

THE EFFECT OF THE FINANCIAL CRISIS ON THE RETURNS OF THE CEE CAPITAL MARKETS

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ABSTRACT

In this article, we study the impact on return and volatility of CEE capital markets during three crises (subprime crisis, global financial crisis and the crisis generated by Brexit), occurred between January, 1st 2007 – August, 26th, 20016, taking into consideration the daily returns of the stock exchange indexes for 5 CEE countries. In order to reduce the initial causal space, represented by the returns on CEE markets, we used the Principal Component Analysis (PCA). A 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, volatility.*

JEL CLASSIFICATION: *C13, C22, C58, D53, G01, G15*

1. 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, there were different developments in the capital markets, 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*).

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The different stages of development in the Central and Eastern European markets lead to different reactions, in terms of amplitude, to shocks occurring on the mature markets in the past 10 years. In the present article, we shall take into account the most important turbulences from 2007 onward, namely the subprime crisis, the global economic crisis and, the most recent event impacting the financial markets, the UK decision to exit the EU. Regarding the global economic crisis, in 2008, a plunge 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 2008-2016) 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.

2. THE THEORETICAL BASIS OF CONTAGION ON THE FINANCIAL MARKETS AND THE PRINCIPAL COMPONENT ANALYSIS

The globalization process 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. Schumkler, 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. Therefore, a common movement of different markets is not always the result of contagion, but can also be an example of 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. Moreover, Yellen proposed that, in order to limit the effects of interconnectedness, some legal requirements to 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*), 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, Pascal and Cioacă (2014) studied the contagion during the occurrence of 4 crisis in the 2008-2014 time frame, finding a divergent behavior of the analyzed markets. Using dynamic correlations models, it was found that the Lehman Brothers collapse, as well as the sovereign debt crisis, generated contagion in all the analyzed markets, and during the Ukrainian conflict a crowd effect occurred. Also, Armeanu, Doia, Hăncilă and Cioacă (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, Tudorache, Cioacă and Burcă (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 2012 financial data for the listed companies on 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.

3. METHODOLOGY AND DATA

In the article we analyze the response of 5 Central and Eastern Europe capital markets (*from Bulgaria, Czech Republic, Poland, Romania and Hungary*) to three of the main crisis occurring during January 1st, 2007 – August, 26th, 2016, using the data representing the main indexes of these markets, 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, 2007), 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.

4. THE RESULTS

We shall calculate the impact of the 3 crisis on the CEE capital markets, considering 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 apply 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, that helps explaining more than 55% of the initial causal space (as shown by Table 3).

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

The same conclusion can be derived from the Figure 1, using the slope criterion, that helps identify the inflection points.

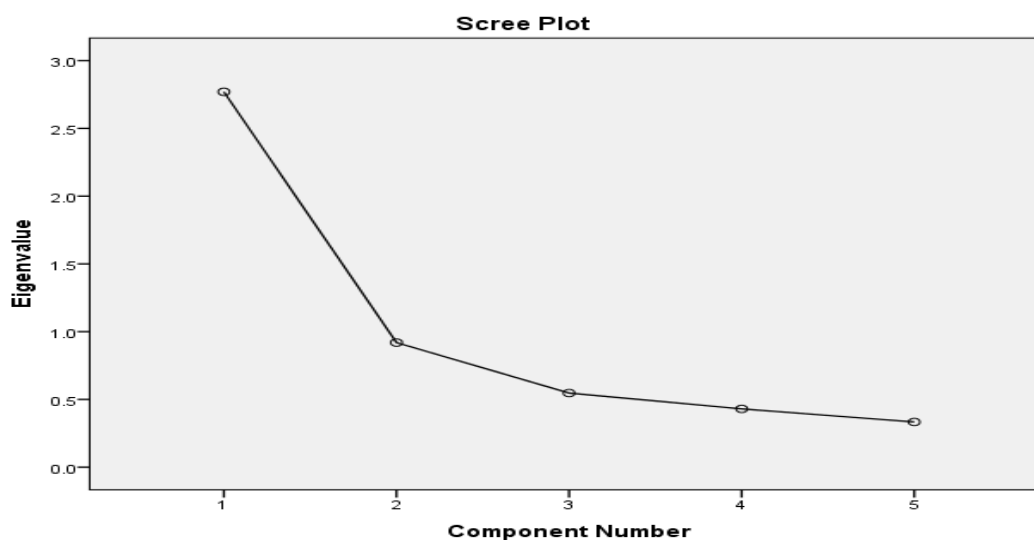


Figure 1. Eigenvalues of correlation matrix

Source: own calculation

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.

