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CONTENTS

Examining the Impact of Structural Breaks on Long Memory of Stock Returns: Evidence from Bombay Stock Exchange of India Long Memory

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ABSTRACT

This study examines the presence of long memory of Stock Returns in India with reference to structural breaks. The study used the Hurst Exponent in Rescaled Range Analysis as proposed by Lo (1991) to measure the presence of long memory on daily stock returns of the Bombay Stock Exchange Indices from January 2000 to December 2017. The analysis indicates that all indices show long memory effects. It is also evident that all indices exhibit long memory effect in the pre and post subprime crisis period. These findings are consistent with Bhattacharya and Bhattacharya (2018), Jha et al.(2018), Goudarzi (2010) and Lillo and Farmer (2004).

Keywords: *Long Memory, Hurst exponent, Market Efficiency. Structural Breaks*

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INTRODUCTION

The financial economist continues to explore a deeper understanding of the nature of micro as well as macroeconomic market forces that determine stock price movements and the dynamics of market efficiency. A time series that follows a random walk process has two important properties; *first, when time series is correlated with distant past observations and if the decay is very slow, the series is assumed to have a long memory. Second, the first difference of series is a white noise i.e. short memory in which price changes persist* (Fama, 1998).

Peter (1994) observed that most of the economic time series hold a long memory, which implies that what happens today is going to influence prices over an indefinite period of time. Moreover, returns are not independent over time, thus, future returns can be predicted by using past prices (Turkyilmaz and Balibey, 2014).

The presence of long memory is an indicator for anticipating asset returns, which reflect the dynamic behavior of time series. It associates the future asset returns to past returns thereby expressing time taken by the news to adjust in the market. This would be beneficial to earn money from speculative activities and managing the portfolio to get profitable returns from the market (Nikoomaram and Anbarestani (2012), Kasman et al., (2009), Badani (2008) and Diebold and Inoue (2001)).

This study was an attempt to examine whether long memory exhibits in the return of stock indices of Bombay Stock Exchange of India (BSE). If the returns series exhibits a long memory, they display significant autocorrelation between distant past observations. The study also tried to study whether long memory is contingent upon structural breaks such as the Subprime Crisis in 2008.

The paper is organized as follows. Section II reviews the literature. Section III describes the database and research methodology. Section IV presents results and analysis and Section V concludes the study.

REVIEW OF LITERATURE

The seminal work on long memory in asset returns is derived largely from Hurst (1951), Greene and Fietlitz (1977), Aydogan and Booth (1988) and Lo (1991). They found no evidence of long memory in their respective samples of the US stock returns. However, Mandelbrot (1971) argued that the Random Walk and Martingale models of speculative prices may not be realizable through arbitrage in the presence of a long-term memory. Lo (1991) observed that the reported anomalous behaviour of stock returns can be a reflection of long memory dynamics. In addition, Badani (2008) examined the behaviour of stock returns and volatility in India and found that returns do not show a long memory but squared returns and absolute value (which represent the volatility) show long range dependencies. However, in their sub-sample covering the period March 2001 to December, 2007, the volatility measures did not show a long memory.

In addition, Hiremath and Bandi (2010) explored that in a recent scenario there is increasing interest among researchers, investors, and practitioners to understand the behaviour of the Indian stock market. They advocated that thin trading, high volatility and various frictions generally characterize the stock market of emerging market economies. This asserts that due to these imperfections, long memories could exist in the emerging markets. Ma et al., (2006) investigated the long memory in the Chinese stock market and found that though returns themselves contain serial correlation, the variability of returns has a significant long memory.

Goudarzi (2010) observed a long memory in the Indian stock market by using BSE500 returns and found that the leverage effect to be significant in BSE500 returns and the asymmetric volatility model turnout to be superior. Similarly, Verma (2008) investigated the long memory in daily returns of 60 companies with around 62% of the total market capitalization over a period of five years and observed that returns of only three companies' exhibit long-range dependence. In addition, Bhattacharya and Bhattacharya (2012) observed a long-term property in ten global emerging markets. Their findings indicate the presence of a long memory in volatility as well as in absolute returns. However, they did not support the presence of Taylor's effect on the selected emerging markets. Chen and Diaz (2013) investigated the long memory and shift in the returns of green and non-green exchange-traded funds and found no significant long memory process among green ETFs. However, there is a presence of a long memory in the volatility for non-green ETFs. Henry (2002) investigated long memory in international stock markets and advocate that long memory is present in the German, South Korean and Taiwanese markets. Hiremath and Kamaiah (2010) argued that the issue of long memory has important implications for the theory of finance and practical application but has yet not received much attention in India.

