International Research Journal of Applied Finance ISSN 2229 - 6891
Vol. VIII Issue – 7 July, 2017 www.irjaf.com

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

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Abstract

The Bombay Stock Exchange is India's oldest stock exchange. Over the past 137 years, BSE has facilitated the growth of the Indian corporate sector by providing an efficient platform to raise capital. New approaches to stock market prediction are considered in this paper on the basis of the intensity of stock index fluctuations that are estimated by fractal analysis techniques. The study uses tools like Kolmogorov-Smirnov for testing normality, and Rescaled Ranged (R/S) analysis for testing the long range dependence in the index returns. The paper examines the fractal dimension in BSE Broad Market Index returns for the time period between 2003 and 2013. The study found long range dependence in the sample index returns.

Keywords: Fractal Analysis, Long Range Dependence, Broad Market Indices
JEL Code: C12, C15, C53, D53

I. Introduction

Fractal Market Hypothesis (FMH) analyses the daily randomness of the market and the turbulence witnessed during periods of crises. Major components of the theory focus on the investment horizons and liquidity of markets given a certain amount of information. The market is considered stable when it is comprised of investors of different investment horizons given the same information. Conversely, leading into crashes and crisis, FMH asserts that investment strategies converge to shorter time horizons. As a result, markets become less liquid and more inefficient.

Fractal analysis is a tool that studies the repeating patterns of price over long periods of time that are created by a common driver of price that can be isolated. In essence, fractal development is the means by which the main fundamental variable that drives a market's price creates repeating patterns of price growth at ever higher degree over time due to repetitive market psychology. In assessing the fractal dimension of stock returns, investors may better understand the systematic pattern of price returns and consequently adjust their pricing strategies to buy or sell their stock in the market (Thiele, 2007).

II. Literature Review

Mishra, et al. (2011) tested the presence of nonlinear dependence and deterministic chaos in the rate of returns series for the Indian stock market. The study found long term dependence in sample indices of Indian stock market and suggested that the existence of long memory in market indices could be exploitable and helpful for market players in the Indian case. Selvam, et al. (2011) tested the fractal structure in BSE Sensex returns of Indian stock market and found that the fractal structure existed in the BSE Sensex. Rahman and Misiran (2011) investigated the long memory properties in daily returns of conventional indices like the Dow Jones Industrial Average (DJIA), S&P 500, and the Dow Jones Islamic Market Index (DJIM) in return series, absolute returns, and the squared returns. The study found significant difference for both the conventional and the Islamic indices in terms of their respective Hurst value. Mahalingam and Selvam (2011a) studied the efficiency of Fractal Market Hypothesis in the Indian Stock Market. Their study found any new information would be immediately and fully reflected in prices and short term and long term trade follow technical information and fundamental information respectively. Mahalingam and Selvam (2011b) analyzed the

fractal structure in the National Stock Exchange of India and found long range dependence of daily returns. Mahalingam, et al. (2012) analyzed the daily index returns of BSE Sensex and found long range dependence in the returns. Battacharya and Bhattacharya (2012) examined the long term memory properties in ten emerging stock market indices viz., BUX (Hungary), CSI 300 (China), BOVEPSA (Brazil), IPSA (Chile), KLSE (Malaysia), KOSPI (Korea), MICEX (Russia), MXX-IPC (Mexico), S&P CNX Nifty (India) and TWII (Taiwan) across the Globe. Their results indicated that all the emerging stock market returns follow random walk and there was no evidence of long term memory in the chosen emerging stock market returns. Kumar and Maheswaran (2013) tested for the presence of long term memory in daily index returns of S&P CNX Nifty, CNX 100, S&P CNX 500, CNX Nifty Junior, Nifty Midcap 50 and CNX Smallcap from the Indian stock market. The study found long term dependence existed in the Indian stock market for the six index returns of NSE.

