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Multifractal analysis of the Chinese stock, bond and fund markets

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HIGHLIGHTS

- Auto-correlations and cross-correlations of Chinese security markets are verified.
- Existence of the multifractality of the three return series is confirmed.
- Sources of the multifractality are explored.
- Dynamic behaviors of the cross-correlations among the three markets are investigated.

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ABSTRACT

The stock, bond and fund markets are three important components of a financial market, and the volatility of the markets and correlations between the markets have been paid extensive attention by researchers and investors. In this paper, we devote our efforts to studying the Shanghai financial market, while the return series of Shanghai Composite Index, Shanghai Bond Index and Shanghai Fund Index are considered. Statistical tests are used to detect the nonlinear auto-correlated structures and long-range cross-correlations of the three time series. The multifractal detrended fluctuation analysis and multifractal spectrum analysis methods are applied, by which the existence of multifractality in these three return series are revealed and the sources of multifractality are explored. In particular, the multiscale multifractal detrended cross-correlation analysis method is employed for the first time to generate the Hurst surfaces, which can be used to visualize the dynamic behaviors of cross-correlations among the markets. Empirical results show that the cross-correlations among the markets present different fractal features at different time scales. Further, our study finds that the correlation between the stock and fund markets is stronger than that of the other two groups, and the correlation between the stock and bond markets is unstable. These findings can help to better understand the dynamic mechanisms that govern the volatility of security markets and aid in performing better financial risk assessment and management.

1. Introduction

In recent years, the dynamic features of financial markets have attracted much attention of many researchers. Especially, the dynamic relationships between the stock market and other financial markets have become hot topics in financial economics. For instance, Fang et al. [1] used the GARCH (1,1) model to investigate the relationship between the stock and

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bond markets in the United States, Britain, Japan and Germany during 1998–2004, and verified the existence of volatility transmission in these markets. Chuliá and Torró [2] utilized the multivariate GARCH model to analyze the European stock and bond markets, and found that there was a two-way volatility spillover effect between them. Chordia et al. [3] studied the liquidity of stock and bond markets by using the vector autoregressive model and pointed out that the volatility and liquidity of the two markets were significantly correlated, meaning that the liquidity and volatility of both the stock and bond markets were co-driven by some factors. Besides, Goetzmann and Massa [4] discussed the relationship between the index fund and the return series of S&P500 index, and showed that there was a simultaneous correlation between them. Connolly and Stivers [5] considered the influences of the treasury yields and the stock market volatility on market pricing. They showed that the uncertainty of stock market played an important role in cross-market pricing. Recently, Cenedese and Mallucci [6] investigated the dynamic correlation between the international stock and bond markets. They found that the international bonds flowing into emerging markets were more sensitive to the impact of interest rates than the stock market was. Kolluri et al. [7] used the multivariate cointegration test to examine the dynamics of India's stock and bond markets, and their interrelationships with five foreign equity markets. Kim et al. [8] utilized the Granger causality test to investigate the relationships between the Korean stock and fund markets, and showed that the information created from the fund market affected the return and volatility of the stock market. Li et al. in [9] proposed an asset pricing model for stock and bond markets and analyzed the dynamic relationship between the two markets from the perspective of portfolios.

Statistical methods including the GARCH-class and vector auto-regression models were mainly applied to investigate the volatility, risk measurement and volatility spillover of stock market, bond market or fund market in the aforementioned studies. They focused more on the linear correlation of the price fluctuation factors in different markets. However, many empirical studies have shown that financial markets are complex nonlinear dynamic systems with fractal and chaotic structures [10–14]. Financial time series are usually non-stationary because of their complexity and speculative natures. Therefore, using nonlinear statistical analysis methods to study financial time series has become a popular approach in financial market analysis.

During the last decades, several models and methods of fractal analysis, such as the rescaled range analysis (R/S analysis) [15], detrended fluctuation analysis (DFA) [16] and multifractal detrended fluctuation analysis (MF-DFA) [17], have been established and developed to detect the long-range auto-correlation, to examine the market efficiency, to explore the market volatility and to describe the nonlinear characteristics of markets, etc. [18–24]. In order to detect the long-range cross-correlation between two non-stationary time series, Podobnik and Stanley [25] proposed a new method based on detrended covariance, called detrended cross-correlation analysis (DCCA). Lately, a DCCA cross-correlation coefficient was introduced [26,27] based on the DFA and DCCA methods to quantify power-law cross-correlations in non-stationary time series. The DCCA method and the DCCA cross-correlation coefficient have been used to investigate the cross-correlations between two financial series in some papers [28,29]. Moreover, the DCCA method was extended to its multifractal version [30], named MF-DCCA or MF-DXA, which can reveal the multifractal features of two cross-correlated non-stationary series effectively. Recently, Shi and Shang et al. [31] generalized MF-DCCA to multiscale multifractal detrended cross-correlation analysis (MM-DCCA), which may provide much richer information than MF-DCCA does in the discussion of multifractal structures for two cross-correlated time series. Now, the fractal analysis methods have been widely used in the study of many fields, such as financial markets, energy markets, air pollution and geological survey, etc. [32–43].

On January 2, 2003, the issuance of Shanghai bond index marked the establishment of the index system of China's security markets involving the stock, bond and fund markets. In recent years, with the rapid development of China's economy and the gradual improvement of the financial market systems, the co-movements among different financial markets in China have also been greatly enhanced. The volatility, risk assessment and mutual relationships of China's security markets have attracted wide attention from researchers and investors.

In this paper the MF-DFA and multifractal spectrum analysis methods are firstly used to empirically analyze the multifractal volatility characteristics of the Shanghai stock, bond and fund markets, and to investigate the possible sources of multifractality. The MM-DCCA method is then employed to produce the Hurst surfaces for visualizing the dynamic cross-correlations between the markets at different time scales. Compared with some previous publications that mainly discussed the relationships between two markets, this paper considers the three indispensable components of a financial market namely the stock, bond and fund markets. The contributions of our study are threefold. First, we show that the return series of the considered three security markets are not Gaussian series, but fractal series with nonlinear auto-correlation structures and multifractal features. Second, we explore the sources of multifractality for the three return series, and find that both the long-range correlations and fat-tailed distributions are common reasons of the multifractality, while the fat-tailed distributions contribute more to the multifractality. Third, the MM-DCCA method is employed to investigate the cross-correlations among the three security markets in China, and the dynamic behaviors of multifractal cross-correlations are analyzed and compared at different time scales. To the best of our knowledge, this paper is the first one to visualize the cross-correlations among Chinese security markets from a three-dimensional perspective.

The rest of the paper is organized as follows. Section 2 introduces the methodology. Section 3 presents the data description and the basic statistical tests. In Section 4, the multifractal analysis of the three return series are performed based on the MF-DFA and multifractal spectrum analysis. The multifractal auto-correlation are discussed and the sources of multifractality are explored. The cross-correlations of three return series are empirically studied in Section 5 based on the MM-DCCA. Finally, the conclusions are drawn in Section 6.