The Financial Crisis' Impact on the Central and Eastern Europe Capital Markets

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Abstract

We study the impact on return and volatility of 8 capital markets (Bulgaria, Czech Republic, France, Germany, Hungary, Poland, Romania and US) during three crisis (subprime crisis, global financial crisis and Brexit), that occurred in January, 1st 2007 – August, 26th, 2016 time frame.

In order to reduce the initial causal space represented by the returns on CEE markets, we used the Principal Component Analysis. One principal component was identified and placed within a AR(2)-GARCH(1,1) model for return and associated volatility.

The results show that the volatility during the global crisis and that related to the Brexit moment are statistically significant, but they present different coefficients: the volatility boosted during the global financial crisis and lowered after the Brexit announcement. This late result can be explained by the prudent stance of the investors who are concerned to evaluate the impact of the Brexit and the consequences for the financial markets of the associated measures.

Keywords: *capital market, contagion risk, crisis, volatility, principal component*

JEL classification: C22, G01, G15.

Introduction

The transition of the Central and Eastern European countries towards market economy post 1989 comes along with the revival of capital market institutions, necessary as an alternative to finance the real economy. In this region, the effective implementation of the economic reforms aiming at restructuring of the

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stock exchange mechanisms followed local patterns (the most advanced being the stock exchanges in Poland and the Czech Republic and less developed capital markets in Romania and Bulgaria). In Poland, the development of the capital market was closely related to the state decision to use this mechanism to finance structural reforms and important privatizations. Similarly, the Bulgarian and Hungarian state measures helped the development of their national stock exchanges, although at a different pace. In the Czech Republic, the stock exchange was taken over by the Wiener Boerse in 2008, which represented a booster in terms of the consolidation of the institutional architecture and functioning. In Romania, the stock exchange grew in a moderate manner, so that in the first 8 months of 2016, the average volume of the transactions on this market was of only 6.67 million euro (second last in the EU, after Bulgaria).

The different stages of development in the Central and Eastern European markets resulted in different reactions, in terms of amplitude, to negative events occurring on the mature markets in the past 10 years. Regarding the global economic crisis, in 2008, a depreciation of around 50% of the relevant indexes was recorded on the Czech, Polish and Hungarian stock exchanges, while Romania and Bulgaria were more affected (with a depreciation of 70.5% for Romania and 79.7% for Bulgaria).

The closest crisis episode to be analyzed is the one generated by the announcement of the results of the UK poll on June 23rd, 2016, a moment that can count as the main turbulence generator in the last 5 years. Being such an unprecedented event, the impact on the returns and volatility in the financial markets are still hard to predict and they are under scrutiny by a large number of actors in the financial system (regulators, professional investors, retail investors, listed companies, so on).

In the present article we shall apply statistical methods of analysis to see the impact that the 3 major crisis (during 2008-20016) have had on the stock prices on the capital markets in Bulgaria, Czech Republic, Poland, Romania and Hungary (emerging and frontier markets). The results confirm a different impact of the financial global crisis and of the Brexit on the volatility of the stock prices in the CEE capital markets belonging to countries that are EU members but not yet euro-zone members. The same methods of analysis were applied to the developed markets in the EU (Germany and France) and to the United States capital market.

1. The theoretical basis of contagion and the principal component analysis

Extended globalization of the financial markets led to better interconnections between different markets, with positive outcomes in terms of growing investment opportunities for both individual and professional portfolio managers. All these positive effects come along with a wide range of downsizes that are visible during major crisis. The markets response to crisis shows common

features that can be explained as a consequence of the contagion and interdependence between different markets in a globalized environment.

Pritsker (2000) defines contagion as an extended effect of a shock over several markets, countries or institutions. Dornbusch, Park and Claessens (2000) present contagion as a phenomenon marked by the spillover of market turbulences (mainly related to depreciation of prices), starting from one market (generally an emerging market) towards another market. Schmukler, Zoido and Halac (2003) define contagion as an export of volatility – cross-country spillover effect from a country undergoing a crisis to other countries.

