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Fractal Analysis in the Indian Stock Market with Special Reference to CNX 500 Index Returns

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Abstract

Fractal Analysis assesses the fractal characteristics of data. It consists of several methods to assign a fractal dimension and other fractal characteristics in a data set which may be a theoretical data set or a pattern of signals extracted from phenomena including natural geometric objects, sound, market fluctuations, heart rates, digital images, molecular motion, networks, etc. A fractal dimension is an index for characterizing fractal patterns or sets by quantifying their complexity as a ratio of the change in detail to the change in scale. Fractal dimensions are used to characterize a broad spectrum of objects ranging from the abstract to practical phenomena including turbulence, river networks, urban growth, human physiology, medicine, and market trends. Analysing the fractal structure is now widely used in stock market to predict the future prices. The main aim of this study is to analyze the fractal dimension in CNX 500 index returns which is India's first broad based benchmark of the Indian capital market.

Keywords: Fractal Analysis, CNX 500 Index, Indian Stock Market, Hurst Exponent, Long Range Dependence and R/S Analysis

JEL Classification: C12, C53, G19

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INTRODUCTION

The Fractal Market Hypothesis of Edgar Peters lies at the root of the analysis of financial markets with the help of chaotic structures. Time series analysis has been extensively used in market analysis. Financial time series are analysed by using nonlinear time series analysis tools like Rescaled Range (R/S) Analysis (**Cakar .O, *et al.* 2010)**. A stock market index is a measure of the relative value of a group of stocks in numerical terms. It is to be noted that as the stocks within an index change value, the index value changes. An index measures the performance of investments against a relevant market index.

The broad-market indices consist of the large, liquid stocks listed on the Exchange. The indices serve as a benchmark for measuring the performance of the stocks or portfolios such as mutual fund investments. The total traded value for the last six months ending March 2013 of all broad-market index constituents was approximately 94.60% of the traded value of all stocks on NSE. The broad-market index includes CNX Nifty, CNX Nifty Junior, CNX 100, CNX 200, CNX 500, Nifty MIDCAP 50, CNX MIDCAP, CNX SMALLCAP Index, CNX MIDCAP 200 and India VIX. Among all the broad-market indices, the CNX 500 Index represents about 95.87% of the free float market capitalization of the stocks listed on NSE as on March 28, 2013. The CNX 500 companies are disaggregated into 72 industry indices viz. CNX Industry Indices **(http://www.nseindia.com/products/content/equities/indices/cnx_500.htm).**

LITERATURE REVIEWS

The previous studies which analyzed the fractal dimension and market predictions in stock markets in India and abroad, are reviewed below

Madhusoodanan T.P. (1998) analyzed the movements in the Bombay Stock Exchange stock prices with the help of variance ratio test and the study was carried out by using aggregate level of market indices and disaggregated level of individual companies. The study found that there was long-term mean reversion in the Indian stock market. **Hardayanna Abd. Rahman** and **Masnita Misiran (2011)** demonstrated the indices S&P 500, The Dow Jones Industrial Average (DJIA) 30, Islamic index and The Dow Jones Islamic Market Index (DJIM). The

study found that there was significant difference between the conventional and the Islamic indices. **Murugesan Selvam, et al., (2011)** tested the Fractal Structure in BSE Sensex returns of Indian stock market. The study found that the fractal structure existed in the BSE Sensex and advised the investors to take their investment decision based on important information. **Gayathri M. and Selvam M. (2011a)** studied the efficiency of Fractal Market Hypothesis in the Indian Stock Market. According to this study, any new information would be immediately and fully reflected in prices and stock returns of equity. **Gayathri M. and Selvam M. (2011b)** analyzed the Fractal Structure in the National Stock Exchange of India and examined the long range dependence of daily returns of Nifty in the stock market. **Ladislav Kristoufek (2010)** focussed on finite sample properties of two methods of Hurst exponent estimation-Rescaled Range Analysis (R/S) and Detrended Fluctuation Analysis (DFA). The author concluded that testing the hypothesis of long range dependence for short time series, especially with 256 and 512 observations, can be complicated as the confidence intervals are very broad.

