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Multifractal detrended Cross Correlation Analysis of Foreign Exchange and SENSEX fluctuation in Indian perspective

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HIGHLIGHTS

- Auto and cross correlations of SENSEX and FX rate for Indian currency.
- MFDFA and MFDXA methodologies were employed.
- Degree of correlation with time is studied.
- Results are found to be consistent with data and explained qualitatively.

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ABSTRACT

The manuscript studies autocorrelation and cross correlation of SENSEX fluctuations and Forex Exchange Rate in respect to Indian scenario. Multifractal detrended fluctuation analysis (MFDFA) and multifractal detrended cross correlation analysis (MFDXA) were employed to study the correlation between the two series. It was observed that the two series are strongly cross correlated. The change of degree of cross correlation with time was studied and the results are interpreted qualitatively.

1. Introduction

The last few decades have experienced that concepts and methods of Statistical Physics have been effective in elucidating the properties and complex dynamics exhibited in economic and financial time series. The study of the Foreign Exchange market and the stock market is very important. The two markets are considered to be the barometers measuring the economic growth of a country. In finance, exchange rate between the two currencies is the rate at which one currency is exchanged for another. The Foreign Exchange rate is the key variable, that affects the Foreign Exchange investors, bankers, policymakers, economic institutions, the imports and exports of a country, tourists visits in a country in terms of the value of their foreign currency. A value of a local currency appreciates whenever the demand for it is greater than the available supply while the reverse will depreciate the value. Thus the movements in the exchange rates have important impacts on the economy's business cycle, country's trade, inflow of foreign funds and are therefore extremely vital for understanding the financial developments, industry policies, future cash flows and stock prices of the firms. The stock markets give

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benchmark indices that are representative of the entire market. The stock markets are based on the demand and supply forces prevailing in the market and therefore are highly volatile. A growing stock market would attract capital flows from foreign investors, which may cause an increase in the demand for a country's currency. While in case of a falling stock market the investors would try to sell their stocks to avoid further losses and would convert their money into foreign currency to move out of the country. There would be demand for foreign currency in exchange of local currency and it would lead to the depreciation of local currency. A knowledge about the daily changes in the stock prices is very crucial for the investors. This shows that it is necessary to study the existence of a relation between the Foreign Exchange market and the stock market. Several researchers have tried to investigate the relationship between the two markets in the Indian scenario [1–3]. Gulati and Kakhani [1] attempted to examine whether or not a casual relationship existed between the two markets. Patel and Kagalwala [2] analysed the relationship between exchange rates and Indian stock exchanges. This paper attempts at a deeper insight into the subject by utilizing the multifractal properties of the time series to reveal the correlation between the two. Such an investigation was not attempted in past in the Indian scenario.

Stanley et al. [4] have observed that physical systems which consist of a large number of interacting particles obey universal laws that are independent of the microscopic details. Since economic systems also consist of a large number of interacting units, scaling theory can also be applied to economics. Lux and Marchesi [5] have shown that in financial Stock markets, the dynamical change of price over time illustrates a highly complex behaviour because it is generated by the non-linear interactions among heterogeneous agents. The economic systems are characterized with extreme complexities and have recently become an interesting area of study for the physicists as well as economists [6,7]. Many studies have found the financial time series to exhibit some non-linear properties such as long-memory in volatility [8–11], a multifractal nature [12–16] and fat tails [16–20]. Various empirical studies have also shown financial time series to exhibit scaling like characteristics. Muller et al. [21] and Guillaume et al. [22] have reported an empirical scaling law for mean absolute price changes over a time interval for Foreign Exchange Rate. Dacorogna et al. [23] have presented empirical scaling laws for US Dollar–Japanese Yen (USD–JPY) and British Pound–US Dollar (GBP–USD). Mantegna and Stanley [17] also found scaling behaviour in the Standard and Poor's index (S&P 500) by examining high frequency data. Gencay et al. [24] suggested that financial time series may not follow a single-scaling law across all horizons. They have used a wavelet multi-scaling approach to show that Foreign Exchange Rate volatilities follow different scaling laws at different horizons. It was also evident from the study that there was no unique global scaling in financial time series but rather scaling was time varying.

Various time series in the financial markets are reported to possess multifractal properties [18,25,26], such as the Foreign Exchange Rate [27–40], Gold price [12,41,42], commodity price [43], Stock price [43–54], to list a few. Extensive methods have been adopted to extract the empirical multifractal properties in financial data sets, for instance, Wavelet Transform Modulus Maxima (WTMM) [55–57], and the Multifractal Detrended Fluctuation Analysis (MFDFA) [58], Multifractal Detrended Cross Correlation analysis [59], Multifractal Detrending Moving-Average Cross Correlation Analysis [60], Multifractal Cross Correlation Analysis [61]. A time series of the price fluctuations possessing multifractal nature usually has either fat tails in the distribution or long-range temporal correlation or both [58]. However, possessing long memory is not sufficient for the presence of multifractality and one has to have a non-linear process with long-memory in order to have multifractality [62].

The present investigation studies the multifractal properties of Foreign Exchange Rate in terms of Indian Rupee and US Dollar (abbreviated as FX) and SENSEX, an index of Bombay Stock Exchange, India. The term Foreign Exchange refers to the exchange of one currency for another. The value of a country's currency is very much linked with its economic conditions, policies and political conditions. The origin of the Foreign Exchange market in India could be traced to the year 1978. The currency price is always stated in relation to another currency. So when one currency appreciates, the other depreciates. A currency will tend to become valuable whenever the demand for it is greater than the available supply causing the currency to appreciate. The exchange rate changes daily with the international supply and demand for currency depending on the country's economy such as imports, exports, inflation, employment, etc.

The SENSEX or Sensitive Index was first compiled in the year 1986. Over the years it has become a prime indicator of the Indian Stock Market. The index is calculated based on a free float capitalization method and accordingly the level of index at any point of time reflects the free float market value of 30 largest and most actively traded stocks relative to a base period. Stock prices change every day because of pressure from the markets. If the SENSEX goes up it means that the prices of the stocks of most of the major companies on the BSE have gone up and vice versa. SENSEX is highly volatile and the Foreign Exchange Institutional Investors (FIIs) have a major impact on the movement of the SENSEX and are responsible for the rise and fall of the SENSEX. The global financial crisis that appeared by September 2008 had a negative impact on the Indian economy. The recession in the US resulted in the outflow of the Foreign Institutional Investment (FII) and the value of the Indian Rupee underwent a steep depreciation and the SENSEX experienced a sharp fall. Figs. 1 and 2 represent the variation of FX and SENSEX over a period from January 1995 to December 2012. At the onset, it can be observed that both the series show fluctuations with respect to time which are huge in the recent years from 2006 to 2012. In the present study autocorrelation and cross correlation between FX and SENSEX are studied using Multifractal Detrended Fluctuation Analysis (MFDFA) and Multifractal Detrended Cross Correlation Analysis (MFDXA).

Fractal geometry is associated with systems that are basically irregular at all scales [63]. They have two important properties, self-similarity and non-integer dimensions. Fractals can be classified into two categories: monofractals and multifractals. The monofractal systems are those, whose scaling properties are the same in different regions of the systems and a single scaling exponent is sufficient to describe such systems. On the other hand, the multifractal systems which