ADAPTIVE MARKET HYPOTHESIS: AN ANALYSIS OF INDIAN EQUITY MARKET

A Dissertation submitted in Partial fulfilment of the requirement for the degree of Master of Philosophy

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Registration No:
MZU/M.PHIL./504 of 07.05.2019

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MIZORAM UNIVERSITY
TANHRIL, AIZAWL
(May 2020)

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IN PARTIAL FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PHILOSOPHY IN MANAGEMENT OF MIZORAM UNIVERSITY, AIZAWL

LIST OF ABBREVIATIONS

ABB	: Adaptive Bollinger Band
AMH	: Adaptive Market Hypothesis
AC	: Auto Correlation
ACF	: Auto Correlation function
ARIMA	: Auto-Integrated moving average
ADF	: Augmented Dickey Fuller
APT	: Arbitrage Pricing Model
BFC	: Belaire- Franch and Contreras
BDS	: Brock- Dechert – Scheinkman
BSE	: Bombay Stock Exchange
CAC	: Central Asian Countries
CATC	: Cambridge Bancorp
CAPM	: Capital Asset Pricing Model
CB	: Commercial Bill
CCI	: Controller of Capital Issue
CMB	: Cash Management Bill
CBLO	: Collateralized Borrowing and Lending Obligation
EMH	: Efficient Market Hypothesis
GARCH	: Generalised Auto-regressive Conditional Heteroscedasticity
GARCH- M	: Generalised Auto-regressive Conditional Heteroscedasticity in Mean
FTSE	: Financial Stock Market Exchange
JB	: Jarque Bera
J-K	: Jagadesh and Titman
LM	: Lagrange Multiplier
MDM	: Modified Diebold- Mariano
MVR	: Multiple Variance Ratio test
NIKKEI	: Nihon Keizai Shimbun
NSCC	: National Securities Clearing Corporation

NSDL	: National Securities Depositories Limited
NSE	: National Stock Exchange
OLS	: Ordinary Least Square
KPSS	: Kwiatkowski–Phillips–Schmidt–Shin
RALS	: Residual Augmented Least Square
RWM	: Random Walk Movement
SEBI	: Securities and Exchange Board of India
SMM	: Studentized Maximum Modulus
SOP	: Swarm Optimization
UTI	: Unit Trust of India
VR	: Variance Ratio
WFME	: Weak Form Market Efficient

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CHAPTER – I
INTRODUCTION

1.1 Introduction

The issue of the efficient market was a longstanding debate among academics in term of fundamentalist and behavioural theory as well as practitioners. Financial predictability was a homogeneous expectation for investors. The issue on risk, return, volatility and predictibility have been an unending process that needs further research because inconclusive and anomalous results arise. After more than five decades there is no clear resolution about the efficient market. For this a new theory that reconciles the two schools of thought in a natural and satisfying conclusive manner. The theory called the Adaptive Market Hypothesis (AMH) was propounded by Andrew Lo in 2004. According to Lo (2004) "Price reflects as much information as dictated by the combination of environmental condition and the number and nature of species in the economy". Species here means individuals which seem to have the common behaviour. Hedges funds, mutual funds, pension funds etc. behave in the same manner even though their investment styles differ. The AMH is creating more holistic view of the market which combines the efficient market and behavioural finance that vitalize and transform the intersection of psychology and economics through recent research in cognitive neuroscience (Lo, 2004).

The theory, EMH is one of the most important and influential theories in the area of finance where many theories like CAPM(1960), APT(1976) or other are developed directly and indirectly from it. Eugene F. Fama (1970, 1990) sets forth the idea of EMH on the framework of Samuelson's Random walk model (RWM). It says the current prices of the stock fully "reflect" all available information about the intrinsic value of the asset. The efficient market is a market condition where prices of the securities adjust rapidly with the infusion of new information. Therefore, the current stock prices render new information predictable (Bhat 2008, p.336-337). Therefore, investors without prior research have the same level of returns as those technical analysts using past data or recommendation by the analysis (Smiles, 2013). This makes it imperative to conduct further research on the inconclusiveness that persists in this topic. Academic researches and

financial traders during the past 30 years are unable to come to consent whether the capital markets are efficient or not.

An efficient market is one of the most controversial areas in investment research and a new dimension was added to the controversy in EMH because of the expanding behavioural finance. Academics seek to support the concept of efficient market, regulators aim to increase market efficiency and trader aims to exploit inefficiency to generate abnormal profit (Almail & Almuddhaf, 2017). Various studies, (Lo, 2004; Worthington and Higgs, 2005; Borges, 2010; Gupta & Yang, 2011; Kapoor 2017 & Parulekar, 2017), found the stock market a mixed result i.e. market with efficiency and inefficiency co-exist in a rationally steady manner over a period of time. The study of market efficiency in the Indian equity market also found mixed results. Some of the studies (Poshakwale, 1996; Jain & Jain, 2013; Nalina & Suraj, 2013; Mishra, Mishra & Smyth, 2015) observed that the price of the Indian stock price is efficient in weak form while others (Srinivasan, 2010; Khan, Ikram & Mehtab, 2011; Malafeyev, Awasthi, Kamberkar, & Kupinskaya, 2019) rejected this hypothesis.

It can be stated that stock markets are neither efficient nor inefficient, it follows certain bound rationally (Simon, 1955). This means that the EMH was not false but rather incomplete; it cannot be disapproved as well. In the light of this prevailing scenario an investor acts irrationally. This irrationality includes behaviour and psychological factors. In contrast to EMH, financial markets are adaptive and switch between periods of efficiency and inefficiency (Lo, 2004). This same market behaviour was observed in various studies (such as Al-khazali & Mirzaei, 2017; Worthington & Higgs, 2005; Borges, 2010; Gupta & Yang, 2011; Kapoor, 2017; Parulekar, 2017). In the light of this, the study was undertaken to determine the fluctuation of market efficiency overtime. The study scrutinizes the controversial EMH. For this, linearity and non-linearity test was espoused by taking data from the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) in India. It is important to emphasize that the testing of efficient market hypothesis cannot be neglected although we are mostly concerned about the evolutionary model.

1.2 Financial Market

Financial market can be described as complex, dynamic and ever changing and has been driven by various economic factors. Movement in the stocks market can be volatile; moreover it can be diverted from the main economic factors. Supply and demand, economic growth, interest rate, stability, unpredictability and market expectations affect changes in asset price per tick of second. With the arrival and assimilation of information, the interaction of supply and demand is ever changing as a result of reaction to market more complex in nature, the fear and greed in search of additional profit from traders and academic exploration (Seetharam, 2016). One can easily conceived without an argument that financial market is dynamic in nature.

The financial market is divided into two types - the money market and capital market. The money market is a market for financial assets which is almost equivalent to substitute of money i.e. short term and more liquidity. It is a market instrument which can be availed for overnight to a short period. It is an instrument having maturity of less than one year. The money market instrument includes Treasury Bill (T-bill), Cash Management Bill (CMBs), call/ notice money market, Commercial Paper (CP), Certificate of Deposit (CDs), Commercial Bill (CBs) and Collateralized Borrowing and Lending Obligation (CBLO). The capital market on the other side is an important constituent of the financial system which deals with long term funds – equity and debt, funds raise within and outside the countries.

1.3 Capital Market

Capital market is an important constituent of the financial system where financial securities were traded that engage in arranging the progress of lending and borrowing of financial securities like bond and stock in the long term. It is an entity where various securities are traded; where supplier and user of the fund met each other depending upon the capital requirement of financial products like equity and debt security. The capital market is composed of primary and secondary markets. The primary market is a market for new issue securities i.e. securities are issued to investors for the first time that lead to capital formation. The secondary market is a market where outstanding or existing securities are traded. The Securities and Exchange Board of India (SEBI) is a regulatory body in India which controls, regulates and maintains fair practice in the capital market. The regulation of the SEBI not only helps the investors but also the corporation whose securities are being traded.

1.4 History of Indian Capital Market

The history of the capital market in India was dated back to the eighteen century under the East India Company, where securities were traded in the country. The main trading centres during those days were Bombay (now Mumbai) and Calcutta (now Kolkata). Security trading was unorganised and did not have a well regulatory body in that period. Until the end of the nineteenth century, security trading was through speculation with unorganised trading performance. Back in 1860-61, during the American war, trading activities flourish due to the opening of Suez canal in 1860s. There

was a tremendous increase in export and import between United States and United Kingdom. Bombay was one of the important supplies of cotton, trading activities flourished in this period, resulting in boom of share price.

Trading at the time was limited and broker could assign limited securities due to physical movement of stock. The trading was organised and performed under a banyan tree in front of the town hall in Bombay. The Native Shares and Stock Broker Association was formed in 1875 in Bombay. This is a milestone in the introduction of Bombay Stock Exchange. Later the Bombay stock exchange was recognized as a formal stock exchange in May 1927 under the Bombay Securities Contract Act, 1925.

The capital market was not well organised and developed under the British rule. The British government restricted the economic development of the Indians but they focus investing on the London capital market rather than on the Indian capital market. During post-independence, the size of capital market remains small, the first and the second five year plans focus mainly on agriculture and public sector undertaking. The industrial growths were small and a large part of capital market was under gilt-edge market for government securities. During the time, the Controller of Capital Issue (CCI) regulated and controlled the timing, composition, interest rates , price allotment and floating cost for new issue.

In the 1950s, Century Textiles, Tata Steels, Bombay Dyeing, National Rayon and Kohinoor Mill were the favourite scrips of speculation. The securities were unchecked and they flourished, the stock market came to be known as *satta bazar*. Despite being rampant, non-payment and default were

not frequent. Due to various issues and preventive measures the Government of India enacted the Securities Contract (Regulation) Act in 1956 to regulate and control the stock market.

In the 1960s, there were war and drought in the country which led to bearish market movement. The trend in the bearish market movement in this period led to the ban of forward trading and *badla*, technically called 'Contract for clearing'. *Badla* provide a mechanism for carrying forward position and for borrowing fund. The first mutual fund of India, the Unit Trust of India (UTI) came into existence in 1964.

In the 1970s, *badla* trading was resumed under the guise of 'hand-delivery contract- a group'. The capital market revived. Another setback arose on July 6, 1974, when the government promulgated the Dividend Restriction Ordinance, restricting the payment of dividend by companies to 12 percent of the face value or one third of the profits of the companies that can be distributed as computed under section 369 of the Company Act. The 1980s witnessed an explosive growth of the security market in India. Many investors jumped into the stock market for the first time when the government's liberalisation process initiated during the mid-1980s. The decade of the 1980s was characterised by an increase in the number of stock exchange, listed companies, paid-up capital and market capitalisation.

