

# Long Term Memory: Evidence from Major Sectoral Indices of India

Anju Bala\*, Kapil Gupta\*\*

## Abstract

This paper tests the existence of long term memory with reference to structural changes/breaks in Indian Stock Market. Furthermore, the present paper applied Hurst Exponent in Rescaled Range Analysis as suggested by Hurst (1951) and Lo (1991) and structural breaks detected by using Multiple Break Test (Balcilar et al., 2015) by using daily returns of sectoral indices from January 2010 to May 2018. Empirical evidence shows the predictable structure in all sectoral indices (2010-2018) except Nifty Private Bank with H value 0.4972. The findings imply that existence of long memory would be useful for the investors, practitioners, academicians, and policymakers.

**Keywords:** Emerging Market, Long Term Memory, Hurst Exponent, Structural Breaks, Market Efficiency

## Introduction

Forecasting the economic series like stock returns, prices, interest rate, inflation rate and trade rate are quite certain areas to be investigated. Prediction the time series could be possible through the testing of long-range dependence. When any new information or shock comes into the market and does not adjust quickly and has a long-term impact on prices or returns, is called long memory component (Peters, 1994). If returns series demonstrate the presence of persistence behavior, previous returns can be utilized to estimate the upcoming returns. Presence of long range property provides support for taking investment decision which may also help to generate abnormal profits from the financial investment. This paper has two major contributions; first, to analysis the structural break dates

on sectoral index of the National Stock Exchange of India (NSEI). The break seems to be related to the causes of long term property in sectoral indices. Second, the study also tested for long memory component for returns of indices and found the degree of persistence level with respect to Hurst Exponent.

The study also tries to pursuit whether long memory effect is contingent upon structural breaks. There is a paucity of literature to studying the occurrence of persistence behavior of Indian Stock Market. Therefore, this paper is considered to plug this gap. Paper is further organized in the following sections. The second section concerns with reviews of the literature. Section third covers the database and research methodology. The empirical observations of the study are discussed in the fourth section. The conclusion of the study has been presented in the last section.

## Literature Review

The seminal research on long range dependence in stock market initiated by Hurst (1951). Furthermore, Greene and Fietlitz (1977), and Aydogan and Booth (1988) demonstrate that long memory behavior exhibits in US stock returns. However, Lo (1991), did not report significant long-term persistence in US stock returns. Nonetheless, Mandelbrot (1971) confronted that the arbitrage may not be negotiable when a long-term memory is exhibited. Thereafter, Lo (1991), investigated that the dynamic behavior in financial market considerable reason for long memory dynamics Furthermore, Hiremath and Bandi (2010) examined that researchers, academicians, investors, and practitioner are more concerned to explore the nature of Indian equity market. They propose that high

\* Research Scholar (Finance), Department of Management, I.K. Gujral Punjab Technical University, Jalandhar.  
Email: anjubala\_attri@yahoo.in

\*\* Assistant Professor, Department of Management, I.K. Gujral Punjab Technical University, Jalandhar, Punjab, India.  
Email: kapilfutures@gmail.com

volatility, anomalous behavior, and market resistance are the characteristics of developing economies. This affirms that due to these shortcomings and inadequacy long memory behavior might arise in the developing country.

Moreover, Badani (2006, 2008), explored the persistence behavior in India and found that stock returns do not report the presence of long term behavior whereas; absolute returns and squared returns (which represent volatility) exhibit the persistence behavior. On the other hand, subsample covering the duration from March 2001 to December 2007, affirms that volatility does not contain the persistence behavior.

In addition, Goudarzi (2010) observed long memory in BSE 500 returns. Evidence contended that BSE 500 returns and volatility is more significant with leverage. Moreover, Ma et al. (2006) examined little serial correlation in returns of Chinese stock market. Likewise, Verma (2008) affirms that only three companies out of sixty entail the persistence behavior in returns. In a related study, Killic (2004) reported a serial correlation in the volatility process in Turkey. Furthermore, Edgar E. Peters (1989), observed the stronger influence of investors sentiments on bond and stock returns of standard & Poor 500 by using the Hurst Exponent. In addition, Bala and Gupta (2018) reported significant long term memory in Sensex and Nifty returns series. However, volatility series does not contain any persistence behavior but exhibit clustering.

Similarly, Nath and Reddy (2012) examined the persistence behavior in Rupee-Dollar exchange rates. Evidence indicates there are chances of random walk in three month, while for other time period it may have mean reverting or persistence tendency. Furthermore, Mahalingam et.al (2012) observed high degree of persistence behavior in Indian stock market.

Furthermore, Persistence behavior exhibited in absolute returns along with volatility in ten international markets (Bhattacharya and Bhattacharya (2012)). However, evidence did not hold the Taylor effect. Moreover, Chen and Diaz (2013) observed significant persistence behavior in green exchange traded funds. Whereas, non-green exchange traded funds did not advocates serial correlation in volatility. In similar study, Hiremath and Kamaiah (2010) advocates that long range dependence has major inference for the literary work of finance and factual applicability, which has little consideration

toward Indian framework. Henry (2002) examined the persistence behavior in Taiwanese, German and South Korean International stock markets. Moreover, literature has emphasized on the concern of observed long memory attribute have a real or spurious effect. Evidence indicates that observed persistence behavior insinuate to be genuine not due to shift enhancement and structural breaks of Africa (MENA) region and Middle East in variance.