Furthermore, a strand of literature raises the issue of whether the long memory effect is spurious or real by detecting a period of volatility (Granger and Hyung (2004).They found long memory appears to be real and not due to structural shifts in the variance for several stock markets of the Middle East and Africa (MENA) region. On the contrary, Chunget al; (2000) found empirical evidence supporting spurious long memory due to shifts in variance for a group of Asia-pacific markets. Jayasuriya (2009) advocated that in sub-period analysis there exists no clear link between long memory and structural changes in volatility. Cevik and Emec (2013) indicated that Turkey's financial market showed a long memory as it did not respond to the Arab Spring but reacted to it gradually over time.

In addition, Sadique and Silvapulle (2001) advocate that Korea, Malaysia, Singapore and New Zealand have long memory property in mean returns. They also emphasized that the size and strength of long memory is an important issue and their findings suggest that emerging markets possess stronger long-range dependence in equity returns than developed countries. However, it is not true for volatility (Cajueiro and Tabak, 2008). Additionally, there are some studies, which have focused on long memory in volatility in developed markets particularly in the United States (US) (please see; Ding et al; 1993; Crato and Lima, 1994; Dig and Granger, 1996;Andersenand Bollerslev, 1997; Granger et al;1997; Lobato and Savin, 1998; Andersen et al; 2003; Andersen, 2005 and Gurgul and Wojtowicz, 2006).

Furthermore, Badani (2008 and 2009) suggested that stock index returns do not show a long memory property but found stronger long-range dependence in volatility, which is possibly caused by structural breaks rather than true fractional integration. Danilenko (2009) investigated the presence of long memory of the Baltic sector indices and found that the industrial sector exerted stronger long-term dependence than in other sectors because the utilities and health care sectors showed weak long-term dependence. Similarly, Cavalcante and Assaf (2002) investigated the long memory in returns and volatility of the Brazilian stock market and their findings support that long memory is found not only in returns but also in absolute returns, squared returns and modified log-squared returns.

Turkyilmaz and Balibey(2014) also found predictable structure of volatility in the Pakistan stock market. Tolvi (2003) examined the presence of long memory in the Finnish stock market returns and found that there was significant long memory in 24% to 64% of the series. On the contrary, Onour (2010) examined long memory and persistence of shocks in the North African stock markets (Egypt, Tunisia, and Morocco) and their results indicate that shocks in these markets do not persist for long periods and equity futures returns can be better predicted by using most lagged returns.

In a nutshell, a plethora of literature is available in emerging as well as developed markets, however, there is a dearth of empirical research on examining the presence of long memory in India, which is one of the most liquid capital market of the world (Krishanet.,al(2013) and Goudarziet.,al(2011)). The present study is an attempt to plug this gap.

RESEARCH DESIGN

Database of Study

The present study uses daily data from the Bombay Stock Exchange of India (BSE) from January 2000 to December 2017 as presented in table 1. The study has also calculated long memory components for each year from January, 2000 to December, 2017 to check whether the presence of long memory is due to structural breaks, regime shift, market friction, political changes and market microstructure etc. that have taken place during the sample period in India.

Table 1: Description of Data

Index	Number of Observations (N)	Period Covered
S&P BSE 100	4482	1st January, 2000 to 31st December, 2017
S&P BSE 200	4482	1st January, 2000 to 31st December, 2017
S&P BSE 500	4482	1st January, 2000 to 31st December, 2017
S&P BSE Sensex	4475	1st January, 2000 to 31st December, 2017
BSE Mid-Cap	3667	1st January, 2003 to 31st December 2017
BSE Small-Cap	3477	1st January, 2004 to 31st December 2017

Source: www.bseindia.com

METHODOLOGY

Daily returns were computed as the difference in the natural logarithm of the closing index value for the two consecutive trading days. It is presented as equation 1:

$R_t = \ln (P_t / P_{t-1})$ or $R_t = \ln ({}_pt) - \ln (P_{t-1})$ .... Equation 1

Where R_t is natural logarithmic daily return at time t. P_{t-1} and P_t are daily prices of an asset on two successive days t-1 and t respectively.

Structural Break

A time series may show long memory not because it is I(d) but because of the neglected occasional structural breaks in the series (Granger and Hyung, 2004). In this section, we show that occasional shifts in mean return give rise to the observed long memory phenomenon. The condition under which occasional shifts occurs in mean return or variance could result into long memory (Granger anintog, 2004 and Beltratti and Morana, 2006).

