THE IMPACT OF THE FINANCIAL CRISIS ON LONG MEMORY: EVIDENCE FROM EUROPEAN BANKING INDICES

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Abstact: *We have analyzed the impact of the financial crisis on the existence of the long term dependency for European banking indices. By estimating Hurst Exponent, ARFIMA and FIGARCH models we found that major financial crisis such as, Mexican, Asian and Russian, Argentine crisis and Global crisis from 2008-2009 had different effects on long memory. In the case of STOXX 600 Bank Index, when estimating an ARFIMA models by using Willinger, Taqqu and Teverovsky method, the H-estimate was higher than 0.5, highlighting the presence of long memory during Mexican and Global financial crisis from 2008-2009. In the case of MSCI Europe Bank Index we found evidence of long memory during Asian and Russian crisis and Argentine crisis. For both indices, during the Global crisis, the results of FIGARCH models reflected the presence of long term dependency in volatility with covariance non-stationary, but mean reverting, showing the likelihood of persistence of a shock for a long period. Moreover, during Argentine crisis, the results reflected evidence of stationarity intermediate memory process.*

Key words: long memory, banking indices, financial crisis

JEL classification: C13, C32, G01

1.Introduction

The long memory property is an area that has been capturing the attention of economists and econometricians since 1980. During time, a series of authors tried to develop a clear definition associated with this phenomenon (See Hurts, 1951, Mandelbrot, 1968). Baillie (1996) defines the long memory presence "*in terms of the persistence of observed correlation*".

The interconnection between the long term volatility and the dynamics of the stock markets has been a subject of considerable debate across the international economic forums and not only. The empirical literature related to this field implies a series of methodologies in order to investigate this issue, providing mixed results.

It is a well known fact the impact of the financial crisis generates great transformations across worldwide economies. The recent financial crisis is a strong argument in favour of this statement, being considered by many authors one of the most important tests of sustainability from the entire history. All sectors of the economies registered impressive shocks and the responsible authorities around the world faced the great challenge to develop strategies that would counteract the negative effects of the crisis. Taking into consideration the interconnections of the global economies the exchange rate system was definitely reconfigured. Kohler (2010), Razin and Rosefielde (2010) investigated the interconnection between different financial crisis and the exchange rates. Kohler (2010) argues that during financial crisis capital flows into what in generally known as safe heaven currencies such the US dollar and Swiss franc.

Financial and monetary stability are considered to be the engines of the current global architecture. Financial development is a necessary condition for achieving high rates of economic growth, which is a main objective for every economy. The European Union, as a key actor in global flows, intensified its efforts in elaborating strategies that target the efficient management of the monetary and financial system. Despite all efforts, the financial crisis whether we refer to the recent one or the Asian, Mexican, Russian crisis happened frequently during history and no efforts will guarantee they will not appear in the future.

The main purpose of this paper is to assess the long memory property of European banking indices taking into consideration the impact of different financial crisis: Mexican crisis, Asian and Russian crisis, Argentine crisis, Global financial crisis from 2008-2009. In order to achieve this objective a series of methodologies were used: Hurst Exponent, ARFIMA models, FIGARCH models, Willinger, Taqqu and Teverovski method. This paper is structured as follows: Section 2 presents the literature review, Section 3 discusses the characteristics of the returns series, Section 3 analyzes the presence of long memory for the banking indices during major financial crisis and Section 4 concludes.

2.Literature review

A number of studies concentrated their research upon the long term property and the interconnection between the financial crises and this phenomenon. Han (2014) examines the impact of two well known financial crisis, namely the Asian crisis from 97-98 and the recent economic crisis from 2008-2009 upon the long term volatility of daily foreign exchange rates. In order to develop a comprehensive analysis of the correlation between the long memory dependency and the financial crisis, the author uses two complex methodologies such as FIGARCH and the Local White model. The results of the empirical findings argue the fact that during crisis periods the long term volatility dependency of the analyzed exchange rates (KRW-USD and JPY-USED) is higher than the one associated with the periods when no shock affects the markets. One main advantage of this paper, that also constitute the starting point of our own analysis is the fact that it provides strong basis for understanding the manner in which the financial crisis influence the dynamics of foreign exchange rates and furthermore it identifies the triggering factors of the long memory property.