Forbes and Rigobon (2002) make a clear distinction between contagion and interdependence. The co-movement of different markets is defined as interdependence when it is not significantly enhanced by a turbulence in spite of the close connection between the financial markets. At a different level, the contagion is evident when the co-movement of different markets is statistically significant. This is the approach also used by Muñoz, Márquez and Sánchez (2010), who argue that contagion appears when there is a significant enhancement of the co-movement of different markets, while interdependence is defined as high and continuous correlations between different markets. Rigobon (2001) studied the contagion phenomenon and proposed different models and tests for changes in the propagation mechanisms and measures for the channels of contagion.

Scott (2011) considers contagion in the banking sector as a process that is associated with panic and bank runs, thereby leading to a general freeze on the markets. Meanwhile, the interconnectedness is a phenomenon in which the problems of a company extends to the companies exposed to the first company.

Allen and Gale (2000) analyze the financial contagion phenomenon, observing that its occurrence is dependent on the completeness of the structure of interregional claims (thus the turbulences being spread over the connected regions). From a practical point of view, Yellen (2013) emphasized the direct link between the contagion and the connectivity, especially in a concentrated financial network with few major players. Furthermore, Yellen proposed that, in order to limit the effects of interconnectedness, some legal requirements can be imposed by the supervisory authorities.

Marais and Bates (2006) identify several types of contagion, such as mechanical contagion based on the financial links between different economies, but also psychological contagion or pure contagion, generated by the investors behavior and information asymmetry. Therefore, investors' behavior, information asymmetry and gaps in the supervision of the international financial and commercial flows can speed up the negative effects of a crisis (intensification of the contagion effect).

Christiansen and Ranaldo (2009) used a multinomial logit model in order to capture the contagion phenomenon present in the new 10 members of the European Union. The authors found that for the new EU member states, the currency and interest rate are important for transmission of shocks.

Using data for 6 European countries, Armeanu et al. (2014) studied the contagion during the occurrence of 4 crisis in the 2008-2014 time frame, finding a divergent behavior of the analyzed markets. It was found that the Lehman Brothers collapse and the sovereign debt crisis generated contagion in all the analyzed markets, and during the Ukrainian conflict a crowd effect occurred. Also, Armeanu et al. (2013) studied the dependence occurred between the Romanian and Turkish capital markets during the global financial crisis, finding a positive relationship of the market returns. The effects of the global financial crisis on the Romanian capital market were also analyzed by Armeanu et al. (2012), revealing the major impact the crisis had on the local capital market (stressing the need of extensive reform of the Romanian stock market).

In order to study big data, such is the case of the models analyzed for contagion, statistical methods are applied meant to reduce the dimension of the initial causal space. The most common method is the Principal Component Analysis, that uses optimization algorithms and computation of the eigenvalues for correlation matrices. PCA was further refined by De la Torre (2008), with the starting point being the results obtained by Borga (1998). So, De la Torre restated some PCA algorithms, Partial Least-Square, Canonical Correlation Analysis and Multiple Linear Regression, by considering generalized eigenvalue problems. Different metric in optimization algorithms were proposed by Cha (2012), named earth mover's distance, and the proposed metric was proved to be more efficient in the classification process than the classical metrics (as the Euclidian distance or the city-block).

These methods can be used in a variety of research fields, from the linguistics to the medical sciences and robotics, as well as economics. For example, using the pattern recognition methods (such as PCA, Discriminant Analysis and Cluster Analysis), and the financial data for the listed companies from the Bucharest Stock Exchange, Armeanu and Cioacă (2015) studied the structure of the issuers listed on the Romanian capital market, in terms of the bankruptcy risk. As such, 3 groups were identified, with the different levels of bankruptcy risk.

2. Methodology and data

In the article we analyze the response of 7 EU financial markets to three of the main crisis occurring during January 1st, 2007 – August, 26th, 2016. We made use of the data representing the main indexes for the Central and Eastern Europe capital markets (Bulgaria, Czech Republic, Poland, Romania and Hungary) and for the most developed markets in the EU (Germany and France), as well as the US market. We used the data available on the financial websites (Google finance, www.stooq.com, www.bvb.ro).