III. Methodology

The stock prices fluctuate daily or even every minute, resulting in a nonlinear pattern. The three outcomes that occur in the stock market price are - rise, fall, or remain the same, which is uncertain. Efficient Market Hypothesis (EMH) states that the stock markets are efficient in which, the opportunities for profit are to be discovered so quickly because they cease to be opportunities very fast. The EMH effectively states that no system can continually beat the market because if this information becomes public, everyone will use it, thus negating its potential gain. There has been an ongoing debate about the validity of the EMH and some researchers attempted to use rescaled range analysis to validate their claims. Therefore, there have been numerous attempts at modelling a reliable price predictor. It is to be noted that the varying levels of awareness among investors across the Globe make it difficult to predict the price. This study describes the prediction of price through fractal model which may prove to be the answer to the problem of price prediction. An attempt has been made in this study to examine the fractal dimension with the help of long range dependence in the Indian Stock Market.

Long-range dependence implies predictable arbitrage opportunities. Long memory property appeals to risk managers, derivative market participants, and asset allocation managers whose interest is to convincingly forecast stock market movements. Evaluation of long range dependence in broad market indices is useful to investors to anticipate price movements and earn positive average returns. This study intends to fill this existing gap in the financial literature by studying long range dependence in broad indices in the Indian Stock Market.

The study uses rescaled range analysis to test for persistence and long range dependence by computing Hurst exponent. In assessing the fractal dimension of asset returns, the investors may better understand the systematic pattern of price returns and consequently may adjust their asset pricing strategies accordingly.

The following two null hypotheses were tested in the study.

H_1: There is no significant difference in the sample index returns of BSE broad market.
H_2: There is no long range dependence in the sample index returns of BSE broad market.

III.1 Sample Selection

The Indian Stock Market is one of the most dynamic and efficient markets in Asia. The Bombay Stock Exchange is the 10th largest stock exchange in the world in terms of market

capitalization. Around 5000 companies are listed on BSE. The companies listed on BSE Ltd command a total market capitalization of USD 1.32 trillion as on January, 2013.

As on 31st March 2013, there were a total of 29 indices in BSE, which include Broad Indices, Investment Strategy Indices, Volatility Indices, Thematic Indices and Sectoral Indices. For the purpose of this study, six indices (Broad Indices) in Bombay Stock Exchange, namely, S&P BSE Sensex, S&P BSE MIDCAP, S&P BSE SMALLCAP, S&P BSE 100, S&P BSE 200, and S&P BSE 500 were selected as sample units. The closing prices of the indices were collected from the BSE official website (www.bseindia.com). Other relevant information for this study was collected from books, journals, research articles, and from various websites.

III.2 Sample Period

All transactions in all groups of securities in the equity segment and Fixed Income Securities listed on BSE, are required to be settled on T+2 basis with effect from April 1, 2003. Hence, the time period chosen for the study is between April 1, 2003 to March 31, 2013.

IV. Test Results

The descriptive statistics for the sample data is found in Table 1. Kolmogorov-Smirnov (KS) test and Shapiro Wilk test were used to test for goodness of fit. The results of Kolmogorov-Smirnov and Shapiro-Wilk Statistics for BSE Broad Market Index Returns are found in Table 2. It is observed that the p-values for the Kolmogorov-Smirnov and Shapiro-Wilk Statistic were significant at 5% significant level. In other words, the data significantly differed from a normal distribution. The KS test strongly supports the findings in the descriptive statistics of excessive kurtosis. The null hypothesis (H1) that there is no significant difference in the sample index returns of BSE broad market is rejected.