Hurst Exponent

To examine long memory, the 'Hurst' exponent was computed. The origin of long memory test can be attributed to the Hurst exponent 'H', which was developed in 1951 by Hurst to measure water related processes. The Hurst exponent (or the self-similarity parameter) is a dimensionless parameter and diverse methodologies exist to estimate it. The concept of the Hurst exponent finds its applications in many research fields including the field of financial studies due to the path-breaking works of Mandelbrot (1963 and 1997) and Peters (1991 and 1994). The Hurst exponent lies in the range $0 \leq H \leq 1$. If the Hurst exponent is 0.5 then the process is said to follow a random walk. When the Hurst exponent is more than 0.5, it suggests positive long-range autocorrelation or persistence in the return series. On the other hand, when the Hurst exponent is smaller than 0.5, it suggests the presence of negative autocorrelation or means reversion in the series (Kumar, 2004).

The values of Hurst exponent range between 0 and 1:	
$0 < H < 0.5$	Anti-persistence
$H = 0.5$	Random walk
$0.5 < H < 1$	Persistence

Hurst Exponent and Rescaled Range (R/S) Analysis

Qian and Rasheed (2004) suggested that the Hurst exponent can be calculated by rescaled range analysis (R/S analysis). For a time, series, X = X1, X2, … Xn, R/S analysis method is as follows:

1. Calculate mean value m.= 1/n ∑ Xi
   i=1

2. Calculate mean adjusted series Y: Yt = Xt – m, t = 1, 2, …, n
   t

3. Calculate cumulative deviate series Z: ∑Yi , t = 1, 2, …, n
   i=1

4. Calculate range series R: Rt = max(Z1, Z2, …, Zt)– min(Z1, Z2, …, Zt) t = 1, 2, .., n
   t   2

5. Calculate standard deviation series St= √1/n∑(Xi-u)
   t=1,2,……,n   i=1

Here, u is the mean value from X1 to Xt.

6. Calculation of Rescaled Range Series(R/S): (R/S)t = Rt/St where, t = 1, 2, …, n

   Note: (R/S) it is averaged over the regions [X1, Xt], [Xt+1, X2t] until [X(m-1) t+1, Xmt] where m=floor(n/t). In practice, to use all data for calculation, a value of t is chosen that is divisible by n.

RESULTS AND ANALYSIS

Table 2 presents the estimated long memory during the full sample period for returns of BSE Mid Cap, BSE Small Cap, S&P BSE 100, S&P BSE 200, S&P BSE 500 and S&P BSE Sensex using Rescaled Range Statistics. The estimated coefficient of H exponent suggests that all indices exhibit long memory, which implies that past returns could forecast the upcoming returns. These findings would be helpful to understand the behaviour of the market for an investor, policymakers and portfolio managers to decide where they would get abnormal profits by using long memory insights.

Table 3 presents the pre-crisis and post-crisis estimated long memory component in the Indian Equity Market. The Pre-Crisis period shows that BSE Mid-Cap, BSE Small-Cap, S&P BSE 100, S&P BSE 200, S&P BSE 500, S&P BSE Sensex, exhibit the long memory component in all indices. Result of Post Crisis period advocates that long memory was present in all indices except for S&P BSE 100 during the post crisis period.

Table 2: Long Memory in BSE Indices during Full Sample Period

Time Period	Index	Hurst Exponent Coefficient	Findings
2003-2017	BSE Mid Cap	0.6335	Long memory is present
2004-2017	BSE Small Cap	0.6249	Long memory is present
2000-2017	S&P BSE 100	0.6112	Long memory is present
2000-2017	S&P BSE 200	0.5795	Long memory is present
2000-2017	S&P BSE 500	0.6202	Long memory is present
2000-2017	S&P BSE Sensex	0.5638	Long memory is present

Table 3: Long Memory in BSE Indices during Across Pre and Post Subprime Crisis Period

Structural Break	Time Period	Index	Hurst Exponent Coefficient	Findings
Pre-Crisis Period	2003-2007	BSE Mid-Cap	0.5869	Long memory is present
	2004-2007	BSE Small-Cap	0.6492	Long memory is present
	2000-2007	S&P BSE 100	0.6114	Long memory is present
		S&P BSE 200	0.6128	Long memory is present
		S&P BSE 500	0.6148	Long memory is present
		S&P BSE Sensex	0.5975	Long memory is present
Post Crisis Period	2008-2017	BSE Mid-Cap	0.5961	Long memory is present
		BSE Small-Cap	0.6151	Long memory is present
		S&P BSE 100	0.4921	Long memory is absent
		S&P BSE 200	0.5550	Long memory is present
		S&P BSE 500	0.5625	Long memory is present
		S&P BSE Sensex	0.5302	Long memory is present

