Testing the Long Memory Feature in Indian Equity Market

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Abstract

The Present paper examined the long memory behavior in Indian equity market. This paper uses the data from January 2000 to March 2018 of Sensex, Nifty-50 and VIX. By using the Rescaled range analysis as proposed by Lo (1951) 'Hurst Exponent', this indicates that there is significant long memory in Sensex and Nifty-50 returns series. However, volatility does not show any persistence but exhibit clustering. The study conclude that there is not persistence behavior with respect to long memory effect on Nifty-50 returns subject to occurrence of structural breaks(demonization).The study concludes with managerial relevance and issued for futures research. Findings would be beneficial for the investors, practitioners, academics and policy makers etc. To the best of our knowledge, there is dearth of literature on the subject in Indian equity market. Therefore the present study is an attempt to plug this gap.

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

1. Introduction

Financial economist continues to explore a deeper understanding of the nature of micro/ macroeconomic market forces that determine the stock price movements and dynamics of the market efficiency. Most of the research in financial economies is based on the assumption of efficient market hypothesis (EMH), which in weak form signifies that returns of time series are white noise process, which consisting independent, comparably distributed random variable. This tendency entails that the time series at the level follow random walk. Time series that follows a random walk process has two important properties; first, when time series are correlated with distant past observations and this decay is very slowly, the series is known as long memory. Second, the first difference of series is a white noise i.e. short memory in which price changes persist.

The present study deals with Long Memory process, which implies that the new information is reflected in prices slowly and this adjustment takes a comparatively longer period of time. Peter, 1994 observed that most of the times, economic time series holds 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 the time and thus, future returns can be predicted by using past prices (Turkyilmaz and Balibey, 2014).

Presence of long memory is an indicator for anticipating the asset returns, which reflects the dynamic behavior of time series. It associates the asset future returns to past returns thereby expressing time taken by news to adjust in the market. This would be beneficial to earn money from speculative activities and managing the portfolio in order to get the profitable returns from

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the market (Nikoomaram and Anbarestani (2012), Kasman et al., (2009), Badani (2008) and Diebold and Inoue (2001)).

The present study is an attempt to examine whether long memory exists in the Indian Equity Market. If returns series exhibit long memory, they display significant autocorrelation between distant observations. Therefore, the series realizations are not independent over time and past returns can predict future returns, thus violating the market efficiency hypothesis.

The paper is organized as follows. Section II reviews the literature. Section III describes the data base and research methodology. Section IV presents results and analysis and Section V presents conclusion of the study.

1. Review of Literature

The seminal work on long memory in asset returns is derived largely from pioneering of Hurst (1951), Greene and Fietlitz (1977) and Aydogan and Booth (1988) and Lo (1991). They found no evidence of long memory in sample of 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 long-term memory. Hereafter, Lo (1991) observed that the reported anomalous behavior of stock returns can be a symptom of long memory dynamics. In addition, Badani (2008) examined the behavior of stock returns and volatility in India and found that returns do not show long memory but squared returns and absolute value (which represent the volatility) show long range dependences. However, in the sub-sample covering the period March 2001 to December 2007, the volatility measures do not show long memory.

In addition, Hiremath and Bandi (2010) explored that in recent scenario there is increasing interest among researchers, investors, and practitioners to understand the behavior of Indian stock market. They advocate 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 term memory in Chinese stock market and they found that though returns themselves contain little serial correlation, the variability of returns has significant long term memory. Goudarzi (2010) observed long memory in Indian stock market by using BSE500 returns and found that leverage effect is significant in BSE 500 returns and asymmetric volatility model turn out 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 year and results indicate that returns of only three companies exhibit long range dependence.

Bhattacharya and Bhattacharya (2012) observed the long term property in ten global emerging markets. Their findings indicate that presence of long memory in volatility as well as in absolute returns. However, the study did not support existence of Taylor effect on the selected emerging markets. Chen and Diaz (2013) investigated long memory and shift in the returns of green and non-green exchange traded funds and they found that there is no significant long memory process among green ETFs. However, there is a presence of long memory attributes1in the volatility for non green ETFs. Henry (2002) has investigated long memory in international stock markets and evidence advocate that long memory present in the German, South Korean, and Taiwanese markets. Hiremath and Kamaiah (2010) argued that the issue of long memory has important implication for the theory of finance and practical application, yet has not much attention received in India.

Furthermore, several authors raise the issue of whether the long memory effect is spurious or real by detecting period of volatility found long memory appears to be real and not due to structural shifts in the variance for several stock markets of Middle East and Africa (MENA) region. On the contrary, Chung, et al (2000) found empirical evidence support spurious long memory due to shifts in variance for a group of Asia-Pacific markets. Jayasuriya (2009) advocated in sub-period analysis that there exists no clear link between long term-memory and structural changes in volatility. Cevik and Emec (2013) indicate that Turkey financial market shows long memory as it does not respond to Arab Spring, but reacts to it gradually over time.