On the contrary, Jayasuriya (2009) advocate that structural changes and persistence behavior in volatility does not contain any significant relation with each other. Similarly, Chung, et al (2000), found that Asia-Pacific markets hold the spurious serial correlation due to shift enhancement in variance series. However, Cevik and Emec (2013) observed persistence behavior in returns series of Turkish stock market.

Moreover, the spillover-effect an indispensable part of price movement from one place to another. Lee (2001) examined the spillover effect among developed countries (Germany, US and, Japan) and developing countries in the MENA region. Result indicates price and volatility series exhibited the spillover impact from developed to emerging markets, but not return back. In similar study, Hamao et al. (1990) support the spillover effects, which vary from New York to Tokyo, but not vice versa.

Furthermore, Turkyilmaz and Balibey (2014) examined the Pakistan security exchange is inefficient in a weak form of market and contain serial correlation structure in volatility series. The Brazil financial market reported the serial correlation behavior in volatility and return series Brazil stock market (Cavalcante and Assaf (2002)). Likewise, Danilenko (2009) discussed that industrial sector report the significant long memory behavior whereas, healthcare and utilities sector entail the weak long range dependence. However, Badani (2008, 2009), support the significant persistence behavior in volatility but not in returns series.

Moreover, Serial correlation and persistence of shocks studied in Egypt, Tunisia, and Morocco stock markets. Evidence advocates that spillover effects and shocks in these markets are not persisted for a longer period of time, and lagged returns could be used for forecasting the future prices (Onour, 2010). In similar study, Tolvi (2003), observed 24% to 64% significant persistence behavior in Finnish stock markets returns.

In nutshell, a plenty of literary work is accessible in developed along with emerging markets. Moreover, there is a paucity of empirical observation on inspecting the presence of long range dependence in Indian context. The current study endeavors to plug this gap.

## Research Design

### Sample and Period of Study

The sample of the study has used daily data of Sectoral Indices namely; Nifty Media, Nifty Auto, Nifty Bank, Nifty Financial Services, Nifty FMCG, Nifty IT, Nifty Metal, Nifty Pharma, Nifty Private Bank, Nifty PSU, Nifty Reality, etc. from National Stock Exchange of India (NSEI). This article computed long term property for every year from January 2010 to May 2018 to ensure existence of persistence behavior occurred because of market microstructure, occasional events, dynamics behavior, market resistance, and peculiar characteristic etc.

**Table 1: Description of Data**

Sr. No	Index	No. of Observations (N)	Period Covered
1.	Nifty Media	2168	January, 2010 to May, 2018
2.	Nifty-Auto	2085	January, 2010 to May, 2018
3.	Nifty Bank	2086	January, 2010 to May, 2018
4.	Nifty Financial Services	2085	January, 2010 to May, 2018
5.	Nifty FMCG	2063	January, 2010 to May, 2018
6.	Nifty IT	2086	January, 2010 to May, 2018
7.	Nifty Metal	1459	July, 2011 to May, 2018
8.	Nifty Pharma	2087	January, 2010 to May, 2018
9.	Nifty Private Bank	2086	January, 2010 to May, 2018
10.	Nifty PSU	2078	January, 2010 to May, 2018
11.	Nifty Reality	2088	January, 2010 to May, 2018

## Methodology

### Hurst Exponent

To computing the long-term property, present study has used Hurst exponent. A Hurst exponent lies between 0 and 1. It deals with three types of patterns in economic series; persistence, randomness, or mean reversion.  $H=0.5$  means time series did not contain persistence behavior.

There is no long term dependence, and the financial market might be efficient. When  $H$  is more than 0.5 and less than 1, time series is persistent, there is long-term memory. The market is inefficient indicating persistence effect. When  $H$  is greater than 0 and less than 0.5, there is a short-term memory and suggesting an anti-persistence effect (Tripathy, 2015).

The estimation of the Hurst exponent lies between 0 and 1:

$0.5 < H < 1$	Persistence
$H = 0.5$	Random walk
$0 < H < 0.5$	Anti-persistence

### Multiple Break Point Test

The present study has used multiple break point test for checking the structural breaks in the data.

**Table 2: Structural Breaks in the Data**

Indices	Number of Breaks	Break date
Nifty Media	1	April 26, 2013
Nifty-Auto	2	May 25, 2015, and
		April 10, 2013
Nifty Bank	3	April 18, 2012,
		May 1, 2014 and
Nifty Financial Services	1	February 11, 2016
Nifty Financial Services	1	February 5, 2010
Nifty FMCG	1	August 3, 2011
Nifty IT	2	August 6, 2014,
		February 10, 2016
Nifty Metal	1	June 4, 2014
Nifty Pharma	1	March 18, 2011
Nifty Private Bank	1	April 12, 2013
Nifty PSU	1	March 22, 2018
Nifty Reality	3	April 18, 2012,
		September 9, 2014,
		and March 15, 2016

Notes: This table reports the break date from January 2010 to May 2018 of Sectoral Indices of National Stock

Exchange of India and breaks date of each series estimated from Multiple Break-Point Test (Balcilar et; al, 2015).

