of modern financial technologies and financial deregulation (Jebran et al., 2017; Okičić, 2015; Baumöhl et al., 2018; Huo and Ahmed, 2017; Panda and Nanda, 2018; BenSaïda et al., 2018).

Simeonov (2020) provides a comprehensive stock profile for four of the most popular East Asian stock exchanges—Tokyo, Hong Kong, Taiwan, and Shanghai, for the period 2007–2019. Simeonov (2020) concludes that the global financial crisis of 2008 has had a significant and lasting negative impact only on the price component of the stock exchange profiles, while the stock exchange activity of the studied exchanges remains completely unaffected. Pece et al. (2013) analyze the existence of long memory in return series for nine indices from Central and Eastern European (Romania, Hungary, Slovakia, Czech Republic, Ukraine) and Balkan emerging markets (Serbia, Bulgaria, Greece, Croatia) and prove that all indices, except the Czech index, manifest predictable behavior, so the investors can obtain abnormal profits, suggesting that these capital markets are not weak-form efficient. Armeanu and Cioaca (2014) tested the EMH on Romania in the period from 2002 to 2014 using four methods, including the GARCH model. They concluded that the Romanian capital market was not weak-form efficient. Dragota and Oprea (2014) analyzed the Romanian stock market's informational efficiency and established that the predictability of returns suggests that the Romanian stock market has a low level of efficiency. Furthermore, the impact of new information is more intense before and after its release. Zdravkovski (2016) examined the impact of the 2008 financial crisis on the interconnection among the SEE stock markets (Macedonian, Croatian, Slovenian, Serbian, and

Bulgarian) and found no evidence of cointegration between the studied markets during the pre- and post-crisis periods. However, during the 2008 financial crisis, the empirical findings support the existence of three cointegration vectors. This means that the recent global financial crisis and the subsequent euro crisis strengthened the connection between the investigated stock markets. Furthermore, the analysis revealed that during periods of financial turmoil, the Macedonian stock market was positively and actively influenced by the Croatian and Serbian markets. A significant implication of these results is that integration between the SEE stock markets tends to vary over time, particularly during stages of financial disturbances. Badhani (2015) explored dynamic correlation between aggregate stock returns in the Indian and U.S. markets (taken as a proxy of the global market) using the asymmetric generalized dynamic conditional correlation (AGDCC) model of Cappiello et al. (2006). The author did not observe a significant shift in correlation during different periods of the financial crisis; therefore, the presence of financial contagion could not be confirmed. Joldes (2019) investigated volatility of daily returns in the Romanian stock market over the period from January 2005 to December 2017. The conditional volatility for the daily return series shows clear evidence of volatility shifting over the period in question. In our examination, we discovered great influence of international stock markets on the capital market operations in Romania. Hung (2019) examined the conditional correlations and spillovers of volatilities across the CEE markets, namely those of Hungary, Poland, the Czech Republic, Romania, and Croatia, in the post-2008 financial crisis period by using five-dimensional GARCH-BEKK alongside with the CCC and DCC models. The estimation results of the three models generally demonstrate that the correlations between these markets are particularly significant. Also, own-volatility spillovers are generally lower than cross-volatility spillovers for all markets.

Dajčman and Festić (2012) examined the co-movement and spillover dynamics between the Slovenian and some European (British, German, French, Austrian, Hungarian, and Czech) stock market returns. A dynamic conditional correlation GARCH (DCC-GARCH) analysis was applied to the return's series of representative national stock indices for the period from April 1997 to May 2010. Results of the DCC-GARCH analysis show that co-movement between Slovenian and European stock markets varied over time and that there were significant return spillovers between the stock markets. Financial crises in the observed period increased co-movement between the Slovenian and European stock markets. Abuselidze et al. (2020) claim that the global financial crisis has clearly identified and reinforced the role of financial risks. Additionally, study of international practice has shown that the main financial risks on the stock exchange are in some way related to the work of trade infrastructure and stock risks arise precisely when it comes to close contracts. Pfeiferová and Kuchařová (2020) state that in the financial market, risk management is associated with the process of identifying individual risks, their analysis, and making investment decisions by reducing the degree of uncertainty. When it comes to collective investment undertakings, risk management can be understood as a situation where the portfolio manager analyzes and quantifies potential losses from the investment and takes measures to reduce them following the chosen investment strategy. Ters and Urban (2018) used a panel VAR methodology and found co-movement effects in the Visegrad group member countries (the Czech Republic, Hungary, Poland, and Slovakia) as they have been only marginally affected by the turmoil in the peripheral countries during the sovereign debt crisis. Harkmann (2014) investigated possible contagion from the West European stock markets to stock markets in Central and Eastern Europe. Dynamic conditional correlation (DCC) bivariate generalized autoregressive conditional heteroskedasticity (GARCH) models were used to estimate the degree of correlations between the stock market benchmark for the eurozone and Central and Eastern Europe. The author concludes that the dynamic conditional correlation

(DCCs) increased steadily between 2002 and 2012, which could be attributed to closer financial integration. During the crisis, dynamic correlations rose substantially, which suggests some degree of contagion.