In addition, spillover effect also play vital role in price movement from one economy to another. Hamao et al., (1990) provided some evidence for spillover effects from New York to Tokyo, but not from Tokyo to either to New York or London. Lee (2001) found strong evidence for the price as well as volatility spillover effects from the US stock markets to the Korean counterparts but not vice versa. As Lee (2001) discussed international spillover effect between the developed market (the

US, Japan and Germany) and the emerging markets in the MENA (Middle East and North American) region (Turkey and Egypt). These finding advocate that price as well volatility spillover effects exist from the developed stock market to MENA counterparts but not vice versa.

Kang et.al (2009) explored Japanese and Korean stock market covering the 1986-2008 period to examine the persistence of volatility in variance. They used ICSS-GARCH models and corroborated the influence of sudden changes, thereby indicating the fact that volatility models can enhance forecasting ability. To recapitulate, price spillover effects are found from Japanese markets to Indian market counterpart and vice verse. But evidence of price spillover effect from either the US or the UK stock markets and vice versa. Little evidence also found for price spillover effects from the developed stock market to emerging Indian counterpart.

In addition, Sadique and Silvapulle (2001) advocate that Korea, Malaysia, Singapore and New Zealand have long memory property in mean returns. This study also focused that the size and strength of long memory is an important issue. Empirical evidence suggested that emerging markets possess the stronger long- range dependence in equity returns then the developed countries, but this is not true for volatility (Cajueiro and Tabak, 2008). In addition, there are some studies which have focused on long memory in volatility in developed markets particularly the US (Ding et al., 1993; Crato and Lima 1994; Dig and Granger 1996; Andersen and Bollerslev 1997; Granger et al., 1997; Lobato and Savin 1998; Andersen et al., 2003, Andersen 2005, Gurgul and Wojtowicz 2006).

Empirical evidence suggested by Badani (2008,2009) that index return does not show the 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 existence of long memory of Baltic sector indices and evidence shows that industrial sector exerts stronger long term dependence then in other sectors, as utilities and health care sectors show weak long term dependence. In related study, Cavalcante and Assaf (2002) investigated the long memory in returns and volatility of Brazil Stock market and result supports that long memory is found in not only in returns, but also in absolute return squared returns and modified log- squared returns.

Empirical evidence found regarding predictable structure of volatility indicates that Pakistan stock market is inefficient in weak form (Turkyilmaz and Balibey, 2014). Tolvi (2003) examined the presence of long memory in Finnish stock market returns and found that there was significant long memory detected in 24% to 64% of the series. In addition, Onour (2010) examined long memory and persistence of shocks in North Africa stock markets (Egypt, Tunisa and Morocco) and results indicate that shocks of in these markets do not persist for long period and futures returns can be better predicted by using most lagged returns.

In nutshell, plethora of literature is available in emerging as well developed markets. However here is dearth of empirical research on examining presence of long memory in Indian Equity Market. The present study aims to plug this gap.

3. Research Design

3.1 Sample and Period of Study

The present study use daily data from National Stock Exchange of India (NSE) and Bombay Stock Exchange of India (BSE) from January 2000 to March 2018 and for VIX the data is available from 2009 to 2018. The present study has calculated long memory component for each year from January 2000 to March 2018 to check whether the presence of long memory is due to structural breaks, regime shift, market friction, political changes and market microstructure etc.

3.2 Methodology

Daily returns are computed as the difference in the natural logarithm of the closing index value for the two consecutive trading days. It can be presented as:

$$\mathbf{Rt = ln(Pt/Pt—1) \text{ or } Rt = ln(Pt) – ln(Pt—1)}$$

Equation 1

Where Rt is natural logarithmic daily return at time t. Pt-1 and Pt are daily prices of an asset at two successive days, t-1 and t respectively.

3.2.1 Hurst Exponent

To examine long memory, Hurst exponent is computed. The origin of the long memory test can be attributed to Hurst exponent '*H*' which was developed in 1951 by Hurst to measure water related process. This exponent calculates for a given time series the long term non periodic dependence

and also indicates how long the periodicity is consistent, then the standard autocorrelation will be able to pinpoint this long-term dependency in a given financial time series. Hurst exponent '*H*' has three distinct classifications: where '*H*' is equal to 0.5, it is considered to be a random series with process being white noise. If '*H*' is greater than zero but less than 0.5, it indicates mean reversion wherein the prices will revert back to their mean values. In case *'H'* lies between 0.5 and 1, it indicates the presence of the long memory properties and trend is clearly visible wherein the chances that a series will go up will be high if it has been in the last period. Similarly, a down trend will probably continue in future. The value of '*H*' will determine whether there is strong pattern is on account of white noise. If '*H*' is closer to 1, then the trend is strong and behavior pattern is likely to be repeated, if '*H*' is close to 0.5 the pattern is not very clear and white noise may be persist in the series (Verma, 2008).