## Results and Analysis

### One Year Analysis of Each Index

**Table 3: Nifty Media**

<i>Nifty Media</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.6103	<b>Long Memory is Present</b>
2011	0.5292	<b>Long Memory is Present</b>
2012	0.6361	<b>Long Memory is Present</b>
2013	0.4546	Long Memory is Absent
2014	0.5207	<b>Long Memory is Present</b>
2015	0.5199	<b>Long Memory is Present</b>
2016	0.6330	<b>Long Memory is Present</b>
2017	0.5776	<b>Long Memory is Present</b>
2018( 31 <sup>st</sup> May )	0.5020	<b>Long Memory is Present</b>

Table 3 presents an analysis of long memory in Nifty Media from 2010 to 2018 by using Hurst exponent. Results advocate that long memory was exhibited in each year except 2013 with H value 0.4546.

**Table 4: Nifty Auto**

<i>Nifty Auto</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5693	<b>Long Memory is Present</b>
2011	0.5014	<b>Long Memory is Present</b>
2012	0.6519	<b>Long Memory is Present</b>
2013	0.5334	<b>Long Memory is Present</b>
2014	0.4816	Long Memory is Absent
2015	0.4498	Long Memory is Absent
2016	0.6210	<b>Long Memory is Present</b>
2017	0.4387	Long Memory is Absent
2018 (31 <sup>st</sup> May)	0.6268	<b>Long Memory is Present</b>

The above table presents that long memory component was exhibited in Nifty Auto in 2010, 2011, 2012, 2013, 2016, 2018. But the similar behavior was not found in 2014 and 2015.

**Table 5: Nifty Bank**

<i>Nifty Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5868	<b>Long Memory is present</b>
2011	0.4878	Long Memory is absent
2012	0.6024	<b>Long Memory is present</b>
2013	0.6166	<b>Long Memory is present</b>
2014	0.6270	<b>Long Memory is present</b>
2015	0.4499	Long Memory is absent
2016	0.6590	<b>Long Memory is present</b>
2017	0.5346	<b>Long Memory is present</b>
2018 (31 <sup>st</sup> May)	0.7337	<b>Long Memory is present</b>

Table 5 present the findings of Nifty Bank that long memory were observed in 2010, 2012, 2013, 2014, 2016, 2017 and 2018. But in 2011 and 2015 persistence behavior not reported.

**Table 6: Nifty Financial Services**

<i>Nifty Financial Services</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5838	<b>Long Memory is Present</b>
2011	0.4786	Long Memory is Absent
2012	0.5926	<b>Long Memory is Present</b>
2013	0.6154	<b>Long Memory is Present</b>
2014	0.5996	<b>Long Memory is Present</b>
2015	0.4627	Long Memory is Absent
2016	0.6842	<b>Long Memory is Present</b>
2017	0.5522	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.6953	<b>Long Memory is Present</b>

Table 5 shows the result of Nifty Financial Services. Empirical evidence shows that long memory was reported in the year 2010, 2012, 2013, 2014, 2016, 2017, 2018. Similar behaviors were not found in 2011 and 2015.

**Table 7: Nifty FMCG**

<i>Nifty FMCG</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.6121	<b>Long Memory is Present</b>
2011	0.5385	<b>Long Memory is Present</b>
2012	0.4756	Long Memory is Absent
2013	0.5581	<b>Long Memory is Present</b>
2014	0.4907	Long Memory is Absent

<i>Nifty FMCG</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2015	0.4620	Long Memory is Absent
2016	0.6099	<b>Long Memory is Present</b>
2017	0.5787	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.6848	<b>Long Memory is Present</b>

Table 7 shows that long memory component were detected on the year 2010, 2011, 2013, 2016, 2017, 2018 except 2012, 2014 and 2015 with H value 0.4756, 0.4907, 0.4620 as respectively.

**Table 8: Nifty IT**

<i>Nifty IT</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5101	<b>Long Memory is Present</b>
2011	0.5788	<b>Long Memory is Present</b>
2012	0.5324	<b>Long Memory is Present</b>
2013	0.5984	<b>Long Memory is Present</b>
2014	0.6128	<b>Long Memory is Present</b>
2015	0.5101	<b>Long Memory is present</b>
2016	0.4990	Long Memory is Absent
2017	0.4513	Long Memory is Absent
2018 (31 <sup>st</sup> May)	0.6113	<b>Long Memory is Present</b>

The above table presents the result of Nifty IT, advocates that persistence behavior were found in 2010, 2011, 2012, 2013, 2014, 2015 and 2018. But similar behavior was not detected in 2016 and 2017 with H value 0.4990, 0.4513 as respectively.

**Table 9: Nifty Metals**

<i>Nifty Metal</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2011	0.5168	<b>Long Memory is Present</b>
2012	0.5510	<b>Long Memory is Present</b>
2013	0.7258	<b>Long Memory is Present</b>
2014	0.7277	<b>Long Memory is Present</b>
2015	0.5321	<b>Long Memory is Present</b>
2016	0.5204	<b>Long Memory is Present</b>
2017	0.5449	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.6298	<b>Long Memory is Present</b>

The above table shows that long memory was exhibited for Nifty Metal from 2011 to 2018 in each year, which indicates the serial correlation behavior in return series.

