Contagion and Comovement – Does the Initiator Matter

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Abstract

We use the wavelet analysis in order to test the presence of financial contagion between three developed Western European capital markets and the Romanian capital market in the recent financial crisis. We test the presence of contagion between the Romanian market and the German, French and United Kingdom markets using wavelet based framework. Our results indicate pure and fundamental contagion between all the Western European capital markets and the Romanian market. Furthermore, we found that there aren't any significant differences when we take into consideration the initiator as the Romanian capital market reacted in a similar manner towards all the markets in the analysis. Thus, during the sub-prime crisis, the Lehman Brothers collapse or the sovereign debt crisis the initiator didn't matter as the effects were similar in the Romanian market. This implies that the Romanian market is sensitive to short-term shocks from the Western European capital markets, which leads to a long-term fundamental contagion.

Key words: financial contagion, capital markets, financial crisis, wavelet analysis
J.E.L. classification: M42, M48, H83

1. Introduction

In the aftermath of financial crisis from 2007-2009 the importance of analyzing the contagion and comovement phenomenons has been a key focus for investors and risk managers, but especially international and national policy makers. While investors and risk managers are interested due to the adverse effects of contagion phenomenon on international portfolios, the international and national financial authorities seek out to find methods and instruments required to isolate and reduce the effects of an external shock on the internal financial markets. Therefore, the study of the contagion phenomenon is important both for investors who seek out to reduce the risk associated to their investments via international diversification, but also for policy makers who want to increase the resilience of internal markets to external shocks. This is even more important in periods of global financial crisis when investors tend to act irrationally, which decreases the effect of international portfolios diversification, but also increases the effect of external shocks on national financial markets.

2. Theoretical background

While the effects of the contagion phenomenon are dependent on the initiator or the recipient of the external shocks, we need to distinguish between fundamental and pure contagion. In general, we consider that the pure based contagion phenomenon is the most destructive as it involves the manner in which a financial markets reacts to short-term shocks, while the fundamental based contagion highlights the role of the macroeconomic factors in preventing or spreading the shock on a global scale (Forbes and Rigobon 2002). While many studies, like (Gallegati 2012; Kiviaho et al., 2014; Dewandaru et al., 2016, Cărăușu, 2017; Cărăușu et al., 2018) have emphasized the role of the US capital market in initiating and escalading the contagion phenomenon in the recent financial crisis, the debate is still ongoing.

One of the major issues of previous studies involves around on focusing testing the effects of external shocks from the US markets to developed markets (Gallegati 2012), or to emerging markets (Kiviaho et al., 2014, Cărăușu, 2017), but they ignore additional initiators that could arise from other markets such as the European Union financial markets. In the case of the Romanian capital market but few studies, test additional initiators but with mixed results. (Syllignakis and Kouretas 2011) find signs of pure contagion between the German most CEE countries during 2008-2009. Meanwhile, (Cărăușu et al., 2018) finds evidence for the contagion phenomenon between the Western European capital markets and the markets from Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Lithuania, Poland and Romania, but no sign of contagion for the Slovakian and Estonian capital markets.

However, few studies try to test the effect of the Lehman Brothers bankruptcy on the contagion phenomenon from Western European capital markets on the Romanian capital market. Also, few studies use modern methods of analyzing financial contagion such as the wavelet analysis which allows the testing simultaneously both pure and fundamental based contagion.

Therefore, the aim of this paper is to investigate if the Romanian capital market experienced pure financial contagion from the German, France and United Kingdom capital markets in the outbreak of the recent financial crisis. The rest of this paper is organized as follows: section 2 presents the data use in the analysis, section 3 presents the methodology, section 4 presents the empirical results while section 5 concludes.

3. Data

The aim of our paper is to test whether the Romanian capital market exhibited a contagion phenomenon in relation to the major European capital markets: Germany, France and United Kingdom. We chose these three markets, as they are the most developed and influential capital markets in the European Union. In order to test the presence of contagion we will use the specific stock market indices for each country namely: *BET* – Romania, *CAC40* – France, *DAX30* – Germany and *FTSE100* – United Kingdom. Furthermore, will split our sample into two distinct periods an *ex-ante* and *ex-post* period with an length of 256 trading days similar to (Dewandaru et al., 2016; Cărăușu, 2017). In addition, we will eliminate all non-trading days, legal holydays in each country, which reduces our analysis period from 19 July 2007 – 19 November 2009.

