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The impact of 2008 financial crisis on the efficiency and contagion of Asian stock markets: A Hurst exponent approach

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ABSTRACT

This study analyzes the dynamics of the Hurst exponent of the Asian stock markets returns in the context of the 2008 financial crisis. Using the Hurst exponents calculated with the MFDMA algorithm, we find that most of the returns exhibit a long memory in the 2008 financial crisis period but not in the tranquil periods, indicating that the 2008 financial crisis has adversely affected the efficiency of Asian stock markets. Then, applying the copula models, we find that there is a significant increase in correlation between the local Hurst exponents of several markets, indicating the existence of financial contagion.

1. Introduction

The 2008 financial crisis has been the subject of extensive investigation within financial market research. Notably, there are many empirical papers that investigate the effects of the 2008 financial crisis on the efficiency and contagion of stock markets.[1] In this study, we contribute to the literature by utilizing the Hurst exponents rather than more common market returns to assess the efficiency of Asian stock markets in the context of the 2008 financial crisis and to measure the extent of financial contagion between the U.S. and Asian stock markets during this crisis. In fact, the Hurst exponent has been interpreted as an indicator of market efficiency and widely used to investigate the impact of historical events, such as financial crisis and market liberalization, on market efficiency (see Cajueiro et al., 2009). To the best of our knowledge, this novel procedure of examining financial contagion using Hurst exponents has never been applied to the Asian stock market in the financial literature. Therefore, the central aim of this study is to understand how the Asian stock markets behavior has been affected by the 2008 financial crisis in terms of efficiency and contagion from the Hurst exponent perspective.

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[1] Researchers define contagion as an excessive increase in the correlation among the countries causing the crisis and all other countries (see Masson, 1999; Forbes and Rigobon, 2002; Corsetti et al., 2005).

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In this paper, we consider 10 Asian stock markets including Japan, Korea, China, Hong Kong, Taiwan, Thailand, Singapore, Indonesia, India and Pakistan using daily stock price indices from 1994 to 2016. The sample includes dynamic economies with high growth and increasing stock market volumes, and its major players consist of developed as well as emerging markets, which are the markets of considerable interest to both finance practitioners and academics. We use the multifractal detrended moving average technique (MFDMA) suggested by Gu and Zhou (2010) to test the presence of long memory in the market returns of the sample in the tranquil periods as well as the crisis period. We further construct a bootstrap experiment to statistically investigate whether the Hurst exponents are different for the tranquil and the crisis periods, and make an adjustment to the algorithm proposed by Gu and Zhou (2010) to examine the dynamics of the local Hurst exponents for the tranquil and crisis periods. Finally, we utilize copula models to assess whether the crisis significantly increases the correlation between the local Hurst exponents of the U.S. market where the crisis originated and those of the Asian markets.

The empirical results are twofold. First, this paper finds that most of the markets exhibit a long memory in the 2008 financial crisis period but not in the tranquil periods. This suggests that the Hurst exponents of the returns may vary depending on period characteristics, and provide information on market efficiency. Second, there is a significant increase in correlation between the local Hurst exponents of the U.S. and those of the Asian stock markets during the 2008 financial crisis, indicating the existence of financial contagion.

The remainder of this paper is organized as follows. Section 2 describes the data and methodology. Section 3 presents the empirical results and discussion. The conclusion is drawn in Section 4.

2. Data and methodology

This study analyzes the Hurst exponents of index returns of the stock markets of Japan, Korea, China, Hong Kong, Taiwan, Thailand, Singapore, Indonesia, India, Pakistan and U.S. in the context of 2008 financial crisis. We use Morgan Stanley Capital International (MSCI) stock indexes, observed on a daily basis and are quoted in U.S. dollars in order to have conformity and to avoid the effects of local inflation and national currency fluctuations on the indexes. Given that the U.S. stock market operating times do not overlap with those of the Asia markets and they are closed after all the Asia markets on the same day, this paper uses one-day lagged observations of the MSCI U.S. to determine the extent of financial contagion between the U.S. and Asian stock markets during this crisis. The data covers the period from May 31, 1994 to January 22, 2016 (5633 data points).[2] As usual, market returns equal the logarithm differences of the daily market indices. Following the dating suggested by Horta et al. (2014), we consider three sub-periods from the entire sample: two periods of tranquil in stock markets and another period corresponding to the 2008 financial crisis. The first tranquil period goes from January 4, 2005 to July 31, 2007 (622 data points), the second tranquil period starts on August 24, 2012 and ends on December 31, 2014 (611 data points), and the 2008 financial crisis period goes from August 1, 2007 to December 7, 2009 (564 data points).

In this study we use the MFDMA algorithm proposed by Gu and Zhou (2010) with a position parameter $\theta = 0$ corresponding to the backward moving average to estimate the Hurst exponent, $\boldsymbol{H}$.[3] This method is chosen due to its ability to capture the multifractality found in the data series.[4] When calculating the Hurst exponent, we adopted the parameters values recommended by Gu and Zhou (2010) as the most appropriate for the MFDMA algorithm: $n_{min} = 10$, $n_{max} = 10\%$ of series length, $N = 40$ (where N is the number of data points used in the linear regression for obtaining the Hurst exponent), $a = 0$ (a is the position parameter) and $q = 2$ (q is the multifractal order and corresponds to the scaling of variance). In order to remove short-range dependence existing in raw data, which may influence the results we obtain, the GARCH (1, 1) model is used to pre-filter the returns of each market.[5]

One important aspect related to the Hurst exponent calculation is that applying the MFDMA algorithm to a finite sample will produce an upward-biased estimator of the Hurst exponent as Kristoufek (2010) argues that the null hypothesis for a time series to reject long memory holds only for infinite samples. It has been shown that the estimators of Hurst exponent might report values different from 0.5 that is the condition for a time series to reject the null hypothesis, and thus hinting long memory, even if the series are not long-range dependent (Couillard and Davison, 2005). To overcome this issue, we perform a bootstrap experiment. We generate one random series (series 1) with dimension N comprising random normal innovations.[6] Then, we randomly draw a sample of N observations with replacement from series 1, and in this way we construct a new series (series 2). The procedure will be repeated 10,000 times such that we can obtain 10,000 simulated series, S_λ for $\lambda = 1, 2, \ldots, 10,000$. The MFDMA algorithm is applied to each of the simulated series S_λ to obtain the estimated

[2] The data series were downloaded from Wind Financial Terminal. Wind is a leading provider of financial data, information and services in mainland China. Wind data has been widely cited in research reports and academic papers either in Chinese or in English.

[3] Note that although θ's value can vary from 0 to 1 corresponding to the backward moving average to the forward moving average, we only consider $\theta = 0$ as in our analysis we always use historical data to calculate the Hurst exponent and apply it in predicting markets. For technical details on MFDMA algorithm, see Gu and Zhou (2010).

[4] Other Hurst exponent calculation methods include the rescaled range analysis (Hurst, 1951), the detrended fluctuation analysis (Peng et al., 1994), and the multifractal detrended fluctuation analysis (Kantelhardt et al., 2002). The empirical results are robust no matter which method is applied.

[5] Similar procedures are adopted by Onali and Goddard (2011) as well as Horta et al. (2014) in their empirical analysis. We also apply the algorithm to the unfiltered returns of each market and can confirm that the empirical results are not affected by the filtering process.

[6] N should be the same as the length of the series used to calculate H_i as the accuracy of the estimated Hurst exponent depends significantly on the sample size (see Horta et al., 2014 for empirical evidence).