The 1990s was an important decade in the history of capital market of India. Liberalisation and Globalisation were the new terms introduced and performed in this decade. The capital Issues (control) Act, 1947 was repealed in May 1992. The decade was characterized by new industrial policy and

emergence of the SEBI as a regulator of the capital market. The Indian stock market witnessed a sea change in term of technology and market prices. Technology brought radical changes in the trading mechanism. The Bombay Stock Exchange was challenged with a national wide competition by two new stock exchanges – the Over the Counter Exchange of India set up in 1992 and The National Stock Exchange in 1994. Later, the National Securities Clearing Corporation (NSCC) in 1995 and the National Securities Depositories Limited (NSDL) in 1996 were established as the clearing house and security depository institution in the country.

1.5 Market movement of Major stock exchange in the World

The movement of selected indices present in the table 1.1 shows a witness of positive trend over the period of 2014-15 in the Indian and foreign market. Hang Seng and Nikkei 225 witness a robust growth in this period with 27.10 percent and 36.46 percent respectively. The performance of the Indian securities market witnessed a positive growth over the period in 2014-15 with more than 20 percent growth rate in both NSE and BSE. All the markets were closed in green colour over 2014-15. The indices FTSE of UK had the least growth during this period with a percentage change of 2.66 percent over the period.

By comparing the movement of Nifty 50 and Sensex 30 for the years 2014-15 to 2015-16 the market experienced a bearish market with a negative growth of -5.20 percent lower closed value at 25606.62 level and – 4.05 percent lower closed value at 7849.80 level respectively. The year turned out to be a complicated year for an investor as the market expected returns were red that failed market expectation. Hang Seng and Nikkei 225 were affected worse with negative impact ended with lower 25.11 percent at 21067.05 point and lower 14. 62 percent at 16666.05 point respectively. Nasdaq was the only index with positive return of 0.13 percent with closed value at 4948.05. Dow Jones showed a negative growth of 14.62 percent with closed value at

7849.80. The European stock market movement also experiences bearish market over 2015-16, FTSE lost by 10.32 percent while CAC lost by 12.23 percent over the period of 2015-16 as compared to the previous year.

Table 1.1: Movement of select indices in Indian and Foreign market (as on 1 April 2016)

Index - Country	Index value as on			Change during 2014-15 (Percent)	Change during 2015-16 (Percent)
	1 April 2014	1 April 2015	1 April 2016		
Sensex 30 – India	22417.80	27011.31	25606.62	20.49	-5.20
Nifty 50 - India	6696.40	8181.50	7849.80	22.17	-4.05
Hang seng- China	22133.97	28133.00	21067.05	27.10	-25.11
Nikkei 225 – Japan	14304.11	19520.01	16666.05	36.46	-14.62
Dow Jones – U.S	6696.40	8181.50	7849.80	22.17	-4.05
Nasdaq – US	4246.62	4941.42	4948.05	16.36	0.13
FTSE – UK	6780.00	6960.60	6241.90	2.66	-10.32
CAC- France	4487.39	5046.49	4428.96	12.45	-12.23

Source : Yahoo!Finance

The movement of major stock market as on 1 April 2019 are presented in table 1.2. The movement of Indian stock market after 2015-16 arise with a gradual increase in the market value. In table 1.2, the closing value in 2017 of Sensex was 29918.40 point with an increase of 16.83 percent. It further increased to 17.52 percent with closed value at 35160.35 point in 2017-18, but the market gradually declined with 5.51 percent in 2018-19. NIFTY 50 witnessed several bull and bear market over the full period. Hang Seng and Nikkei 225 gradually increased after 2015-16 with more than 20 percent increase in return in both the indices returns. The European stock market like FTSE and CAC also experienced a market boom after 2015-16 with closed value of 7203.90 and 5283.63 respectively in 2016-17 as compared to closed value at 6241.90 level and 4428.96 level in 2015-16. Further the market movement in European region comprised stagnant

with little market growth in FTSE in 7418.20 and in CAC 5586.41 closed value as compared to the previous year. The US stock market like Dow Jones and NASDAQ market value increased rapidly after 2015-16 and further the present market value in the current period (2019) experienced a little growth in the market value.

Table 1.2:Movement of select indices in Indian and Foreign market (as on 1 April 2019)

Index - country	Index value as on			Change during 2016-17 (percent)	Change during 20117-18 (percent)	Change during 2018-19 (percent)
	1 April 2017	1 April 2018	1 April 2019			
Sensex 30– India	29918.40	35160.36	39031.55	16.83	17.52	11.01
Nifty 50 - India	9304.05	10739.35	11748.15	18.52	15.42	9.39
Hang seng-China	24615.13	30808.45	29699.11	16.84	25.16	-3.60
Nikkei 225 – Japan	19196.74	22467.87	22258.73	15.18	17.04	-0.93
Dow Jones – U.S	9304.05	10739.35	11748.15	18.52	15.42	9.39
NASDAQ – US	6047.61	7066.27	8095.39	22.22	16.84	14.56
FTSE – UK	7203.90	7509.30	7418.20	15.41	4.23	-1.21
CAC-France	5283.63	5520.50	5586.41	19.29	4.48	1.19

Source : Yahoo!Finance

1.6 Evolution of Adaptive Market Hypothesis

1.7 The Efficient Market

In the mid-1960s, Eugene Fama, a Nobel prize winning economist, introduced the idea of an "efficient" capital market to the literature of financial economics. The logic behind this theory was that the market followed in random walk behaviours, which substantially varies from the past price, meaning that the movement of the past price do not reflect the future movement which is bounded in rational pattern in the stock indices. It also believes and support that the market is rational. Although investors act randomly with irrational exuberance while the market acts rationally (Fama, 1970)

The sweeping statement indeed stimulates insight and controversy even today, which results in the development of many theories and hypothesis in the nineteenth century like CAPM(1960), APT(1976), Cox-Ingersoll-Ross theory(1985). Further, finance has witnessed an important change from a rational approach or a perfectly efficient market, proceeding to behavioural finance in the later. A behavioural finance perspective deviates from the random walk market behaviour that market are rational in nature that leaves "many degrees of freedom to deviate the rationality" (Hommes & Wageners 2009, p.218) and argues that the stock market are inefficient and the market are driven by the behavioural factor, emotional factor and social influence (Chandra 2008, p.294). According to them, sound judgement from behavioural perspective that pushes the desire to make action with critical thinking from human psychology, behaviours and mental are more important than available information (Shiller, 2003).

The Efficient market hypothesis (EMH) describes that the market is a fair game where there is no outperformer even after depth analysis using three forms of information. As such it could be impossible to gain extra-ordinary profit after being analysed through expert stock selection and market timing. Alternately, the only possibility an investor can outperform is buying a riskier investment. Samuelson (1965) and Fama (1970) indicated that the EMH are supposed to alter the share price rapidly with the availability of new information. The price of the current stock fully reflects all available information and should follow random walks (Fama. 1970).

The concept of the efficient market hypothesis was traced back to 1900 by Louise Bachelier, a French mathematician in his work 'The theory of speculative' in which he gave a notion of the principle of EMH that stock price are random in nature. Later (Cowles & Jones, 1937) suggested that forecasting and analysing done by professional investor fail to assure a large profit.

In 1953, Kendall, presented an unusual paper by examining the behaviour of stock and commodity price in search of regular cycles. The result gave a regular price cycles; the series of the outcome drew a random

number implying that successive price changes are independent of one another. In 1959, two authors Harry Robert and Osborne published a paper supporting the efficient market hypothesis (Robert, 1959). They showed that the series obtained cumulative random numbers to a time series in the stock price like roulette wheel where the outcomes are statistically independent. Osborne (1959) found that the stock price behaviour is like a Brownian motion, where movement of small particles are suspended in a liquid medium.

In 1965, Eugene Francis Fama developed an academic concept on effecient market movement. The theory was developed by Fama in 1965 in his Ph.D thesis entitled "The Behaviours of Stock Market Prices" at the University of Chicago Booth School of Business. The articles "The Behaviours of Stock Market Prices" published in a Journal of Business was the introduction of his first notation in "Efficient Market" (Fama, 1965a). (Samuelson, 1965) supported the EMH behaviours. He again published his second article entitled "Random Walk in Stock Market Price" in the same journal (Fama, 1965b). (Fama, 1965b) focussed on EMH and found empirical evidence for Random walk in the stock market. He called the theory a "fair game model". He further dividing an evidence of testing efficient market hypothesis (EMH) into three sub-hypothesis depending upon the information set involved. He published an article titled "A Review Theory and Empirical Work" and stated that "a market is said to be efficient with respect to an information set if the price fully reflects the information set" (Fama, 1970).

The modest and sensible statement of market efficiency hypothesis is that "security prices at any time fully reflect all available information". The EMH is a theory which states that the given financial market prices mirror all the available information at a given time, the "type" and "source" of information is already reflected in stock prices (Thomset, 2018). (Reilly & Brown, 2006) stated that "the prices of the securities change rapidly to the infusion of new information". (Kuepper, 2019) said that it is "investment theory, where share price reflects all the available information and constant alpha generation is possible, neither fundamental nor technical analysis can produce consistent alpha". This means that the movement of the stock price

follows a rational behaviour of random movement and historical price has no-relationship with the forthcoming movements of the price and vice versa (Harper & Jin, 2012).

As the trend of the investment is accelerating in the market, understanding the efficiency of the emerging market is important to investors. If the equity market which the investor is investing is efficient, researching to find an under-pricing and over pricing will be a futile exercise. The rational investor who can predict price could possibly beat the market but this is not true if the market is at all efficient. The only way investors can possibly obtain higher return is to invest in riskier investment.

1.8 Forms of the efficient market hypothesis

EMH is divided into three forms, namely – Weak form efficiency, Semi-strong form efficiency and strong form efficiency.

Weak form: The weak form of market efficiency states that future securities of the price are random and not influenced by the past information from the trading data. The information includes a historical sequence of price, rate of returns, trading volume data, block traders, etc. The weak form of efficiency implies that investors depending on historical rates of return and on knowledge of prior research still have no advantage with regards to understanding or predicting future expected returns.