The stock market indices, collected from DataStream, are transformed into daily returns by calculating the logarithmic differences of the daily end prices as in $r_t=ln\ (P_t/P_{t-1})$, where P_t and P_{t-1} represent the stock price index at time t and $t-1$, respectively. In order to test the actual contagion phenomenon we will use the indices in local currencies as in previous studies like (Kiviaho et al. 2014; Cărăușu et al., 2018) because Mink (2015) indicates that using other currencies could capture the effects of changes in the exchange rates between two or more currencies. Table no 1 contains the descriptive statistics for all the data, including the two sub samples. The first sample contains data from 19 July 2007 and until the Lehman Brothers collapse in 14 September 2008, while the second samples contain data from 16 September 2008 - 19 November 2009.

Table no. 1 Descriptive statistics

	RO1	RO2	RO	FR1	FR2	FR	DE1	DE2	DE	UK1	UK2	UK
Mean	-0.0028	-0.0001	-0.0014	-0.0012	-0.0005	-0.0009	-0.0009	-0.0003	-0.0006	-0.0007	-0.0001	-0.0004
Med.	-0.0016	0.0005	-0.0003	-0.0008	-0.0001	-0.0003	-0.0005	0.0007	0.0002	-0.0002	0.0006	0.0006
Max.	0.0451	0.1009	0.1009	0.0583	0.1059	0.1059	0.0576	0.1079	0.1079	0.0464	0.0964	0.0964
Min.	-0.0756	-0.2201	-0.2201	-0.0707	-0.0947	-0.0947	-0.0743	-0.0861	-0.0861	-0.0563	-0.0926	-0.0926
Std. Dev.	0.0199	0.0350	0.0285	0.0161	0.0276	0.0226	0.0142	0.0267	0.0214	0.0158	0.0249	0.0208
Skewness	-0.4405	-1.103.0	-1.025.8	-0.1963	0.1685	0.1408	-0.4816	0.1924	0.1383	-0.0862	0.0873	0.0749
Kurtosis	3.617.5	9.547.9	1.113.3	4.198.2	6.096.9	7.325.5	6.344.6	6.063.8	7.985.2	3.430.6	6.381.5	7.043.2
Jar. Ber	1.234.9	5.092.6	1.500.9	1.695.9	1.035.2	4.008.5	1.292.2	1.017.0	5.318.3	2.296.1	1.222.9	3.492.2
N	256	256	512	256	256	512	256	256	512	256	256	512

Source: Own computations by the authors on data provided by Datastream

4. Methodology

In order to test the presence of pure and fundamental contagion we will use the methodology developed by Gallegati (2012), which involves plotting and testing specific indicators from the wavelet analysis.

4.1 Multiscale Analysis of Correlation

In order to test the presence of market contagion we will use the multiscale analysis of correlation, which allows testing the degree of independency between two variables at different scales and periods.

If we calculate the variance at scale j, $\sigma_X^2(\lambda_j)$ for a stationary stochastic process$\{X\}$, at the variance *j-level* and the time *t*, we can calculate the wavelet coefficients from the MODWT (Maximal Overlap Discrete Wavelet Transform) filter as in formula (1):

$$\sigma_X^2(\lambda_j) = Var(\omega_{j,t}^X) \tag{1}$$

Moreover, we can calculate the degree of covariance between two processes *X* and *Y* that takes into account the scale degree of dependency as in formula (2):

$$\gamma_{XY}(\lambda_j) = Cov(\omega_{j,t}^X \omega_{j,t}^Y) \tag{2}$$

Where $\omega_{j,t}^X$ – is the stochastic process obtained by filtering the X_t series with the MODWT filter.