Alexakis and Pappas (2018) investigated existence of financial contagion in the European Union during the recent global financial crisis (GFC) of 2007–2009 and the European sovereign debt crisis (ESDC) that started in 2009 using a ADCC-GJR-GARCH model and a Markov-switching GARCH model. They found evidence of a non-synchronized transition of all countries to crisis regime, in both crises. Mohti et al. (2019) examined the effects of the U.S. financial crisis and the Eurozone debt crisis on a large set of frontier stock markets. Evidence of contagion, using the test proposed by Guedes et al. (2018a, 2018b), was found to be weaker in the case of the European debt crisis, leading to the conclusion that frontier stock markets were more affected by the U.S. financial turmoil. Horváth et al. (2016) worked with daily data from 1998 to 2014 and found evidence of financial contagion for emerging markets discussed in our paper (Croatia, the Czech Republic, Estonia, Hungary, Poland, and Romania). Contagion was therefore present regardless of the monetary policy regime the individual countries adopted. We subject this finding to a series of robustness checks. Caporin et al. (2018) analyzed sovereign risk shift-contagion, i.e. positive and significant changes in the propagation mechanisms, using bond yield spreads for the major eurozone countries and found that the propagation of shocks in euro's bond yield spreads showed almost no presence of shift-contagion in the sample periods considered (2003–2006, November 2008–November 2011, December 2011–April 2013). The U.S. crisis did not generate a change in the intensity of propagation of shocks in the eurozone between the 2003–2006 pre-crisis period or the November 2008–November 2011 post-crisis era. Apergis et al. (2019) investigated whether contagion occurred during the recent global financial crisis across the European and U.S. financial markets. The findings indicate significant evidence of contagion, especially through the channels of higher order moments. Maneejuk and Yamaka (2019) investigated contagion effect from the U.S. stock market on ten international stock markets (emerging and developed markets) using dynamic copula-based GARCH models. The results demonstrate the correlation between the U.S. stock market and all investigated stock markets (except China, Canada, and India) was higher during the crisis period than during the normal period.

2. Methodology

In this study, we explore ten EU Member States (France, Germany, the United Kingdom, Belgium, Bulgaria, Romania, Greece, Portugal, Ireland, and Spain), and the USA. The variables that we use represent the capital market indexes for the following countries: France (CAC 40), Germany (DAX), The United Kingdom (FTSE 100), Belgium (BEL-20), Bulgaria (SOFIX), Romania (BET), Greece (ATHEX20), Portugal (PSI-20), Ireland (ISEQ-20), Spain (IBEX35), and USA (DJIA). A country's index data is obtained from the internet websites of their capital markets, collected with monthly frequency. The analyzed period is March 3, 2003 – June 30, 2016, as it includes the effects of the financial crisis of 2008. We further divide this period into sub-periods: the pre-crisis period (March 3, 2003 – December 29, 2006); the crisis period (January 2, 2007 – December 28, 2012), and the post-crisis period (January 3, 2013 – June 30, 2016). The examined stock markets, particularly those of the so-called PIIGS group, were severely affected by the financial crisis of 2008. The development of the crisis in the European stock markets mimicked its unfolding in the U.S. markets.

The following equation is applied for data series analysis, using log first difference to explore their rate of change.

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$$R_t = \log(\frac{PI_t}{PI_{t-1}}) \tag{1}$$

where

R_t	return of the explored indices at time t
PI_t	value of the indices at time t
PI_{t-1}	value of the indices at time t-1

We then apply the ADF test to estimate stationarity and prove that all variables are stationary in the form dlog (x), i.e., the variables were integrated of order one.

The augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the y series follows an AR (p) process and adding p lagged difference terms of the dependent variable y to the right-hand side of the test regression:

$$\Delta y_t = \alpha y_{t-1} + x_t^{'}\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + ... + \beta_p \Delta y_{t-p} + \nu_t \tag{2}$$

To overcome the shortcomings of the constant conditional correlation-generalized autoregressive conditional heteroscedasticity (CCC-GARCH) model, Engle and Sheppard (2001), Engle (2002), and Tse and Tsui (2002) proposed a DCC-GARCH model which estimates conditional correlations in multivariate GARCH models. Their specification allows for a time-varying matrix because the DCC-GARCH presents equations describing the evolution of correlation coefficients in time. Thus, we apply the DCC-GARCH model proposed by Engle (2002) to measure dynamic conditional correlations. The multivariate model is defined by the following formula:

$$\mathrm{X_t} = \mathrm{\mu_t} + \mathrm{\epsilon_t} \tag{3}$$

where

$\mathrm{X_t} = (\mathrm{X_{1t}}, \mathrm{X_{2t}}, \dots \mathrm{X_{Nt}})$	is the vector of past observations;
$\mathrm{\mu_t} = \mathrm{\mu_{1t}} + \mathrm{\mu_{2t}} + \cdots + \mathrm{\mu_{Nt}}$	is the vector of conditional returns;
$\mathrm{\epsilon_t} = \mathrm{\epsilon_{1t}} + \mathrm{\epsilon_{2t}} + \cdots + \mathrm{\epsilon_{Nt}}$	is the vector of standardized residuals.