There is no comprehensive study analyzing the CNX 500 index of Indian stock markets in the recent studies by using the Rescaled Range Analysis. Hence the present study aims to investigate the daily returns of long memory in the Indian Stock Market.

STATEMENT OF THE PROBLEM

The stock market is among the most volatile financial institutions in business. It is the volatility that tends to be the biggest problem with any stock market. Almost any reason, real or imagined, may cause these extreme fluctuations that often affect the stock market's credibility. Factors like, the weather, political instability, political decisions, war, terrorist threats, boycotts and strikes, economic trends and international trade or even company scandals could cause problems for the stock market across the globe.

It is to be noted that there was lack of quantitative evidences in predicting the stock prices in Indian Stock Market and absence of standard statistical analysis to uncover any long range dependence in financial market data. The prediction of stock prices is useful to investors, regulators etc. Hence an attempt has been made to study the long range dependence in the Indian Stock Market.

OBJECTIVES OF THE STUDY

The objective of the study is to analyze the normality and to examine the long range dependence in the daily index returns of CNX 500.

HYPOTHESES OF THE STUDY

The following null hypotheses were tested.

NH 1 - There is no normality in the daily index returns of CNX 500

NH 2 - There is no long range dependence in the daily index returns of CNX 500

METHODOLOGY OF THE STUDY

a) Sources of Data and Computational Details

There are various broad market indices listed on the NSE Exchange. They are CNX Nifty, CNX Nifty Junior, CNX 100, CNX 200, CNX 500, CNX MIDCAP, Nifty MIDCAP 50 and CNX SMALL CAP. The CNX 500 Index represented about 95.87% of the free float market capitalization of the stocks listed on NSE as on March 28, 2013. Hence CNX 500 was taken up for this study. In this study, the daily index returns of CNX 500 were used to examine the evidence of long range dependence. The study period covered ten years from 1st April, 2003 to 31st March, 2013.

b) Tools Used in this Study

The following statistical tools were used in this study.

(i) Descriptive Analysis

The Descriptive Analysis includes Mean, Standard Deviation, Skewness and Kurtosis.

(ii) Rescaled Range Analysis

Hurst (1965) developed the Rescaled Range Analysis to analyze long records of natural phenomena. The same model was used by **Gayathri M. et al. (2012).** In this analysis, two factors were used. Firstly, the range R, which is the difference between the minimum and maximum 'accumulated' values or cumulative sum of X (t,*tau*)of the natural phenomenon at discrete integer-valued time t over a time span *tau* and secondly, the standard deviation S, which is estimated from the observed values *Xi*(t). Hurst found that the ratio R/S is described for a large number of natural phenomena by the following empirical relation.

$$R / S = (a*N)^{H} \qquad \text{----------(1)}$$

where, R / S = Rescaled Range; a = constant (number of intervals); N = Number of observations; H = Hurst Exponent

The V-Statistic takes the following format

$$V_n = \frac{R_n / S_n}{\sqrt{n}} \qquad \text{---------- (2)}$$

where, V_n = V-Statistic; R / S = Rescaled Range; n = increment time

$$H = \frac{\text{In}\,(R_n / S_n) - \text{In}\,(c)}{\text{In}\,(n)} \qquad \text{---------- (3)}$$

where, R / S = Rescaled Range; c = constant (number of intervals); n = time increment
H = Hurst exponent

$$\text{Fractal Dimension} = 2 - H \qquad \text{----------(4)}$$

where, H=Hurst exponent

LIMITATIONS OF THE STUDY

The following are the major limitations of the study.

- The study was focused only on CNX 500 Index Returns.
- The study was based mainly on secondary data.
- All limitations associated with tools like Descriptive Statistics and Rescaled Range Analysis are applicable to this study also.

ANALYSIS OF NORMALITY AND FRACTAL DIMENSION IN THE CNX 500 INDEX

For the purpose of this study, the analysis of normality and fractal dimension in CNX 500 was made as follows.