Semi-Strong Form: The semi-strong form of market efficiency states that the stock price is reflected by the publicly known available information. This is bigger than weak form since it includes company statement, new articles and other relevant information. Here, market efficiency is reflected by current market information like price and volume as well as non-market information like price-earnings ratio, macroeconomic data, industry report, corporate announcement, dividend yield and company internal statement (Chandra, 2008). Semi-strong form implies that neither fundamental analysis nor technical analysis technique will provide a reliable or excess return. Investors who based their decision on new information from publicly available information have no advantage in above-average risk-adjusted profits from their transaction.

Strong form: Strong form encompasses both the weak and the semi-strong form, all the available information from public information as well as private sources are already reflected in the security price. If investors are gathering information from public, private and even unpublished information, he had no advantage to gain excess return as the markets are efficient. Further, Strong form efficiency is sometime referred to as "the perfect market theory".

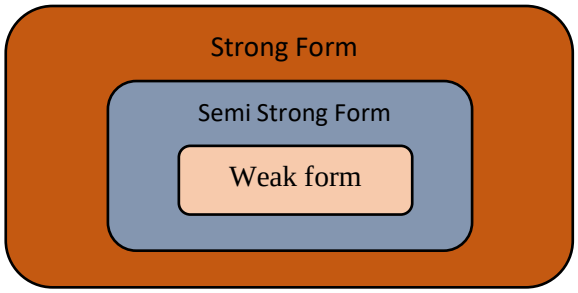

Fig.1.1 Three level of Market efficiency

1.9 Assumption of the efficient market Hypothesis:

Fama (1970) states sufficient condition for an efficient market as follows:

1. There are no transaction costs in trading rules.
2. All available information are easily available to all market participant
3. Information is unbiased and unprejudiced.
4. Market absorbed all the information quickly and effectively.
5. All market participants agree on the implication of current information for the current prices and distribution of futures for each security.

1.10 The Adaptive Market Hypothesis:

The Adaptive market hypothesis is an economic theory proposed by Andrew Lo in 2004, this theory tried to reconcile the efficient market hypothesis and the behavioural finance, creating more holistic view of markets in a larger scope. The approach is based on an influential research of Wilson (1975) in the discipline "Evolutionary psychology" in applying the

principle of competition, reproduction and natural selection to social interaction. This evolutionary approach is based on "evolutionary biology" (competition, mutation, reproduction and natural selection) rather than the law of physics that influences in the rational behaviours of the stock (Lo, 2004).

Evolution concepts have appeared on several occasions in the financial framework or background. The evolution of finance is divided into three forms viz. Traditional phase (1920-1940), Transition Phase (1940-1950), and Modern Phase (1950 and beyond). The modern phase has witnessed an accelerated pace in developing the idea and infusing knowledge in the field of financial and economic theories. (Neiderhoffer, 1997) in his tittle "The Ecology of Market" equates financial market into three, dealers as "Herbivores", Speculators as "Carnivores" and traders and investors as "Decomposers". (Bernstein, 1998) make a convincing case of active management by pointing the concept of bounded rationality, he apprehended that in a real situation or practice the market dynamic, a better explanation on the evolutionary approach.

In 1947, Samuelson tries to find out rational expected behaviour by studying the theory of individual consumer. He claimed that individual have expected utility and have rational expectation contrary to Neoclassical approach. The idea of "Bounded rationality" espoused by Simon (1955) suggests individuals are hardly ever optimal, rather they are engaged in something called "Satisfying", meaning they make a decision based on their satisfaction, not necessary optimal. Individuals are bounded in their degree of rationality. (Samuelson, 1965) and (Fama, 1970) develop another theory called the Efficient Market Hypothesis. The rational behaviours of share price rapidly reflect with the availability of new information. The price of current stock fully reflects all available information and should follow random walks (Fama, 1970).

The rationality of investors' behaviours is becoming debatable as financial theories are unable to explain the anomalies of the market behaviours. The market might be rational but human fear and greed creates

the irrational behaviour to the investors. One of the irrational returns is during the stock market bubbles. The dotcom bubbles in 1990 and the real estate bubbles in 2006 (Zhou & Sornette, 2006) drove the security price above the normal; this might be caused by the herd mentality of the behavioural biases. This further disregards the fundamental valuation (Mackay, 1841). The existence of such anomalies defies the efficient market theory. Behavioural finance focuses on the human side and psychological factor that guide us in to judgement. The sentiment of investment decision is based on "Animal Spirit" of individual (Keneys, 1936). Seldon identified that "the exchange potential price movement relies on mental attitude of investors"(Seldon, 1912). The market efficiency and inefficiency appears in regular and continuous pattern in the last five decades. This creates more ambiguity to come into conclusion.

The encounter between efficient market and the behavioural finance has an intense sound, a controversial upshot and unanimity existed to which neither side is winning in debating the rational expectation and irrational exuberance. This ambiguity and little consensus make it difficult for investors and consulting firm and investment management to give consensus to make a clear inference. Andrew Lo describes a new framework – reconciling efficient market hypothesis with behavioural finance. Here, the traditional finance and modern finance can co-exist with a behavioural perspective in an intellectual manner.

The theory (AMH) was formulated by Andrew Lo in 2004. Lo's (2004) description of the AMH can be viewed as the new variety and successor of efficient market hypothesis which took into consideration the behavioural alternative derived from "evolutionary principle". The theoretical framework attempts to merge EMH with behavioural aspects by using the concepts of bounded rationality and relevant aspect of environment, psychologist aspect of learning from Simon (1955). Lo (2005) implies that the degree or level of efficiency was not only due to the availability of information that reflects stock prices but also environmental conditions from the number of competition in the market (Market ecology).

According to Lo, “Price reflects as much information as dictated by the combination of environmental condition and the number and nature of species in the economy”. Species here meant that a collection of animals that share certain traits and behave in a similar manner. Pension funds, market makers, hedge fund behaves in common manner due to their commonalities in their legal and financial function. In AMH, the predictability of securities returns can vary from various duration which change from time-to-time due to change in market condition, market participants and financial institute. Hence, individuals adapt and learn from their mistake to earn abnormal returns in the dynamic market condition.

The research in term of academic is sceptical. It usually known and perceives the financial economics is based on quantitatively, the theory, presented in mathematical form is quite difficult. But in order to perform the test in adaptive market hypothesis, one of the available information for testable implication of Adaptive market hypothesis is based on the degree of efficiency which varies over times and the degree of market efficiency is governed by the market condition (Kim, Shamsuddin &Lim, 2011). The EMH, which assumes frictionless market contrasts AMH which relies on the law of “natural selection or Survival of the fittest” which determines the evolution of market and institution in the real world which is dynamic market condition.

1.11 Five principles of AMH

1. People act in their own interest.
2. Human beings make mistake
3. Learn from mistake, adapt and innovate.
4. The process of natural selection is based on individual and institute past outcome
5. The evolutionary process determines the market is dynamic.

1.12 Implication of Adaptive Market Hypothesis

In practical implication, quantitative implication of the AMH may be derived through a combination of deductive and inductive inference. The AMH is still in infancy, theoretical analysis of evolutionary dynamics,

empirical analyses of evolutionary forces in financial markets and experimental analysis of decision making at the individual and group level are currently under investigations to come out with a model. Even at this formative stage, the AMH yield several concrete applications for investment management and consulting.

The first implication system is the allocation decision making, unlike the stable market movement over time, AMH creates an opportunity of existence in risk and reward system. The factors of the market condition change over time. Any risk relation is affected by risk and reward through cognitive knowledge of human learning behaviour. The AMH helps in allocation of decision, first individual making mistake by investing in wrong stock, investor learn from the previous mistake and adapt to a new environment of the market condition.

Secondly, arbitrage opportunity does arise overtime in AMH. This contradicts the classical approach of EMH where buying and selling of securities opportunity renders the market static, and no investors are outperformed. The AMH implies considerably more complex market dynamics , with cycles and trends, fear, maniacs, bubbles, crash and other phenomenon that are routinely witnessed in natural market selection which create prospects to investors. The trend changes overtime and argues the bound rational behaviour of the market.

A third implication is that investment strategy will also wax and wane, well performance in one environment will probably lead to poor performance in another market. This implies that an arbitrage investment opportunity occurred; a well performance may decline for some time and then may arise profitably over a certain period of time. This is contrary to EMH where arbitrage opportunities are carried away.

The final implication of the AMH for asset allocation is that characteristics such as value and growth may behave like risk factor from time to time. Portfolio in certain period exhibits expected returns in certain period. The risk factor might change over time with no restriction on what can and cannot be a risk factor, along with so many parameters. Whether or

not the characteristic of price depend on the nature of population invested in the given point of time.

1.13 Feasibility of the study

A study on this nature had been done in various countries but meagre research has been done related to the Indian stock market especially a non-linearity trend testing. Information mainly available was related to the EMH focus on the test on random walk behaviour. The testing on the adaptive market structure was rarely done in India (Hirethmath and Kumar, 2014). There is little literature existing especially in Indian market.

The testing is sub-divided into linearity and non-linearity test that will identify the random movements along with time varying parameter with permutation to the subsample and full sample. The motivation behind this research is to determine the presence of non-linearity in time series.

The observation on the market momentum, environmental condition and market participants are also implied. The study focuses on whether AMH is appropriate to explain the behaviour of the stock return. Thus this dissertation will contribute in providing a better idea to the investigation of the degrees change over time in a half decade period span and try to respond whether the market follows different pattern of efficiency or dynamic market efficiency.

1.14 Significance and Scope of the study

The study was conducted to analyse the adaptive market efficiency hypothesis in the Indian equity market. This study will provide cognizance of investors a better idea with a clearer view that market prices do not fully reflect all available information. It is also necessary to observe the market momentum, environmental condition and market participants are taken into consideration for a market to be efficient (Lo, 2004). The study is intended to provide a hint about whether AMH is suitable to explain the behaviour of the stock return. Further, the result of the study is expected to explore the degree of efficiency change over time and the return predictability is possible in the market. The existence of little literature in linearity testing

lead to a greater attention in the study of non-linearity test. The study that tries to answer whether the market follows a different pattern of efficiency or dynamic market efficiency was important.

Testing the weak-form of efficiency in major Indian stock exchange namely Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) are both taken into condiseration for the study. Hiremath and Kumari (2014) have been one of the first that examined the market evolved overtime in Sensex and Nifty data for a period of January 1991 to March 2013 and January 1994 to March 2013 respectively. The present study further entail the nonlinearity issue that seldom receives attention in Indian indices data for a period of 5 years from 1st April 2014 – 31st March 2019.