**Table 9: Nifty Pharma**

<i>Nifty Pharma</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5860	<b>Long Memory is Present</b>
2011	0.5489	<b>Long Memory is Present</b>
2012	0.5081	<b>Long Memory is Present</b>
2013	0.4914	Long Memory is Absent
2014	0.6551	<b>Long Memory is Present</b>
2015	0.5127	<b>Long Memory is Present</b>
2016	0.4773	Long Memory is Absent
2017	0.4979	Long Memory is Absent
2018 (31 <sup>st</sup> May)	0.6023	<b>Long Memory is present</b>

The above table presents that the results of Nifty Pharma, finding shows that long memory behavior was exhibited for 2010, 2011, 2012, 2014, 2015 and 2018. While persistence behavior was not observed for the year 2013, 2016, 2017 and 2018 with H value 0.4914, 0.4773 and 0.4979.

**Table 10: Nifty Private Bank**

<i>Nifty Private Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.5292	<b>Long Memory is Present</b>
2011	0.4978	Long Memory is Absent
2012	0.6060	<b>Long Memory is Present</b>
2013	0.6237	<b>Long Memory is Present</b>
2014	0.5957	<b>Long Memory is Present</b>
2015	0.4813	Long Memory is Absent
2016	0.6683	<b>Long Memory is Present</b>
2017	0.5396	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.7240	<b>Long Memory is Present</b>

The above table presents the results of Nifty Private, indicates that long memory was detected in 2010, 2012, 2013, 2014, 2015, 2016, 2017 and 2018. But Long memory was not observed in 2011 and 2015.

**Table 11: Nifty PSU**

<i>Nifty PSU Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.6269	<b>Long Memory is Present</b>
2011	0.4927	Long Memory is Absent
2012	0.6167	<b>Long Memory is Present</b>
2013	0.6380	<b>Long Memory is Present</b>
2014	0.7245	<b>Long Memory is Present</b>
2015	0.4372	Long Memory is Absent
2016	0.5555	<b>Long Memory is Present</b>
2017	0.5305	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.6395	<b>Long Memory is Present</b>

The above table presents that long memory were exhibited in 2010, 2012, 2013, 2014, 2016, 2017 and 2018, while in 2011 and 2015 similar behavior was not detected with H value 0.4927, 0.4372 as respectively.

**Table 12: Nifty Reality**

<i>Nifty Reality</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010	0.6110	<b>Long Memory is Present</b>
2011	0.5232	<b>Long Memory is Present</b>
2012	0.6504	<b>Long Memory is Present</b>
2013	0.5543	<b>Long Memory is Present</b>
2014	0.6868	<b>Long Memory is Present</b>
2015	0.5378	<b>Long Memory is Present</b>
2016	0.6657	<b>Long Memory is Present</b>
2017	0.5612	<b>Long Memory is Present</b>
2018 (31 <sup>st</sup> May)	0.5577	<b>Long Memory is Present</b>

Table 12 presents the results of Nifty Reality that persistence behavior was reported from 2010 to 2018 in each year.

### Two Year Analysis of Each Index

**Table 13: Nifty Media**

<i>Nifty Media</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	<b>0.5697</b>	<b>Long Memory is Present</b>
2011-2012	<b>0.5826</b>	<b>Long Memory is Present</b>

<i>Nifty Media</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2012-2013	<b>0.5826</b>	<b>Long Memory is Present</b>
2013-2014	0.4876	Long Memory is Absent
2014-2015	<b>0.5203</b>	<b>Long Memory is Present</b>
2015-2016	0.5764	<b>Long Memory is Present</b>
2016-2017	0.6053	<b>Long Memory is Present</b>
2017-2018	0.5398	<b>Long Memory is Present</b>

In two year analysis, of Nifty Media for long memory indicates that persistence behavior exhibited in all the analysis except 2013-2014 with 0.4876.

**Table 14: Nifty Auto**

<i>Nifty Auto</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5353	<b>Long Memory is Present</b>
2011-2012	0.5766	<b>Long Memory is Present</b>
2012-2013	0.5926	<b>Long Memory is Present</b>
2013-2014	0.5075	<b>Long Memory is Present</b>
2014-2015	0.4657	Long Memory is Absent
2015-2016	0.5354	<b>Long Memory is Present</b>
2016-2017	0.5298	<b>Long Memory is Present</b>
2017-2018	0.5327	<b>Long Memory is Present</b>

In two year analysis of long memory, the finding indicates that persistence behavior was reported for 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2015-2016, 2016-2017 and 2017-2018. But did not observe long memory for 2014-2015.

**Table 15: Nifty Bank**

<i>Nifty Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5373	<b>Long Memory is Present</b>
2011-2012	0.5451	<b>Long Memory is Present</b>
2012-2013	0.6095	<b>Long Memory is Present</b>
2013-2014	0.6218	<b>Long Memory is Present</b>
2014-2015	0.5384	<b>Long Memory is Present</b>
2015-2016	0.5544	<b>Long Memory is Present</b>
2016-2017	0.5968	<b>Long Memory is Present</b>
2017-2018	0.6341	<b>Long Memory is Present</b>

The above table, two-year analysis indicates that persistence behaviors were strongly observed in all years.