Sensoy and Tabak (2013) analyzed the long memory of the European Union stock markets taking into consideration the adoption of the common currency, namely the Euro. The authors use a complex methodology implying a generalized Hurst exponent with a rolling window approach. The main conclusion of the study reveals the fact that all the member states of the European Union have different patterns in what concerns the time varying long memory, due to a series of internal characteristics of these economies. Furthermore, the empirical results argue the fact that there is a strong positive correlation between market efficiency and market maturity, therefore the most developed members of the EU have the most efficient markets such as Denmark, Italy, Finland while at the opposite pole we have some emerging economies from Central and Eastern Europe namely Lithuania, Estonia or Bulgaria. Moreover the recent financial crisis that determined a reconfiguration of the European architecture, generate a negative impact across the Eurozone the most affected economies being France, Greece and Spain.

Caporale and Gi-Alana (2013) studied the existence of long memory for the Ukrainian stock market by using Whittle estimator. They concluded that the returns are characterised by a small degree of long memory. Also, the authors found evidence of long memory in volatility. The results obtained highlighted that the presence of long memory is influenced by the day of the week effect. Mondays and Fridays are characterised by higher dependency.

Dajcman et al. (2010) also analyzed the long term property across stock indices and return series of stocks across three Central and Eastern economies namely (Slovenia, Czech Republic and Hungary). In order to obtain accurate results the authors used a wide range of methodologies including the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, the Geweke and Porter-Hudak (GPH) test or the method of local Whittle approximation. The main findings of the articles reveal the fact that the majority of the stock returns of the Slovenian market have the long term property while the stock returns from the Hungarian or Czech Republic stock markets may be characterized as being stationary.

Kasman et al. (2009) investigated the long memory across eight Central and Eastern european stock markets, by using a wide range of methodologies such as: ARFIMA, GPH, FIGARCH and HYGARCH. The obtained results indicate the presence of long memory across five analyzed stock markets.

Pamula and Grech (2008) analyzed the behavior of WIG Stock Index in the vicinity of crashes' appearance on the financial market. The results indicate that the evolution of the Hurst exponent is influenced by the signal to buy or by the signal to sell. Moreover the results obtained provide evidence of a relation between the rate of the Hurst exponent drop and the local correction the WIG Index gains after the crash. The authors consider that a nervous situation on the market should be characterized by the presence of anticorrelations in price returns of different assests and a decreasing trend of Hurst exponent before the appearance of the crash. The Fed intervention in 2007 drastically changes the Hurst exponent evolution, from its decreasing trend to a horizontal trend with the average value 0.5.

Cajueiro and Tabak (2006) using GARCH models assed the impact of high speculation and rational bubbles upon 39 banking indices from both developed and emerging economies, between 31 December 1994 and 6 October 2003. The main results of the paper suggest the fact that the rational bubbles strongly influence the banking equity indices. Furthermore the identifies nonlinearities should be considered by the investors when making a decision regarding their future investments.

3. Methodology

In order to analyze the impact of the major financial crisis on the evolution of long memory dependency we have used the following statistical methods: Hurst Exponent (1951), Willinger, Taqqu and Teverovski (1999), ARFIMA (1980, 1981) and FIGARCH (1996) models. The Hurst exponent (1951) was estimated by applying R/S statistics. The R/S statistic is the range of partial sums of deviations of time series of its mean rescaled by its standard deviation. The Hurst exponent is calculated using the following equation:

$$(R/S)_\tau = \frac{1}{s_\tau}\left[\max\sum_{t=1}^{\tau}(R_t-\overline{R}_\tau)-\min\sum_{t=1}^{\tau}(R_t-\overline{R}_\tau)\right]$$

where, $s_\tau$represents the usual standard deviation estimator, $R_1, R_2 \ldots, R_\tau$ are continuously compounded returns, $\overline{R_\tau}$ is the sample mean.

