STUDY OF SCALING BEHAVIOR OF NIFTY USING DETRENDED FLUCTUATION ANALYSIS

Ravi Sharma[1], B.G. Sharma[2], D.P. Bisen[3] and Malti Sharma[4]

[1] Arts & Commerce Girls College Devendranagar, Raipur,(C.G.) 492001, India
Email - rvsharma65@gmail.com
[2] Department of Physics and Computer science, Govt.Science College Raipur 492010 India
Email - sharma_balgopal@rediffmail.com
[3] School of studies in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur (C.G.) 492010, India.
Email - dpbisen@rediffmail.com
[4] WQ-1, Govt. Science College Raipur, 492010, India.
Email - sharma_balgopal@rediffmail.com

ABSTRACT: *Detrended fluctuation analysis has been proved to be a useful method in the analysis of nonstationary time series data. Since the changes in the stock market indices are nonstationary, hence DFA method is more suitable than R/S method. In this paper we study National Stock Exchange (NSE) index for fractal behavior and calculated scaling exponents for different time intervals.*

1. INTRODUCTION

The recent body of work done by physicists and others have produced convincing evidences that the standard model of Finance is not fully capable of describing real markets, and hence new ideas and models are called for, some of which have come straight from Physics [1]. Many problems in economics and finance have recently started to attract the interest of statistical physicists. Fundamental problems are whether long-range power-law correlations exist in economic systems and the explanation of economic cycles, indeed, traditional methods (like spectral methods) have corroborated that there is evidence that the Brownian motion idea is only approximately right [2,3,4]. Different approaches have been envisaged to measure the correlations and to analyze them. N.Vandewalle and M .Ausloos performed a Detrended Fluctuation Analysis (DFA) of the USD/DEM ratio [5] and they demonstrated the existence of successive of economic activity having different statistical behaviors. Ashok Razdan [6] performed the R/S analysis of Bombay Stock Index and showed that BSE index time series is monofractal and can be represented by a fractional Brownian motion.

In this paper we perform a detrended fluctuation analysis of NIFTY values at different scales eg. Daily, Weekly, Monthly, Quarterly and Six monthly data and obtained the scaling exponents for the respective data set. We also perform the same study for DAX and DJI index time series data containing daily closing values.

The structure of the paper is as follows. In Sec. 2 we provide the mathematical background for calculating the detrended fluctuation function and discuss its physical meaning. In section 3, we apply DFA method to the time series of NIFTY value at different time scales.

We address the question of quantifying the information in DFA profile for possible prediction. Section 4 is related with the source of the data used. A conclusion will be drawn in sec.5.

2. DETRENDED FLUCTUATION ANALYSIS (DFA)

A simplified and general definition characterizes a time series as stationary if its mean, standard deviation and higher moments, as well as the correlation functions, are invariant under time translation. Signals that do not obey these conditions are non stationary. Many methods have been proposed as a tool for analysis of time series data. Hurst [7] proposed a scaling exponent for the water level of Nile River. However this method is applicable to stationery data only. Such an approach gives misleading result when the mean and variance of the time series varies with time i.e. the data is non stationery. To overcome this complication, Peng et al [8] introduced a modified root mean square analysis of a random walk, termed detrended fluctuation analysis (DFA), which may be applied to the analysis of non stationery data. Among the advantages of DFA over conventional methods are that it permits the detection of intrinsic self-similarity embedded in a seemingly non stationary time series, and also avoids the spurious detection of apparent self-similarity, which may be an artifact of extrinsic trends. This method has been successfully applied to a wide range of time series in recent years ranging from sunspot radiation to heart beat rate pattern, genetic pattern to stock market and so on.

Although the DFA algorithm works well for certain types of non stationary time series, it is not designed to handle all possible non stationarities in real-world data. Method for quantifying the correlation property in non stationary time series is based on the computation of a scaling exponent *d* by means of a modified root mean square analysis of a random walk.