Table I: Description of Data

Index	No. of observations (N)	Period Covered
Sensex	4564	2000-2018
Nifty-50	4520	2000-2018
VIX	2249	2009-2018

4. Result and Analysis: Table II presents the full period estimated long memory for returns of Sensex, Nifty-50 and VIX, using the Rescaled Analysis (Hurst Exponent). Findings indicate that during January 2000 to March 2018, Long memory was present in BSE Sensex and Nifty-50 returns. This indicates that long memory component was present in Indian equity market. But evidence indicates that long memory does not exhibit in VIX return series during January 2009 to March 2018s.

Table II: Full Period

Period	Index	Hurst Exponent	Findings
2000-2018	BSE Sensex	0.567299653	**Long memory is present**
2000-2018	Nifty-50	0.57229268	**Long memory is present**
2009-2018	VIX	0.499172262	Long memory is absent

Table II: Pre-Crisis and Post-Crisis

Period	Index	Hurst Exponent	Findings
2000- 2007	BSE Sensex	0.597598723	Long memory is present
2008-2018 (till march)	Nifty-50	0.596662276	Long memory is present
	BSE Sensex	0.487436075	Long memory is absent
	Nifty-50	0.550269518	Long memory is present
	VIX	0.4963733361	Long memory is absent

Table III presents that Pre-Crisis and Post Crisis estimated long memory component in Indian Equity market. Pre-Crisis period shows the Sensex and Nifty-50 returns exhibit long memory component. Findings of Post- Crisis period advocates that long memory was absent for Sensex and VIX returns but present for Nifty-50 returns.

Table IV: Individual Year

Period	Index	Hurst Exponent	Findings
2000	BSE Sensex	0.506538459	Long memory is present
	Nifty-50	0.509732721	Long memory is present
	VIX	-	-
2001	BSE Sensex	0.604374161	Long memory is present
	Nifty-50	0.604657888	Long memory is present
	VIX	-	-
2002	BSE Sensex	0.574927987	Long memory is present
	Nifty-50	0.591567719	Long memory is present
	VIX	-	-
2003	BSE Sensex	0.671699887	Long memory is present
	Nifty-50	0.652190925	Long memory is present
	VIX	-	
2004	BSE Sensex	0.585650559	Long memory is present
	Nifty-50	0.581935355	Long memory is present
	VIX	-	-
2005	BSE Sensex	0.583025569	Long memory is present
	Nifty-50	0.581541113	Long memory is present
	VIX	-	-
2006	BSE Sensex	0.674753266	Long memory is present
	Nifty-50	0.674165553	Long memory is present
	VIX	-	-
2007	BSE Sensex	0.5798199	Long memory is present
	Nifty-50	0.577506935	Long memory is present
	VIX	-	
2008	BSE Sensex	0.530797642	Long memory is present
	Nifty-50	0.552918531	Long memory is present
	VIX	-	-
2009	BSE Sensex	0.63220715	Long memory is present
	Nifty-50	0.611820064	Long memory is present
	VIX	0.476780857	Long memory is absent
2010	BSE Sensex	0.586289281	Long memory is present
	Nifty-50	0.584423652	Long memory is present
	VIX	0.517462286	Long memory is present
2011	BSE Sensex	0.465222863	Long memory is absent
	Nifty-50	0.484413728	Long memory is absent
	VIX	0.434908368	Long memory is absent

2012	BSE Sensex	0.620191029	Long memory is present
	Nifty-50	0.618220724	Long memory is present
	VIX	0.413057827	Long memory is absent
2013	BSE Sensex	0.471290305	Long memory is absent
	Nifty-50	0.49763313	Long memory is absent
	VIX	0.526893701	Long memory is present
2014	BSE Sensex	0.52915534	Long memory is present
	Nifty-50	0.538386383	Long memory is present
	VIX	0.619436413	Long memory is present
2015	BSE Sensex	0.431676184	Long memory is absent
	Nifty-50	0.43285916	Long memory is absent
	VIX	0.500307498	Long memory is present
2016	BSE Sensex	0.59138519	Long memory is present
	Nifty-50	0.61375029	Long memory is present
	VIX	0.482139739	Long memory is absent
2017	BSE Sensex	0.4821852	Long memory is absent
	Nifty-50	0.47338582	Long memory is absent
	VIX	0.44900573	Long memory is absent
2018 (till March)	BSE Sensex	0.68693269	Long memory is present
	Nifty-50	0.66047648	Long memory is present
	VIX	0.50580547	Long memory is present