In order to identify the presence of long memory, Willinger, Taqqu and Teverovski (1999) developed a new R/S analysis based on equally weighted returns. In this study, we have used EW series over blocks of size 20. In order to remove the ”extra” short-range dependence and isolating hibriden „pure” long-range dependence effects, the authors proposed partitioning of time series into non-overlapping blocks of size m, e.g.$m = 10, 20, 30$, and „shuffle” the observations within each block, so that is a random permutation of the time indices. The effect of such a shuffiling experiment is to destroy any particular structure of the autocorrelation function below lag m, but to leave the high lags essentially unchanged. In this paper we used blocks of size 40.

In order to identify the presence of long memory in the returns series we have applied the ARFIMA model. According to Granger and Joyeaux (1980) and Hosking (1981) the ARFIMA model is given by:

$$(1-L)^d\phi(L)x_t = \theta(L)\varepsilon_t$$

where, $\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$, $\theta(L), \phi(L)$ represent the autoregressive and moving average polynomials of order p and q, L is lag operator.

The FIGARCH (1996) model is used to identify the presence of long memory in volatility.

According to Baillie et al. (1996) the FIGARCH(p,d,q) model is defined by:

$\phi(L)(1-L)^d\varepsilon_t^2 = \omega + [1-\beta(L)]\upsilon_t$, where $0 < d < 1$ denotes the long memory parameter.

4. Data

The sample data contains daily returns of banking indices and covers the period from January 1995 to December 2013. The daily logarithmic returns are given by $R_t = \ln(\frac{I_t}{I_{t-1}})$, where I_t, I_{t-1} represent the index prices at time t and $t-1$. In our analysis we have used two European Banking Indices: STOXX 600 Banks Index, which is a capitalization-weighted index and includes European companies that are involved in the banking sector and the MSCI Europe/Banks Index, which is a free-float weighted equity index.

The summary statistics is reported in Table 1 and indicates that banking indices are characterized by high volatility. Further, the distribution of returns series are skewed to the left with heavy tails. The results of Jarque Bera test highlighted that the normality hypothesis is strongly rejected for both indices.

Table 1: Descriptive statistics

	Mean	Min	Max	St.dev	Skew.	Kurtosis	JB
STOXX 600 Banks Index	0.0001	-0.109	0.161	0.017	0.128	8.217	2914.116 (0.000)
MSCI Europe Banks Index	0.0001	-0.113	0.159	0.017	0.127	8.317	2632.467 (0.000)

Source: Authors' calculation, st.dev – represents the standard deviations and skew. represents the skewness.

5.Empirical results

According to Pamula and Grach (2010) a financial crash change the behavior of the Hurst exponent. It is expected that Hurst exponent to have a downward traed before a financial crisis. Following, the question is what happens with long memory during financial crisis? During the financial crisis the investors may have different behavior, which has impact on how the financial information is incorporated in the price. Moreover, the financial crisis are characterized by the occurance of negative shocks which may lead to an increase in the level of volatility. The objective of this paper is to quantify the impact of the Mexican crisis, Asian and Russian crisis, Argentine crisis and Global financial crisis from 2008-2009 on the level of long memory dependency for the STOXX 600 Banks Index and MSCI Europe Banks Index. According to Chiang and Zheng (2010), the period of the Mexican crisis was during 12/22/1994-12/31/1995. Due to data availability, we have analyzed the period 1/2/1995-12/31/1995. Moreover, the Argentine crisis covered the period from 1/1/1999 to 12/31/1999 and the Global financial crisis was manifested during 3/1/2008 to 3/31/2009. Similar with the study realized by Syllignakis and Kouretas (2011), the Asian and Russian crisis were analyzed during the period 11/21/1997 to 10/30/1998. in order to estimate the impact of the financial crisis on the long memory dependency, we have applied Hurst Exponent, Willinger, Taqqu and Teverovski method, ARFIMA and FIGARCH models. Table 2 describes the values recorded by Hurst Exponent both for all period and for different crisis periods.