In order to see the impact of the three crisis periods, we considered a 30 days timeframe starting from the beginning of each crisis. We defined the dummy1 variable for the subprime crisis (the studied period being August 15th, 2007 to September 14th, 207), the dummy 2 for the global financial crisis (September 15th, 2008 to October 14th, 2008) and the dummy3 for the Brexit crisis (June 24, 2016 to July 23rd, 2016).

We shall apply the Principal Component Analysis to reduce the initial causal space resulting from the 5 data series attached to the Central and Eastern European countries. This method allows us to use the results to see the impact of each of the three events on the return and volatility on the defined markets. The Principal Component Analysis (PCA) identifies the common characteristics of the collected/studied variables, that comprises a large data set, and simplifies them (Jolliffe, 2002). As such, we derive a model that approximates the common features of the 5 series, and use it to study the impact of the crisis on the Central and Eastern Europe countries, members of the European Union, that are not in the euro-zone. So, as the obtained component explains the common features of the studied series, we can conclude that the result obtained in testing the reactions to the crisis can be used to assess the individual effects for every country.

Subsequently we applied the following equations to calculate the return and the volatility of the return, within a level 2 AR(2)-GARCH(1,1) self-regression model (Munoz (2010)):

$$y_{i.t} = \mu + \phi_1 \cdot y_{i.t-1} + \phi_2 \cdot y_{i.t-2} + \alpha_k \cdot dummyk + e_{ij,t} \quad (1)$$

$$h_{i,t} = \omega_0 + \omega_1 \cdot \varepsilon_{i,t-1}^2 + \beta_1 \cdot h_{i,t-1} + \delta_k \cdot dummyk,\ k = \overline{1,3} \quad (2)$$

where $y_{i,t}$ stands for the value of return for the considered indexes, α_k are coefficients associated to the dummy variables in the return equation and δ_k coefficients associated to the dummy variables in the volatility equation.

In order to show an impact of a certain event on the dependent variables, the value of coefficients of the dummies should be positive and statistically significant for each of the studied market. When the coefficients are not statistically significant, we can conclude that there have not been identified any effects of the crisis on the return or volatility in the studied markets.

A similar method shall be applied for a more limited time frame, between November 10th, 2015 (David Cameron, UK Prime Minister, asks the European Council President a renegotiation of the terms of the UK membership of the European Union) and August 26th, 2016, in order to reduce the effects of other turbulences and the perpetration of previous crisis effects into the Brexit shock period.

3. The results

To start with, we shall calculate the impact of the 3 crisis on the CEE capital markets. We worked on the representative indexes for the stock exchanges in Bulgaria (SOFIX), the Czech Republic (PX), Poland (WIG20), Romania (BET) and Hungary (BUX), the main descriptive figures of the statistical terms associated to the 5 data series being listed in Table 1.

It can be seen that the mean for the BET index daily return is almost equal to zero in the analyzed time interval, with a negative sign. From the 5 analyzed

markets, the largest absolute value of the mean is the one of the Bulgarian market, meaning that - marginally – for the analyzed period, the mean is negative.

Table 1 Descriptive Statistics for selected indexes (01.01.2007-26.08.2016)

	Mean	Std. Deviation	Analysis N
BET	-.00002445	.006855355	2520
BUX	.00002229	.006986917	2520
PX	-.00010249	.006538151	2520
SOFIX	-.00016359	.005398771	2520
WIG20	-.00010802	.006461188	2520

Source: www.bvb.ro, own calculation

In order to see the relations between the returns on the studied markets, we use the correlation matrix, listed in Table 2. The results show stronger correlations between the markets in Poland, Hungary and the Czech Republic, as compared to the Romanian and Bulgarian capital markets.