1.15 Statement of the problem

The predictability of price is basically derived from information generating from the source (Stock exchange), information processing, and inference of dependable and relevant conclusions by using various analysis. The efficient market is where security prices adjust rapidly to the arrivals of new information. The efficiency market hypothesis is an issue for both academics and the business world. Academics seek to support the efficiency while traders aim to exploit efficiency to gain abnormal returns. It is necessary to understand whether stock market adjusts publicly available information quickly or not; whether investors can earn abnormally from their investment or not. The purpose of the study is to examine the controversial EMH. Some researchers believe the emerging equity market was efficient whereas some criticise it. Various studies have been made and hundreds of journal articles were published. Yet unable to reach consensus whether market are in fact efficient or not. The results from various studies indicate that the market is efficient in various episodes i.e. in different place with time period. Lo (2004) found that the level or degree of return certainty depends on the changes in market condition. Therefore, finding out Indian stock market follow random walk or will this market efficiency depends on time-varying needs to be answered in order to increase the literature that support the adaptive market.

1.16 Objectives of the study

1. To examine whether the Indian equity market follows random walk.
2. To analyse whether past movements have an impact on the predictibility of the future movement.
3. To examine whether the Indian equity market experience time-varying degree efficiency or episode of efficiency and inefficiency.

1.17 Hypotheses

H_0: The stock price change is dependent and price movements are random.

$H_{0:}$ The Indian equity market returns exhibit significant serial correlation.

$H_{0:}$ The Indian equity market returns is independent and identically distributed.

1.18 Research Design

a) Source of data

Data was collected from secondary sources, which are disclosed in NSE and BSE and historical data from Yahoo! Finance website.

b) Sampling unit

The Sensex 30 and Nifty 50 data consist of 1219 observations for daily returns. Weekly returns comprise of 260 observations and monthly returns comprise of 60 observations. A yearly subsample over the period was also conducted in the daily, weekly and monthly returns.

c) Period of the study

The study cover a period of 5 years i.e. 1st April 2014 to 31st March 2019.

d) Analysis of the data

The analysis is divided in to three sections in order to find the result of our hypothesis. Firstly, the analysis the data required a normal distribution. The normality test was performed using JB test. The non-parametric KPSS test was performed as the data was found to be not normally distributed. Secondly a random walk test was performed using

variance ratio and multiple variance ratio test was performed. Finally, a linearity and non-linearity test using Ljung-Box and BDS test was performed.

1.19 Limitation of the study

The study is limited to the Indian contest as it has taken BSE Sensex 30 and NSE Nifty 50 composite. Two composite will not represent the stock market movement of Indian Equity Market. The research period and the data taken for the sample period was over a short period of half a decade i.e. 5 years. The market movement and time varying returns predictibility detection could be negligible in short memory data. The seasonal effect can be evaluated by taking Semi-monthly effect, bi-annual effect and calendar effect to a broader market comprehensive. Due to time limit, the study focuses only on the daily, weekly and monthly effect.

1.20 Chapter Outline

The present study is divided into six chapters

Chapter 1: Introduction

The first chapter is about introduction of the related topic, the Indian financial market, history of Indian capital Market and Market movement of major markets are presented for clearer perspective for the readers, the history and evolution of EMH to AMH are discussed, The five principles and applications of AMH, feasibility of the study, scope of the study and limitation, the objective of the study, research design and the problem related to this research are included in chapter one.

Chapter 2: Conceptual framework in EMH and AMH

Chapter two comprises of efficient market behaviours, the review of various literatures related in India and different continent across the globe are presented, Various study on AMH and EMH are presented with tabulation.

Chapter 3: Research Methodology

In this chapter, research design, tools and technique applied are discussed. The Normality test, non- parametric unit root test, variance ratio test, multiple variance ratio test, Brock-Dechert-Scheinkman test are discussed.

Chapter 4: Data analysis and interpretation of BSE Sensex returns data.

The analysis of data related to daily return, weekly return and monthly return of Bombay stock exchange (BSE) particularly Sensex 30 were tested using various tool and technique. The purpose of the analysis was to find out the random walk movement and time bound random walk movement.

Chapter 5: Data Analysis and interpretation of NSE Nifty returns data

The analysis of data related to daily return, weekly return and monthly return of National Stock Exchange (NSE) particularly Nifty 50 using various tools and techniques was tested. The analysis was to find out the random walk movement and time bound random walk movement.

Chapter 6: Conclusion and suggestion.

In this chapter, a summary of the finding of the research on the validity of AMH in the Indian equity market was discussed. The conclusion related to the studies has drawn. A scope for further studies is also written in the last chapter.

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CHAPTER-2

REVIEW OF LITERATURE

2.1 Introduction:

This chapter begins by presenting a brief history of market efficiency. Various studies relating to random walks in Indian, Asian and various regions of the world are discussed. A review of studies related to adaptive market hypothesis in Indian equity, Asian and various regions was conducted. The summary of finding related to weak form market efficiency and semi strong form in various regions/ market are reported in Table 2.1. Table 2.2 summarizes studies conducted on AMH in Indian, Asian and other continent. Most of the studies of weak form market were conducted using the daily return data. Overall, the Indian market is not weak form market efficient (WFME) but there are certain condition that market follows random walks. The adaptive market arises in various market conditions like U.S. long data, Taiwan, U.K and French market.

2.2 Market efficiency

The behavioural share prices have been a paradox or enigma for academics in research i.e. "current price of the stock fully reflects all the available information". The seminal work of (Fama, 1970) gives much attention in the literature. An empirical testable form in the subject related matter is required (Jeffferis and Smith, 2004) to provide an opportunity for analysing efficiency in both emerging and developing market (Antoniou, Ergul & Holmes, 1997). Later, the most convincing with regard to testing was formulated into three forms of market efficiency viz weak, semi-strong and strong form in 1970.

In the mid-1960s, market efficiency got recognition in the work of (Bachelier, 1900), his novel concept on stochastic analysis. The work done by Bachelier was further replicated and over took in regard to empirical testing in various stock markets. A study was conducted in US stock by Cowles & Jones in 1937. The empirical result exhibits some random pattern over four and half years data analysed. By the end of 1940, there was scattered evidence that market follows random walks. Samuelson in 1965 postulates a theoretical framework on the Random Walk Model (RWM) by providing a rational and scientific explanation to the phenomenon by way of postulating a

model. This is one of the stepping stones regarding efficient market theory. In 1965, a scholar Eugene Francis Fama in his PhD thesis entitled "The behaviours of stock market prices", published in the *Journal of Business* the notation in "Efficient Market" was introduced (Fama, 1965a). Later, he again published his second article entitled "Random walk in Stock Market Price" in the same journal (Fama, 1965b). Finally, in 1970 he also published a paper entitled "Efficient capital market: A review of theory and empirical work" and further reviewed the theoretical and empirical literature on the efficient market model and came up with three relevant subset in support of the theoretical framework to prove the efficient market hypothesis. First is the weak form test of information related to historical price; second is the semi-strong form test of information related to price available information and historical price; and strong form test of information related to all public, private of any relevant price information.

2.3 Studies conducted in India

The issues on weak efficient market arise after (Fama, 1970) paper and there have been a lot of research in this related topic across the globe over five decades. In 1977, Sharma and Kennedy ran a test in India, U.S and London market and found the random walk behaviour in the selected markets; the hypothesis was accepted by using Runs test. (Bernes, 1986), (Sharma and Mahendru, 2009) and (Gupta and Gedam, 2014) found the same result by applying run test in Malaysian stock exchange and Indian Stock Exchange (BSE) over various period. But, the study conducted by (Khan, Ikram and Mehtab, 2011) found different result using a Run test; and rejected the weak form efficiency in Indian equity i.e., BSE using the same tools over the period from 1st April, 2000 to 31st March, 2010.

In India various studies related to the efficiency market hypothesis using both parametric and non-parametric test like Run test, K-S test, PP test, KPSS test, serial correlation, etc, were conducted. The various researchers have empirically tested the EMH using daily, weekly or monthly data. The EMH was rejected by Srinivasan (2010), Khan, Ikram & Mehtab (2011), Haroan and Jin (2012), Kumar & Kumar (2017), Kumar & Jawar (2017), and

Malafeyev, Awasthi, Kamberkar, & Kupinskaya, (2019). The finding of the above studies show that the Indian market follows non-random walk and an investor can earn abnormal returns. However, Sharma & Kenedy (1977), Poshakwale (1996), Sharma & Mahendru (2009), Jain & Jain (2013), Nalina & Suraj (2013), Gupta & Gedam (2014) and Mishra, Mishra & Smyth (2015) accepted the random walk. The finding of Gupta and Yang (2011) can give an idea that the market efficiency existed in an inconsistent manner. In their study, Gupta and Yang (2011) accepted the weak form hypothesis for the period from 1997-2007 while for the 2007-2011 periods the weak form hypothesis was rejected. Parulekar (2017) also studied the random walk and found that the market would be efficient in the medium and long run however it is inefficient in the short run.

2.4 Studies Conducted in Asian Region

Stationary test to find the variable data is stationary or non-stationary was conducted by Huang (1995) in Asian stock market and found a mixed result where random walk is accepted in Indonesia, Japan and Taiwan while it is rejected in Hongkong, Korea, Malaysia, Singapore, and Philippine. Later, Chang and Ting (2000) rejected the random walk movement in Taiwan stock market using variance ratio test. Huang (1995) found that as the market shows efficiency and inefficiency over the time period, the monthly and yearly data follow random walk while the weekly data rejected the random walk. Abrosimova, Dissanaikeand and Linowski in 2002 studied the Russian stock market using Variance ratio test, ARIMA, and GARCH. They found a mixed result in the stock performance in terms of daily, weekly and monthly. A multivariance ratio test conducted over fifteen emerging market carried the same result too (Karemera, Ojah & Cole, 1999). Budd (2012) rejected the EMH in Saudi Arabia Tadawul Stock Exchange over a period of 2007-2011. The Run Test and Variance Ratio Test were employed to examine various market commodity and found each of the market to be in weak form and inefficient in behaviour (Mittal and Thakral, 2018). So the behaviour of market follows some trend, time varying predictibility occurs, and is more adaptive than the traditional EMH (Shahid and Sattar, 2017).

Moustafa (2004) examined the movement of stock price in United Arab Emirates (UAE) market and found the weak-form in the market too. Asiri (2008) measured the behaviour of stock market in the Bahrain stock exchange (BSE) and result observed was in support of efficiency in the weak form. However, the test done by Omar, Hussain, Bhatti & Altaf (2012) on random walk theory in Karachi Stock Exchange could not find consistency to efficient market behaviour.