To examine the contagion effect, we apply methodology developed by Forbes and Rigobon (2002); and Trabelsi and Hmida (2018). We denote stock return of the Bulgarian index with X_t and stock returns of the other examined indices with Y_t, respectively. The relation between them can be represented by the following equation:

$$Y_t = \alpha + \beta X_t + \epsilon_t \tag{4}$$

where

α and β	constants
ϵ_t	error terms

Forbes and Rigobon (2002) argue that the correlation coefficient ρ between X_t and Y_t is calculated by means of the following equation:

$$\rho^* = \frac{\rho}{\sqrt{1+\delta(1-\rho^2)}} \tag{5}$$

where $\delta = \frac{\sigma_x^c}{\sigma_x^t - 1}$

and

δ	relative increase in the volatility of X_t across the crisis and pre-crisis periods
σ_x^c	conditional variances of X_t during the crisis period
σ_x^t	conditional variances of X_t during the pre-crisis period.

Following the methodology of Trabelsi and Hmida (2018), we develop two hypotheses. The null hypothesis (H_0) states that correlation between the two markets does not significantly change during a crisis compared to a not-crisis period, and we can conclude that there is no financial contagion. Accepting the null hypothesis implies that the markets are interdependent.

Rejection of the null hypothesis leads to adoption of the alternative hypothesis H_1. The alternative hypothesis states that correlation between the two capital markets changes significantly based on whether a crisis arises in one of them. We can then propose that the change in volatility of the Bulgarian stock market is in part a result of the volatility of another market. Consequently, we can conclude that there is indeed financial contagion:

$$H_0: \rho_c^* = \rho_t^* \tag{6}$$
$$H_1: \rho_c^* > \rho_t^* \tag{7}$$

To reject or accept one of these hypotheses, we apply a Student's t- test (Collin and Biekpe, 2003).

$$t = (\rho_c^* - \rho_t)\sqrt{\frac{n_c + n_t - 4}{1 - (\rho_c^* - \rho_t)^2}} \tag{8}$$

An autoregressive model of the order p , denoted as AR (p), has the form:

$$Y_t = \rho_1 Y_{t-1} + \rho_2 Y_{t-2} + \ldots \rho_p Y_{t-p} + \varepsilon_t = \sum_{i=1}^{p} \rho_j Y_{t-j} + \varepsilon_t \tag{9}$$

where

ε_t	are the independent and identically distributed innovations for the process and the autoregressive parameters
p_i	characterize the nature of the dependence. Note that autocorrelations of a stationary AR (p) are infinite but decline geometrically, so they die off quickly, and the partial autocorrelations for lags greater than p are zero.

AR (1) measures the impact of returns from the previous day, i.e., the impact of the previous day information on the current day returns. (Collins and Biekpe, 2003)

TARCH or threshold ARCH and threshold GARCH models were introduced independently by Zakoïan (1994) and Glosten, Jaganathan,, and Runkle (1993). The generalized specification for the conditional variance is given by:

$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{k=1}^{r} \gamma_k \varepsilon_{t-k}^2 I_{t-k} \tag{10}$$

where

$I_t = 1$	if $\varepsilon_t < 0$ and 0 otherwise.

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In this model, good news, $\varepsilon_{t-i} > 0$, and bad news, $\varepsilon_{t-i} < 0$, have differential effects on the conditional variance; good news has an impact on α_i, while bad news has an impact on $\alpha_i + \gamma_i$.

If $\gamma_i > 0$, bad news increases volatility, and we speak of a *leverage effect* of the i-th order. If $\gamma_i \neq 0$, the news impact is asymmetric.

3. Results

Table 1 shows descriptive statistics of returns of the analyzed indices. First, for the whole period and for mean, most of the data manifests positive return, the exception being BEL20. For skewness, we found that not all indices are equal to zero, which indicates asymmetry for all series. Kurtosis is greater than three for all analyzed countries, indicating that their distributions are leptokurtic. The normality hypothesis is disproved by the Jarque-Bera test, whose coefficients exceed the critical values. Standard deviation is interpreted as a measure of risk. From the values of standard deviation, we prove that during the whole analyzed period, the Romanian stock market has the highest level of volatility. We should mention that the values of standard deviation of the Greek and Bulgarian capital markets are almost identical to that of the Romanian stock market. The descriptive statistics of the indices during the three sub-periods are also presented in Table 1. We notice that the means of stock returns took on negative values during the crisis, except for BEL20, DAX, and DJIA. Standard deviation of index returns was higher during the crisis compared to the more stable periods. This reflects an increase in volatility during the crisis for all European capital markets analyzed.