The fractal dimension of BSE Broad Market index returns was analysed using rescaled range analysis. The returns data were split into two sets of 126 contiguous sub periods for the two sets of 1258 and 1239 sample observations. The figures below represent a plot of log(R/S) and log E(R/S) against log (n) for the study periods from April 2003 to March 2008 and April 2008 to March 2013. The plots in Figure 1&2 show long term memory for the Sensex between 2008-13. Figures 3 & 4 shows long term memory for Midcap index for both sample periods. Figures 5 & 6 shows long term memory for Small cap index for both sample periods. Figures 7 & 8 show long term memory for BSE 100 index for both sample periods. Figures 9 & 10 show long term memory for BSE 200 index for both sample periods. Figures 11 & 12 show long term memory for BSE 200 index for both sample periods.

A measure of bias in fractional Brownian Motion is known as Hurst Exponent. The results of Hurst Exponent for the two sample periods from April 2003 to March 2008 and April 2008 to March 2013 for all the BSE Broad market sample indices are found in Table 3. A Hurst value, greater than 0.5, indicates the presence of long-range persistency. The results show strong evidence of long term memory in the return data.

V. Conclusion

The long memory property in stock market returns is an intriguing issue in financial literature. It would allow investors to anticipate price movements and earn positive returns. This study investigated the presence of the long memory property in the Bombay Stock Exchange, especially in Broad Market index returns. It was found that the daily Broad Market indices returns displayed long range dependency. These results are not consistent

with random walk behaviour. The participants in the Bombay Stock Exchange may consider the long-term movements while determining the dynamics of their investment plans.

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Table-1: Results of Descriptive Statistics for Sample Indices Return during for 2003-2008 and 2008-2013

INDEX / DESCRIPTIVE VARIABLES	SENSEX		MID CAP		SMALL CAP		BSE 100		BSE 200		BSE 500	
	2003-2008	2008-2013	2003-2008	2008-2013	2003-2008	2008-2013	2003-2008	2008-2013	2003-2008	2008-2013	2003-2008	2008-2013
Mean	0.0014	0.0003	0.0017	0.0001	0.0020	-0.0001	0.0015	0.0003	0.0015	0.0003	0.0015	0.0003
Standard Deviation	0.0153	0.0172	0.0162	0.0151	0.0176	0.0152	0.0159	0.0168	0.0160	0.0165	0.0159	0.0161
Skewness	-0.5782	0.7151	-1.3435	-0.1759	-1.1656	-0.2453	-0.7298	0.5689	-0.8913	0.5179	-0.9662	0.4374
Kurtosis	8.08	14.25	11.11	8.76	7.18	7.34	8.61	13.92	9.47	13.63	9.66	13.28
Jarque-Bera	1421.70	6637.73	3825.45	1717.35	1201.53	983.07	1758.77	6220.36	2362.84	5892.68	2523.31	5498.19
Minimum	-0.1114	-0.1096	-0.1138	-0.0838	-0.1027	-0.0766	-0.1125	-0.1103	-0.1187	-0.1073	-0.1170	-0.1050
Maximum	0.0825	0.1734	0.0815	0.1175	0.0594	0.0905	0.0817	0.1675	0.0794	0.1631	0.0782	0.1574
Number of observations	1258	1239	1258	1239	1258	1239	1258	1239	1258	1239	1258	1239

Source: Collected from www.bseindia.com and computed using SPSS 16.0 version

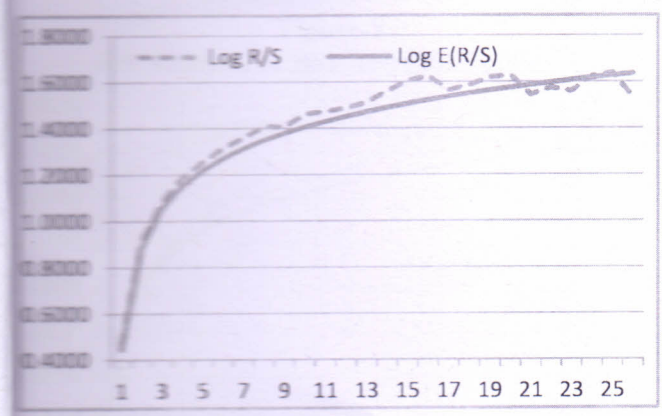
Table 2: Results of Normality of Broad Market Index Returns during the period from April 2003 to March 2008 and April 2008 to March 2013