2.1. CALCULATION OF DETRENDED FLUCTUATION FUNCTION

To compute *d* from a time-series x(*i*) [*i*=1,..., N], the time series is first integrated:

$$y(k) = \sum_{i=1}^{k} [x(i) - M]$$

Where *M* is the average value of the series x(*i*), and *k* ranges between 1 and *N*.
Next, we detrend the integrated time series, $y(k)$, by subtracting the local trend, $y_n(k)$, in each box. The root-mean-square fluctuation of this integrated and detrended time series is calculated by

$$F(n) = \sqrt{\frac{1}{N}\sum_{k=1}^{N}[y(k) - y_n(k)]^2}.$$

This computation is repeated over all time scales (box sizes) to characterize the relationship between *F* (*n*), the average fluctuation, and the box size, *n*. Typically, *F* (*n*) will increase with box size. A linear relationship on a log-log plot indicates the presence of power law (fractal) scaling. Under such conditions, the fluctuations can be characterized by a scaling exponent d, the slope of the line relating log *F (n)* to log *n*.

F (n) is computed for all time-scales n. Typically, F(n) increases with n, the "box-size". If log F(n) increases linearly with log n, then the slope of the line relating F(n) and n in a log-log scale gives the scaling exponent ***d***.

Scaling exponent *d* is related to the behavior of the data as follows:

If d = 0.5, the time-series x(*i*) is uncorrelated (white noise).
If d = 1.0, the correlation of the time-series is the same of 1/f noise.
If d = 1.5, x (*i*) behaves like Brown noise (random walk) Brownian motion

3. DATA ANALYSIS

The DFA analysis was performed for the data sets and the results obtained are as follows:

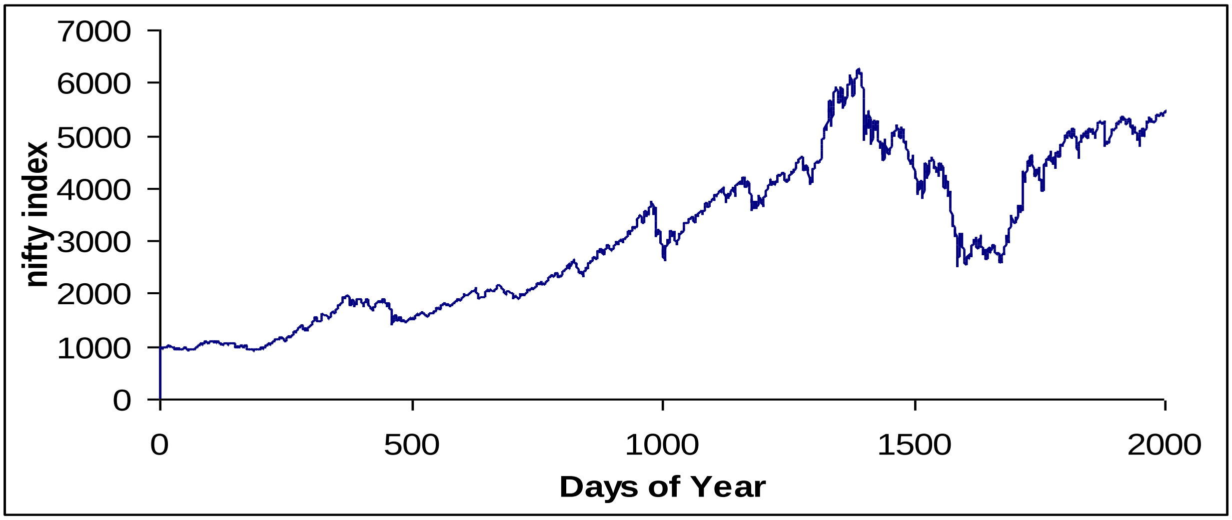

Fig. 1[A] NSE INDEX DAILY CLOSING VALUES FROM 12.08.2002 TO 25.08.2010

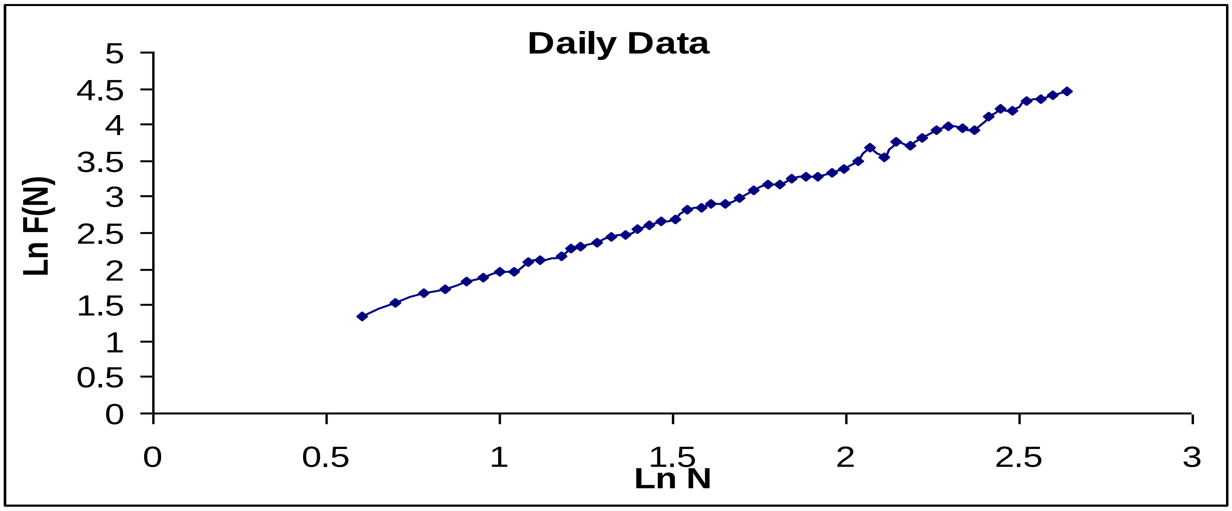

Fig. 1[B] DFA PROFILE FOR NSE INDEX DAILY CLOSING VALUES FROM 12.08.2002 TO 25.8.2010

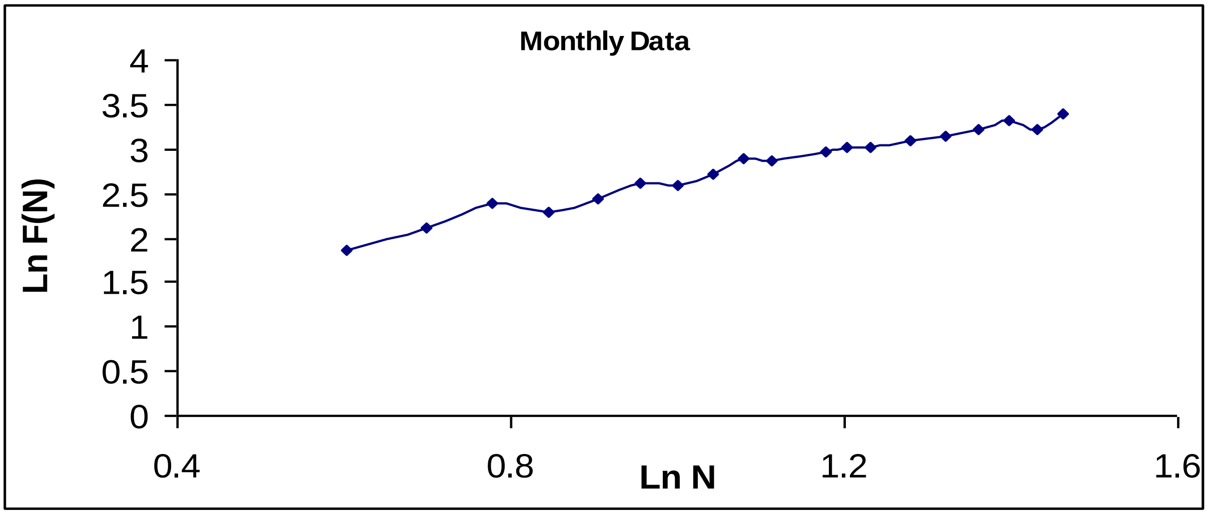

Fig. 1[C] DFA PROFILE FOR NSE INDEX MONTHLY CLOSING VALUES FROM 12.08.2002 TO 25.8.2010

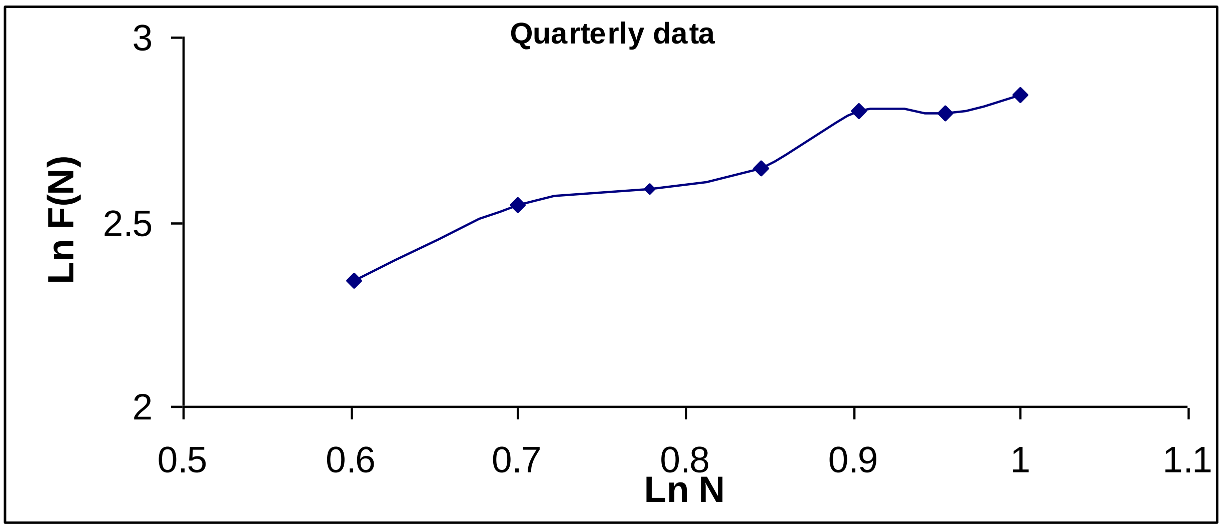

Fig. 1[D] DFA PROFILE FOR NSE INDEX QUARTERLY CLOSING VALUES FROM 12.08.2002 TO 25.8.2010