Table 1: Descriptive statistic of the explored indices

The Full Explored Period: March 2003 - June 2016											
	RATHEX	**RBEL20**	**RBET**	**RCAC40**	**RDAX**	**RDJIA**	**RFTSE100**	**RIBEX35**	**RISEQ**	**RPSI20**	**RSOFIX**
Mean	0.002962	-0.000446	0.008515	0.003028	0.008736	0.005082	0.003697	0.002074	0.002277	0.001653	0.004322
Median	-0.002969	0.000176	0.015797	0.010546	0.019494	0.007609	0.007970	0.008008	0.008432	-0.001335	0.002388
Maximum	0.663535	0.073016	0.257241	0.120462	0.191631	0.091161	0.083000	0.153789	0.178253	0.370302	0.251207
Minimum	-0.355481	-0.048918	-0.414192	-0.145225	-0.224954	-0.151526	-0.139536	-0.186727	-0.235823	-0.202173	-0.476323
Std. Dev.	0.087514	0.015765	0.088261	0.047970	0.055599	0.038350	0.037810	0.056205	0.058590	0.050531	0.086087
Skewness	2.134574	0.285622	-0.979921	-0.562221	-0.699231	-0.812321	-0.707958	-0.474524	-1.057397	1.669294	-1.272899
Kurtosis	24.17154	7.603920	7.211122	3.570364	5.462489	4.993187	4.128654	3.985350	5.611811	21.84667	10.17312
Jarque-Bera	3090.296	142.5859	142.9312	10.53165	53.12951	43.80622	21.72124	12.39939	74.82216	2427.024	383.8178
Probability	0.000000	0.000000	0.000000	0.005165	0.000000	0.000000	0.000019	0.002030	0.000000	0.000000	0.000000
Sum	0.471000	-0.070963	1.353929	0.481382	1.389014	0.808017	0.587842	0.329709	0.362012	0.262876	0.687172
Sum Sq. Dev.	1.210063	0.039267	1.230823	0.363574	0.488423	0.232371	0.225875	0.499130	0.542373	0.403430	1.170923

Obs.	159	159	159	159	159	159	159	159	159	159	159
Pre-crisis period: March 2003 – December 2006											
Mean	0.026740	-0.004652	0.034856	0.016661	0.020145	0.009874	0.012073	0.019545	0.019406	0.016031	0.037237
Std. Dev.	0.053725	0.016808	0.080896	0.031709	0.046241	0.024189	0.023576	0.033007	0.032882	0.033355	0.065413
Crisis period: January 2007 – December 2012											
Mean	-0.009499	0.000788	-0.007475	-0.006084	0.001632	0.000528	-0.000711	-0.008136	-0.014042	-0.006073	-0.019087
Std. Dev.	0.121883	0.018663	0.108912	0.057722	0.065997	0.048059	0.046987	0.068873	0.073404	0.069672	0.107261
Post-crisis Period: January 2013 – June 2016											
Mean	-0.003161	0.002066	0.004140	0.003094	0.006993	0.006279	0.000868	-0.000587	0.011327	-0.001351	0.003197
Std. Dev.	0.000120	0.005646	0.036673	0.042217	0.044124	0.031515	0.031038	0.049136	0.044697	0.051284	0.039469

Source: authors' calculations

The coefficients of lagged variances and shock-square terms are all significant at 1%, which means that the volatilities of these markets are time-varying (Table 2). This completely supports the GARCH (1,1) models. The estimated parameters θ1 and θ2 of the DCC processes are all significant at 1%. The conditions θ1 + θ2 < 1 are all satisfied. The results for significance of conditional variances prove that market volatility changed during the analyzed period and confirms conditional heteroscedasticity in index returns. This proves that conditional variances depend on past observations and past shocks (Katzke, 2013). The β coefficients represent long-term persistence while α coefficients measure short-term persistence and the reaction of conditional volatility to market shocks. In Table 2, we prove that the α coefficient applies during the pre-crisis period. It rose for all indices analyzed during the crisis period and dropped during the post-crisis period. Comparing the stable pre-crisis and post-crisis periods, it should be noted that during the pre-crisis period, the values of α coefficients were higher than during the post-crisis period. This confirms increased caution in the financial markets. The highest values of α coefficients were registered during the crisis. We may conclude that during crisis, volatility of indices is more sensitive to market shocks and more dynamic than during the pre- and post-crisis periods. Similarly, the autoregressive coefficient of volatility β is also higher during the crisis period than during the stable periods. β coefficients measure persistence of conditional volatility to different market events and in cases where the value of β is high, volatility takes longer to vanish. θ1 and θ2 are significant at the 1% level. This proves that the impact of lagged shocks and the impact of lagged dynamic correlations on dynamic conditional correlations are highly significant. These results support the dynamic conditional correlations model and allow us to reject the hypothesis of a constant correlation between the returns series.

Table 2: Results from the applied Bivariate DCC-GARCH model

Pre-crisis period: March 2003 – December 2006										
Par.	SOFIX-ATHEX	SOFIX-BEL20	SOFIX-BET	SOFIX-CAC40	SOFIX-DAX	SOFIX-DJIA	SOFIX-FTSE100	SOFIX-IBEX35	SOFIX-ISEQ	SOFIX-PSI20
α(1)	0.088**	0.088**	0.088**	0.088**	0.088**	0.088**	0.088**	0.088**	0.088**	0.088**
α(2)	0.097**	0.106**	0.102**	0.094**	0.112**	0.124*	0.096**	0.121*	0.099***	0.095**
$\beta(1)$	0.931*	0.931*	0.931*	0.931*	0.931*	0.931*	0.931*	0.931*	0.931*	0.931*
$\beta(2)$	0.832	0.994*	0.896*	0.902*	0.835*	0.918**	0.915*	0.891*	0.901*	0.825*
Θ(1)	0.011*	0.023*	0.015*	0.035*	0.011*	0.028*	0.020*	0.025*	0.018*	0.037*
Θ(2)	0.824*	0.925*	0.857*	0.927*	0.967*	0.805*	0.971*	0.834*	0.915*	0.795*
Crisis period: January 2007 – December 2012										
α(1)	0.102*	0.102*	0.102*	0.102*	0.102*	0.102*	0.102*	0.102*	0.102*	0.102*