**Table 16: Nifty Financial Services**

<i>Nifty Financial Services</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5312	<b>Long Memory is Present</b>
2011-2012	0.5356	<b>Long Memory is Present</b>
2012-2013	0.6040	<b>Long Memory is Present</b>
2013-2014	0.6075	<b>Long Memory is Present</b>
2014-2015	0.5311	<b>Long Memory is Present</b>
2015-2016	0.5734	<b>Long Memory is Present</b>
2016-2017	0.6182	<b>Long Memory is Present</b>
2017-2018	0.6237	<b>Long Memory is Present</b>

In two-year analysis of Nifty Financial Services, indicates that long memory exhibited in all the year from 2010-2018.

**Table 17: Nifty FMCG**

<i>Nifty FMCG</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5753	<b>Long Memory is Present</b>
2011-2012	0.5070	<b>Long Memory is Present</b>
2012-2013	0.5168	<b>Long Memory is Present</b>
2013-2014	0.5244	<b>Long Memory is Present</b>
2014-2015	0.4763	Long Memory is Absent
2015-2016	0.5359	<b>Long Memory is Present</b>
2016-2017	0.5943	<b>Long Memory is Present</b>
2017-2018	0.6317	<b>Long Memory is Present</b>

Above table presents the two-year long memory analysis, indicates that persistence behavior was reported each year except 2014-2015.

**Table 18: Nifty IT**

<i>Nifty IT</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5444	<b>Long Memory is Present</b>
2011-2012	0.5556	<b>Long Memory is Present</b>
2012-2013	0.5654	<b>Long Memory is Present</b>
2013-2014	0.6056	<b>Long Memory is Present</b>
2014-2015	0.5614	<b>Long Memory is Present</b>
2015-2016	0.5045	<b>Long Memory is Present</b>
2016-2017	0.4751	Long Memory is Absent
2017-2018	0.5313	<b>Long Memory is Present</b>

Above table presents the two-year analysis, indicates that Long memory component is reported in every year except 2016-2017.

**Table 19: Nifty Metal**

<i>Nifty Metal</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2011-2012	0.5339	<b>Long Memory is present</b>
2012-2013	0.6384	<b>Long Memory is present</b>
2013-2014	0.72675	<b>Long Memory is present</b>
2014-2015	0.6299	<b>Long Memory is present</b>
2015-2016	0.5262	<b>Long Memory is present</b>
2016-2017	0.5326	<b>Long Memory is present</b>
2017-2018	0.5873	<b>Long Memory is present</b>

Above table shows that long memory was strongly exhibited in Nifty Metal return series.

**Table 20: Nifty Pharma**

<i>Nifty Pharma</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5674	<b>Long Memory is Present</b>
2011-2012	0.5285	<b>Long Memory is Present</b>
2012-2013	0.4997	Long Memory is Absent
2013-2014	0.5732	<b>Long Memory is Present</b>
2014-2015	0.5839	<b>Long Memory is Present</b>
2015-2016	0.4950	Long Memory is Absent
2016-2017	0.4876	Long Memory is Absent
2017-2018	0.5501	<b>Long Memory is Present</b>

Above table shows that long memory was exhibited in 2010-2011, 2011-2012, 2013-2014, 2014-2015, 2017-2018. But similar findings did not observe in 2012-2013, 2015-2016 and 2016-2017.

**Table 21: Nifty Private Bank**

<i>Nifty Private Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5135	<b>Long Memory is Present</b>
2011-2012	0.5519	<b>Long Memory is Present</b>
2012-2013	0.6148	<b>Long Memory is present</b>
2013-2014	0.6097	<b>Long Memory is present</b>

<i>Nifty Private Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2014-2015	0.5385	<b>Long Memory is present</b>
2015-2016	0.5748	<b>Long Memory is Present</b>
2016-2017	0.6039	<b>Long Memory is Present</b>
2017-2018	0.6318	<b>Long Memory is Present</b>

Above table presents that long memory was observed in all whole the analysis of Nifty Private Bank series.

**Table 22: Nifty PSU**

<i>Nifty PSU Bank</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5598	<b>Long Memory is Present</b>
2011-2012	0.5547	<b>Long Memory is Present</b>
2012-2013	0.6273	<b>Long Memory is Present</b>
2013-2014	0.6812	<b>Long Memory is Present</b>
2014-2015	0.5808	<b>Long Memory is Present</b>
2015-2016	0.4963	Long Memory is Absent
2016-2017	0.543	<b>Long Memory is Present</b>
2017-2018	0.585	<b>Long Memory is Present</b>

In two year analysis of Nifty PSU shows that persistence behavior was exhibited in the whole sample except 2015-2016.

**Table 23: Nifty Reality**

<i>Nifty Reality</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
2010-2011	0.5671	<b>Long Memory is Present</b>
2011-2012	0.5868	<b>Long Memory is Present</b>
2012-2013	0.6023	<b>Long Memory is Present</b>
2013-2014	0.6205	<b>Long Memory is Present</b>
2014-2015	0.6123	<b>Long Memory is Present</b>
2015-2016	0.6017	<b>Long Memory is Present</b>
2016-2017	0.6134	<b>Long Memory is Present</b>
2017-2018	0.5594	<b>Long Memory is Present</b>

Above table presents that long memory was strongly observed in the entire sample of Nifty Reality.