Furthermore, with the help of two unbiased estimators $\tilde{\sigma}_X(\lambda_j)$, $\tilde{\sigma}_Y(\lambda_j)$, and the scale dependent covariance $\tilde{\gamma}_{XY}(\lambda_j)$, we can compute the wavelet correlation coefficient between two variables $\rho_{XY}(\lambda_j)$ as in formula (3):

$$\tilde{\rho}_{XY}(\lambda_j) = \frac{\tilde{\gamma}_{XY}(\lambda_j)}{\tilde{\sigma}_X(\lambda_j)\tilde{\sigma}_Y(\lambda_j)} \tag{3}$$

As recommended by Gallegati (2012), we can test the presence of contagion via the confidence interval of each individual estimator of the wavelet correlation for scale *j*, $\tilde{\rho}_{XY}(\lambda_j)$. By plotting the upper and lower confidence intervals of each coefficient at all the scales, we can test the presence of pure contagion. If there are significant changes in the *ex-ante* and *ex-post* periods, we will notice downwards or upwards shifts in the graph. Moreover, if the random intervals that form 100*(1-2*p*)% confidence interval, from the robust estimator MODWT are non-overlapping we assume pure contagion. This involves plotting the wavelet coefficients for the ex-ante and the ex-post periods as $\tilde{\rho}_{xy}^I(\lambda_j)$ and $\tilde{\rho}_{xy}^{II}(\lambda_j)$, and testing the null hyphothesis of no market contagion as in Gallegati (2012) and in formula (4):

$$H_0: \tilde{\rho}_{xy}^I(\lambda_j) = \tilde{\rho}_{xy}^{II}(\lambda_j) \tag{4}$$

If any point of the wavelet scale graph are non-overlapping the null hypothesis of no-contagion is rejected and we accept the presence of pure market contagion. Alternatively, if the confidence intervals are overlapping we reject the presence of contagion between two markets.

When calculating the MODTW coefficients we will use the Daubechies compactly supported least asymmetric (LA) wavelet filter (Daubechies 1992) of length $L = 8$, noted by LA (8) for determining the $\tilde{\rho}_{XY}(\lambda_j)$ for each scale of the analysis. We prefer to use this wavelet filter, because previous studies like (Gallegati 2012; Cărăușu et al., 2018) have indicated that LA (8) filter is most adequate to handle high frequency data such as time series data.

4.2 The Continuous Wavelet Transform

The continuous wavelet transform (CWT), developed by Torrence and Compo (1998) allows us to test for synchronization and delays between two different time series. The CWT $W_n^X(s)$ of an individual time series x_n at a scale *s* can be determined by transposing a mother wavelet ψ_0 on the time series. If we use the Morlet wavelet, the CWT becomes as in formula (5):

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} \sum_{n'=1}^{N} x_{n'} \psi_0 \left((n' - n) \frac{\delta t}{s} \right), \quad n' = 1,2, \dots, N \tag{5}$$

4.3 Wavelet coherence

The wavelet coherence analysis can test the degree of interaction between two time series *X* and *Y* in both time and frequency. By comparing the cross-wavelet spectrum to the product of the spectrum of each individual series, we can compare the degree of interaction between two variables in both time and frequency domain. Torrence and Webster (1998) and Grinsted et al. (2004) argue that wavelet coherence between two variables $R_n^2(s)$ is calculated as in formula (6):

$$R_n^2(s) = \frac{\left| S\left(s^{-1} W_n^{XY}(s)\right) \right|^2}{S(s^{-1}|W_n^X(s)|^2).S(s^{-1}|W_n^Y(s)|^2)} \tag{6}$$

where: $W_n^X(s)$ and $W_n^Y(s)$ are the wavelet transforms (WTC) of two time series, S(.) is the smoothing operator and *s* is the wavelet scale.