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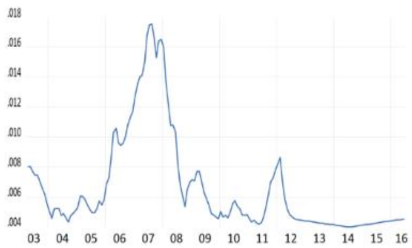
α(2)	0.118*	0.154*	0.124*	0.094	0.174*	0.152**	0.096*	0.116*	0.109**	0.118*
β(1)	0.995*	0.995*	0.995*	0.995*	0.995*	0.995*	0.995*	0.995*	0.995*	0.995*
β(2)	0.874*	0.825*	0.915*	0.942*	0.926*	0.915**	0.894**	0.948**	0.879**	0.918*
Θ(1)	0.018*	0.034*	0.028*	0.039*	0.152*	0.028*	0.034*	0.011*	0.013*	0.039*
Θ(2)	0.902*	0.892*	0.912*	0.915*	0.834*	0.905*	0.911*	0.907*	0.832*	0.902*
Post-crisis Period: January 2013 – June 2016										
α(1)	0.086*	0.086*	0.086*	0.086*	0.086*	0.086*	0.086*	0.086*	0.086*	0.086*
α(2)	0.079*	0.082*	0.091**	0.101**	0.086**	0.093**	0.105	0.084	0.094*	0.090*
β(1)	0.898*	0.898*	0.898*	0.898*	0.898*	0.898*	0.898*	0.898*	0.898*	0.898*
β(2)	0.912*	0.864*	0.906*	0.894	0.975	0.932*	0.906**	0.861*	0.946	0.857**
Θ(1)	0.015*	0.021*	0.018*	0.032*	0.019*	0.012*	0.025*	0.019*	0.038*	0.028*
Θ(2)	0.805*	0.912*	0.947*	0.835*	0.875*	0.912*	0.908*	0.846*	0.835*	0.812*

*Notes: ***, ** denote statistical significance at the 1% and 5% respectively*
Source: authors' calculations

Figures 1–10 present the dynamic conditional correlations between the Bulgarian stock index and the other examined stock indices. We register an increase in dynamic conditional correlation between all pairs of indices during the crisis period. The following observations should be taken into account:

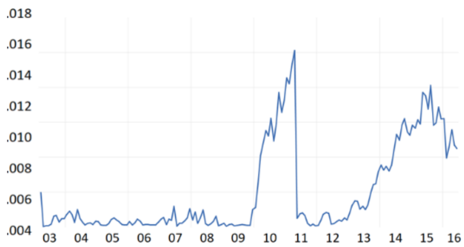
- Dynamic correlation between **SOFIX-ATHEX** reaches its peak in 2009, at the peak of the Greek financial crisis, and remains at high values during the sovereign debt crisis. Dynamic correlation between SOFIX and IBEX35 is characterized by two peaks, in 2008 and 2011. This suggests a strong transmission of negative information shocks during the sovereign debt crisis. We also register a similar dynamic between the Bulgarian and Portuguese markets.
- The most significant dynamic correlation is found between **SOFIX** and **DJIA,** with the highest peak between 2008-2009. The results show increased (stronger) correlation dynamics between the Bulgarian stock market and developed European countries and the United States during the crisis period, with impact of information overspill between **SOFIX** and **DAX.**

