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The impact of the 2008 and 2010 financial crises on the Hurst exponents of international stock markets: Implications for efficiency and contagion

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A B S T R A C T

This study analyzes how the 2008 and 2010 financial crises, which began in the US and Greece respectively, affected the Hurst exponents of index returns of the stock markets of Belgium, France, Greece, Japan, the Netherlands, Portugal, the UK and US. We perform two innovative statistical tests for this purpose. The first assesses whether the returns exhibit a long memory in the pre-crisis and crisis periods and determines the extent to which the Hurst exponents, calculated with the multifractal detrended moving average technique (MFDMA), differ from the tranquil to the crisis periods. The second test uses copula models to assess whether the correlation between the local Hurst exponents of the markets where the crises originated and those of the other markets increased due to the crises. The results of the first test suggest that although most of the returns exhibit a long memory in the 2008 crisis period, this is not the case in either the pre-crisis or the 2010 crisis periods. These findings shed light on the dynamics of market efficiency. The results of the second test show a significant increase in correlation between the local Hurst exponents of several markets, suggesting the existence of financial contagion. We observed that the 2008 crisis had a greater impact on the memory properties of stock returns than the 2010 financial crisis.

1. Introduction

The Hurst exponent has been used in financial literature to study the dynamics of stock markets, and market efficiency is one of the most frequent topics under discussion. For example, Cajueiro, Gogas, and Tabak (2009) and Wang, Liu, and Gu (2009) use the Hurst exponent to examine the efficiency of the Greek and the Shenzhen stock markets in the context of local market reforms. In our study, we use the Hurst exponent to evaluate the efficiency of stock markets in the context of the 2008 and 2010 financial crises.[1] We analyze the impact of these two financial crises on the dynamics of the Hurst exponents in the stock markets of Belgium, France, Greece, Japan, the Netherlands, Portugal, UK and US. We also use the exponent to determine the extent of financial contagion between stock markets during these crises. To our knowledge, this procedure of examining financial contagion using Hurst exponents constitutes a novelty in the financial literature. Our goal is to understand how the exponent evolves over time and use it to detect the effects of financial crises on stock market behavior.

The analysis of the impact of financial crises is relevant because crises are recurrent phenomena with serious consequences on the real economy, particularly in terms of economic growth and employment, and increased risk for financial institutions that operate globally (Horta, 2013). The so called financial contagion effect is one of the possible direct impacts of financial crises on stock markets. Forbes and Rigobon (2002) defined financial contagion as 'a significant increase in cross-market linkages after a shock to an individual country (or group of countries)'.

Markets affected by contagion exhibit unstable behavior and overreact to unexpected events that take place in the country that originated the crisis. This behavior of instability can even jeopardize the regular functioning of financial markets, which have pernicious consequences for various players, from investors to issuers. Therefore, the early detection of contagion phenomena assumes particular importance for regulatory authorities because it can help them to take measures to prevent or mitigate financial contagion.

Using the definition of Forbes and Rigobon (2002), Horta, Mendes, and Vieira (2010) found that the 2008 financial crisis caused contagion

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[1] We also refer to the 2008 financial crisis, which began in the US, as the Subprime Crisis, and the 2010 Financial Crisis that started in Greece as the 2010 European Sovereign Debt Crisis.

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effects in the European stock markets of the NYSE Euronext group (Belgium, France, the Netherlands and Portugal) as the correlation between the US returns and those of the indices of the other four markets increased from the tranquil to the crisis period. Horta (2013) studied the same markets in the context of the 2010 European Sovereign Debt Crisis; he found contagion effects from the Greek stock market to the Portuguese stock market, but not to the markets of Belgium, France and the Netherlands.

In this paper we examine the dynamics of the Hurst exponent in the context of the 2008 and the 2010 financial crises by performing two tests. In the first, we test the presence of long memory in the market returns of the sample in the pre-crisis period (tranquil period) and in both the Subprime and the European sovereign debt crisis periods. For this purpose, we construct a bootstrap experiment inspired by Jiang, Xie, and Zhou (2012), which allows us to assess whether the estimated Hurst exponent of each market returns differs from the Hurst exponents obtained from standard Gaussian distributions. We use the MFDMA technique proposed by Gu and Zhou (2010) to calculate the Hurst exponent, and we take into account the problem of finite samples reported by Kristoufek (2010a). This novel procedure allows us to assess whether the Hurst exponents are statistically different in the three periods.

In the second test, we calculate the local Hurst exponents for the market returns for the pre-crisis and for the two crisis periods, after making an adjustment to the algorithm proposed by Gu and Zhou (2010). We then analyze the time-pattern of the correlation between the exponents by means of copula theory, assessing whether there is a significant increase in correlation between the local Hurst exponents of the markets where the 2008 and 2010 crises originated (US and Greece, respectively) and the local Hurst exponents of the other markets in the sample. We can confirm empirically whether or not local Hurst exponents can be used to measure financial contagion by comparing our results with those of Horta et al. (2010) and Horta (2013), who used the same source data and crisis dates.