Worthington & Higgs (2005) suggested contrasting scenario between developing market and developed market in the market efficiency. They did not find market efficiency in developing market such as India, Indonesia, Sri Lanka, but found efficiency in developed market such as Hong Kong, New Zealand and Japan that follow the random movement in a weak form. Their findings were consistent and similar to the finding of Kim & Shamsuddin (2008) using multiple variance ratio test. Kim & Shamsuddin (2008) found that behaviour of the stock return predictability of market fluctuate over time. Kim, Shamsuddin & Lim (2011) found the efficient market is adaptive in nature in which return predictability changes over time which is driven by the market condition. They showed that during the political and economic crisis, the predictability of return is high while during bubbles period are uncertainty.

Nasir & Narif (2012) conducted a test on the weak form of efficient market in South East Asia. Stock exchanges from India, Pakistan, Bangladesh and Sri Lanka were taken for the study. They found that market is inefficient in the weak form. Budd (2012) examined the EMH and Random Walk Hypothesis (RHW) in seventeen sector of the Saudi Arabia Tadawul stock exchange and found them to be inefficient. Almujamed,

Fifield & Power (2018) rejected the EMH as observed in the empirical test in the Kuwait Stock Exchange (KSE).

2.5 Studies conducted in various regions

The EMH were studied in various regions of the world such as Gilmore & McManus (2003) in Central European market; Magnus (2008) in Ghana; Dimas &Milos (2009) in Romania; Kilic & Bugan (2016) in Turkey; Ameanu and Cioca (2014) in Romania; Erdem & Ulucak (2016) in G7 countries ; Khrapko (2013)in Ukraine; Borges (2010) in European countries; Boya (2019) in France; Ndubuisi and Okere (2018) in Nigeria; Almujamed, Fifiled &Power (2008) in Kuwait; Huang (2019) in United States, etc.

Magnus (2008) rejected the weak-form efficiency in a study of the Ghana Stock Exchange. Ameanu and Cioca (2014) testing the EMH in Bucharest Stock Exchange found invalid and opined that abnormal return can be earned by investors. Examining the information efficiency and integrations simultaneously for select Asian and US stock market, Seth and Sharma (2015) rejected the EMH. Erdem & Ulucak (2016) examined the validity of EMH on the interconnection relationship among G7 (Canada, France, Germany, Italy, Japan, United Kingdom, and United States) countries using Bootstrap causality test and found EMH to be valid among each G7 countries' stock exchange markets. They also observed existence of the benefit of portfolio diversification among these markets.

The study conducted by Khrapo (2013) in the Ukraine stock market found mixed result depending on the type of test used. The weak form was accepted using I.I.D test. The test using Bartel test, Runs test, Mann-Kendall test and Inversions test did not reject the EMH while Lo-Mackinlay variance test rejected the EMH. Borges (2010) also provided a mixed result on the level of efficiency of the six stock market efficiency in his findings. In Germany and Spain the findings supported the EMH; in UK and France the EMH was rejected; in Portugal and Greece EMH was rejected, however, the two countries have been approaching martingale behaviour after 2013.

The daily and weekly data was tested by Gilmore & McManas (2003) using ARIMA and GARCH model. The result suggested that random walk

is followed in central European market over the period of 1989-1995. Linearity and non-linearity tests conducted over the period of nine years (2000- 2009) suggest that predictibility regarding information efficiency is consistent in Romanian stock market (Dimas & Milos, 2009). But, the null hypothesis in the same market was rejected in the entire test employed i.e Unit root test**,** JB test, Multiple Variance ratio Test and GARCH Model over a period of 2002-2014 (Armeanu & Cioaca, 2014). The stationary test conducted by Mweni, Njuguna & Okech (2016) in daily and weekly data over a period of seven years (2008 -2015) rejected the hypothesis in Kenyan market and found to be weak form inefficient. No strong evidence on calendar was found on all the four countries examined (Rossi & Gunardi, 2018). So the market follows some period of efficiency and some period of inefficiency and the period seem to improve in recent year (Andabai, 2019).

The studies conducted in various market condition related to the efficient market hypothesis was presented in table 2.1

Table 2.1: Studies conducted on market efficiency in various markets

Sl. No.	Authors	Country/ Market	Period	Data (Stock/Indices	Test Used	Conclusion /Result	EMH
1.	Sharma & Kennedy (1977)	BSE, NSE and LSE	1963-1973	Monthly	Run test, Spectral Density test	The run test for all indices follow random test. The spectral density test confirmed randomness and periodicity was present.	Accepted
2	Bernes (1986)	Malaysian Stock Exchange	1974-1978	Stock and index data	Autocorrelation, Run test	The result exhibit weak form efficient in the market	Accepted
3.	Huang (1995)	Asian 9 Stock market	1 Jan, 1988 – 30 Jun,1992	Weekly return	Variance ratio test	Random walk is accepted in Indonesia, Japan and Taiwan while rejected at Hongkong, Korea, Malaysia, Singapore, Philippine	Mixed
4	Poshakwale (1996)	Bombay Stock Exchange	2nd Jan, 1987- 31st Oct,1994	Daily Closing	Kolmogorov Smirnov (KS) test, Runs test, Serial corelation coefficient test	The result of the test (Run test and Serial Correlation coefficient test violate the nature of random walk in BSE	Rejected
5	Karemera, Ojah,	15 Emergin	1986- 1995	Monthly data	Multi-Variance	Ten out of fifteen follows random walk in MVRT,	Mixed

	& Cole (1999)	g Market			ratio test, Variance ratio test, Runs Test	nine out of fifteen flows random walks in Runs test and six out of fifteen follows in VR test.	
6	Chang & Tinge(2000)	Taiwan's Stock Market	9 Jan 1971 -6 Jan, 1996	Weekly, Monthly, Quarterly, Yearly	Variance ratio test	The random walk hypothesis cannot be rejected in monthly, quarterly and yearly but rejected in weakly data	Mixed
7	Abeysekera (2001)	Colombo Stock Exchange	Jan 1991-Nov 1996	Daily, weekly, Monthly returns	Run test, Autocorrelation test and Unit root test	The Empirical reject the random walk in the weak form	Rejected
8	Natalia, Gishan, & Dirk (2002)	Russian Stock Market	1 Sep, 1995 – 1 May, 2001	Daily, Weekly and Monthly closing data	Unit root, Autocorrelation, Variance ratio test, ARIMA, GARCH	The Weak form efficient accept in monthly but rejected in both daily and weakly	Mixed
9	Gilmore & McManus (2003)	Central European Market	Daily and Weekly data	1989-1995	Serial correlation, ARIMA and GARCH	The empirical results suggest that RW was followed by three central European markets. i.e., Czech Republic, Hungary and Poland	Mixed
10	Islam & Khaled (2005)	Dhaka Stock Market	1990-2001	Daily, weekly, monthly	ADF test, Variance ratio test, Box-pierce Test	The conflicting weak form efficient gave evidence on 4short term p5redictibility prior to 1966 boom.	Rejected
11	Worthington & Higgs (2005)	Asian Emerging and Developed Equity market	Varies from different equity market	Daily data	Serial corelation coefficient and runs test, ADF test, PP test, KPSS Test, Multiple Variance ratio test	The Asian markets are weak form inefficient. Hongkong and New Zealand satisfy the random walk. Japan satisfied strict random walk	Efficient and ineffi cient
12	Asiri (2008)	Bahrain Stock Market (BSE)	1st Jun, 1990- 31st Dec, 2000	Daily closing	Unit Root test, Dickey - Fuller test, AIRMA and Exponential smoothing	The unit root and Dickey fuller test result obtained BSE follows random walk and ARIMA and Exponential smoothing also provide evidence weak form efficiency.	Accepted
13	Dimas & Milos (2009)	Romanian Stock Market	2000-2009	Daily	BDS test, Correlogram, ADF, KPSS, ERS	The empirical evidence regarding information efficiency is consistent in Romanian stock market	Accepted
14	Sharma & Mahnedr	Indian Securities Market	July, 2007-Oct 2007	Weekly closing	Runs test, Autocorrelation test	Although, the runs test is difficult to a definite conclusion , both the test	Accepted

	u (2009)	(BSE)				provide evidence on efficient in the weak form	
15	Gupta & Yang (2011)	Indian Capital Market (BSE and NSE)	1997-2011	Daily and weekly closing	ADF Test, PP Test and KPPS Test	The weak for effecient was accepted in the later sub sample in all the test but inefficient in the earlier stage	Mixed
16	Khan, Ikram, & Mehtab (2011)	Indian Capital Market (BSE and NSE)	1st April 2000- 31st March 2010	Daily closing	Runs test	Both the NSE and BSE do not follow random walks neither weak form efficient	Rejected
17	Budd,B. Q., (2012)	Saudi Arabia Tadawul Stock Exchange	April 2007-May 2011	Daily closing	Variance ratio Test, Run test,	Price fully do not effected to the available information as independent price movement neither distrusted randomly,	Rejected
18	Harper, A., & Jin, Z. (2012)	Indian stock Market (BSE)	July 1997-Dec 2011	Daily closing	Autocorrelations and Run test	It was found that the Indian market is not efficient in the weak form	Rejected
19	Patel, Radadhia, & Dhawan (2012)	Asian Stock Market (SSE, BSE, HANGSENG and NIKKEI	1st Jan, 2000- 31st Mar, 2011	Daily Closing	Run test, Unit root test, variance ratio and Auto correlation.	Unable to provide evidence on the weak form efficacy over full sample and sub-sample period	Rejected
20	Jain & Jain (2013)	Indian Stock Market(BSE &NSE)	April 1933-March 2013	Daily closing	Run test, Auto corelation test, Dickey - Fuller Test	The test result in all the three suggest the index follows a random walk and exhibit weak form efficient	Accepted
21	Eddien & Ananzeh (2014)	Amman Stock Market (ASE)	Jan 2003-Dec 2013	Daily Closing	ACF test, Run test and Unit root Test	The result from the three test suggest weak-form inefficient in stock returns	Rejected
22	Armeanu & Cioaca (2014)	Romania Capital Market (BET index)	1st Jan, 2002-15th May, 2014	Daily Closing	Unit Root test, JB test, Multiple Variance ratio Test and GARCH Model	The null hypothesis is rejected in the entire test employed. The market is not weak-form efficient.	Rejected
23	Gupta & Gedam (2014)	Indian Stock Exchange (NSE)	1st Jan, 2014- 31st March 2014	Daily Closing	Run test	The market is weakly efficient in most of the case except Tech Mahindra	Accepted
24	Chishti, Chaudhary, & Afzal (2016)	Pakistan Stock Market (PSX)	3,Jan 2000- 31, March 2016	Daily	ADF, PP, KPSS, Ljung-Box test	The KSE-100 returns do not follows a random walk, so abnormal returns are possible.	Rejected
25	Kilic & BUĞAN	Turkey Stock	Jan 2003 - Sep 2015	Daily Closing	Harvey *et al* (2008)	Weak form efficiency was accepted in KPSS test,	Mixed