The results in Table 2 and 3 are consistent, which suggests that structural breaks do not have a significant impact on the long memory of stock returns in India. Moreover, for a detailed analysis, year-wise long memory was estimated for all indices. Table 4 presents the year-wise estimated long memory component for all indices and findings suggest that long memory is persistent across all indices except for the year 2015 and 2017. It is pertinent to note that year 2014 observed a political change from the Congress Lead Government to the BJP lead Government, which brought significant changes in the political, regulatory and governance environment in India. Moreover, on November 8, 2016 a major announcement was made by Prime Minister Mr. Narender Modi regarding demonetization of Rs. 1,000 and Rs. 500 currency notes, which amounted to nearly 86% of the total currency in circulation. This announcement brought a revolution in the Indian economy and there was major shift in the mode of transactions from cash to digital modes of transactions.

Table 4: Year-wise Analysis of Long Memory

Time Period	Index	Hurst Exponent Coefficient	Findings
2000	S&P BSE 100	0.6493	**Long memory is present**
	S&P BSE 200	0.6544	**Long memory is present**
	S&P BSE 500	0.6500	**Long memory is present**
	S&P BSE Sensex	0.5065	**Long memory is present**
2001	S&P BSE 100	0.6159	**Long memory is present**
	S&P BSE 200	0.6217	**Long memory is present**
	S&P BSE 500	0.6251	**Long memory is present**
	S&P BSE Sensex	0.6043	**Long memory is present**
2002	S&P BSE 100	0.5729	**Long memory is present**
	S&P BSE 200	0.5659	**Long memory is present**
	S&P BSE 500	0.5733	**Long memory is present**
	S&P BSE Sensex	0.5749	**Long memory is present**
2003	S&P BSE 100	0.6275	**Long memory is present**
	S&P BSE 200	0.6378	**Long memory is present**
	S&P BSE 500	0.6367	**Long memory is present**
	S&P BSE Sensex	0.6716	**Long memory is present**
	BSE Mid Cap	0.4825	Long memory is absent
2004	S&P BSE 100	0.5721	**Long memory is present**
	S&P BSE 200	0.5707	**Long memory is present**
	S&P BSE 500	0.5709	**Long memory is present**
	S&P BSE Sensex	0.5856	**Long memory is present**
	BSE Mid Cap	0.5601	**Long memory is present**
	BSE Small Cap	0.6406	**Long memory is present**
2005	S&P BSE 100	0.5891	**Long memory is present**
	S&P BSE 200	0.5791	**Long memory is present**
	S&P BSE 500	0.5759	**Long memory is present**
	S&P BSE Sensex	0.5830	**Long memory is present**
	BSE Mid Cap	0.5742	**Long memory is present**
	BSE Small Cap	0.6143	**Long memory is present**

	S&P BSE 100	0.6856	**Long memory is present**
	S&P BSE 200	0.6939	**Long memory is present**
2006	S&P BSE 500	0.7045	**Long memory is present**
	S&P BSE Sensex	0.6747	**Long memory is present**
	BSE Mid Cap	0.7226	**Long memory is present**
	BSE Small Cap	0.7179	**Long memory is present**
	S&P BSE 100	0.5789	**Long memory is present**
	S&P BSE 200	0.5789	**Long memory is present**
2007	S&P BSE 500	0.5818	**Long memory is present**
	S&P BSE Sensex	0.5798	**Long memory is present**
	BSE Mid Cap	0.5950	**Long memory is present**
	BSE Small Cap	0.6240	**Long memory is present**
	S&P BSE 100	0.5412	**Long memory is present**
	S&P BSE 200	0.5479	**Long memory is present**
2008	S&P BSE 500	0.5558	**Long memory is present**
	S&P BSE Sensex	0.5307	**Long memory is present**
	BSE Mid Cap	0.6169	**Long memory is present**
	BSE Small Cap	0.6664	**Long memory is present**
	S&P BSE 100	0.6505	**Long memory is present**
	S&P BSE 200	0.6567	**Long memory is present**
2009	S&P BSE 500	0.6627	**Long memory is present**
	S&P BSE Sensex	0.6322	**Long memory is present**
	BSE Mid Cap	0.6921	**Long memory is present**
	BSE Small Cap	0.7022	**Long memory is present**
	S&P BSE 100	0.5987	**Long memory is present**
	S&P BSE 200	0.6005	**Long memory is present**
2010	S&P BSE 500	0.6057	**Long memory is present**
	S&P BSE Sensex	0.5862	**Long memory is present**
	BSE Mid Cap	0.6079	**Long memory is present**
	BSE Small Cap	0.6070	**Long memory is present**
	S&P BSE 100	0.4834	Long memory is absent
	S&P BSE 200	0.4934	Long memory is absent
2011	S&P BSE 500	0.5054	**Long memory is present**
	S&P BSE Sensex	0.4652	Long memory is absent
	BSE Mid Cap	0.5718	**Long memory is present**
	BSE Small Cap	0.6205	**Long memory is present**

