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Cross-correlations between Baltic Dry Index and crude oil prices

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HIGHLIGHTS

- We examine cross-correlations between BDI and crude oil prices.
- The cross-correlations between BDI and crude oil prices are significantly multifractal.
- The cross-correlations are strongly persistent in the short term.
- The cross-correlations are weakly anti-persistent in the long term.
- The multifractality of the cross-correlations is attributable to the volatility persistence and fat-tailed distributions.

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ABSTRACT

This paper examines the cross-correlation properties of Baltic Dry Index (BDI) and crude oil prices using cross-correlation statistics test and multifractal detrended cross-correlation analysis (MF-DCCA). The empirical results show that the cross-correlations between BDI and crude oil prices are significantly multifractal. By introducing the concept of a "crossover", we find that the cross-correlations are strongly persistent in the short term and weakly anti-persistent in the long term. Moreover, cross-correlations of all kinds of fluctuations are persistent in the short time while cross-correlations of small fluctuations are persistent and those of large fluctuations are anti-persistent in the long term. We have also verified that the multifractality of the cross-correlations of BDI and crude oil prices is both attributable to the persistence of fluctuations of time series and fat-tailed distributions.

1. Introduction

As a shipping and trade index created by the London-based Baltic Exchange, Baltic Dry Index (BDI)[1] is widely used to measure changes in the cost to transport raw materials such as metals, grains and fossil fuels by sea. Because the goods shipped are mainly raw, pre-production material, which is typically an area with very low levels of speculation, changes in the Baltic Dry Index are believed to be able to give the market investors insight into the trend in global supply and demand, and also the trend in the world business prosperity. The changes in BDI are often seen a leading indicator of future economic growth or contraction.

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[1] The BDI index is a composite of three sub-indexes that measure different sizes of dry bulk carriers (merchant ships)—Capesize, Supramax and Panamax. Multiple geographic routes are evaluated for each index to give depth to the index's composite measurement.

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International crude oil market is closely linked with the BDI by that (1) the crude oil price fluctuations often affect the shipping costs of the raw materials shipped and thus the BDI itself; (2) The BDI and the crude oil price movements in international markets are both dependent on the global economic and business conditions—the expansion or contraction of the global economy.

As a leading indicator on the cost of shipping and a standard gauge on the volume of commodity trading, the BDI is thus relevant for the changes in the international crude oil prices. Therefore, analyzing the time varying features of the relationship between the BDI and international crude oil market is of critical importance for investors in international shipping and crude oil markets, and also for macroeconomic analysts across boundaries.

This paper aims at testing the cross-correlation properties of Baltic Dry Index (BDI) and crude oil prices by using cross-correlation statistics test and multifractal detrended cross-correlation analysis (MF-DCCA).

Since Mandelbrot [1] proposed the theory of fractals, quite a number of empirical studies have been conducted to test the long-range dependence of financial time series. Peters [2,3] studied the long-range auto-correlations in stock markets, Cajueiro and Tabak examined the long memory in both developed and emerging equity markets [4–6], interest rate markets [7] and real state equity markets [8]. They all provided the evidence of the market inefficiency. In existing literature, several approaches have been developed to study the multifractal features in various financial markets, the results show that financial markets are fractality, long-range autocorrelated [9,10] and long-range cross-correlated [11–13] which is a great challenge to the traditional efficient market hypothesis. Peng et al. [14] proposed detrended fluctuation analysis (DFA) to explore the long-range auto-correlations of a non-stationary time series, Kantelhardt et al. [15] developed MF-DFA with a generalization of DFA. Then a method based on the moving average was first proposed by Vandewalle and Ausloos [16] and further developed to the detrending moving average (DMA) by Alessio et al. [17]. Gu and Zhou [18] extend the DMA method to multifractal detrending moving average (MF-DMA), which is designed to analyze multifractal time series and multifractal surfaces. MF-DFA and MF-DMA have been used to describe the fractal properties, including in crude oil market [19], stock market [20–22], and foreign exchange market [23,24].

Podobnik and Stanley [25] extended DFA to investigate the power-law cross-correlations between two nonstationary time series, this method is then named detrended cross-correlation analysis (DCCA, or called DXA). Zhou [26] proposed multifractal detrended cross-correlation analysis (MF-DCCA, or called MF-DXA) by combining MF-DFA and DCCA approaches. Several versions of MF-DCCA models, including the MF-X-DMA [27] based on DMA and MF-DMA, MF-HXA [28], MF-XPF [29,30] and MF-DPX [31] have been developed in the last few years.

The DCCA and MF-DCCA methods have now been widely used to detect the multifractal nature of the cross-correlations between two financial series [32–38]. For example, Liu and Wan [39] studied the cross-correlations between West Texas Intermediate (WTI) spot and futures markets, Zhuang et al. [40] researched the cross-correlations between carbon and crude oil markets as well as their dynamic behaviors, Pal et al. [41] investigated the cross-correlation behavior and fractal nature between crude oil prices and foreign exchange rate time series. However, to the best of our knowledge, there have been no studies conducted for the multifractal properties of cross-correlation between Baltic Dry Index (BDI) and crude oil prices.

This paper aims to investigate the cross-correlations between the BDI and crude oil prices. For the crude oil prices, we choose data of Brent oil spot price and West Texas Intermediate (WTI) spot price, respectively. The novel features of this study can be summarized as follows. First, we conduct the qualitative analysis of the cross-correlations between the return series of the BDI and crude oil prices, and we further explore the cross-correlations quantitatively by using the multifractal detrended cross-correlation analysis (MF-DCCA). Second, through our empirical study, we revealed the sources of multifractality for the cross-correlations between BDI and crude oil prices. Third, by using the rolling windows approach, we can, for the first time, investigate the time-varying features of multifractal cross-correlations between the BDI and international crude oil prices.

This article is organized as follows. Section 2 presents the MF-DCCA procedure. Section 3 describes the data for Baltic Dry Index, Brent and WTI crude oil prices. Section 4 provides qualitative and quantitative analysis on the cross-correlations between BDI and crude oil prices by using MF-DCCA. Section 5 presents discussions on our empirical results. The last section concludes the paper.

2. Methodology

Multifractal detrended cross-correlation analysis (MF-DCCA) can be described as follows.

Step 1. Consider two time series, $x(i)$ and $y(i)$ $(i = 1, 2, \dots, N)$, where N is the equal length of these two series. Then, we describe the "profile" of each series and get two new series,

$$X_i = \sum_{k=1}^{i}(x_k - \bar{x}), \qquad Y_i = \sum_{k=1}^{i}(y_k - \bar{y}), \quad i = 1, 2, \dots, N, \tag{1}$$

where $\bar{x}$ and $\bar{y}$ denote the average returns over the two whole time series $x(i)$ and $y(i)$.

Step 2. Divide the two profiles $x(i)$ and $y(i)$ into $N_s = [N/s]$ non-overlapping segments of equal length s. Since the length N of the series is often not a multiple of the considered time scale s, a short part at the end of each profile may remain. In order not to disregard this part of the series, the same procedure is repeated starting from the opposite end of each profile. Thereby, $2N_s$ segments are obtained together.

Step 3. Estimate the local trends for each of the $2N_s$ segments by a mth-order polynomial fit. Then the detrended covariance is determined by