	(2016)	Exchange (ISE national Index)		data	Linearity test, Kapetanios et. al(2003) non-linearity, Unit root	Kapetanios et. al(2003) test accepted weak form efficient while Kruse(2011) rejected the random walk.	
26	Njuguna (2016).	Nairobi Securities Exchange	Feb 2008-Jan 2015	Daily and weekly data	Unit root test (ADF and PP test), Run test	The empirical finding suggest that test reject the hypothesis and Kenya market are found to be weak form inefficient	Rejected
27	Awan & Subayyal (2016)	Gulf Stock Market	Jan 2011 - Dec 2015	Daily closing data	Run test, Auto corelation test	The serial corelation in all the stock at different lag reject the hypothesis, the parametric test rejected the random walk	Rejected
28	Kumar & Kumar (2017)	NSE Midcap	Sep 2015 - Nov 2014	Daily closing data	Autocorrelation, Q-statistic, Runs test	The result suggested that the investor are able to earn abnormal profit, as the midcap price do not reflect to the available information	Rejected
29	Shahid & Sattar (2017)	Pakistan Stock exchange	Jan 1992-Dec 2015	Daily returns data	GARCH(1, 1), Kruskal Wallis test,	The behaviours of all the calendar effect anomalies are time varying over time. The KSE-100 can be describe as more adaptive in nature than traditional EMH	Mixed
30	Amelot, Ushad, & Lamport (2017)	Mauritius Forex Marekt - EUR/MUR, USD/MUR,GBP/MUR and JPY/MUR	Jan 2012 - Dec2016	Daily closing data	ADF test, PP test, Johansen Cointegration test, Granger Causality test, variance Decomposition	The empirical result using Unit root test accept the hypothesis. Overall, the Mauritius foreign market is weak form effcient	Accepted
31	Hallunov (2017)	Indonesia Stock Exchange	Data of all traded company	Monthly data	Augmented Dickey fuller test, Granger causality test	The efficiency cannot be predicted fully and difficult to understand because it a matter of economic behaviour	Rejected
32	Hamid, Suleman, Ali Shah, Akash, & Shahid (2017)	Asian Pacific Market	Jan 2004 - Dec 2009	Monthly Data	Autocorrelation, Ljung-Box test, Runs test, Unit root test and Variance ratio test	The Asian Pacific Market does not follow random walk in the market. No one in the market in the market flows weak form Efficient	Rejected
33	Kumar & Jawa (2017)	Indian Stock Market	Jan 1995 - Dec 2015	Daily and monthly	Dummy variable multiple	The study reveals the existence of calendar effect especially Wednesday	Rejected

		(NIFTY 50)		returns	linear regression technique, OLS, EGARCH	effect and December effect still exist.	
34	Almujamed, Fifield, & Power (2018)	Kuwait stock exchange	1988-2011	Weekly	Filter test,	The KSE follows certain patterns and trends, which means not weak-form efficient	Rejected
35	Rossi & Gunardi (2018)	Four European Market (French, Germany, Italy and Spain)	2001- 2010 (New Millenniu m)	Daily, Weekly, Monthly	GARCH, OLS regression	No strong evidence on calendar was found on all the four countries examined	Rejected
36	Mittal & Thakral (2018)	Indian Commodity Market	2009 – 2017	Daily Spot price	Run test, ADF test, Variance ratio test	The result of all the test deployed are consistent with each other that the commodity market are weak form inefficient behaviour	Rejected
37	Firoj & Khanom (2018)	FEM of Bangladesh	Jan 2010 - Nov 2017	Spot price of FEM	Unit Root test, Cointegration test	The Foreign exchange of Market of Bangladesh is weak form efficiency by applying unit root test, but no indication of Semi strong form efficiency in FEM of Bangladesh	Accepted
38	Andabai (2019).	Nigerian Stock Market	1990 -2017	Monthly	Unit Root test (ADF), OLS	The finding shows there is no weak form efficient between 1990 to 2017 but seem to improve in the in recent time i.e., 2011 - 2014	Mixed
39	Huang (2019)	US Stock Market (S&P500)	19th oct, 1988- 18th oct, 2018	Daily returns	Modified Diebold – Mariano (MDM) test and ARIMA model,	The efficient or inefficient market depends on whether the investor calculated their loss. It not in a weak form efficiency	Mixed

2.6 Adaptive Market Hypothesis

The Adaptive Market Hypothesis was formulated by Andrew Lo in 2004. Lo (2004) state that AMH can be observed as a successor to efficient market hypothesis which took into consideration of classic EMH and behavioural alternative derived from “evolutionary principle”. The AMH, which is dynamic of evolution; competition, mutation, reproduction and natural selection determines the rational behaviours. The irrational behaviours

of institute and individual towards investment product, lead to wax and wane in the market movement (Lo, 2004).

The theoretical framework attempts to merge EMH with behavioural aspects by using the concepts of bounded rationality and relevant aspect of environment, psychological aspect of learning from Simon (1955). Lo (2005) implies that the degree or level of efficiency was not only due to the availability of information that reflects stock prices but also environmental condition from the number of competition in the market (Market ecology). According to him "Price reflects as much information as dictated by the combination of environmental condition and the number and nature of species in the economy". Species here means a collection of animal that share certain trait and behave in a similar manner. Pension funds, market makers, hedge fund behaves in common manner due to their commonalities in their legal and financial function. In AMH, the predictability of securities returns can vary from various duration which changes from time-to-time due to change in market condition, market participant and financial institute. Hence, individuals adapt and learn from their mistake to earn abnormal returns in the dynamic market condition.

As the AMH is in infancy, it is attracting attention in research (Hiremath and Kumari, 2014). A comprehensive view of market momentum, environmental and participant is required to provide whether AMH is appropriate to explain the behaviour of stock returns (Sing & Singh, 2019). Some studies like Ito and Surgiyama (2009), Kim, Lim and Shamsuddin (2010) found time varying pattern of return predictability in U.S market. Urquart and Hudson (2013) found mixed result in U.S, UK and Japan and conclude that the AMH is moving toward in these markets. Charles, Darne & Kim (2012) studied the major stock market using AVR, GS-test and DL consistent test, and suggested that the returns predictability occurs from time to time. Hiremath and Kumari (2014), Kumar (2018) suggested the Indian market switch between efficiency and inefficiency, the unpredictability and predictability occur simultaneously over time and the market are moving toward inefficient to efficient. Dash (2019), Charles & Darne (2019) experience mixed result from their findings, the change in different market condition change the random walk movement in that particular stock market.

A summary of the studies on AMH is given in the table.2.2 and explanations of the studies are provided in the chronological manner.

Table 2.2: Review of Adaptive market hypothesis in various market

Sl. No	Authors	Country /Market	Period	Data (Stock/ index)	Test used	Conclusion/ Result	EMH /AMH
1.	Ito and Sugiyam (2009)	S&P 500 (Monthly returns)	1955-2006	Monthly data	Auto-correlation	The degree of market inefficiency experience through time	AMH
2.	Kim, Lim, & Shamsuddin (2011)	U.S	Jan 1900-June2009	Daily data	Automatic Variance Ratio test, Automatic Portmanteau Test, Generalised Spectral	Cyclical evolution of return predictability	AMH
3.	Butler & Kazakov (2012)	S & P 500	2001-2010	Daily	GARCH, Adaptive Bollinger Band (ABBs), Particles Swarm optimization (SOP)	The paper compute on variable efficiency and cyclical efficiency, found that the non-linear dependence and cylical predictibility occurs	Support AMH
4.	Charles, Darné, & Kim (2012).	Foreign exchange	1975 -2009	Daily data	Automatic Variance Ratio test, Generalised Spectral test, DL consistent test.	The return predictability occurs from time to time. It follows AMH	AMH
5.	Popović, Mugoša, & Đurović (2013)	Montenegro Equity Market	Jan 2004-Dec 2011	Daily data	First order Serial autocorrelation coefficient (AC1), Runs test	The result of both the test proved time varying return predictibility	Consistent AMH
6.	Zhou & Lee (2013)	REIT	Jan 1980-Dec 2009	Daily Weekly Monthly	Automatic Portmanteau test, Automatic variance ratio test	The returns predictibility of REIT was time variation which change over time due to market condition	AMH
7.	Ghazani & Araghi (2014)	Tehran Stock market	1999-2013	Daily data	Automatic Variance Ratio test , Automatic Portmanteau Test, Generalised Spectral and Mcleod-Li test	All the test suggest that market movement is consistent with the inference of Adaptive market hypothesis	AMH

8.	Hiremath and Kumarim (2014)	India Stock Market (BSE and NSE)	Jan 1991 - March 2013	Daily data	AC, Runs test, VR test, MVR test, McLeod-Li test, T-say test, ARCH - LM test, Hinich Bi-correlation test and BDS test	The linearity suggested that the Indian market experience switch between efficient and inefficient, the non-linearity test suggest the non-linearity dependent over time. As a result the Indian market is moving toward efficient	AMH
9.	Ramirez, Arellano, & Rojas (2015)	Agriculture commodities futures markets	7th July, 1994- 15th Nov, 2010	Future price	ADF test, RALS test and Hinich Portmanteau bicorrelation test	The evidence on the futures contract on 8 commodities on adaptive market hypothesis was satisfied	AMH
10	Sensoy, & Tabak (2015)	European stock market	Jan 1999-Feb 2013	Daily price	Generalised Hurst exponential	Denmark, Hungary, Italy and Finland experience efficient while Lithuania, Estonia, Malta and Bulgaria experience least efficient	Mixed
11	Madhavan & Arrawatia (2016)	G8 Sovereign Credit Default swaps and Bond scrips (SCDS)	---	Daily Closing	ADF Test, Rolling Hurst Exponent Technique, AR-GARCH(1,1)	Of all G8 countries, US was the only country which exhibit the long memory structure. Apart from that other countries. Overall there is a disenable degree of market efficiency	AMH
12	Noda (2016)	Japanese stock Markets (TOPIX and TSE2)	Oct, 1961-Dec,2015	Monthly Returns	Time varying First orders Autocorrelation, Autoregressive Model	The empirical result in the Japanese stock exchange show the market efficiency change over time in both TOPIX and TSE2.	AMH