Figure 1: Dynamic conditional correlations SOFIX-CAC40



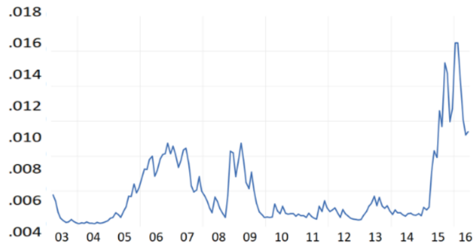
Source: authors' calculations

Figure 2: Dynamic conditional correlations SOFIX- ATHEX



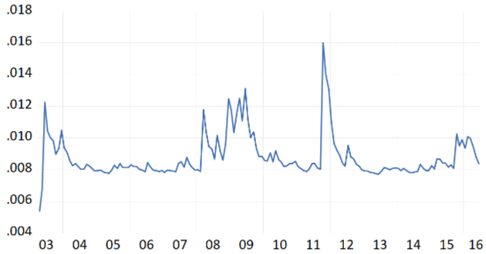
Source: authors' calculations

Figure 3: Dynamic conditional correlations SOFIX-ISEQ



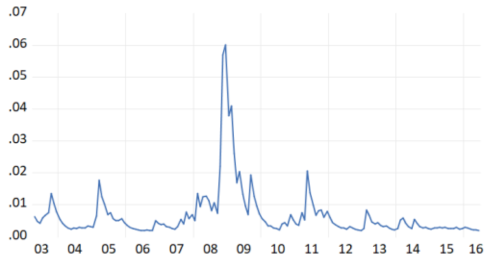
Source: authors' calculations

Figure 4: Dynamic conditional correlations SOFIX-IBEX35



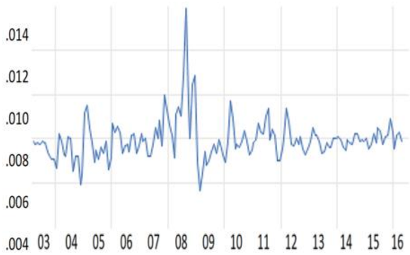
Source: authors' calculations

Figure 5: Dynamic conditional correlations SOFIX-PSI20



Source: authors' calculations

Figure 6: Dynamic conditional correlations SOFIX- BEL20

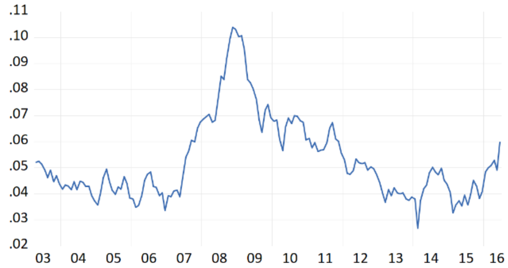


Source: authors' calculations

Figure 7: Dynamic conditional correlations SOFIX- DJIA

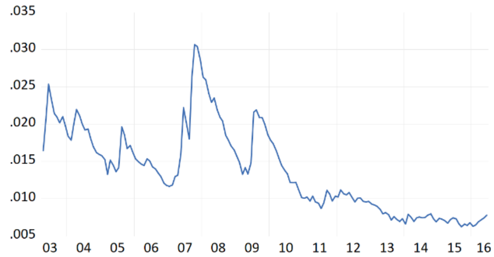
Source: authors' calculations

Figure 8: Dynamic conditional correlations SOFIX- DAX



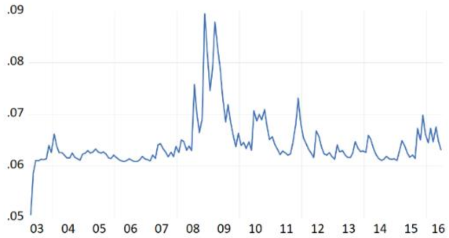
Source: authors' calculations

Figure 9: Dynamic conditional correlations SOFIX- BET



Source: authors' calculations

Figure 10: Dynamic conditional correlations SOFIX-FTSE100



Source: authors' calculations

Table 3 presents the results of the contagion test. We prove that dynamic condition correlations between the examined indices increase from the period with low volatility (pre-crisis period) to the period with high volatility (crisis period). Additionally, the values of the t-statistic are statistically significant for the following market pairs: SOFIX-ATHEX; SOFIX-BET; SOFIX-DAX; SOFIX-DJIA; SOFIX-FTSE100; SOFIX-IBEX35; SOFIX-ISEQ, and SOFIX-PSI20, and, consequently, we can accept the alternative hypothesis of presence of a structural change in the correlation for these pairs of markets. We register the strongest negative information flow for the Bulgarian and U.S. capital markets, with the Bulgarian capital market significantly influenced by volatility of the U.S. DJIA. The German DAX index also has a significant impact on SOFIX returns. Our results show that financial contagion between Bulgarian and Romanian capital markets does exist. The PIIGS block, which was most affected by the global financial crisis, transferred negative shocks to SOFIX.

Despite the trends of increasing integration between Bulgarian national economy and other member states of the European Union, the Bulgarian stock market is relatively less developed. Strong synchronization and monetary policy implemented through the currency board can be identified as the prerequisites for spread of negative shocks of financial crises. Bulgarian economy and the Bulgarian stock market were among those most affected by the 2008 global financial crisis within the EU. Based on the results in Table 3, we prove existence of financial contagion between the Bulgarian stock market and the other markets, with the most significant information shock impact originating in the U.S. market. The obtained results lead to the conclusion that European markets are characterized by a high degree of harmonization due to the maintenance of clearly defined transmission mechanisms.

During the crisis, Bulgarian stock index SOFIX reacted to negative news from the U.S. capital market. According to the results of the contagion test, we can distinguish two channels through which financial contagion spreads from developed to emerging markets. This also indicates strong correlation between the Bulgarian and Romanian capital markets.