The results for the first test indicate that most of the markets do not exhibit long memory in the pre-crisis or 2010 crisis periods, contrary to what happens in the 2008 crisis period. This suggests that the Hurst exponents of the returns may vary according with period characteristics, and provide information on market efficiency.

The results of the second test suggest that there is a significant increase in correlation between the local Hurst exponents during the 2008 crisis. Some increase in correlations was also detected for the 2010 crisis period, albeit less intense. We obtained the same results as Horta et al. (2010) and Horta (2013) regarding financial contagion, but in our study we use local Hurst exponents instead of market returns.[2] Thus, the Hurst exponent seems to be useful in measuring financial contagion between stock markets.

The rest of the paper is organized as follows. In Section 2 we discuss several applications of the Hurst exponent. In Section 3 we describe the data and the methodology. In Section 4 we present and discuss the results, and in Section 5 we draw the main conclusions.

2. Brief literature review on the Hurst exponent and market efficiency

Since the seminal work of Hurst (1951) in the area of hydrology, the calculation of the Hurst exponent has been applied to different topics in the financial literature. One application of the exponent is the ability to provide an indication of the maturity stage of stock markets. Di Matteo, Aste, and Dacorogna (2005) found that more developed stock markets exhibit lower Hurst exponents when compared to less developed markets.

Another application of the Hurst exponent is the test of the Efficient Market Hypothesis (EMH) of Fama (1965) and the prediction of the evolution of financial markets. The EMH suggests that the market price behaves like a random walk and is unpredictable. The series of market returns are characterized by Hurst exponents ranging between 0 and 1, and an exponent $H = 1/2$ gives an indication of a random walk, a random process without long memory where increments are independent and identically normally distributed, and thus consistent with the EMH (Da Silva, Figueiredo, Gleria, & Matsushita, 2007).

Series presenting Hurst exponents different from 1/2 exhibit long-term memory and their increments are therefore not independent; this makes the series predictable, which may originate arbitrage opportunities. Values of H ranging from 1/2 to 1 are indicative of a persistent, trend-reinforcing series (positive long range dependence). In this case, there is a higher than 50% probability that a positive (negative) value of a series is preceded by a positive (negative) value. Additionally, values ranging from 0 to 1/2 suggest anti-persistence, and therefore the past trends of a series tend to reverse in the future (negative long range dependence). In this case, there is a higher than 50% probability that a positive (negative) value of a series is preceded by a negative (positive) value (Da Silva et al., 2007).

Eom, Choi, Gabjin, and Jung (2008) empirically investigated the relationship between the Hurst exponent and the predictability of 60 different market indices in various countries, and they found that the relationship is strongly positive. A market index with a higher Hurst exponent tends to have a higher level of predictability.

Onali and Goddard (2011) used the Hurst exponent to study the efficiency of six developed European stock markets; they confirmed the existence of long-range autocorrelation in the Italian market, which suggests that this market does not behave according to the random walk hypothesis.

Cajueiro et al. (2009) and Wang et al. (2009) also use the Hurst exponent to study the efficiency of stock markets, but in the context of market reforms. Cajueiro et al. (2009) studied the Greek stock market and found that the liberalization of the financial market introduced in Greece in the early 1990s improved its efficiency. Wang et al. (2009) studied the Shenzhen stock market and concluded that the market became more efficient (with the Hurst exponent closer to 0.5) after a regulatory change limiting price changes within one trading day. The latter authors also suggest that market efficiency declined after October 2007 when the index began falling and experienced strong fluctuations for a year. The authors argue that the loss of market efficiency was due to the market pressure on investors, which led to herding behavior.

The turning points in market trends and the anticipation of stock market crashes are other aspects related to market prediction explored by some authors. Grech and Mazur (2004), Grech and Pamula (2008), Kristoufek (2010b) and Domino (2011) are among the authors who found evidence that the local (time-dependent) Hurst exponent can give important information before a critical market event occurs. They suggest that a downward trend in the local Hurst exponent can be interpreted as increasing nervousness on the market and, therefore, indicates that the market will be at a turning point in the near future. The authors noted that the well-defined trends and stable behavior of the markets facilitate predictions.

Another related issue studied in the literature and close to the subject of our study is the impact of financial crises on market efficiency; this can be addressed by the EMH or the Fractal Market Hypothesis (FMH), among others. The EMH argues that the market is always weakly efficient, even during crises, and that past prices and volumes do not help to predict present and future prices. However, there is no consensus in the literature on whether the market is efficient (Lo, 2004), and some authors propose using the concept of relative efficiency. It makes sense to assess the degree of market efficiency using this concept, and it is now widely accepted that market efficiency is time-varying (Kim, Lim, & Shamsuddin, 2011).

[2] Although it is more common to use market returns in the measurement of financial contagion, the definition of Forbes and Rigobon (2002) does not refer explicitly to returns, and therefore is not inconsistent with the use of Hurst exponents. The definition refers to 'cross-market linkages', which, we argue, can be measured using the long memory properties of the markets instead of market returns.