13	Almail & Almudhaf (2017)	UK stock market and Currency	April 1779 - April 2016	Daily stock price	Auto Variance Ratio test, AQ	Evidence of adaptive market	AMH
14	Charles, Darné, & Kim (2017)	Dow Jones Islamic	1996- 2013	Daily closing data	AQ, Variance Ratio test	High degree of information efficient than conventional. the stock returns follows AMH	AMH
15	Numapau (2017)	Ghanaian Stock Exchange	Jan 2011- Aug 2015	Daily closing price	Generalised Spectral test, Automatic Portmanteau Box-Pierce test , Wild-bootstrapped, automatic variance ratio test	Based on the investigation on both index in Ghana stock exchange - Ghana composite index and Ghana Financial index found the result consistent with AMH	AMH
16	Neely, Weller, & Ulrich (2017)	Foreign Exchange Market	1981-2005		ARIMA	Consistent with adaptive system subject to evolutionary pressure.	AMH
17	Rojas (2017)	Mexican Stock Exchange (IPC)	3, Jan 1994- 31 Dec 2015	Daily Return	Unit root test, Tsay and LM non-linearity test, BDS test	The market behaves in a random followed by a period of adaptability over a period, where non-linearity in the series were found.	AMH and EMH
18	Soteriou & Svensson (2017)	Stockholm Stock Exchange (OMXS30)	Oct 1986 - Oct 2016	Daily	Variance ratio test, BDS test	the empirical results find evidence on predictability in the Swedish stock market fluctuates over time, opposed to previous the study on the Swedish market conducted by Frennberg and Hansson (1993)	AMH

19	Brito-Cervantes, Morales-Garcia, Coronado, & Rojas (2018)	Mexican Stock exchange	1982-2015	Daily price	Linear and non-parametric Granger Causality , Cross Bi-correlation test	BH test give evidence of AMH with 71.42 of non-linearity at certain point of time. CBC with non-linearity causality 25.51 percent and DP test with 48.57 non linearity.	AMH
20	Charfeddine, Khediri, Aye, & Gupta (2018)	Two developed (U.S., UK) and two emerging (Africa and India)	216 yrs for U.S. 84 yrs for U.K , 157 yrs for Africa and 217 yrs for India	Monthly Bond	Long Memory estimation method, Multiple Break structural Break technique and GARCH- M	Results show that efficiency of these markets has been changing over time, depending on the prevailing economic, political and market conditions. Further, the observed in weak-form efficiency in those markets has been gradually improved. results suggest that the AMH provides a better description of the behavior of government bond returns as compred to Efficient Market Hypothesis (EMH).	AMH
21	Khuntia & Pattannayak (2018)	Bitcoin Market	July 2010 – Dec 2017	Daily	Augmented Dickey fuller(ADF), ARCH-LM, Ljung-Box-Q,	The study verifies the movement on the evolving efficiency of bitcoin and found dynamic proportion of AMH was adhere in the movement of the bitcoin	AMH
22	Ndubuisi & Okere 2018)	Nigeria Capital Market	Jan 1987-Dec-2016	Daily data	Autocorrelation test, Run test, Variance ratio test, Mcleod-li test, Engle LM test, BDS test	Evidence from the linearity test supports the AMH, while the non-linearity test indicated nonlinear	Acce pted

						independent i.e. Inefficiency. while the inefficiency was not declined over time	
23	Kumar (2018)	Indian Exchange rate to US, Great Britain, Euro and Japanese Currency	1999-2017	Daily closing data/price	AVR, VR BFC(2004)	Volatility of Martingale approach in related US dollar and Japanese yen. And unpredictability and predictability are occurring alternately over time	EMH /AMH Mixed
24	Xiong, Meng, Li, & Shen (2018)	China Stock Market	Since established - December 2015	Daily closing	GARCH (1,1), Rolling windows analysis	The paper examines four calendar effect, based on the empirical finding the calendar effect perform excess return over time that suggest AMH give a better explanation.	AMH
25	Akhter & Yong (2019)	Dhaka Stock Exchange	Jan 1995 – Dec 2018		J-K Momentum Strategy	Momentum profit in different market condition and time varying behaviour that support the existence of AMH was found	AMH
26	Dash (2019)	20 Major stock in India Banking	April 1, 2017- March 31, 2018	Daily Closing Price	ARMA (Auto regressive moving average)	Not follow pure random, some scope of randomness in log-return series.	Mixed
27	Boya (2019)	French Stock market	1988 -2018	Daily closing price	Variance ratio test	The finding of the test suggested that the AMH give a better result to read French Market	AMH
28	Charles & Darne (2019)	Chinese Stock Market	1992-2007	Daily data	VR, [Chow-Denning(1993)Wang and Kim(2003 and Kim test(2006)	Shenzhen Stock market do not follow RW and Shanghai stock market seem more efficient	Mixed

29	Shah & Bahri (2019)	US, Hong Kong and India	July 1997-June 2018	Daily closing data	Ljung-Box and Chow-Denning, VR	Time varying risk premia and changing return varies overtime	AMH
30	Trung & Quang (2019)	Vietnamese stock market	2006- 2018	Weekly returns	Auto correlation and Time varying auto regressive test	The empirical result proof evidence of AMH in Vietnamese stock exchange, Ho Chi Minh city Stock exchange (HSX) serve as an important factor for AMH	AMH
31	Ghazani & Ebrahimi (2019)	3 Global oil Market: West Texas Intermediate, Brent and OPEC basket crude oil	Jan 2013-March 2018	Daily Closing	Generalised Spectral and Automatic Portmanteau Test	West Texas intermediate and Brent market condition witness similar feature with AMH while OPEC basket date decline the conformity of AMH. The market is inefficient throughout the time	Partially AMH
32	Zhu (2019)	Chinese Stock Market (Shenzhen Composite index and Shangngai Composite Index	January 1992 -Jan 2017	Daily and weekly data	Autocorrelation test, Variance ratio Test, ARIMA model test and Risk returned relationship test.	The whole result in the Chinese stock exchange is inefficient over time. The sub sample analyses tend to find out the market efficiency over numerous period. This time varies market efficiency support the AMH	AMH, EMH over the sub sample.

2.7 Studies Conducted on AMH in India

The study conducted in India is very limited in term of literature. As far as our knowledge is, there was no study conducted in this kind of hypothesis before 2014 in India (Hiremath & Kumari, 2014). Hiremath & Kumari (2014) studied the AMH using the linear test including autocorrelation, runs test and multiple variance ratio tests and observed the

linear dependence of Indian equity market. The finding suggested switching of behaviour of the market between efficiency and inefficiency. On the other hand non-linear test including Mcleod-Li, ARCH-LM, Hinich bicorrelation and BDS suggested that the predictability of returns was uncertain during financial crisis and market bubbles. Overall, the Indian market was not fully adaptive as it follow single period of efficiency however the Indian market was moving toward efficient. Similar results were found in the study conducted by Hiremath & Narayan (2016) using the Generalized Hurst Exponential in which the Indian stock market was moving toward efficiency.

A study conducted by Kumar (2018) examines Indian exchange related to US, Great Britain, Euro and Japanese currency, using Automatic Variance ratio, Belaire-Franch and Contreras (2004) test to examine adaptive market hypothesis. This provides evidence for the predictibility of the Indian Market occurs from time to time and depend upon the macroeconomic events (recession, market crash, crisis bubble etc). Dash (2019) performs auto regressive moving average and finds a clue for adaptive nature in the market of the Indian banking sector, and further finds some form of randomness in log- return over the series but in general it follows non-random.

2.8 Studies Conducted on AMH in Asian Region:

Both the linear and non-linear tests were conducted to find out any change in market efficiency and any change in market behaviour overtime. A linear and non- linear test was conducted by (Ghazani &Araghi, 2014) in Tehran stock market in Iran during the period of 1999-2013. All the test

included Automatic Variance Ratio test, Automatic Portmanteau Test, Generalised Spectral and Mcleod-Li test found that market movement is consistent with the inference of Adaptive market hypothesis. The degree of market return predictibility approach was employed by Noda (2016) over Japanese stock market as it found the same result. A rolling window analysis over a long period to determine the long run data was conducted by Xiong, Meng & Shen (2018) in Chinese market, based on their studies of the calendar effect perform excess return over time that suggests AMH gives a better explanation in the chines market.

A study on momentum strategy was conducted over a period of twenty-three years (1995 -2018) by Akhter & Yong (2019) in Dhaka Stock exchange and found that momentum profit was different in market condition and the period varies overtime. They suggested that the market is moving toward adaptive behaviour. A random walk hypothesis was conducted by Charles & Darne (2019) in Chinese stock market and found that Shenzhen Stock market do not follow RW and Shanghai stock market seem more efficient. Trung & Quang (2019) conducted a study a time varying approached in Vietnam stock market using auto regressive and auto-correlation test for a period of 12 years, suggested the empirical result in Vietnamese stock exchange is adaptive in nature. It further states that Ho Chi Minh city Stock exchange (HSX) serves as an important factor for AMH. A degree of efficient and moving window method by (Xiong, Meng & Shen, 2018), (Zhu ,2019), (Boya , 2019) using different tools like Auto correlation , Variance ratio test, ARIMA, cross relationship and rolling windows analysis found market efficiency over numerous period. The testing on AMH in Asian

market are found to be relevant and applicable as the result through various studies conducted was consistent with the adaptive market hypothesis propounded by Lo (2004).

2.9 Studies conducted on AMH in various regions

In 2009, Ito and Sugiyam conducted a study in U.S stock market over a long memory data using auto correlation, AR Model and State space model, the result suggests that market follow inefficient through time. The U.S market is inefficient over during the late 1980s and mostly efficient at around 2000 or at a later half of a century. Return predictibility during market crashes, bubbles and economic and political crisis has uncertainty in the predictibility of the market (Kim, Lim and Shamsuddin, 2011). Butler & Kazakov (2012) published a paper in the same topic but employing different tools likes GARCH, Adaptive Bollinger Band (ABBs), Particles Swarm optimization (SOP) over a period of 9 years (2001-2010). The paper computed on variable efficiency and cyclical efficiency; found that the non-linear dependence and cyclical predictibility occurs that support adaptive behaviours.