**Table 24: (Full period Analysis of All Indices)**

<i>Sr. No</i>	<i>Period Covered</i>	<i>Indices</i>	<i>Coefficient of Hurst Exponent</i>	<i>Findings</i>
1.	January 1, 2010-May 31,2018	Nifty Media	0.5537	<b>Long memory is present</b>
2.	January 1, 2010-May 31,2018	Nifty Auto	0.5415	<b>Long memory is present</b>
3.	January 1, 2010-May 31,2018	Nifty Bank	0.5886	<b>Long Memory is present</b>
4.	January 1, 2010-May 31,2018	Nifty Financial Service	0.5849	<b>Long Memory is present</b>
5.	January 1, 2010-May 31,2018	Nifty FMCG	0.5567	<b>Long Memory is present</b>
6.	January 1, 2010-May 31,2018	Nifty IT	0.5449	<b>Long Memory is present</b>
7.	January 1,2011-May 31,2018	Nifty Metal	0.5935	<b>Long Memory is present</b>
8.	January 1, 2010-May 31,2018	Nifty Pharma	0.5421	<b>Long Memory is present</b>
9.	January 1, 2010-May 31,2018	Nifty Private Bank	0.4972	Long Memory is absent
10.	January 1, 2010-May 31,2018	Nifty PSU	0.5846	<b>Long Memory is present</b>
11.	January 1, 2010-May 31,2018	Nifty Reality	0.5942	<b>Long Memory is present</b>

The above Table presents the full period analysis of Long term memory in sectoral indices of the National Stock Exchange of India by using Rescaled Range Statistics (Hurst Exponent, 1951). All Indices have shown long memory component in returns series. However, Nifty Private Bank does not contain the persistence behavior in returns series.

## Conclusion

In this paper, the presence of long memory in sectoral indices of National Stock Exchange of India has been examined by using the Rescaled Range Analysis. (Hurst Exponent, 1951). Analysis for the full sample period indicates that all sectoral indices show long memory effect (2010-2018) except Nifty Private Bank with H value 0.4972. On examining the data for individual years, all indices exhibit long memory effect, except Nifty Media in 2013 with H value 0.4546, Nifty Auto in 2014, 2015, and 2017 with H value 0.4816, 0.4498 and 0.4387, Nifty Bank on 2011 and 2015 with H value 0.4878 and 0.4499, Nifty Financial Services in 2011 and 2015 with H value 0.4786 and 0.4627, Nifty FMCG in 2012, 2014 and 2015 with H value 0.4756, 0.4907 and 0.4620, Nifty IT in 2016 and 2017 with H value 0.4990 and 0.4513. Similar findings are reported for Nifty Pharma in 2013, 2016 and 2017 with H value 0.4914, 0.4773 and 0.4979, Nifty Private Bank in 2011 and 2015 with H value 0.4978 and 0.4813 and Nifty PSU in 2011 and 2015 with H value 0.4927 and 0.4372, where they do not indicate persistence behavior. Furthermore, Nifty Metal (2011-2018) and Nifty Reality (2010-2018) reported long memory component for each year with respect of Hurst Exponent coefficient. Moreover, in the two-year analysis, Nifty Bank, Nifty Financial Services, Nifty Metal, Nifty Private Bank, Nifty Reality are significantly reported the persistence behavior of sectoral indices of NSE. With reference to structural break dates, it can be inferred that all returns series from 2010 to 2018 reported a significant long memory effect whereby confirming the significant persistence behavior after the occurrence of break date in the data Findings of Hurst Exponent indicates that market exhibits a degree of persistence, which means “mean” reverting nature is slower than a random walk. Evidence suggests that Indian equity market returns pursue serial correlation with the presence of long range dependence. There is little evidence that market persists random walk process.

The findings would be useful to investor, broker, mutual funds, etc., in undertaking the investment decisions.

## References

- Barkoulas, J. T., & Baum, C. F. (1996). Long-term dependence in stock returns. *Economics Letters*, 53(3), 253–259.
- Bali, T. G., Peng, L., Shen, Y., & Tang, Y. (2014). Liquidity shocks and stock market reactions. *Review of Financial Studies*, 27(5), 1434–1485.
- Balcilar, M., Ozdemir, Z. A., & Cakan, E. (2015). Structural breaks, long memory, or unit roots in stock prices: Evidence from emerging markets. *International Econometric Review (IER)*, 7(1), 13–33.
- Barkoulas, J. T., Baum, C. F., & Travlos, N. (2000). Long memory in the Greek stock market. *Applied Financial Economics*, 10(2), 177–184.
- Baillie, R. T., & Morana, C. (2009). Modelling long memory and structural breaks in conditional variances: An adaptive FIGARCH approach. *Journal of Economic Dynamics and Control*, 33(8), 1577–1592.
- Backus, D., & Zin, S. E. (1993). *Long-memory inflation uncertainty: Evidence from the term structure of interest rates*. Working paper No.133, National Bureau of Economic Research.
- Bhattacharya, S. N., & Bhattacharya, M. (2012). Long memory in stock returns: A study of emerging markets. *Iranian Journal of Management Studies*, 5(5), 67–88.
- Badhani, K. N. (2012). Does Nifty have a Long Memory? Semi-parametric Estimation of Fractional Integration in Returns and Volatility. *Decision*, 39(3), 86–100.
- Badhani, K. N. (2008). Long memory in stock returns and volatility in India: A nonparametric analysis. *ICFAI Journal of Applied Finance*, 14(12), 34–53.
- Baum, C. F., Barkoulas, J. T., & Caglayan, M. (1999). Long memory or structural breaks: can either explain nonstationary real exchange rates under the current float? *Journal of International Financial Markets, Institutions and Money*, 9(4), 359–376.
- Barkoulas, J. T., & Baum, C. F. (1997). Long memory and forecasting in Euroyen deposit rates. *Financial Engineering and the Japanese Markets*, 4(3), 189–201.
- Booth, G. G., & Tse, Y. (1995). Long memory in interest rate futures markets: A fractional cointegration analysis. *Journal of Futures Markets*, 15(5), 573–584.