Table 2 Correlation Matrix for selected indexes (01.01.2007-26.08.2016)

		BET	BUX	PX	SOFIX	WIG20
Correlation	BET	1.000	.429	.544	.366	.417
	BUX	.429	1.000	.587	.196	.582
	PX	.544	.587	1.000	.310	.639
	SOFIX	.366	.196	.310	1.000	.206
	WIG20	.417	.582	.639	.206	1.000

Source: www.bvb.ro, own calculation

We use the correlation matrix to calculate the eigenvalues and, using the Kaiser criterion for identifying the number of principal components, we can state that there is a principal component, as shown by Table 3. This principal component helps explains more than 55% of the initial causal space. Therefore, the identified principal component can be written as a linear combination of the initial variables, its dynamic explaining more than 55% of the initial causal space.

Table 3 Eigenvalues of the Correlation Matrix

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.770	55.393	55.393	2.770	55.393	55.393
2	.919	18.389	73.782			
3	.547	10.940	84.722			
4	.430	8.607	93.329			
5	.334	6.671	100.000			

Source: www.bvb.ro, own calculation

Using the component scores relative to the identified principal component, we define the variable fa, that will be used in the assessment of the impact of the

recent crises on the Eastern European indexes. In order to construct the composite index fa, we use the relationship:

$$fa = 0.268*BET + 0.282*BUX + 0.310*PX + 0.174*SOFIX + 0.288*WIG20 \quad (3)$$

Furthermore, we use regressions from an AR(2)-GARCH(1,1) model, with the return equation:

$$FA=C(1)+C(2)*FA(-1)+C(3)*FA(-2)+C(4)*Dum1+C(5)*Dum2+C(6)*Dum3 \quad (4)$$

and the variance equation:

$$GARCH = C(7) + C(8)*Resid(-1)^2 + C(9)*GARCH(-1) + C(10)*Dum1 + C(11)*Dum2 + C(12)*Dum3 \quad (5)$$

The results are summarized in Table 4.

As we can see, the model for the constructed factor returns series has none of the dummy variables' coefficients as being significant (the only significant coefficient is the one associated with the lag 2 variable), a result that is in line with those obtained by other researchers (Munoz, 2010). But in the variance equation, the dummy variable associated with the global financial crises is significant and shows an increased volatility of returns. In respect with the Brexit event, we see that the coefficient is statistically significant, but it shows that the volatility decreased in the first 30 days after the UK referendum. This result can be explained by the cautious strategies adopted by the investors and the uncertainty related to the schedule associated with the UK exist from the European Union.

Table 4: AR(2)-GARCH(1,1) estimation for fa variable (01.01.2007-26.08.2016)

	Variable	Coefficient	Std. Error	z-Statistic	Prob.
Return equation	C(1)	0.000173	8.59E-05	2.017997	0.0436
	C(2)	0.082817	0.021448	3.861267	0.0001
	C(3)	-0.014668	0.022155	-0.662058	0.5079
	C(4)	-9.72E-05	0.00159	-0.061126	0.9513
	C(5)	-0.005998	0.00425	-1.411357	0.1581
	C(6)	0.000485	0.000741	0.653697	0.5133
Variance equation	C	6.87E-07	8.82E-08	7.793834	0
	RESID(-1)^2	0.118119	0.00859	13.75137	0
	GARCH(-1)	0.861965	0.0077	111.9415	0
	DUMMY1	-4.06E-07	8.28E-07	-0.490773	0.6236
	DUMMY2	6.18E-05	2.85E-05	2.17357	0.0297
	DUMMY3	-1.97E-06	6.71E-07	-2.931856	0.0034

Source: own calculation

We continue this analysis by considering the impact of those crises on the developed markets from the European Union, namely Germany and France, and also for the United States.

The obtained results are summarized in Table 5. We obtained that the model for the mean is different across the studied markets: the model for the German market has no statistically significant coefficient at the 10% level, whereas in the case of the French capital market, the returns depend on the previous level (the coefficient for the lag 1 is statistically significant). For the US market, the returns depend on the lag one level of returns, being also present the influence of the Global Financial crisis (as the coefficient for the associated dummy variable is statistically significant).