Period		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
SENSEX	2003-2008	.076	1258	.000	.941	1258	.000
	2008-2013	.083	1239	.000	.916	1239	.000
MID CAP	2003-2008	.101	1258	.000	.884	1258	.000
	2008-2013	.066	1239	.000	.945	1239	.000
SMALL CAP	2003-2008	.080	1258	.000	.932	1258	.000
	2008-2013	.063	1239	.000	.945	1239	.000
BSE 100	2003-2008	.094	1258	.000	.925	1258	.000
	2008-2013	.078	1239	.000	.920	1239	.000
BSE 200	2003-2008	.094	1258	.000	.915	1258	.000
	2008-2013	.077	1239	.000	.923	1239	.000
BSE 500	2003-2008	.096	1258	.000	.910	1258	.000
	2008-2013	.076	1239	.000	.925	1239	.000

[a]Lilliefors Significance Correction

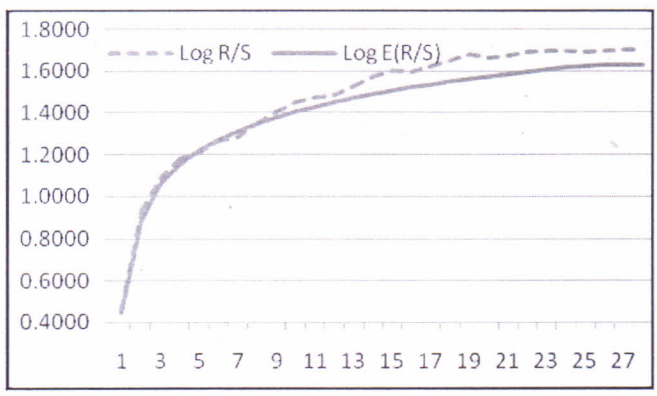
Sources: collected from www.bseindia.com and computed using SPSS 16.0 version

Figure-1
R/S Analysis of Sensex (2003-2008)



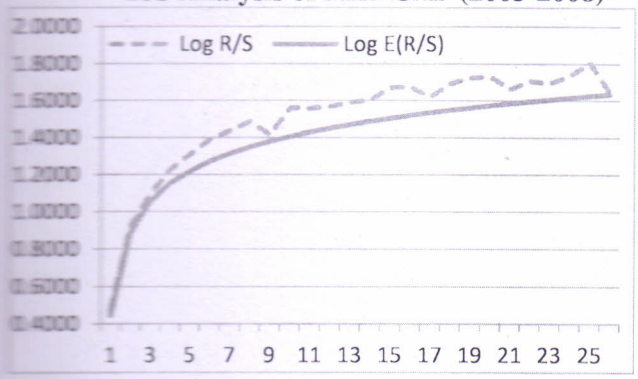
Source: Computed from www.bseindia.com

Figure-2
R/S Analysis of Sensex (2008-2013)



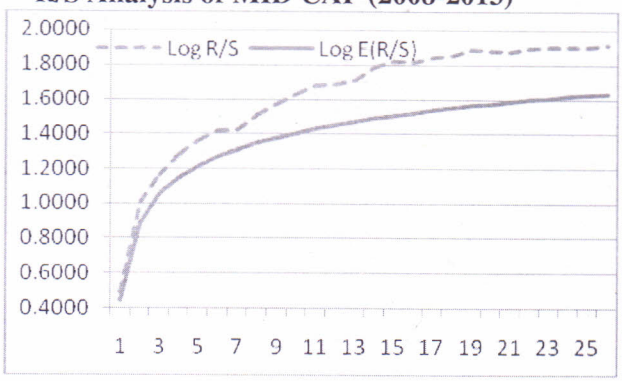
Source: Computed from www.bseindia.com

Figure-3
R/S Analysis of MID CAP (2003-2008)