(a) Descriptive Statistics of CNX 500 Index

(b) Estimating Rescaled Range Analysis of CNX 500 Index

(c) Analysis of Fractal Dimension of CNX 500 Index

(a) Descriptive Statistics of CNX 500 Index

Table-1 reveals the results of Descriptive Statistics for CNX 500 Returns for a ten year period from April 2003 to March 2013**.** The above **Table** clearly shows that CNX 500 had

earned positive average returns of 0.0007 and the standard deviation of 0.0161 reveals the level of market risk in the stock market. The negative skewness of -0.5125 indicates a distribution to be asymmetrical, extending towards more negative values. The Kurtosis at 8.7576, was leptokurtic as the value was higher the number above 3. It indicates that the investors could earn extremely positive outcomes in CNX 500 Index during the study period from April 2003 to March 2013.

Table-1
Descriptive Statistics for CNX 500 Returns from April 2003 to March 2013

Descriptive Variables	CNX 500 Index
Mean	0.0007
Maximum	0.1503
Minimum	-0.1288
Standard Deviation	0.0161
Skewness	-0.5125
Kurtosis	8.7576
Number of observations	2494

Source: Computed from PROWESS database using SPSS 16.0

(b) Estimating Rescaled Range Analysis of CNX 500 index

The data of daily returns for CNX 500 Index over the period from 1st April, 2003 to 31st March 2013, giving a total of 2494 observations, were used to study the fractal dimension of CNX 500 Index returns by using the Rescaled Range Analysis. These returns were the log price relative to a composite representative CNX 500 Index. To test the nature of systematic bias, Rescaled Range Analysis was applied. In the first step, the sample period was divided into sub periods of length n. Then the data were split into 340 contiguous sub periods for the sample of 2490 observations.

TABLE-2 displays the results of Rescaled Range Value for CNX 500 Index returns between the period April 2003 and March 2013, using the matlab algorithm coding given in Appendix-1. The highest value (1.4278) of log R/S was registered during the 340 day period. It is to be noted from the above **TABLE-2** that the log R/S values and log E(R/S) values (from N=10) were closer to N=40. Later the value went up from 0.9283 at N=50 up to 1.4278 at N=340. In the case of V-Statistics, the highest value of 1.4523 was witnessed at the end of the 340 day period. It implies the interesting fact that the index returns tended to increase gradually in future.

The overall analysis shows the fact that the CNX 500 Index returns were influenced by the past data. In other words, there was long range dependence in the daily index returns of CNX

500 because there was strong evidence of long term memory in the daily index returns of CNX 500 during the study period.

Table-2
Rescaled Range Analysis of CNX 500 index during April 2003 to March 2013

N	log N	log R/S	log E(R/S)	V-Statistic R/S	V-Statistic E(R/S)
10	1	0.4692	0.4805	0.9314	0.9561
20	1.3010	0.6726	0.6638	1.0523	1.0311
30	1.4771	0.7877	0.7667	1.1198	1.0670
40	1.6021	0.8634	0.8382	1.1544	1.0893
50	1.6990	0.9283	0.8928	1.1989	1.1050
60	1.7782	0.9831	0.9370	1.2417	1.1167
70	1.8451	1.0150	0.9741	1.2372	1.1260
80	1.9031	1.0577	1.0060	1.2770	1.1336
90	1.9542	1.0871	1.0340	1.2882	1.1399
100	2	1.0927	1.0589	1.2380	1.1453
110	2.0414	1.1195	1.0814	1.2554	1.1500
120	2.0792	1.1610	1.1018	1.3227	1.1541
130	2.1139	1.1667	1.1206	1.2876	1.1578
140	2.1461	1.1838	1.1379	1.2905	1.1610
150	2.1761	1.2038	1.1540	1.3054	1.1640
160	2.2041	1.2263	1.1690	1.3312	1.1666
170	2.2304	1.2211	1.1831	1.2762	1.1691
180	2.2553	1.2547	1.1963	1.3398	1.1713
190	2.2788	1.2445	1.2088	1.2738	1.1734
200	2.3010	1.2707	1.2207	1.3188	1.1753
210	2.3222	1.2860	1.2319	1.3333	1.1771
220	2.3424	1.3144	1.2426	1.3906	1.1788
230	2.3617	1.2916	1.2529	1.2905	1.1803
240	2.3802	1.3115	1.2626	1.3225	1.1818
250	2.3979	1.3342	1.2720	1.3654	1.1832
260	2.4150	1.3367	1.2810	1.3466	1.1845
270	2.4314	1.3464	1.2896	1.3512	1.1857
280	2.4472	1.3774	1.2980	1.4251	1.1868
290	2.4624	1.3803	1.3060	1.4097	1.1880
300	2.4771	1.3615	1.3137	1.3272	1.1890
310	2.4914	1.3770	1.3212	1.3532	1.1900
320	2.5051	1.3934	1.3285	1.3831	1.1910
330	2.5185	1.4211	1.3355	1.4517	1.1919
340	2.5315	1.4278	1.3423	1.4523	1.1927