Analyzing the volatility equation, we can conclude that the volatility increased during the Global Financial crisis in all the markets we studied, as the coefficients are positive and statistically significant. In respect to the dummy variable associated with the Brexit (dummy3), the model suggests that the coefficients are statistically significant, but have negative values. This can lead to the conclusion that, during the time frame considered (one month after the UK referendum), the volatility of the markets decreased, as a sign of investor's reluctance to invest for medium and long term. This result can be explained by the uncertainty related to the mechanisms and procedures that will be necessary for Great Britain to exit the European Union (especially by the trigger event, according to the article 50 from the European Union Treaty).

Table 5 The results of AR(2)-GARCH(1,1) estimation for DAX, CAC40 and DJIA returns (01.01.2007-26.08.2016)

		DAX		CAC40		DJIA	
		Estimators	**Standard errors**	**Estimators**	**Standard errors**	**Estimators**	**Standard errors**
Mean equation	C(1)	0.000322*	0.0001	0.000200	0.0001	0.000254*	0.0001
	C(2)	-0.011061	0.0226	-0.049144*	0.0222	-0.068060*	0.0230
	C(3)	-0.015841	0.0217	-0.021792	0.0215	0.000142	0.0217
	C(4)	-0.000446	0.0009	-0.000358	0.0015	0.000145	0.0011
	C(5)	-0.003977	0.0031	-0.004145	0.0040	-0.005066*	0.0029
	C(6)	-0.000660	0.0008	-0.000976	0.0008	-0.000224	0.0003
Variance equation	C	6.61E-07*	0.0001	9.48E-07*	0.0001	4.76E-07*	0.0000
	RESID(-1)^2	0.079086*	0.0080	0.095677*	0.0091	0.110187*	0.0106
	GARCH(-1)	0.902441*	0.0092	0.880617*	0.0107	0.865649*	0.0116
	DUMMY1	-6.89E-07	0.0001	-5.40E-07	0.0001	2.13E-07	0.0000
	DUMMY2	2.59E-05*	0.0001	4.51E-05*	0.0000	3.89E-05*	0.0001
	DUMMY3	-3.08E-06*	0.0001	-4.40E-06*	0.0000	-1.22E-06*	0.0000
* denote statistical significance at the 10% level							

Source: own calculation

In order to see if the selected time frame influences the results of the Brexit effect on the analyzed markets, we shall work on a more limited time frame, between November 10th 2015 and August 26th, 2016 (November 10th, 2015 being

the date when Prime Minister David Cameron sent the official request to renegotiate the EU membership of the UK). We use an AR(2)-GARCH(1,1) model in order to assess the return equation:

$$FACT=C(1)+C(2)*FACT(-1)+C(3)*FACT(-2)+C(4)*Dummy \quad (6)$$

and the variance equation, given by:

$$GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1) + C(8)*Dummy \quad (7)$$

The results are presented in Table 6.

Similarly, we reduced the initial causal space (of the returns for the 5 CEE countries) applying the Principal Component Analysis and we obtained one principal component (explaining over 53% of the common characteristics of the 5 data series). The dummy variable associated to the Brexit is the 30 days time frame following the referendum and the AR(2)-GARCH(1,1) model for the resulting principal component is presented in Table 6.

Table 6 AR(2)-GARCH(1,1) estimation for fact variable (10.11.2015-26.08.2016)

	Variable	Coefficient	Std. Error	z-Statistic	Prob.
Return Equation	C(1)	-0.000201	0.000288	-0.695429	0.4868
	C(2)	0.06531	0.086161	0.757997	0.4485
	C(3)	-0.036099	0.08386	-0.430466	0.6669
	C(4)	0.001006	0.001055	0.953771	0.3402
Variance equation	C	6.72E-07	4.90E-07	1.372909	0.1698
	RESID(-1)^2	0.143556	0.059403	2.416655	0.0157
	GARCH(-1)	0.841054	0.065738	12.79401	0
	DUMMY	-1.86E-06	9.15E-07	-2.031779	0.0422

Source: own calculation

Therefore, the conclusions drawn from the analysis of the time frame January 1st, 2007 to August 26th, 2016 remain valid as there is not a single coefficient in the return equation that is statistically significant and only two coefficients that are statistically significant in the volatility equation. The negative value of the dummy variable shows that, within 30 days since the referendum, the volatility on the CEE markets lowered (this could be most probably explained as an effect of a high appetite towards risk of the investors).