2012	S&P BSE 100	0.6236	**Long memory is present**
	S&P BSE 200	0.6249	**Long memory is present**
	S&P BSE 500	0.6267	**Long memory is present**
	S&P BSE Sensex	0.6201	**Long memory is present**
	BSE Mid Cap	0.6298	**Long memory is present**
	BSE Small Cap	0.6235	**Long memory is present**
2013	S&P BSE 100	0.5125	**Long memory is present**
	S&P BSE 200	0.5311	**Long memory is present**
	S&P BSE 500	0.5424	**Long memory is present**
	S&P BSE Sensex	0.4712	Long memory is absent
	BSE Mid Cap	0.6643	**Long memory is present**
	BSE Small Cap	0.7002	**Long memory is present**
2014	S&P BSE 100	0.5781	**Long memory is present**
	S&P BSE 200	0.5809	**Long memory is present**
	S&P BSE 500	0.5950	**Long memory is present**
	S&P BSE Sensex	0.5291	**Long memory is present**
	BSE Mid Cap	0.6297	**Long memory is present**
	BSE Small Cap	0.6410	**Long memory is present**
2015	S&P BSE 100	0.4288	Long memory is absent
	S&P BSE 200	0.4275	Long memory is absent
	S&P BSE 500	0.4299	Long memory is absent
	S&P BSE Sensex	0.4316	Long memory is absent
	BSE Mid Cap	0.4156	Long memory is absent
	BSE Small Cap	0.4204	Long memory is absent
2016	S&P BSE 100	0.6380	**Long memory is present**
	S&P BSE 200	0.6440	**Long memory is present**
	S&P BSE 500	0.6467	**Long memory is present**
	S&P BSE Sensex	0.5913	**Long memory is present**
	BSE Mid Cap	0.6636	**Long memory is present**
	BSE Small Cap	0.6430	**Long memory is present**
2017	S&P BSE 100	0.4448	Long memory is absent
	S&P BSE 200	0.4427	Long memory is absent
	S&P BSE 500	0.4549	Long memory is absent
	S&P BSE Sensex	0.5107	**Long memory is present**
	BSE Mid Cap	0.4690	Long memory is absent
	BSE Small Cap	0.5271	**Long memory is present**

Based on analyses in Tables II, III and IV, it can be stated that the Indian equity market is not efficient as long memory is persistent. It is also important to note that regulatory, technological, market-microstructural and other changes in the Indian capital market from 2000-2017have not brought any significant change in the information absorption speed. Nonetheless, significant micro-structural changes in the Indian capital market like introduction and trading of one of the most liquid equity derivatives; introduction of rolling settlement; 100% book building process for public issues; efficient risk management and clearing settlement mechanism etc. might have brought efficiency in the system and market depth. Whereas, the last one decade has observed phenomenal changes in the media of communication and the quantum of information has increased over the period, which may have added noise in the system and the market may be taking more time in price discovery processes because noise leads to persistence of lead-lag transactions across informed and uninformed traders, which might delay price discovery.

CONCLUSION

The present study was an attempt to examine the impact of structural breaks on the presence of long memory in stock returns in India. Using daily log returns of BSE Mid Cap, BSE Small Cap, S&P BSE 100, S&P BSE 200, S&P BSE 500, S&P BSE Sensex index in India Hurst Exponent in Rescaled Range Analysis was estimated. It was observed that long memory persists in the returns of various BSE indices during the full sample period; pre and post subprime crisis period and year-wise analysis. These findings suggest that the Indian equity market is not efficient in weak form and portfolio managers may be able to formulate strategies and they may earn supernormal returns in the market. An important observation from the year-wise analysis is that although various regulatory, technological, structural changes have taken place in the Indian equity market during last two decades, price discovery in the Indian equity market is not efficient yet.

These findings propose a future scope of research for investigating the impact of various reforms that have taken place in the Indian capital market in last 2-3 decades on price discovery processes and efficiency.

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