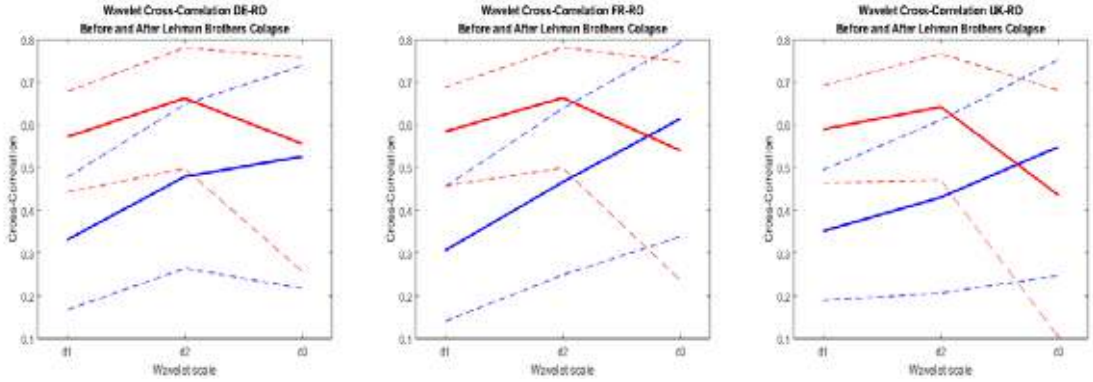
If we are testing for contagion, we will consider high values of coherence coefficients as proof for higher degrees of interactions between two variables. Moreover, if the high coherency coefficients are in the lower scale we consider them as signs of "pure" contagion, while high values are signs of "fundamental" based contagion.

5. Empirical results

Our analysis focuses on testing the presence of pure contagion between the Romanian capital market and three distinct capital markets from Western Europe: Germany, France and United Kingdom. Thus, we will use the wavelet analysis to test the presence of pure contagion.

The results from figure no. 1 offer a general perspective of the changes occurred in Romanian capital market before and after the Lehman Bother collapse. We first note that the average wavelet correlation coefficients are higher for the ex-post period 16 September 2008 - 19 November 2009 than the respective coefficients for the ex-ante period 19 July 2007 - 14 September 2008. The shift upwards in the graphs of the ex-post periods indicates a higher degree of interdependence between two markets, which almost doubles in the short time-window of 2-4 days corresponding to scale d1. Furthermore, we notice that there aren't any significant differences between the degree of interdependence between the Romanian capital market and Germany, France and United Kingdom respectively. This is a sign of the ongoing European Integration process and similar behavior (herding) among Western European markets.

Figure no. 1. Wavelet Cross-Correlations DE-FR-UK-RO before and after Lehman Brothers Collapse



Source: Own computations by the author on data provided by Datastream

Note: Estimated wavelet correlation of US and RO countries stock market returns for before the Lehman Brothers collapse (blue line) and after the collapse (red line) periods. The dashed lines denote the upper and lower bounds for the 95 percent confidence interval before (blue dashed line) and after (red dashed line) Lehman. The null hypothesis of no contagion is rejected when the confidence intervals are not overlapping.

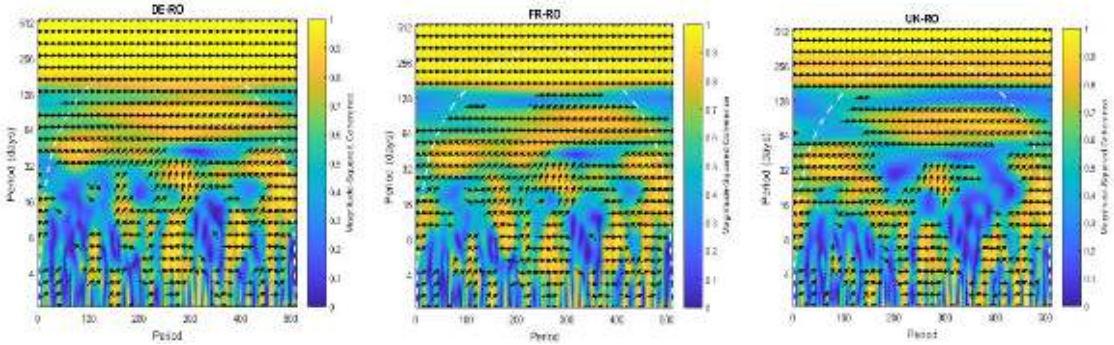
While we notice on the graphs and obvious shift for the ex-post period, the changes are not significant enough for us to conclude that there was sign of pure contagion, as the doted upper and lower confidence intervals are overlapping at all the scales. This, intriguing results could indicate that there are no signs of contagion, but this could also indicate that there were multiple shocks in our analysis period similar to the results of (Cărăușu, 2017). We incline to believe that we are witnessing multiple shocks before and after the Lehman Brothers collapse such as the US mortgage bubble or the Eurozone sovereign debt crisis. The Romanian capital market reacted to external shocks long before the Lehman Brothers collapse. However, our results indicate that the Romanian capital market was sensitive to shocks from the Western Europe capital markets, but in the aftermath of the Lehman Brothers collapse, there were no significant changes.