Source: Computed from yahoo finance website using MATLAB R2012a

(c) Analysis of Fractal Dimension of CNX 500 Index Returns

The results of Hurst Exponent, computed by using the Equation (5) initially over the period from April 2003 to March 2013, are depicted in **TABLE-3.** The value of Hurst Exponent of 0.5979 was found for the CNX 500 Index. From this analysis, it is to be understood that CNX 500 Index recorded high Hurst value (0.5979), indicating more persistent behaviour. Thus the actual value for Hurst Exponent was greater than 0.5, indicating that the return series showed the persistence and the value of returns would increase in the future.

TABLE-3 represents the Fractal Dimension values for CNX 500 Index. It was observed that the sample data registered the Fractal Dimension value of 1.4021, computed from Equation (4). Since the value of fractal dimension for CNX 500 Index was closer to one, was evident, persistent behaviour with fractal dimension at $1 < D < 1.5$. Therefore, the fractal dimension was evident in CNX 500 Index during the study period.

TABLE-3
Fractal Dimension of CNX 500 index

Statistic	April 2003 to March 2013
Hurst Values	0.5979
Fractal Dimension	1.4021

Source: Computed from yahoo finance website using equation (3) and (4)

CONCLUSION AND IMPLICATIONS

This study investigated the long range memory by using daily data of the CNX 500 Index returns of the Indian Stock Market over a period of ten years. The results of this study evidenced the presence of fractal structure, with long memory in the CNX 500 returns. The long memory was found for the sample period. The daily returns of CNX 500 displayed the persistent behaviour. The above analysis indicated the persistence of samples evident in the upward trends for the next period as the value of Hurst Exponent was greater than 0.5.

It is to be noted that some previous studies using R/S analysis did find evidence of long term dependence in various financial markets. **Madhusoodanan T.P. (1998)** found long-term mean reversion in the Indian stock market. **Hardayanna Abd. Rahman** and **Masnita Misiran (2011)** found long memory properties in the return series, absolute returns and the squared returns. **Murugesan Selvam, et al., (2011)** found fractal structure in the BSE Sensex. **Gayathri M. and Selvam M. (2011a)** studied the efficiency of Fractal Market Hypothesis in the Indian Stock Market. According to this study, any new information would

be immediately and fully reflected in prices and stock returns of equity. A study conducted by **Gayathri M. and Selvam M. (2011b)** examined the long range dependence of daily returns of Nifty in the stock market. **Ladislav Kristoufek (2010)** tested the long range dependence for short time series. The findings of the present study did not confirm the findings of **Gayathri M.** and **Selvam M (2011 a)**.The Hurst Exponent can be a powerful measurement of current market conditions and helps in the technical analysis of predicting the share price in the market. The returns series of CNX 500 Index returns have a fractal structure and these returns are predictable in the long term.

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