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:

$$fa = 0.268*BET + 0.282*BUX + 0.310*PX + 0.174*SOFIX + 0.288*WIG20.$$

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

$$FA=C(1)+C(2)*FA(-1)+C(3)*FA(-2)+C(4)*Dummy1+C(5)*Dummy2+C(6)*Dummy3 \quad (3)$$

and the variance equation:

$$GARCH = C(7) + C(8)*Resid(-1)^2 + C(9)*GARCH(-1) + C(10)*Dummy1 + C(11)*Dummy2 + C(12)*Dummy3 \quad (4)$$

The results are summarized in Table 4.

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

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.

5. CONCLUSIONS

Based on data associated to January 1st, 2007 – August 26th, 2016 time frame, for 5 Central and Eastern European countries, 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).

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).

REFERENCES

- Allen, F. and Gale, D. (2000). Financial Contagion, *The Journal of Political Economy*, vol.108, 1-33
- Armeanu, D., Tudorache, A., Cioacă, S.I., Burcă, A.M. (2012). Financial crisis impact of the development of the Romanian capital market, *Internal Auditing & Risk Management*, vol.7(1), 54-62
- Armeanu, D., Doia, C.A., Hăncilă, M., Cioacă, S.(2013). The Analysis of the correlation intensity between emerging markets during economic crisis, *Romanian Statistical Review Supplement*, vol.61(2), 307-318
- Armeanu, D.S., Pascal, C.E., Cioacă, S.I. (2014). Managing contagion risk during economic, financial and political shocks, *Proceedings of the 8th International Management Conference "Management challenges for sustainable development"*, November 6th-7th, 2014, Bucharest, 1148-1157
- Armeanu, D.S., Cioacă, S.I. (2015). An Assessment of the Bankruptcy Risk on the Romanian Capital Market, *Procedia-Social and Behavioral Sciences*, vol.182, 535-542
- Borga, M. (1998). Learning multidimensional signal processing, PhD Dissertation, Linkping University, Sweden. Retrieved August 26, 2016, from <http://www.diva-portal.org/smash/get/diva2:302872/FULLTEXT01.pdf>
- Cha, S.-H. (2012). Distance between distributions with special topologies of cost matrices, *Journal of Pattern Recognition Research*, vol.7, 1-25
- Christiansen, C. and Ranaldo, A. (2007). Extreme Coexceedances in New EU Member States' Stock Markets. Retrieved September 26, 2016, from <http://www.efmaefm.org/OEFMAMEETINGS/EFMA%20ANNUAL%20MEETINGS/2008-Athens/papers/Ranaldo.pdf>
- De la Torre, F. (2008). A least-squares unified view of pca, lda, cca and spectral graph methods, *Technology Report CMU-RI-TR-08-29*, Robotics Institutem Carnegie Mellon University. Retrieved August 26, 2016, from http://www.ri.cmu.edu/publication_view.html?pub_id=6086
- Dornbusch R., Park Y. C. & Claessens S. (2000). Contagion: Understanding how it spreads, *The World Bank Research Observer*, vol. 15, no. 2, 177–197
- Forbes, K. & Rigobon, R., (2002). No Contagion, Only Interdependence: Measuring Stock Market Comovements, *The Journal of Finance*, vol. LVII, no.5, 2223-2261
- Jolliffe, IT (2002). *Principal Component Analysis, Second Edition*, Springer-Verlag, New York
- Marais E. & Bates S. (2006). An empirical study to identify shift contagion during the Asian crisis, *Journal of International Financial Markets Institutions and Money*, vol.16(5), 468-479

- Muñoz M. P., Márquez M.D., Chuliá H. (2010). Contagion between markets during financial crises, <http://dx.doi.org/10.2139/ssrn.1654262>
- Pritsker, M (2000). The Channels for Financial Contagion. Retrieved August 26, 2016, from <http://siteresources.worldbank.org/INTMACRO/Resources/Pritsker.pdf>
- Rigobon, R. (2001). Contagion: How to measure it? Retrieved September 26, 2016, from <http://www.nber.org/papers/w8118.pdf>
- Schmukler, S.L., Zoido, P., Halac, M. (2003). Financial Globalization, Crises and Contagion. Retrieved August 26, 2016, from [http://siteresources.worldbank.org/DEC/Resources/32459_Schmukler,_Zoido,_and_Halac_\(Oct_2003\).pdf](http://siteresources.worldbank.org/DEC/Resources/32459_Schmukler,_Zoido,_and_Halac_(Oct_2003).pdf)
- Scott, H. (2011). Interconnectedness and contagion. Retrieved September 26, 2016, from http://isites.harvard.edu/fs/docs/icb.topic954703.files/Paper04_Scott_10-4.pdf
- Yellen, J.L.(2013). Interconnectedness and Systemic Risk: Lessons from the Financial Crisis and Policy Implications. Retrieved September 26, 2016, from <http://www.federalreserve.gov/newsevents/speech/Yellen20130104a.pdf>