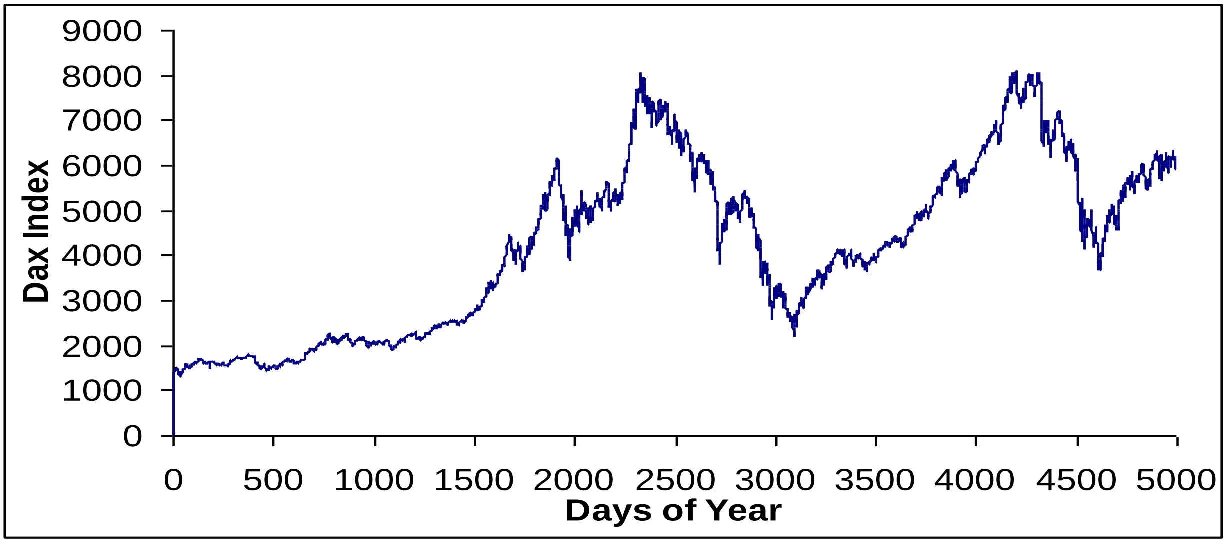

FIG 2[A] DAX DAILY CLOSING VALUES FROM 26-11-1990 to 25-08-2010

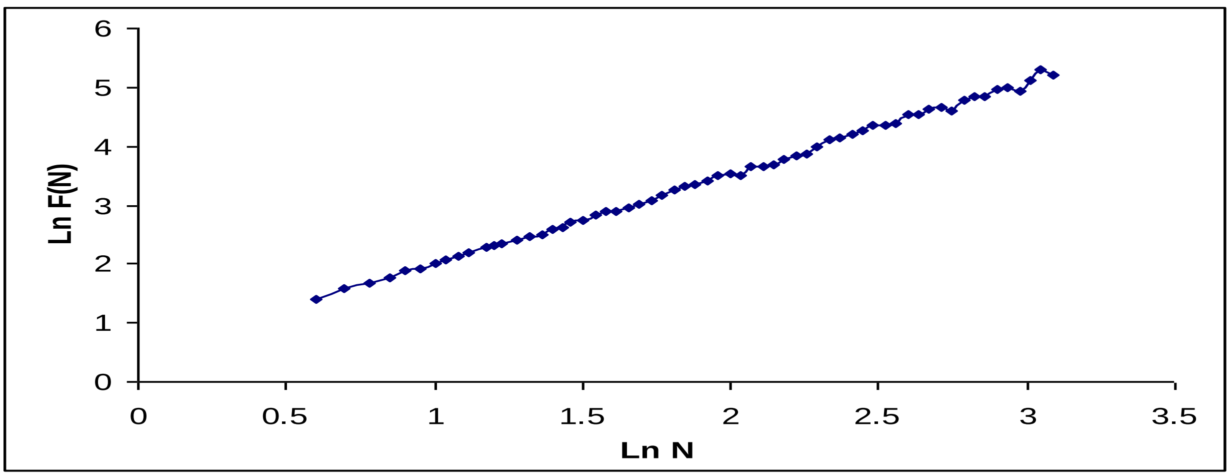

FIG 2[B] DFA PROFILE FOR DAX CLOSING VALUES FROM 26-11-1990 to 25-08-2010

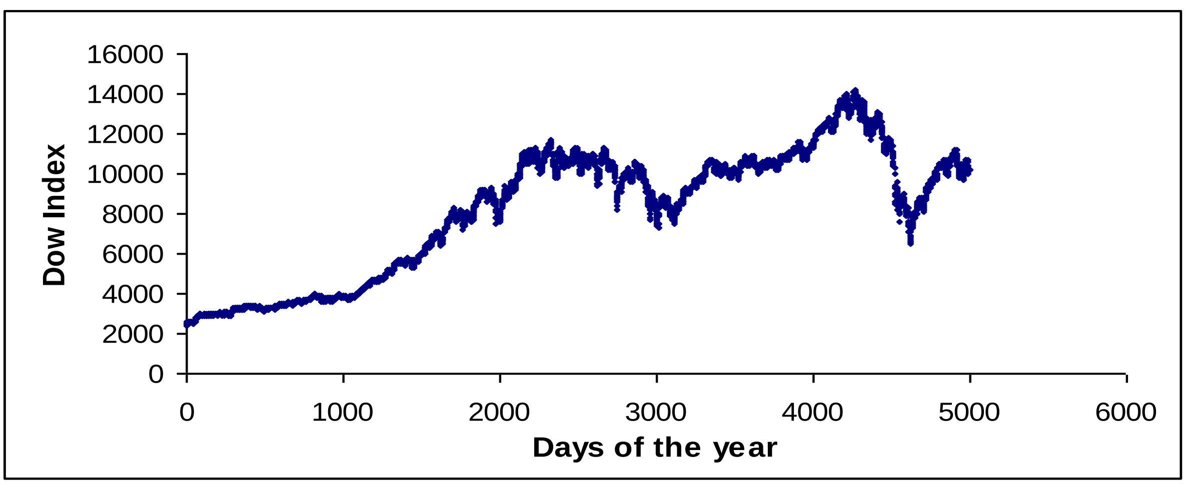

FIG 3[A] DJI CLOSING VALUES FROM 03- 01-1950 to 25-08-2010

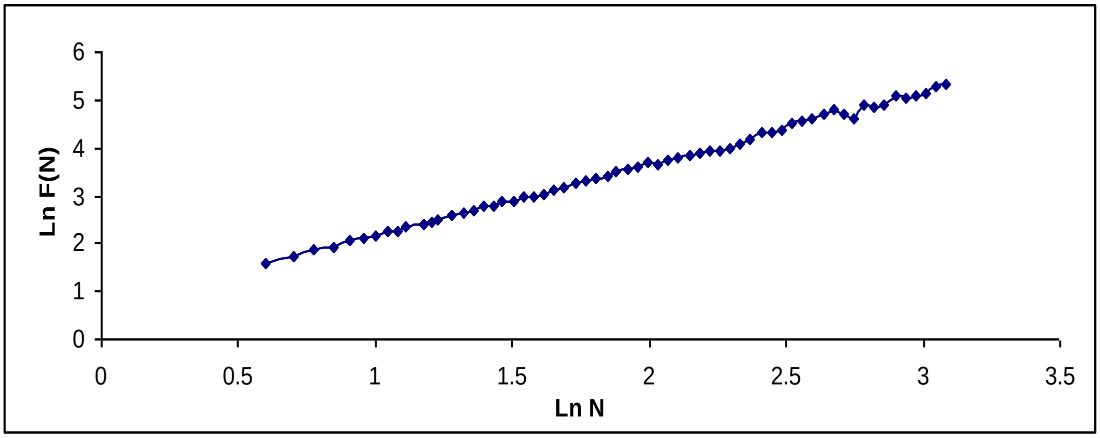

FIG 3[B] DFA PROFILE FOR DOW CLOSING VALUES FROM 03- 01- 1950 to 25-08-2010

4. SOURCE OF DATA SETS

We have considered the daily closing value of indices till 26th sep. 2010. Dataset of NIFTY contains 2015 data points where as DAX data contains 4991 and DJI data contains 5262 data points. The week ends and holidays are not considered. The data were collected from the website of yahoo finance [9].

5. RESULT AND CONCLUSION

By using DFA analysis, we calculate the fractal dimension of NSE index for daily, monthly, and quarterly closing values. The variation of DFA function values of NIFTY index with n shows that data follows simple scaling behavior. Almost same result is obtained for daily closing values of DAX and DJI indices. Since the value of slope is found to be near to 1.5, for all types of data sets with small variance, the market behavior shows nearly classical Brownian random walk. But it is important to note that we have used closing values of Indices only. It will be interesting to look for mono/multifractal features in short term (single day data, but intra-day behavior).

6. REFERENCES

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