- Baillie, R. T. (1996). Long memory processes and fractional integration in econometrics. *Journal of econometrics*, 73(1), 5–59.
- Bala, & Gupta (2018) Testing the long memory feature in Indian equity market. *Journal of Research in Management*, 10(2), 24–33.
- Chung, H., Lin, W. T., & Wu, S. (2000). An analysis of long memory in volatility for Asian stock markets. *Review of Pacific Basin Financial Markets and Policies*, 3(3), 309–330.
- Chen, J. H., & Diaz, J. F. (2013). Long memory and shifts in the returns of green and non-green Exchange-Traded Funds (ETFs). *International Journal of Humanities and Social Science Invention*, 2(10), 29–32.
- Cont, R. (2005). Long range dependence in financial markets. In *Fractals in Engineering* (pp. 159–179). London: Springer.
- Christodoulou-Volos, C., and Siokis, F. M. (2006). Long range dependence in stock market returns. *Applied Financial Economics*, 16(18), 1331–1338.
- Caporale, G. M., & Gil-Alana, L. A. (2008). Long memory and structural breaks in the Spanish stock market index. *Open Operational Research Journal*, 2, 13–17.
- Cheung, Y. W., & Lai, K. S. (1995). A search for long memory in international stock market returns. *Journal of International Money and Finance*, 14(4), 597–615.
- Chen, J. H., & Huang, Y. F. (2014). Long memory and structural breaks in modelling the volatility dynamics of VIX-ETFs. *International Journal of Business, Economics and Laws*, 4(1), 54–63.
- Cajueiro, D. O., & Tabak, B. M. (2005). Possible causes of long-range dependence in the Brazilian stock market. *Physica A: Statistical Mechanics and its Applications*, 345(3), 635–645.
- Cevik, P., & Emec, H. (2013). Long memory properties in return and volatility: An application of the impact of arab spring in turkey financial market. *Current Research Journal of Social Sciences*, 5(2), 60–66.
- Dicle, M. F., Beyhan, A., & Yao, L. J. (2010). Market efficiency and international diversification: Evidence from India. *International Review of Economics & Finance*, 19(2), 313–339.
- Caccioli, F., & Marsili, M. (2010). Information efficiency and financial stability. *Economics: The Open-Access, Open-Assessment E-Journal*, 4(2010–20), 1–20.
- Figlewski, S. (1978). Market “efficiency” in a market with heterogeneous information. *The Journal of Political Economy*, 581–597.
- Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The journal of Finance*, 25(2), 383–417.
- Fama, E. F. (1991). Efficient capital markets: II. *The Journal of Finance*, 46(5), 1575–1617.
- Gayathri, M., Murugesan, S., & Gayathri, J. (2012). Persistence and long range dependence in Indian stock market returns. *International Journal of Management and Business Studies*, 2(4), 72–77.
- Granger, C. W., & Hyung, N. (2004). Occasional structural breaks and long memory with an application to the S and P 500 absolute stock returns. *Journal of Empirical Finance*, 11(3), 399–421.
- Gurgul, H., & Wojtowicz, T. (2006). Long memory on the German stock exchange. *Czech Journal of Economics and Finance (Finance a uver)*, 56(9–10), 447–468.
- Greene, M. T., & Fielitz, B. D. (1977). Long-term dependence in common stock returns. *Journal of Financial Economics*, 4(3), 339–349.
- Ho, T. S., Schwartz, R. A., & Whitcomb, D. K. (1985). The trading decision and market clearing under transaction price uncertainty. *Journal of Finance*, 40(1) 21–42.
- Hassler, U., & Wolters, J. (1995). Long memory in inflation rates: International evidence. *Journal of Business & Economic Statistics*, 13(1), 37–45.
- Hurst, H. E. (1951) *The long-term storage capacity of reservoir*. Transactions of the American Society of Civil Engineers 116, Paper 2447, Published in 1950 as Proceedings-Separate No. 11.
- Hiremath, G. S., & Kamaiah, B. (2011). Testing long memory in stock returns of emerging markets: Some further evidence. *Economics, Management, and Financial Markets*, 6(3), 136–147.
- Hiremath, G. S., & Kamaiah, B. (2010). Long memory in stock market volatility: Indian evidences. *Artha Vijnana*, 52(4), 332–345.
- Heidarpoor, F., Rouhi, A., & Mashaei, K. F. (2012). Relationship between stock liquidity and stock price changes rate. *African Journal of Business Management*, 6(37), 10178–10184.
- Huang, B. N., & Yang, C. W. (1999). *An examination of long-term memory using the intraday stock returns*.