Table 2: Hurst Exponent

	Period	Hurst Exponent-R/S Statistics	Hurst Exponent-R/S with E/W returns	Hurst Exponent-R/S with shuffled returns
STOXX 600 Banks Index	All period	0.562	0.553	0.575
	Mexican crisis	0.586	0.698	0.672
	Asian and Russian crisis	0.645	0.747	0.714
	Argentine crisis	0.641	0.685	0.583
	Global crisis	0.615	0.618	0.697
MSCI Europe Banks Index	All period	0.557	0.558	0.600
	Mexican crisis	0.589	0.615	0.675
	Asian and Russian crisis	0.663	0.639	0.683
	Argentine crisis	0.677	0.659	0.683
	Global crisis	0.613	0.631	0.585

Source: Authors' calculation; EW-equally weighted,***,**,* Significat at 1%, 5%, 10% level, respectively.

Both for all period and for all crisis periods that we have analyzed, the value recorded by the Hurst exponent is higher than 0.5, providing evidence of long memory for banking indices. The impact of financial crisis has lead to a change in the Hurst Exponent evolution. During the financial crisis, there has been an increase in the value of the Hurst exponent. In the case of Stocks 600 Banks Index the greatest increase of Hurst exponent occurs during Asian and Russian crisis and in the case of MSCI Europe Bank Index, during Argentine crisis. According to Pamula and Grech (2008) big investors cash their profits when they estimates that the critical point in the uptrend is coming and triggers the same behavior for the small investors, which will cause a change in the market trend that can create the premises for the appearance of a market crash. Moreover, the authors considers that before a crash, the market is characterized by the existence of anticorrelations in price returns of different assets and downward trend of Hurst Exponent and the appearance of a crash will change the evolution of the Hurst exponent, having impact on the level of predictability.

Further, we test the existence of long memory in returns series by using ARFIMA model. Table 3 provides evidence of the estimation of the ARFIMA

Table 3: ARFIMA (1,d,1) model estimates using Willinger, Taqqu and Teverovsky method

	All period	Mexican crisis	Assian and Russian crisis	Argentine crisis	Global financial crisis
STOXX 600 Banks Index					
H	0.447***	0.798***	0.504***	0.241*	0.661***
ϕ	-0.723***	0.3010**	0.218	0.219*	0.316**
θ	0.782***	-0.644***	-0.432*	-0.128	-0.741***
IV	0.00008***	0.00001***	0.00012***	0.00005***	0.00037***
H (for EW=20)	0.568	0.538	0.630***	0.229	0.787***
IV (for EW=20)	0.001	0.00001***	0.00002***	0.00003***	0.00026***
MSCI Europe Bank Index					
H	0.458***	0.419***	0.650***	0.5132***	0.312***
ϕ	0.021	-0.286	0.276**	0.015	-0.332
θ	-0.003	0.403*	-0.602***	-0.211	0.538
IV	0.00009***	0.00002***	0.0001***	0.00005***	0.0003***
H (for EW=20)	0.423	0.487***	0.740***	0.236	0.761***
IV (for EW=20)	0.001	0.00001***	0.00005***	0.00003***	0.0001

Source: Authors' calculation; IV – innovation variance; EW – returns equally weighted; ***,**,* Significat at 1%, 5%, 10% level, respectively.

According to Fouquau and Spieser (2011), there is a relation between the Hurst exponent and the ARFIMA model developed by Hosking (1981) and Geweke Porter Hudak (1983) The relation between the fractional integration parameter d and the Hurst exponent is given by: $H = d + \frac{1}{2}$.

For all the period, both banking indices recorded Hurst exponents, lower than 0.5, the return series present an anti-persistent behavior, indicating that the performances from the past will change in the future.

