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Cross-correlations between price and volume in Chinese gold markets

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HIGHLIGHTS

- We investigate the cross-correlations of price and volume in Chinese gold markets.
- Qualitative analysis and quantitative MF-DCCA method are used in this research.
- We examine the sources of multifractal features between price and volume.
- We investigate the time-varying features between price and volume.

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ABSTRACT

We apply the multifractal detrended cross-correlation analysis (MF-DCCA) method to investigate the cross-correlation behaviors between price and volume in Chinese gold spot and futures markets. Qualitatively, we find that the price and volume series are significantly cross-correlated using the cross-correlation test statistics $Q_{cc}(m)$ and the ρ_{DCCA} coefficients. Quantitatively, by employing the MF-DCCA analysis, we find that there is a power-law cross-correlation and significant multifractal features between price and volume in gold spot and futures markets. Furthermore, by comparing the multifractality of the original series to the shuffled and surrogated series, we find that, for the gold spot market, the main contribution of multifractality is fat-tail distribution; for the gold futures market, both long-range correlations and fat-tail distributions play important roles in the contribution of multifractality. Finally, by employing the method of rolling windows, we undertake further investigation into the time-varying features of the cross-correlations between price and volume. We find that for both spot and futures markets, the cross-correlations are anti-persistent in general. In the short term, the cross-correlation shows obvious fluctuations due to exogenous shocks while, in the long term, the relationship tends to be at a metastable level due to the dynamic mechanism.

1. Introduction

By the Financial Crisis in 2008, the global bulk commodity markets have suffered quite a severe recession. However, the global gold markets attain consecutive growth, which can largely be attributed to the rapid growth of China's gold market. According to the statistics released by the China Gold Association in early 2015, production and consumption reached 451.8 tons and 886.1 tons respectively in 2014. As the world's largest gold producer and the second largest gold consumer for many

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years, China's gold market has already become the fastest growing market in the world. Historically, gold has a dual nature of being both a currency and a commodity, and has commonly been used to hedge against inflation, deflation and currency depreciation. It is an important tool of investment and an important reserve asset as well as industrial raw materials. Hence, the products of the gold markets have been snapped up by many investors. So far, futures and spot gold are traded on Shanghai Futures Exchange (SHFE) and Shanghai Gold Exchange (SGE) respectively. In 2014, the volume of transactions on the Shanghai Futures Exchange reached 47 730 tons, enjoying a year-on-year growth rate of 18.81% while the figures are 18 490 tons and 59.17% for the Shanghai Gold Exchange, both of which are ranked the top in the world [1]. The cross-correlation between price and volume is the key indicator for investigating the gold market's dynamic mechanisms. It sheds light on the interrelationship among the behaviors of return, risk and information by quantifying the dynamic relationship between price and volume. The price changes represent the market's responses to new information while the volume shows the discrepancy in investors' cognition of new information. Research on the cross-correlation between price and volume can reveal the velocity of the market information stream, spread, absorption and how far the price reflects market information.

In recent decades, a burgeoning empirical literature shows that the returns on crude oil, metal and other commodity markets conflict with the efficient market hypothesis (EMH) [2–5], in which the volatility of price obeys a random walk and a standard normal distribution. These studies further illustrate that many financial time series' price fluctuations are peak fat-tail distribution, and remain persistent behavior for quite a long period of time, and that the future price volatility and risk may be measured and forecast. This also leads to the failure of the traditional asset pricing theory and the arbitrage pricing theory. Therefore, the theory of fractals proposed by Mandelbrot [6] has been adopted for financial market research in recent years. This not only explains the economic phenomenon that cannot be explained by the traditional efficient market hypothesis but also helps investors to avoid risks and therefore is attracting increasing attention.

A large amount of research has been carried out to understand the fractal characteristics and correlations of non-stationary time series which are more complex in the financial markets. The early fractals research mainly focuses on the Rescaled Range Analysis (R/S) presented by Hurst [7,8] when explored in the field of hydrology. Peters [9,10] found evidence of long-term auto-correlations in several financial markets when using the Rescaled Range analysis (R/S), implying the inefficiency of the financial markets. However, Lo [11] found that R/S method is sensitive to short-term auto-correlations, which is likely to cause bias error for unstable time series data. To overcome this drawback, Peng et al. [12] proposed detrended fluctuation analysis (DFA), which applied a long-range power-law correlation to compensate for the requirement of a strict short-range correlation in the time series so that it can avoid the spurious detection of apparent long-range auto-correlations. As a multifractal extension of DFA, Kantelhardt et al. [13] developed the MF-DFA approach, which has been widely applied to the crude oil markets [14–16], stock markets [17,18], international exchange rate markets [19], and gold markets [20].

Recently, many researchers attempt to quantify cross-correlations between non-stationary time series from various complex systems. Podobnik and Stanley [21,22] extended the DFA to introduce an approach detrended cross-correlation analysis (DCCA), which can be applied to investigate the long-range cross-correlations between two non-stationary time series and had been widely tested in previous work [23–25]. Then, on this basis, Zhou [26] proposed a new approach—multifractal detrended cross-correlation analysis (MF-DCCA, or called MF-DXA/MF-X-DFA) by combining MF-DFA and DCCA approaches. Jiang and Zhou [27] developed a class of MF-DCCA algorithm based on DMA [28] and MF-DMA [29], called multifractal detrending moving average cross-correlation analysis (MF-X-DMA). To detect long-range cross-correlations, Kristoufek [30] introduced multifractal height cross-correlation analysis (MF-HXA) based on scaling of qth order covariance. Meneveau et al. [31] and Wang et al. [32] presented multifractal cross-correlation analysis (MF-X-PF) based on statistical moments, to investigate the long-term cross-correlations and cross-multifractality between two time series. Qian et al. [33] developed the multifractal DPXA (MF-DPXA) method in order to quantify the hidden multifractal nature. Heretofore, the MF-DCCA method has been widely applied to characterize the multifractal features of two cross-correlated time series, e.g. foreign exchange markets, stock markets, crude oil markets and agricultural products markets [34–39].

Previous research shows that: (1) the gold market research is mainly based on the efficient market hypothesis (EMH) while the gold market may depart from the efficient market hypothesis. (2) Existing papers on fractal theory mainly focused on the fractal features of a single market or a cross fractal of the gold, foreign exchange or crude oil markets, neglecting the price and volume as well as volatility in the market, given that the cross-correlation between price and volume is crucial for understanding information transmission and reflectiveness of price to information and volatility. Therefore, in this article, we take MF-DCCA and rolling windows to quantify the relationship between price and volume as well as its dynamic mechanisms, to figure out the mechanisms of nonlinear dependencies and suggest relevant policy as well as risk averse measures.

This paper is organized as follows. The next section provides the methodology of MF-DCCA. We show the data description and some preliminary analysis in Section 3. We provide empirical results and the conclusions in Section 4 and the last section, respectively.

2. Methodology

Let us briefly introduce the MF-DCCA method. Assume that there are two time series $x(t)$ and $y(t)$, where $t = 1, 2, \ldots, N$, where N is the equal length of these two series.