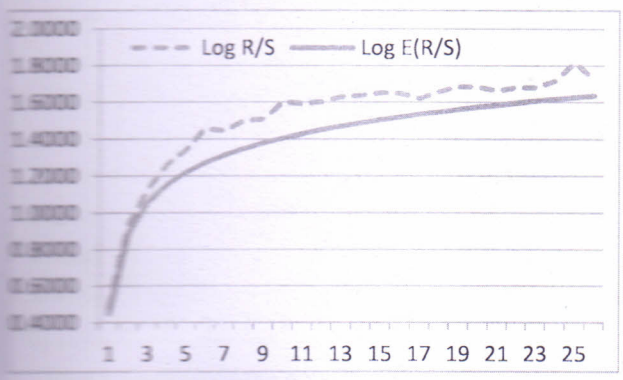
Source: Computed from www.bseindia.com

Figure-4
R/S Analysis of MID CAP (2008-2013)



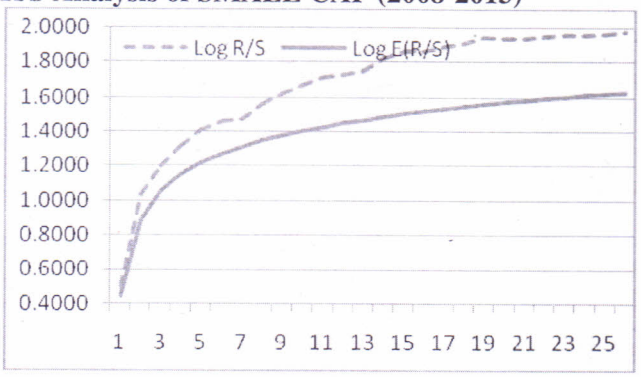
Source: Computed from www.bseindia.com

Figure-5
R/S Analysis of SMALL CAP (2003-2008)



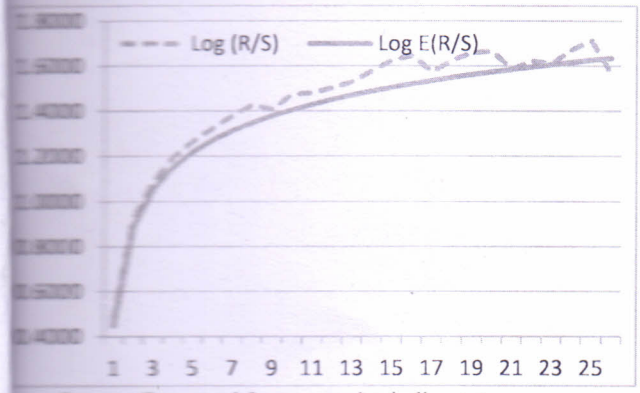
Source: Computed from www.bseindia.com

Figure-6
R/S Analysis of SMALL CAP (2008-2013)



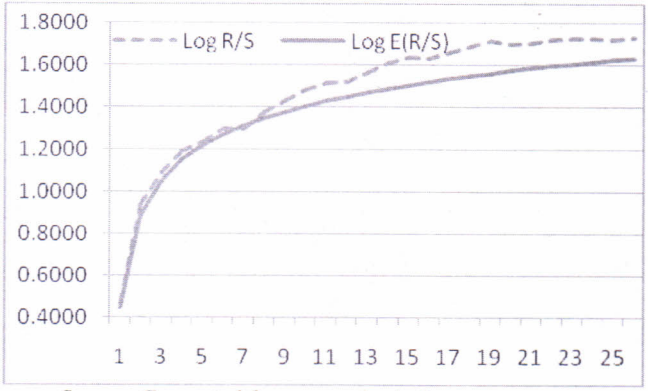
Source: Computed from www.bseindia.com

Figure-7
R/S Analysis of BSE 100 (2003-2008)



