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# Q1 Multifractal behavior of commodity markets: Fuel versus non-fuel products

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## HIGHLIGHTS

- We compare multifractal spectra of agricultural commodity and energy markets.
- Agricultural and energy-related commodities exhibit very similar behavior.
- Results support importance of the corporate management for agribusiness.

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## ABSTRACT

We investigate multifractal properties of commodity time series using multifractal detrended fluctuation analysis (MF-DFA). We find that agricultural and energy-related commodities exhibit very similar behavior, while the multifractal behavior of daily and monthly commodity series is rather different. Daily series demonstrate overall uncorrelated behavior, lower degree of multifractality and the dominance of small fluctuations. On the other hand, monthly commodity series show overall persistent behavior, higher degree of multifractality and the dominance of large fluctuations. After shuffling the series, we find that the multifractality is due to a broad probability density function for daily commodities series, while for monthly commodities series multifractality is caused by both a broad probability density function and long term correlations.



## 1. Introduction

A remarkable aspect of the world economy at the beginning of the XXI century and up to 2013/2014 was the steep Q3 increase of the price of commodities, that is, primary and essentially fungible goods like agricultural products, minerals and oil [1]. The main explanation for this is the increasing demand for such products by China and other fast growing Asian economies [2]. Also the incentives for the production of biofuels contributed to this trend [3]. Furthermore, the rapid gains of trading in commodities lead to the creation of financial instruments based on them, more sophisticated than the traditional futures contracts [4]. The trade in these secondary markets may have added impulse for the increment in the prices of commodities [5].

An obvious consequence of this appreciation of commodities was the induction of rapid growth processes of other emerging economies in Latin America and Africa, specialized in the production of such goods [6]. Another consequence involves the increase of prices for the low-income segments of the population around the world, whose consumption baskets

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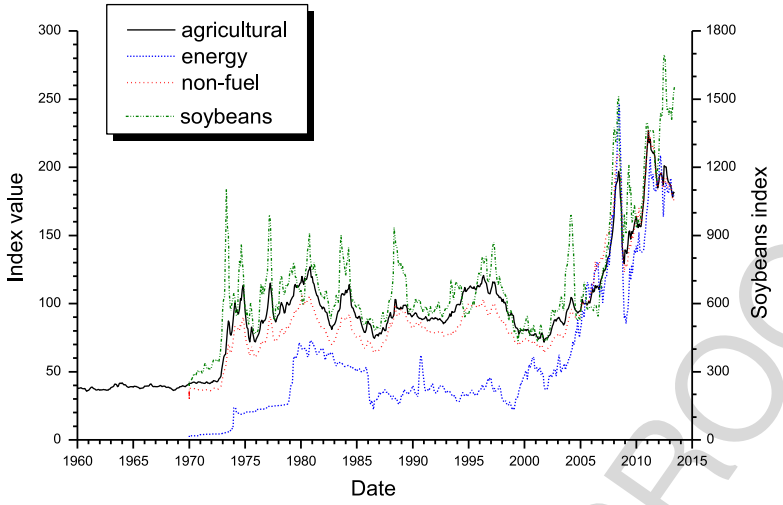


**Fig. 1.** Evolution of commodity prices.

are constituted by food and fuel [7]. This, in turn, is deemed as a major cause of political upheavals like the so-called "Arab Spring" [8], but also a contributing cause of the sub-prime crisis of 2007 which later triggered the larger crisis that affected the developed economies [9].

In any case, it is remarkable that, as shown in Fig. 1, the composite price indexes of the main commodity types (agricultural and energy goods) aligned around 2003/2004. This is rather surprising, given the different market structures of those types of goods. It is well known that agricultural markets are close to be competitive (i.e. where no producer can fix prices) while energy markets, are highly concentrated [10]. In particular, the oil market has only a few big participants that are able to change the prices [11].[1]

In this paper we will show that the evidence exhibited in Fig. 1 is backed by further analyses of the data. We examine the time series of the price indexes to look for their multifractal pattern. Multifractal properties of financial markets were extensively studied for different market variables such as market indices [13], stock prices [14,15] and foreign exchange rates [16,17]. Recently, more attention was shifted toward commodities, as the economies of developing countries are often strongly affected by fluctuations of commodities prices. For countries that export commodities the increase (decrease) in prices has positive (negative) effects on the balance of payments, while for countries that import commodities the increases in prices can result in an increase of overall inflation. Recent studies showed that prices of different types of commodities (agricultural, metals, nonmetals, crude oil) also display multifractal correlations [18,19] and cross correlations between commodities [20], as well as between commodities and other financial indices [21,22]. In order to contribute to a more complete understanding of the scaling behavior of commodity markets, we investigate multifractal properties of daily and monthly series of agricultural and energy related commodities. The changes of prices of these commodities over the last years have had a significant impact on global economy. By comparing the properties of the multifractal spectrum for different commodities at different temporal scales we can disclose the characteristics of their price fluctuations and how they are related to market efficiency.

## 2. Methodology

While the scaling behavior of monofractal temporal series can be described by a single scaling exponent, for multifractal processes a hierarchy of scaling exponents is required for a full description of different scaling behavior of subsets with small and large fluctuations [23]. Several methods have been proposed for non stationary time series [24–26]. In this work we use the Multifractal Detrended Fluctuation Analysis (MF-DFA) method [25], which has been successfully applied in the analysis of physiological signals [27,28], geophysical data [29,30], weather data [31,32], hydrological records [33,34], forest fires records [35], traffic time series [36], and financial time series [17,19,37,38]. The MF-DFA method is implemented through the following sequence of steps [25]:

(i) First, the original temporal series $x(i)$, $i = 1, \ldots, N$ is integrated to produce $X(k) = \sum_{i=1}^{k} [x(i) - \langle x \rangle]$, where $\langle x \rangle$ is the mean value of $x(i)$ and $k = 1, \ldots, N$.

(ii) Next, the integrated series $X(k)$ is divided into $N_n = int(N/n)$ non-overlapping segments of length $n$ and in each segment $\nu = 1, \ldots, N_n$ the local trend $X_{n,\nu}(k)$ (calculated from a m-th order polynomial regression) is subtracted from $X(k)$.

[1] Consider the jump in prices induced by OPEC in 1973, or the more subtle manipulation of Saudi Arabia in 2014 that led to much lower prices than in the previous decade [12].

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