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Multifractal Detrended Cross-correlation Analysis of Market Clearing Price of electricity and SENSEX in India

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HIGHLIGHTS

- We analyze Market Clearing Price of Electricity biding price in India.
- Data from all over the country was analyzed.
- Cross-correlation analysis of Electricity Market Clearing Price and SENSEX in India using MF-DXA technique.

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ABSTRACT

This paper reports a study on the cross-correlation between the electric bid price and SENSEX using Multifractal Detrended Cross-correlation Analysis (MF-DXA). MF-DXA is a very rigorous and robust technique for assessment of cross-correction between two non-linear time series. The study reveals power law cross-correlation between Market Clearing Price (MCP) and SENSEX which suggests that a change in the value of one can create a subjective change in the value of the other.

1. Introduction

Electricity as a commodity has many interesting characteristics, most of which stem from the fact that it cannot be economically stored. The absence of storage allows for predictable inter temporal variation in equilibrium prices. Power prices during day time are typically more than twice as high, as during night time, and power prices during the summer are predictably higher than winter. In addition, power prices are subject to sudden, but generally temporary, upward spikes [1].

The relationship between electricity consumption and economic growth is an area of immense interest. Empirical analysis on the causal relationship between electricity consumption and economic growth is important because once we can control the price fluctuations; it will be helpful to design optimal electricity programs. If electricity consumption causes economic growth, then policies encouraging a reduction in electricity consumption will have an effect on growth. If electricity consumption does not cause economic growth or economic growth causes consumption, then electricity conservation policies will have no impact on growth. If results suggest that there is a mutual relationship between electricity

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and Gross Domestic Product (GDP), then any global policy to reduce electricity consumption in order to reduce emissions would have an impact on the GDP of overall countries [2].

Many empirical studies, have suggested the dynamic relationship among energy sector variables (such as oil, electricity, gasoline, coal, and renewable energy) and economic variables (such as financial markets, real economy and the overall economy) [3].

Several studies have examined the relationship between energy or electricity consumption and economic growth at country level [4–9]. As the growth rate increases, the demand for energy (especially oil, electricity, renewable energy, etc.) increases. But the main failure of these studies is that the time series sample size is usually small, so the results of the econometric tests might be not reliable [3].

In a recent paper [10] we have made an exhaustive analysis of biding price of electric power using the rigorous and robust nonlinear technique Multifractal Detrended Fluctuation Analysis (MFDFA). The study revealed the bid prices to be multifractal. The degree of multifractality is different during different month for different regions. The results of the experiment are quite interesting and have scope for further systematic investigations in other parts of India too.

But to the best of our knowledge no study has been reported on the cross-correlation between the fluctuations of biding price of electric power and stock exchange. The aim of the present study is to investigate if any cross-correlation exists between Indian energy market (biding price of electric power) and SENSEX by Multifractal Detrended Cross-correlation Analysis (MF-DXA).

SENSEX or 'Sensitive Index' is an index of the Bombay Stock Exchange (BSE). It is calculated using the free flow market capitalization methodology, according to which the level of index at any point of time reflects the free-float market value of the 30 most traded stocks relative to a base period. It was first complied in 1986. Over the years it has become the barometer of the Indian market. If the SENSEX goes up, the prices of stocks of most of the major companies on the BSE goes up. On the other hand if the SENSEX goes down, the stock price of most of the major stocks on the BSE goes down. There has been enormous debate as to whether SENSEX reflects a true picture of Indian economy or not. To a great extent the policies of the government are reflected on the SENSEX, but at end of the day performance of the blue chip companies is responsible for the rise or fall. Though SENSEX is a good indicator of the market, it can also give an untrue picture of the market. SENSEX is highly volatile and often, trading dynamics govern the rise or fall rather than performance of the companies. Foreign investors are largely responsible for rises or falls in the market. The rise or fall in the international market also affects the value of SENSEX [11].

In stock market's volatility is known to be closely tied to the trading volume [12], and it is reasonable to assume that the same is true for the electricity market. Since it is expensive to store electric energy, the delivered volume must equal the consumption. Thus it is surprising that electricity spot prices have such clear memory effects in volatility, and it shows that volatility clustering can be present even in markets with limited room for speculative behavior. On the other hand, the (non-periodic component of the) demand for electric energy is not constant. It depends on a range of physical and economic factors, which contain long-range memory effects [13]. The "stylized facts" mentioned above can be described in a parsimonious way using multifractal models. Some authors have suggested [14–16] to apply multifractal modeling to electricity spot prices.

Empirical evidence supports the existence of fractals or multifractals in commodity or financial markets [17–22]. The existence of multifractality in the markets implies that the scaling geometry of the market patterns can be better described by a spectrum of scaling exponents. Many simultaneously recorded time series in various real world commodity or financial markets exhibit spatial or temporal cross-correlations [19,23–32]. In recent years, there have been several attempts to quantify cross-correlations between real systems. Podobnik et al. analyzed 1340 members of the NYSE Composite by using random matrix theory (RMT), and found the power-law magnitude cross-correlations as a collective mode [31]. Podobnik et al. also found long range cross-correlations in absolute values of returns between Dow Jones and S&P500 by cross-correlation function [33]. Plerou et al. applied random matrix theory to analyze the cross-correlation matrix of price changes of the largest 1000 US stocks [27]. Many previous methods which deal with cross-correlations are mainly based on the assumption that both the time series are stationary, but various empirical studies have shown that many real world time series are non-stationary [22,34,35] which may lead to a spurious detection of auto- or cross-correlation.

As powerful fractal and multifractal analysis technique, the Detrended Fluctuation Analysis (DFA) and the Multifractal Detrended Fluctuation Analysis (MF-DFA) are used in different fields [18,36–40]. As a generalization of the DFA method, the detrended cross-correlation analysis (DXA) is proposed to investigate the long-term cross-correlations between two non stationary time series [41–49], and Multifractal Detrended Cross-Correlation Analysis (MF-DXA) can unveil the multifractal features of two cross-correlated signals [50–54]. Since then, DXA and MF-DXA have been discussed on methodology [55–58] and used widely in the detection of cross-correlations in several papers [19,47,59–61].

There are alternative methods too, to analyze cross-correlations such as the approximate entropy (ApEn) [24] and sample entropy (SampEn) [62]. Pincus et al. [24] used the method of approximate entropy, a model independent measure of sequential irregularity which is based Kolmogorov entropy, as an indicator of system stability. Richman et al. [62], proposed the sample entropy, a modified and unbiased version of approximate entropy, as a measure of degree of asynchrony in physiological signals. They also evaluated cross-ApEn and cross-SampEn, which used cardiovascular data sets to measure the similarity of two distinct time series.

Arianos et al. [63] developed a method based on the model of fractional Brownian motion and Hurst exponent to describe the coupling of the non-stationary signals with long-range correlations.