Source: Computed from www.bseindia.com

Figure-8
R/S Analysis of BSE 100 (2008-2013)

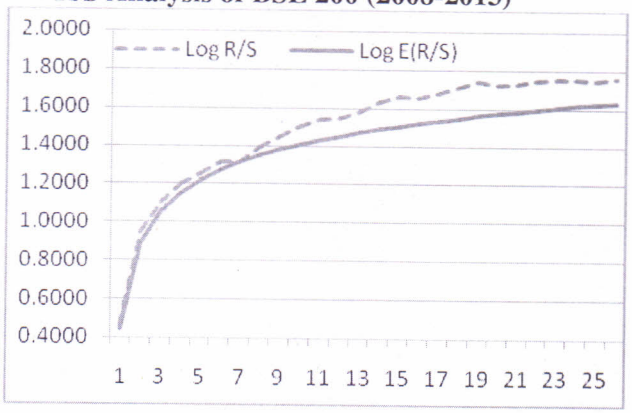


Source: Computed from www.bseindia.com

Figure-9
R/S Analysis of BSE 200 (2003-2008)

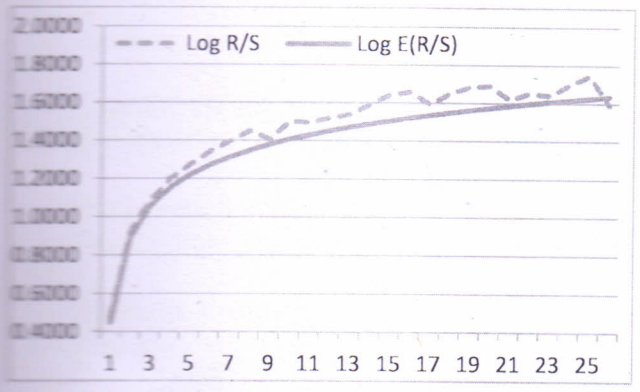
Source: Computed from www.bseindia.com

Figure-10
R/S Analysis of BSE 200 (2008-2013)



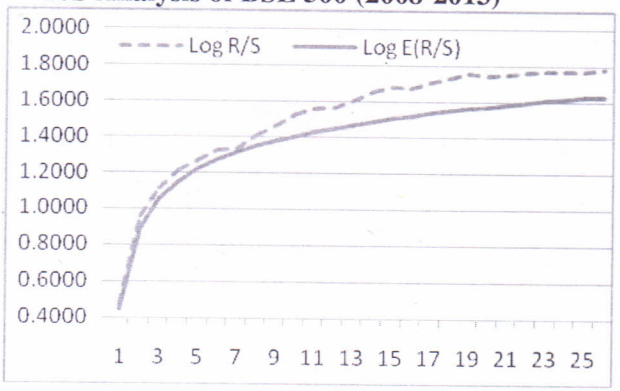
Source: Computed from www.bseindia.com

Figure-11
R/S Analysis of BSE 500 (2003-2008)



Source: Computed from www.bseindia.com

Figure-12
R/S Analysis of BSE 500 (2008-2013)



Source: Computed from www.bseindia.com

Table-3: Analysis of Fractal Dimension of Broad Market Index returns

Sample Indices	Period	Hurst Exponent	Fractal Dimension
Sensex	2003-2008	0.5362	1.4638
	2008-2013	0.6022	1.3978
MIDCAP	2003-2008	0.6038	1.3962
	2008-2013	0.7004	1.2996
SMALLCAP	2003-2008	0.5859	1.4141
	2008-2013	0.7231	1.2769
BSE 100	2003-2008	0.5622	1.4378
	2008-2013	0.6183	1.3817
BSE 200	2003-2008	0.5746	1.4254
	2008-2013	0.6311	1.3689
BSE 500	2003-2008	0.5797	1.4203
	2008-2013	0.6422	1.3578

Source: Computed from www.bseindia.com using the equations (3) and (4)

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