A further investigation of our initial results, we will use the wavelet coherency analysis, which has the advantage of plotting simultaneously both time and frequency domain. Therefore, we can use the wavelet coherence analysis to view multiple contagion periods between two markets, as depicted in the horizontal timeline or the vertical frequency domain. The results from figure no. 2 offer a general perspective on the degree of contagion and comovement between the Romanian capital market and the capital markets from Germany, France and United Kingdom from 19 July 2007 – 19 November 2009.

The wavelet coherency analysis plots the degree of interdependence between two markets from light blue (low coherency values) to yellow (high coherency values) in order to test the interdependence and contagion phenomenon on a scale-by-scale basis. We note multiple periods of „pure" contagion in the lower bands 1-8 days trading before and after the Lehman Brothers collapse between the Romanian capital market and all Western European markets in our analysis. This suggests multiples shocks, before and after the 256 days point, which marks the start of the global financial crisis. We can even note o clear sign of pure contagion right before and after 14 September 2008. Furthermore, we can note signs of fundamental based contagion between the Romanian capital market and Western European markets, as the coherency values are very high for 128-512 trading window period.

Overall, we find evidence of „pure" and „fundamental" contagion from all of the Western European capital markets towards the Romanian capital market in 2007 during the sub-prime crisis, before and after the Lehman Brother collapse in 2008 and during the European Sovereign debt crisis from 2009. On the long run, the Romanian capital market was in sync with both the German, French and United Kingdom capital markets between 2007 and 2009. In addition, we note a higher degree of comovement between the Romanian capital market and the German capital market, and lower level as opposed to the French and the UK market. Furthermore, this would indicated that despite the fact that the external shock was initially started in the US capital market it slowly enveloped all the capital markets in Western Europe and later on emerging markets like Romania.

Figure no. 2. Results of the wavelet coherence methodology for US vs. RO



Source: Own computations by the author on data provided by Datastream

While, our initial results from the MODTW analysis provided mixed results, the results from the wavelet coherency analysis indicated both pure and fundamental based contagion periods. We found evidence of pure contagion in the sub-prime crisis, before, after the Lehman Brothers collapse, and during the sovereign debt crisis period. Our results, confirm previous studies like (Syllignakis and Kouretas 2011) who found evidence of pure contagion between the Romanian capital market and German capital market, but also with the results of (Cărăușu et al., 2018) who found evidence of market contagion between the whole Western European capital markets and the Romanian capital market between 2005-2009.

6. Conclusions

The aim of this paper was to investigate whether the Lehman Brothers collapse from 14 September 2008 was propagated from the Western European capital markets towards the Romanian capital market. We used the wavelet analysis in order to test and measure the degree of contagion and comovement between the Romanian capital and the German, French and UK markets. Our results indicate two distinct phenomenons. Firstly, we find evidence of pure and fundamental contagion not only after the Lehman Brothers collapse but also before in the sub-prime crisis period, and after during the sovereign debt crisis period. This indicates an increase of inter-market linkages and a higher degree of sensitivity on the Romanian capital markets towards developed markets. Secondly, we found that while the external shock was initially started in the US capital market it slowly enveloped all the capital markets in Western Europe and later on emerging markets like Romania. Thus, our results indicate a higher degree of linkages between the Romanian capital market and the developed Western European capital markets, as the initiator didn't matter.

Our second phenomenon emphasizes a general reduction in the efficiency of international portfolios because shock, which originated in the US spread towards both developed and emerging capital markets. Meanwhile, the presence of multiple pure contagion periods emphasize the need for higher vigilance from the Romanian national authorities in order to protect the local capital market from external shocks. Therefore, in the aftermath of the recent financial crisis, when capital markets get more and more interconnected preventing and combating the effects of external shocks on national markets must be a key objective of national authorities. With the help of an adequate monetary policy and changes in the regulatory framework, national and international authorities could increase the degree of protection for their national capital markets

7. References

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