Further, we will analyse the impact of financial crisis on STOXX 600 Banks Index. In the case of Mexican and subprime crisis, the Hurst exponent is higher than 0.5, indicating the presence of long memory, autocorrelations are positive and hyperbolically decrease towards zero, indicating a predictable behavior. The impact of those financial crisis led to the growth of Hurst exponent. The presence of long memory is sustained by the correlations of large lags. On the other hand, during the Argentine crisis, the Hurst exponent had recorded a very low value, indicating an anti-persistent behavior, high volatility and a mean reverting process. The series is mean reverting, indicating that the effects of shocks disapear in a long run. A particular situation can be observed in the case of Assian and Russian crisis, when the value recorded by Hurst exponent is very close to 0.5, corresponding to a Brownian motion, which means that index follow a random walk process and any predictions of the future evolution are impossible to be realized.

In the case of MSCI Europe Bank Index, when estimating an ARFIMA (1,d,1) by using Willinger, Taqqu and Teverovski method, the resulting H-estimate is greater than 0.5 in the case of Asian and Russian crisis and Argentine crisis, highlighting the presence of long memory. During Mexican and Global financial crisis, the Hurst Exponent is lower than 0.5, indicating an antipersistent behavior.

Table 4: FIGARCH model estimates

	All period	**Mexican crisis**	**Assian and Russian crisis**	**Argentine crisis**	**Global financial crisis 2008-2009**
STOXX 600 Banks Index					
μ	0.0006***	0.0009***	0.00258***	0.0006	-0.0026
d	0.567***	0.190	1.000***	0.211*	0.750***
ϖ	0.000002	0.0000***	0.0000***	0.0000	0.00002
β	0.527***	0.1072***	0.816***	0.151*	0.737***
$Q(20)$	47.806***	21.298	25.837	35.524**	25.352
$Q^2(20)$	20.440	19.908	16.897	8.488	14.049
MSCI Europe Bank Index					
μ	0.00059***	0.00065***	0.00207***	0.00084	-0.003*
d	0.5407***	0.204	1.000***	0.188*	0.776***
ϖ	0.0000	0.0000	0.0000	0.0000	0.0000
β	0.504***	0.0692***	0.875***	0.128*	0.757***
$Q(20)$	42.436***	22.502	31.785**	30.455*	25.446
$Q^2(20)$	22.407	13.678	8.576	9.435	13.177

Source: Authors' calculation; ***,**,* Significat at 1%, 5%, 10% level, respectively.

For all the sample, the long memory coefficient d is higher than 0.5, the series are not covariance stationary, but still mean reverting witch means that the effects of a shocks persist for a long run. The series exhibits long memory in volatility.

Regarding the impact of crisis on the evolution of long memory, both indices have a similar behavior. During the Mexican crisis, the long memory coefficient is not statistically significant. During the Asian and Russian crisis, the value recorded by the long memory coefficient is equal to one, which reflects that the model is transformed into an IGARCH, indicating that the effects of shocks are persistent. In the case of Argentine crisis, the value recorded by long memory coefficient is lower than 0.5, the series is covariance stationary. During the Global crisis from 2008-2009, the coefficient of long memory is higher than 0.5, which implies the existence of covariance nonstationary, but mean reverting, indicates that the effects of shocks will be observed for long periods. The indices exhibit long memory in volatility.

5.Conclusions

In this paper we have analyzed the impact of financial crisis on the evolution of long memory dependency for the European banking indices. In order to investigate the presence of long memory, we have applied different statistical methods: Hurst Exponent, Willinger, Taqqu and Teverovski method and ARFIMA and FIGARCH models. According to the estimates of Hurst exponent, we conclude that the financial crisis change the evolution of Hurst exponent. The estimation results indicate that the values recorded by Hurst exponent are higher during the financial crashes. When estimating an ARFIMA (1,d,1) by using Willinger, Taqqu and Teverovski method, the resulting H-estimate are different for the two indices that we have analyzed. In the case of STOXX 600 Banks Index, we found evidence of long memory during Mexican crisis and Global financial crisis from 2008-2009. In the case of MSCI Europe Bank Index, the results provides evidence of long memory during Asian and Russian crisis and Argentine crisis. Finally, we conclude that during the Global crisis for 2008-2009, both indices exhibit long memory in volatility. In order to properly manage their trading portofolios, the investors should consider the existence of long memory in returns and in volatility of banking indices and the impact of financial crisis on the evolution of long memory.

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