- Technical Report 99–03. Clarion University of Pennsylvania, Clarion.
- Jennings, R. H., & Barry, C. B. (1983). Information dissemination and portfolio choice. *Journal of Financial and Quantitative Analysis*, 18(1), 1–19.
- Joshiyura, M. (2008). Price and liquidity effects of stock split: Empirical evidence from Indian stock market. *NSE Research initiative*.
- Karpoff, J. M. (1987). The relation between price changes and trading volume: A survey. *Journal of Financial and Quantitative Analysis*, 22(1), 109–126.
- Kumar, A. (2004). *Long memory in stock trading volume: Evidence from Indian stock market*. This paper has been downloaded from Social Science Research Network (SSRN) on May 19, 2015.
- Kumar, D. (2014). Long-range dependence in Indian stock market: A study of Indian sectoral indices. *International Journal of Emerging Markets*, 9(4), 505–519.
- Kasman, A., Kasman, S., & Torun, E. (2009). Dual long memory property in returns and volatility: Evidence from the CEE countries' stock markets. *Emerging Markets Review*, 10(2), 122–139.
- Kasman, A., & Torun, E. (2012). Long memory in the Turkish stock market return and volatility. *Central Bank Review*, 7(2), 13–27.
- Kasman, S., Turgutlu, E., & Ayhan, A. D. (2009). Long memory in stock returns: Evidence from the major emerging Central European stock markets. *Applied Economics Letters*, 16(17), 1763–1768.
- Kang, S. H., & Yoon, S. M. (2007). Long memory properties in return and volatility: Evidence from the Korean stock market. *Physica A: Statistical Mechanics and its Applications*, 385(2), 591–600.
- Lesmond, D. A. (2005). Liquidity of emerging markets. *Journal of Financial Economics*, 77(2), 411–452.
- Lo, A. (1991). Long term memory in stock market prices. *Econometrica*, 59(5), 1279–1313.
- Limam, I. (2003). Is long memory a property of thin stock markets? International Evidence using Arab countries. *Review of Middle East Economics and Finance*, 1(3), 251–266.
- Mukherjee, I., Sen, C., & Sarkar, A. (2011). Long memory in stock returns: Insights from the Indian market. *The International Journal of Applied Economics and Finance*, 5(1), 62–74.
- Nath, G. C., & Dalvi, M. (2004). *Day of the week effect and market efficiency-evidence from Indian equity market using high frequency data of national stock exchange*. This paper has been Downloaded from Social Science Research Network on June 2nd, 2015.
- Nath, G. C., & Reddy, Y. V. (2002, December). Long memory in rupee-dollar exchange rate: An empirical study. In *Capital Market Conference*.
- Onour, I. A. (2010). North Africa stock markets: Analysis of long memory and persistence of shocks. *International Journal of Monetary Economics and Finance*, 3(2), 101–111.
- Prasanna, K., & Bansal, B. (2014). Foreign institutional investments and liquidity of stock markets: Evidence from India. *International Journal of Economics and Finance*, 6(6), 103–118.
- Raj, M., & Kumari, D. (2006). Day-of-the-week and other market anomalies in the Indian stock market. *International Journal of Emerging Markets*, 1(3), 235–246.
- Pati, P. C., & Rajib, P. (2011). Intraday return dynamics and volatility spillovers between NSE S&P CNX Nifty stock index and stock index futures. *Applied Economics Letters*, 18(6), 567–574.
- Souza, S. R., Tabak, B. M., & Cajueiro, D. O. (2008). Long-range dependence in exchange rates: the case of the European monetary system. *International Journal of Theoretical and Applied Finance*, 11(2), 199–223.
- Souza, S. R., Tabak, B. M., & Cajueiro, D. O. (2008). Long memory testing for Fed Funds Futures' contracts. *Chaos, Solitons & Fractals*, 37(1), 180–186.
- Suresha, B. (2014). Ownership structure and market Liquidity-Sectorial Evidence from India. *Research Journal of Finance and Accounting*, 5(19), 127–133.
- Sadique, S., & Silvapulle, P. (2001). Long-term memory in stock market returns: International evidence. *International Journal of Finance & Economics*, 6(1), 59–67.
- Soofi, A. S., Wang, S., and Zhang, Y. (2006). Testing for long memory in the Asian foreign exchange rates. *Journal of Systems Science and Complexity*, 19(2), 182–190.
- Sensoy, A. (2013). Time-varying long range dependence in market returns of FEAS members. *Chaos, Solitons and Fractals*, 53, 39–45.

- Taqqu, M. S., Teverovsky, V., & Willinger, W. (1995). Estimators for long-range dependence: An empirical study. *Fractals*, 3(4), 785–798.
- Turkyilmaz, S., & Balibey, M. (2014). Long memory behavior in the returns of Pakistan stock market: ARFIMA-FIGARCH models. *International Journal of Economics and Financial Issues*, 4(2), 400–441.
- Tayal, R., & Thomas, S. (2012). *Measuring and explaining the asymmetry of liquidity*. This paper has been downloaded from Social Science Research Network (SSRN) on May19, 2015.
- Verma, A. (2008). Long memory of the Indian stock market. *The IUP Journal of Financial Economics*, 6(3), 74–83.
- Willinger, W., Taqqu, M. S., & Teverovsky, V. (1999). Stock market prices and long-range dependence. *Finance and stochastics*, 3(1), 1–13.