Table 3: The Results from the Contagion Test

Relation	**Pre-crisis** ρ_{ij}^{t}	**Crisis period** ρ_{ij}^{c}	**t-student**	**Change of correlation coefficients**	**Contagion**
Unadjusted Conditional Correlation					
SOFIX-ATHEX	0.492	0.715	11.14*	45.33%	YES
SOFIX-BEL20	0.435	0.402	0.266	-7.59%	NO
SOFIX-BET	0.401	0.618	6.282*	54.11%	YES
SOFIX-CAC40	0.358	0.418	0.083	16.76%	NO
SOFIX-DAX	0.374	0.608	9.084*	62.56	YES
SOFIX-DJIA	0.318	0.524	5.159*	64.77%	YES
SOFIX-FTSE100	0.349	0.504	6.188*	44.41%	YES
SOFIX-IBEX35	0.385	0.648	4.190*	44.41%	YES
SOFIX-ISEQ	0.486	0.682	8.154*	40.33%	YES
SOFIX-PSI20	0.418	0.591	9.182*	41.39%	YES
Adjusted Conditional Correlation					
SOFIX-ATHEX	0.232	0.352	7.315*	51.72%	YES
SOFIX-BEL20	0.218	0.204	0.158	-6.42%	NO
SOFIX-BET	0.195	0.350	3.085*	79.48%	YES
SOFIX-CAC40	0.182	0.218	0.018	19.78%	NO
SOFIX-DAX	0.186	0.358	6.084*	92.47%	YES
SOFIX-DJIA	0.192	0.376	3.794*	95.83%	YES
SOFIX-FTSE100	0.159	0.284	3.042*	78.61%	YES
SOFIX-IBEX35	0.197	0.326	2.381*	65.48%	YES
SOFIX-ISEQ	0.231	0.354	3.908*	53.24%	YES
SOFIX-PSI20	0.198	0.259	4.082*	30.80%	YES

*Notes: ***, ** denote statistical significance at the 1% and 5% respectively*

Source: authors' calculations

We include the AR (1) term in the mean equation in the TGARCH model. The GARCH family of models are used to capture volatility clustering. Table 4 shows the statistical significance of AR (1) for the whole period. If the statistically significant value of AR (1) is other than 0, we can reject the weak form of the efficient market hypothesis (EMH).

Table 4: The values of AR (1) in the TGARCH model for the whole period under examination

Index	**AR (1) for the whole examined period**
BEL 20	-0.007471
CAC	0.107091
DAX	0.125258
IBEX 35	0.012454
DJIA	0.281503
ATHEX	0.948586*
ISEQ	0.154979***
FTSE 100	-0.110156***
PSI 20	0.078225**
SOFIX	0.300833*
BET	0.086118*

*Notes: *, **, *** denote statistical significance at the 1%, 5% and 10% respectively*
Source: authors' calculations

We register statistically significant AR (1) for the following countries: the United Kingdom, Greece, Ireland, Portugal, Romania, and Bulgaria. We can moreover define these capital markets as inefficient and can divide them into three distinct groups: developed markets, Eurozone's problem countries, and emerging markets.

The values of AR (1) range from -0.007471 (the developed Belgian market) to 0.948586 (the developed Greek market, classified here as one of Eurozone's problem markets). We can reject the weak form of market efficiency for the capital markets of the United Kingdom, Greece, Ireland, Portugal, Romania, and Bulgaria. The highest value of the AR (1) is registered for the Greek index ATHEX (0.948568) and this financial market can be determined as the most inefficient one compared to the other markets in the sample for the period 2003-2016. In comparison, the U.S. capital market can be defined as efficient due to the non-statistically significant values of AR (1).

Based on the positive values of AR (1) of the Greek, Irish, Portuguese, Romanian, and Bulgarian indices, we can conclude that AR (1) gives greater weight to return of the previous period and therefore strengthens the established market trend. Additionally, the positive values of AR (1) lead to accumulation and acceleration of the positive market trend. These results indicate an irrational acceptance and subsequent acceleration of the positive market trend due to incoherent behavior of investors who follow the development prospects of the said markets. Overall, considering the statistically significant positive values of AR (1), we can assume that there are sustainable market trends. Besides, we should note that ATHEX, ISEQ, PSI 20, SOFIX, and BET follow sustainable market trends and positive AR (1) gives greater weight to returns of the preceding day.

Additionally, the negative value of AR (1) for the UK FTSI 100 index (-0.110156) shows an opposite reaction to the positive market trends from the previous period. We can also assume that this developed capital market is not inclined to pursue long-term market trends from the previous period, giving greater weight to current information from the market. Based on this assumption we can conclude that the information influence from period t is so incorporated in the market trend, that when it comes to lag t-1, the information loses all of its influence and becomes obsolete.

The assumption that there is a leverage effect (Black, 1976) in stock markets indicates a tendency for changes in the price of financial assets, and these changes are negatively correlated with changes in the volatility of the same assets.

Our analysis of the values of coefficients of persistence is based on the efficient market hypothesis' (EMH) assumptions, namely: low coefficients of persistence indicate a high degree of information efficiency. Thus, a lower coefficient of persistence values confirms the weak form of EMH.

We can separate the examined indices into two groups based on values of the coefficient of persistence. To examine market efficiency, we calculated the average arithmetic values of the coefficients of persistence of all the studied indices for the period from 2003 to 2016. In our case, it has the value of 0.94:

- Indices with relatively high market efficiency (the value of their coefficient of persistence is below 0.94);
- Indices with relatively low market efficiency (the value of their coefficient of persistence is higher than 0.94).

The first group contains the following indices—DAX, FTSE 100, IBEX, CAC, SOFIX, PSI 20, and BET, with coefficients of persistence below 0.94 (Table 5). Put differently, the indices from the first group manifest relatively high levels of efficiency. These results show decreased impact of market shocks on volatility dynamics.