Table 7 The results of AR(2)-GARCH(1,1) estimation for DAX, CAC40 and DJIA returns (10.11.2015-26.08.2016)

		DAX		CAC40		DJIA	
		Estimators	**Standard errors**	**Estimators**	**Standard errors**	**Estimators**	**Standard errors**
Mean equation	C(1)	0.000126	0.0004	-0.000280	0.0004	0.000140	0.0002
	C(2)	0.046159	0.0647	0.032517	0.0880	-0.058712	0.0871
	C(3)	-0.049676	0.0681	-0.017043	0.0678	0.075954	0.0827
	C(4)	0.000848	0.0011	-1.09E-05	0.0032	0.000111	0.0004
Variance equation	C	1.29E-06	0.0000	2.61E-05*	0.0000	9.14E-07*	0.0000
	RESID(-1)^2	-0.017981	0.0099	0.127012	0.1101	0.337297*	0.0885
	GARCH (-1)	0.99532*	0.0074	0.134365	0.4655	0.636109*	0.0757
	DUMMY	-2.99E-06*	0.0000	4.46E-05	0.0000	-4.46E-07	0.0000
* denote statistical significance at the 10% level							

Source: own calculation

In the case of the developed countries, the results are shown in Table 7, where we can see major differences as compared to the first group of countries.

The previous conclusion is maintained (the conclusion stating that the volatility went down post referendum in the UK) in the case of Germany only, where the coefficient associated to the dummy variable is statistically significant and its value is negative. For all the other markets, the French and the American capital markets, the effect of the Brexit is not relevant by applying the selected model. This can be explained by the weaker interconnections between the French and the British markets (two markets that have different transactional philosophy, the British market is much more developed), but also by considering the indifference of the American market in relation to events in the EU (the EU does not have a unified stock exchange to compete the US stock exchange).

Conclusions

Based on data associated to January 1st, 2007 – August 26th, 2016 time frame, for 8 countries, out of which 5 belong to the Central and Eastern Europe, we studied the way capital markets responded to exogenous negative events, first occurring on the mature markets. We referred to 3 periods of crisis – the subprime crisis, the global financial crisis and the Brexit, attaching to each event 3 dummy variables. In order to reduce the initial causal space generated by the returns in the CEE markets, we applied the Principal Component Analysis, identifying the number of principal components that can predict (with a certain degree of accuracy) the common development of the 5 data series. The conclusion is that there is one single principal component, that was subsequently used to approximate the values of return and volatility within a AR(2)-GARCH (1,1) model. The return

equation shows that the current value of the aggregated return depends on the previous value (with a lag), its coefficient being a positive one. The equation of the return volatility shows that, except for the coefficient attached to the dummy variable (the subprime crisis coefficient), all the other coefficients are statistically significant. In conclusion, the result confirms the empirical data stating that the returns volatility on the CEE financial markets increased as an effect of the global financial crisis. The negative value of the dummy coefficient attached to the Brexit crisis shows that the volatility decreased in the studied time frame (one month after June 2016). The result can be explained by the reserved attitude of the investors confronted with the Brexit decision (the Brexit is a process that can take almost 2 years to fulfill, according to Art. 50 of the EU Treaty). Similar results were obtained for a shorter period of time (November 10th, 2015 – August 26th, 2016), considered in order to eliminate possible effects of previous turbulences.

We applied a similar method to evaluate the impact of the 3 major crisis on two developed EU markets, Germany and France, and on the US financial market. For the equation comparing the present return to previous ones impacted by the three moments of shock we got totally different results, but for the equation of the volatility we got similar results with a significance threshold of 10% (moreover the significance threshold could be around 5% when one of the coefficients is not statistically significant).

The results included in this study are relevant to a wide range of actors - supervision authorities of the capital market, individual investors, investment funds- interested in the impact of crisis/turbulences on growing markets in the European Union (the Romanian and Bulgarian capital markets are the least developed in the EU, a disadvantage for their future candidacy to the Capital Markets Union, expected in 2019).

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