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Multifractality, efficiency analysis of Chinese stock market and its cross-correlation with WTI crude oil price

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HIGHLIGHTS

- All the ten sector indices of Chinese stock market exist different degrees of multifractality.
- Cross-correlation analysis between WTI crude oil price and the ten sector indices of Chinese stock market is carried out.
- Efficient degrees via different efficient measures based on the generalized Hurst exponents are calculated.

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ABSTRACT

In this paper, the multifractality and efficiency degrees of ten important Chinese sectoral indices are evaluated using the methods of MF-DFA and generalized Hurst exponents. The study also scrutinizes the dynamics of the efficiency of Chinese sectoral stock market by the rolling window approach. The overall empirical findings revealed that all the sectoral indices of Chinese stock market exist different degrees of multifractality. The results of different efficiency measures have agreed on that the 300 Materials index is the least efficient index. However, they have a slight diffidence on the most efficient one. The 300 Information Technology, 300 Telecommunication Services and 300 Health Care indices are comparatively efficient. We also investigate the cross-correlations between the ten sectoral indices and WTI crude oil price based on Multifractal Detrended Cross-correlation Analysis. At last, some relevant discussions and implications of the empirical results are presented.

1. Introduction

Since Hurst [1,2] derived the long memory of the hydrological time series from tide data using the rescaled range analysis (R/S), and Mandelbrot et al. [3] laid the scrutinized mathematical foundation by introducing the Brownian movement and the Sectioning conception, research of long memory has aroused widespread interests. In the last two decades, the R/S methods of examining long memory are widely applied to mature stock markets [4], emerging stock markets [5] and other areas.

However, Lo [6] pointed out that R/S was sensitive to short-term auto-correlation and non-stationary series, which is likely to lead to a biased estimation of long memory parameters. In order to overcome the drawbacks, Peng et al. [7] proposed detrended fluctuation analysis (DFA), which applied long-range power-law correlation to make up for the requirement of strict short-range correlation in time series for R/S. Furthermore, Kantelhardt et al. [8] proposed the MF-DFA based on the DFA and its multifractal generalization. The MF-DFA method has been widely used to detect the long-range auto-correlations in financial markets, such as the stock markets [9,10], foreign exchange markets [11,12], and gold markets [13]. Moreover, some scholars [13,14] explored the efficiency of the stock markets using the MF-DFA method, which gives us a new way to research the market efficiency. Wang et al. [13] investigated the efficiency and multifractality of a gold market based

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on multifractal detrended fluctuation analysis, and found that the gold market became more and more efficient over time, especially after 2001. Gu et al. [14] found that WTI and Brent crude oil markets become more and more efficient for long-term and two Gulf Wars cannot change time scale behavior of crude oil return series. The abnormal points of scaling exponents can also be related to some occasional events. Jiang et al. [15] investigated the efficiency of the WTI crude oil futures market and found that the market was inefficient after the financial crisis and the Gulf war.

Recently, Podobnik and Stanley [16] extend the DFA into the DXA method to quantify power-law cross-correlations in non-stationary time series. Subsequently, Zhou [17] proposed multifractal detrended cross-correlation analysis (MF-DCCA) by combining MF-DFA and DXA approaches. Since then, DXA and MF-DXA methods have been widely used in various fields including financial data [18,19], traffic flows [20–22], sunspot numbers and river flow fluctuations [23], and meteorological data [24]. Moreover, due to the vast development of the methodology, Jiang and Zhou [25] created MF-X-DMA which is based on MF-DMA [26] and DMA [27]. Kristoufek [28] proposed MF-HXA based on the height–height correlation analysis of Barabasi and Vicsek [29], and Hedayatifar et al. [30]. In addition, Shi et al. [31] introduce a method multiscale multifractal detrended crosscorrelation analysis (MM-DCCA), extending the description of the cross-correlation properties between two time series. In our analysis, we only consider the MF-DCCA method proposed by Zhou [17] to do our research.

In recent years, it is well known that the Chinese stock market is one of the biggest emerging stock markets in the world and has been attracting an enormous amount of attention from policy makers, investors, and academics. Until the end of 2012, the total market capitalization of the Chinese stock market has broken 3.7 trillion dollars to become the second biggest of all stock markets.[1] Therefore, it is no wonder to find that many scholars used the MF-DCCA to explore the cross-correlations and market efficiency between the Chinese stock and other markets. For example, Wang et al. [32] investigated the cross-correlations between Chinese A-share and B-share markets, and found that the cross-correlations were strongly multifractal in the short-term and weakly multifractal in the long-term. They also found that the cross-correlations were weaker and weaker over time, especially after the price-limited reform, which attributed the fact to the improvement of market efficiency. Cao et al. [33] discussed the cross-correlations between the Chinese stock market and the foreign exchange market of Chinese yuan. Ma et al. [34] examined and confirmed the cross-correlations between Chinese stock market and surrounding stock markets by MF-DCCA method and rolling windows, found that the Chinese stock market, as an emerging market, becomes more and more efficient over time after some important reforms, especially the shareholder structure in listed companies. Of course, there are many research on the market efficiency by using different multifractal analysis method (for example, MF-HXA and MF-DMA), such as Kristoufek and Vosvrda [35], Wang et al. [36].

As we know, the stock markets are composed of many industries, such as the energy industry, financial industry and so on. There are lots of evidences that many stock markets possess multifractality, however, the literature has mainly focused on aggregate indices. Less attention has been devoted for in-depth studies on sectoral indices of stock markets. In addition, crude oil is one of the most important commodities in global financial markets. It is considered as the life support of many economies and may serve as the underlying asset in the trading of various financial instruments. The price changes of the crude oil market are usually acknowledged as an important incentive for the price fluctuations of the stock market. Thus, it is very valuable and interesting to investigate the cross-correlations between each industry of the Chinese stock market and the crude oil.

Given the above considerations, our contributions in this paper are as follows. First, to the best of our knowledge, we use the MF-DFA method to explore the long range auto-correlations of the sectoral indices of the Chinese stock market and evaluate the efficiency degrees. Second, we use the technique of rolling windows to capture the time-varying features of multifractality. Third, employing the MF-DCCA, we take into consideration the cross-correlations between the sectoral indices of the Chinese stock market and crude oil market.

The remaining of this paper is organized as follows. Section 2 mainly focuses on the description of methods used in the paper. Section 3 describes the data of West Texas Intermediate crude oil and every industry of the Chinese stock market. Section 4 provides the detailed empirical results. Section 5 details the conclusions.

2. Methodology

2.1. MF-DFA

The MF-DFA method, introduced by Kantelhardt et al. [8] for non-stationary multifractal data, has been widely used for many years. Therefore, we provide a brief description here.

Suppose that there a finite length time series $\{x(i)\}$, $i = 1, 2, \ldots, N$, where N is the length of the series. The method can be accomplished though five steps:

First of all, calculate the profile

$$X(i) = \sum_{k=1}^{i} (x(k) - \bar{x}), \quad i = 1, 2, \ldots, N, \tag{1}$$

where $\bar{x}$ denotes the averaging over the whole time series $x(i)$.

[1] See http://data.worldbank.org.