The second group includes ISEQ, BEL 20, and ATHEX, with coefficients of persistence higher than 0.94. These indices manifest relatively low market efficiency. The higher values of coefficients of persistence represents the change in response to shocks in terms of volatility persistence, which implies that volatility response increases with time.

Table 5: The indices with relatively high market efficiency and their coefficients of persistence below 0,94 and leverage coefficients

Index	**Coefficient of persistence < 0,94**	**Leverage coefficient**
DAX	0.666247	0.293095**
FTSE 100	0.756942	0.335537*
IBEX	0.795043	0.268119*
CAC	0.828806	0.769672**
SOFIX	0.849258	-0.017604
PSI 20	0.863198	-0.108970
BET	0.895839	0.169299**
DJIA	0.901308	0.381560*

*Notes: *, **, *** denote statistical significance at the 1%, 5% and 10% respectively*
Source: authors' calculations

Table 5 presents the values of the coefficient of persistence and leverage coefficient for the capital markets with relatively high market efficiency, namely the capital markets of Germany, the United Kingdom, Spain, France, Portugal, Bulgaria, Romania, and the USA. The most efficient financial market in the group is the German one with the lowest value of the coefficient of persistence for its DAX index (0.666247). Based on the results above, we can clearly distinguish developed countries like Germany (0.666247) and the UK (0.756942) from the relatively new European stock markets of Bulgaria (0.849258) and Romania (0.895839).

The values of the leverage coefficient represent the way market volatility reacts in terms of whether market impulses lead to positive or negative returns. The statistically significant values of leverage coefficients are in the range between 0.169299 (BET) and 0.769672 (CAC). Additionally, all leverage coefficients are positive. The highest positive value of the leverage coefficient is registered for the French CAC index (0.769672). This relatively high and positive leverage coefficient shows no leverage effect in the French market because new positive information entering the market has significant influence on its volatility. Conversely, the lowest positive value of the leverage coefficient is registered for the Romanian BET index (0.169299). This can be attributed to the fact that the market dynamics of the Romanian stock exchange follow short-term trends rather than stable, longer-term market trends.

Table 6: The indices with relatively low market efficiency and their coefficients of persistence higher than 0,94 and leverage coefficients

Index	**Coefficient of persistence > 0,94**	**Leverage coefficient**
ATHEX	1.838203	-0.692084***
BEL 20	1.015379	-0.064635*
ISEQ	0.942459	0.078306*

*Notes: *, **, *** denote statistical significance at the 1%, 5% and 10% respectively*
Source: authors' calculations

Table 6 presents the values of the coefficient of persistence and leverage coefficient for the capital markets with relatively low market efficiency. We can conclude that Greek, Belgian, and Irish capital markets are relatively informationally inefficient markets compared to the other examined markets. The statistically significant values of leverage coefficients are in the range between -0.692084 (ATHEX) and 0.078306 (ISEQ). The highest coefficient value was calculated for the Irish ISEQ index (0.078306), indicating that market information has a large effect on its volatility. On the other hand, the relatively high negative value of the leverage coefficient of the Greek index implies a stronger leverage effect. Thus, market impulses of the Greek index led to the most significant restriction of volatility of all examined indices for the period of 2003-2016. We can make the same conclusion for BEL 20, considering the registered negative leverage coefficient (-0.064635), albeit to a much weaker degree.

4. Discussion

Our results show that a contagion did exist between the Bulgarian capital market and the eight capital markets analyzed during the financial crisis of 2008, with the strongest contagion effects from the U.S. and German capital markets. Our findings reconfirm the analysis made by Trabelsi and Hmida (2018). Moreover, Trabelsi and Hmida (2018) attempted to determine whether there were contagion effects between the Greek stock market and the Belgian, French, Portuguese, Irish, Italian, and Spanish stock markets during both crises in question. They used a bivariate dynamic conditional correlation-generalized autoregressive conditional heteroscedasticity (DCC-GARCH) model to measure the extent of dynamic correlations between stock returns of our sample. The results point to presence of a contagion effect between all market pairs during the subprime crisis and between the Greek and Portuguese stock markets during the European sovereign debt crisis.

On the other hand, we register statistically significant AR (1) for the following countries: the United Kingdom, Greece, Ireland, Portugal, Romania, and Bulgaria, and we can label these capital markets as inefficient. The most efficient financial market in the group is the German one, with the lowest value of the coefficient of persistence for its DAX index (0.666247).

5. Conclusion

Financial globalization has opened international capital markets to investors and companies worldwide. However, the global financial crisis also caused massive stock price volatility due in part to global availability of market information.

The obtained results indicate that the Bulgarian capital market is relatively integrated with the stock markets of Germany and the United States. This explains its exposure to financial contagion effects from the U.S. capital market and the capital markets of EU member states during crises and correlation trends between bull and bear market phases, indicating their dynamic nature and conditions. Overall, our results suggest that financial contagion from the US stock market and the capital markets of the developed European countries to the Bulgarian capital market occurred just before the financial crisis, but we found that the contagion was stronger during the crisis proper. Likewise, negative shocks from the PIIGS block had a strong impact on financial contagion during the sovereign debt crisis.

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