The values of the Hurst exponent range between 0 and 1:

$0 < H < 0.5$ anti-persistence

$H = 0.5$ random walk

$0.5 < H < 1$ persistence

Table IV presents the individual year estimated long memory for BSE Sensex, Nifty-50 and VIX returns. BSE Sensex and Nifty-50 return shows the long memory during January 2000 to December 2000. Although, in 2001 long memory were strongly present in BSE Sensex and Nifty-50 returns with 'H' value 0.604374161 and 0.604657888 as respectively. This indicates that return series are serially correlated.

Furthermore, the also examines the long memory during January 2002 to December 2002. Evidence advocates that long memory were present in BSE Sensex and Nifty-50 returns with 'H' value 0.574927987 and 0.591567719 respectively, which show the dependent nature of return series. Moreover, long memory component were strongly found during January 2003 to December 2003 for BSE Sensex and Nifty-50 returns with 'H' value 0.671699884 and 0.652190925 respectively, which indicates the future returns are correlated with past return.

During 2004, 2005, 2006, 2006 and 2007long memory property were present in BSE Sensex and Nifty-50 returns, which implies that return are serially correlated and contains dependent nature. This shows that investors are more dependent on previous returns while calculating the future returns.

During the post crisis period 2008, Indian equity market also exhibit long memory behavior in return of BSe Sensex and Nifty-50 with 'H' value 0.530797 and 0.552918531. Although, long memory were also strongly detected in BSE Sensex and Nifty-50 returns during January 2009 to December 2009 with 'H' value 0.63220715 and 0.611820064. But VIX return series does not exhibit long memory component, which indicates the independent nature of VIX returns series.

Moreover, in January 2010 to December 2010 long memory component were present for all the series with 'H' value 0.56289281, 0.584423652 and 0.517462286 as respectively BSE Sensex, Nifty-50 and VIX. However in January 2011 to December 2011, long memory component were absent in all the series. In 2011 election results were announced and investor's behavior also influenced.

Furthermore, during 2012 long memory were strongly present in BSE Sensex and Nifty-50 returns but does not exist in VIX returns. However in 2013, long memory was present in VIX return series but does not exhibit in BSE Sensex and Nifty-50 returns. Although, in 2014 long memory was present in BSE Sensex, Nifty-50 and VIX, which advocate dependent nature of return series.

During 2015, VIX return series shows the long memory behavior, which indicate that volatility clustering in series. While BSE Sensex and Nifty-50 returns does not show long memory behavior. However, in 2016 long memory was present in BSE Sensex and Nifty-50 returns. But VIX series does not show long memory component.

In 2017, after the structural breaks (happened on 8th November 2016 i.e demonetization), no such long memory effect was exhibited the data in all series. However, another interesting finding is that from January 2018 to March 2018, all the returns series exhibited the presence of long memory (BSE Sensex, Nifty-50 and VIX as respectively H value 0.68693269, 0.68693269 and 0.50580547). The findings confirms that there no persistence behaviors. The study conclude that there is not persistence behavior with respect to long memory effect on Nifty-50 returns subject to occurrence of structural breaks(demonization).The study concludes with managerial relevance and issued for futures research.

Also, The above findings are only descriptive in nature not conclusive. Hence there is need to conduct similar study on sectoral indices.

5. Conclusion

Present study examines the feature of long memory behavior in Indian equity market. The study has used Rescaled range analysis as proposed by Lo (1991) 'Hurst Exponent' to measure the presence of long memory in returns and volatility from January 2000 to March 2018. Findings indicate that long memory was present in January 2000 to March 2018 for Sensex and Nifty-50 returns, which shows the serially correlated nature of equity market. Although Volatility Index (VIX) does not exhibit long memory in return series. During the pre-crisis period 2000-2007 Sensex and Nifty-50 contain the long memory. However, in post crisis period 2008-2018 only Nifty-50 return exhibit the long memory but Sensex and VIX does not show long memory. Moreover, Sensex and Nifty-50 return series presents the long memory in 2000, 2001,2002,2003,2004,2005,2006,2007,2008,2009,2010,2012,2014 and 2016, 2018 and VIX shows long memory in 2010,2013,2014,2015 and 2018. Hence, Sensex and Nifty-50 returns shows the dependent nature of Indian equity market which indicates that past returns helps to predict the future return. And Volatility Index shows long memory in clustering, as it does not show persistency in continuity. Finding shows that there is significant long memory in Sensex and Nifty-50 returns series. Findings would be beneficial for the investors, practitioners, academics and policy makers etc.

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