First order Serial autocorrelation coefficient (AC1) was conducted by Popović, Mugoša. &Đurović (2013) suggest time varying predictibility in Montenegro equity market. A long- term memory time series analysis using Generalised Hurst Exponential was conducted in European market and found different market condition and the return predictibility was varied in over different countries (Sensoy &Tabak, 2015). A degree of efficient, regressive and rolling hurst, exponential moving of daily closing price was conducted

by Madhavan & Arrawatia (2016) also suggest that of all G8 countries, US, Japan, French and Russia are more efficient while Italy, German and Canada are less efficient Overall there is a disenable degree of market efficiency. Almail & Almudhaf (2017) conducted a linear test in UK stock market over a period of 1779- 2017 and gave evidence of time varying degree of efficiency. A non-linearity test BDS test suggests the predictibility of stock market fluctuates over time (Rojas, 2017; Soteriou & Syenssor, 2017) and exhibit some form of non-linear dependence over certain period of time (Brito-Cervantes, Morales-Garcia, Coronado & Rojas, 2018).

Long memory estimation method, Multiple Break structural Break technique and GARCH- M results show that efficiency of these markets has been changing over time, depending on the prevailing "economics, politics and market condition" (Charfeddine, Khediri, Aye & Gupta, 2018). Long memory test from Nigerian Capital market evidence from the linearity test supports the AMH, while the non-linearity test indicated nonlinear independent i.e. Inefficiency. while the inefficiency did not declined over time (Ndubuisi & Okere, 2018).

2.10 Research Gap

Existing researches and studies on market efficiency had been done in weak form using different model from traditional models to advance statistics. At the same time, agreeable accounts on whether the market is neither efficient nor inefficient could not be drawn, but mixed result (Al-khazali & Mirzaei, 2017). Worthington & Higgs (2005), Borges (2010), Gupta & Yang (2011), Kapoor (2017) and Parulekar (2017), found evidence

the efficient market is mixed. Srinivasan (2010), Khan, Ikram & Mehtab, (2011) Dsouza(2018) and Malafeyev, Awasthi, Kamberkar, & Kupinskaya, (2019) found the Indian market was weak form inefficient. While Poshakwale (1996), Jain & Jain (2013), Nalina & Suraj (2013) and Mishra, Mishra & Smyth (2015) suggested the existence of weak from of efficiency in the Indian stock market.

This contradictory result provides that there was an existence of seasonal predictibility of the future price through past stock price. The literatures also provided market efficiency is characterised by the changing sequence overtime (Shah & Bahri, 2019; Almail & Almudhaf 2017; Zhu, 2019). This means that the market is adaptive in nature. So, testing the linear relation along with nonlinear relation in the Indian equity market would be able to provide the existing literature that support or contradict. It is apparent that studies on weekly and monthly effect especially in Indian market were not conducted. The non-linearity test has great much attention recent times was slightly negligible in emerging markets mainly Indian equity market as compared to other emerging markets like China, Bangladesh, Vietnam etc. Hence the present study was conducted to re-examine and contribution in extending the existing literature related to the adaptive market hypothesis in Indian major equity market i.e. Sensex 30 and Nifty 50 index over a short period of half decade.

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CHAPTER – IV

DATA ANALYSIS & RESULT

OF SENSEX 30 INDEX

4.1 Introduction

In this chapter, an analysis based on daily data, weekly data and monthly data of Sensex30 index are Presented. The analysis was conducted using various test like unit root test, variance ratio test, Ljung-Box test, and BDS test. The analysis was conducted both on the overall sample period and yearly divided subsample form the sample period to test the robustness of the different time period.

4.2 Descriptive Statistics of Sensex 30

The descriptive statistics of the daily Sensex returns are presented in the given table 4.1 below. The number of observations in daily returns over the full sample was 1219. The number of observation in daily returns for the sub-sample varies over different period, this could be due to various holiday arise in a year (see table 4.1). According to the study, the variables have positive means except in the subsample of 2015-16. A positive standard deviation was found in all the sample and sub-samples. A positive kurtosis with leptokurtic higher peak than the normal distribution was also found in all the sample and sub-samples.

The Indian market experience market crash in 2015. On 24 August 2015, the BSE Sensex 30 crashed by 1,624 points and the NSE fell by 490 points (www.Wikepedia.com) where the market continue to fall in this sub-sample. The daily returns in subsample of 2017-18 in both in the market are lowest as compared to different observed period, one of the reason could be the post-demonetization effect.

The standard deviation in daily returns was very low, it means that the market volatility was slightly negligible. The standard deviation over the sub-sample was highest in the year 2015-16, this means that the sub-sample of 2015-16 are highly volatile and risky. The result of standard deviation in all the sub sample and the full period provides a low market volatility and a little returns that spread over a wide period.

Table 4.1: Descriptive statistic of Sensex 30 Index Daily return

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full Sample	1219	0.0004	0.0005	0.0337	-0.0593	0.0083	-0.426	5.789	432.27	0.00
April 2014-March 2015	237	0.0009	0.0006	0.0291	-0.0307	0.0087	-0.051	3.879	7.75	0.02
April 2015-March 2016	244	-0.0003	-0.0004	0.0033	-0.0594	0.0107	-0.070	6.350	134.14	0.00
April 2016-March 2017	246	0.0006	0.0006	0.0227	-0.0254	0.0077	-0.077	3.898	8.52	0.01
April 2017-March 2018	245	0.0004	0.0006	0.0183	-0.0234	0.0062	-0.311	3.475	6.26	0.04
April 2018-March 2019	244	0.0006	0.0008	0.0225	-0.0225	0.0076	-0.233	3.457	4.35	0.11

Source: Computed with the use of E-view 10

The skewness is negative during the whole period, which means the return are bended towards the left in comparing to the normal distribution. The skewness is used to measure the symmetrical distribution of the data. We found the full sample and sub sample are negative. The skewness in sub-sample 2015-16 are highly skew as compared to others.

The whole sample and sub sample show leptokurtic nature, as the return of the data shows positive kurtosis, which is not normally distributed and tend to be more risky. The period of the sub-sample in BSE (Sensex30) are closed to normally distributed in 2014-15, 2017-18 and 2018-19. Normally, the normal data have a kurtosis value equal to three is indicted as normally distributed.

The JB test represents the normality for the goodness-of fit test. Since the daily distribution of returns is far away from the normal value zero hence, daily returns are not normally distributed. The sub-sample in April 2015 - March 2016 in the index is deviated highly from the normal JB distribution. The goodness of fit test found that the data is not normally distributed. So, a non- parametric test need to be conducted. But, if the data is not sensitive to normality test we can still performed the test. Moreover (Hiremath and Kumar 2014, Xiong, Meng,Li & Shen, D. (2018) had performed the test even with non-normally distributed data.

Table 4.2: Descriptive statistic of Sensex 30 weekly return

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full Sample	260	0.002	0.003	0.064	-0.066	-0.018	-0.134	3.807	7.84	0.01
April 2014-March 2015	52	0.004	0.001	0.049	-0.039	0.020	0.115	2.707	0.30	0.86
April 2015-March 2016	52	-0.001	0.001	0.064	-0.066	0.024	-0.139	3.241	0.29	0.86
April 2016-March 2017	52	0.003	0.002	0.053	-0.028	0.016	0.539	3,414	2.89	0.23
April 2017-March 2018	52	0.001	0.003	0.026	-0.036	0.014	-0.751	3.062	4.81	0.09
April 2018-March 2019	52	0.002	0.005	0.050	-0.051	0.017	-0.282	4.618	6.24	0.04

Source: Computed with the use of E-view 10

The descriptive statistics of Sensex 30 weekly returns is represented in table 4.2. The number of observations over the full sample is 52 observations. According to the analysis, the variables have positive means in all the subsample except over 2015-16 subsample. It can also be observed that positive standard deviation with low volatility in the statistics. The kurtosis are slightly more leptokurtic with medium peak suggest that the data bend toward with normal distribution. The skewness in full sample and subsample 2015-16, 2017-18 and 2018-19 are negative that fall in the left side which means the data is bend toward left, this mean the weekly data is not normally distributed. The standard deviation in all full sample and subsample are with small value which means that low volatility occurs in the study period. The JB test on the weekly distribution of returns in the full sample was not normally distributed. The sub sample of weekly returns rejects the null hypothesis in all the subsample except 2018-19. So the sub samples of Sensex 30 weekly returns are normally distributed.

Table 4.3: Descriptive statistic of Sensex 30 monthly return

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full sample	60	0.010	0.010	0.102	-0.075	0.039	-0.078	2.505	0.662	0.71
April 2014-March 2015	11	0.020	0.029	0.080	-0.043	0.039	-0.037	2.207	0.540	0.76
April 2015-March 2016	11	-0.004	-0.002	0.102	-0.075	0.049	0.0554	3.269	0.596	0.74
April 2016-March 2017	11	0.013	0,014	0,041	-0.046	0.028	-0.839	2.711	1.329	0.51
April 2017-March 2018	11	0.009	-0.002	0.062	-0.050	0.039	-0.008	1.563	0.946	0.62
April 2018-March 2019	11	0.009	0.005	0.078	-0.063	0.043	-0.071	2.237	0.276	0.87

Source: Computed with the use of E-view 10

The descriptive statistics of monthly returns are given in table 4.3. The number of observation over the full sample is 60 observations. According to the study, the variables have positive means in the entire sample except 2015-16 sub-sample periods. The monthly statistic provided a positive standard deviation with less volatility rate. The kurtosis value provide a positive value (leptokurtic) with medium peak suggest that the data are normally distributed. The skewness fall in the left side over the period except 2015-16 which means returns are normally distributed. The standard deviation in all the test data are small in all the sample and sub sample which means that low volatility occurs in the study period. The JB test failed to reject the null hypothesis at 5 % level of significance on the monthly returns, therefore the distribution of data is around the normal value zero, and hence, monthly returns are normally distributed.

4.3 Unit root test

The stationarity test required the data are in normally distributed. The Daily and weekly full sample and subsamples result suggest that parametric test could lead to wrong representation of information. Hence, the data

analysed was performed using a non-parametric Kwiatkowski-Phillips-Schmidt-Shin(KPSS).

4.4 Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test

KPSS test is non-parametric statistical test for a stationary around a deterministic trend test. If the LM statistic is greater than the critical value, then the null hypothesis is rejected i.e. the series is non-stationary.

H0: The daily returns data is stationary

H1: The daily returns data is non-stationary

Table 4.4 shows the result of the KPSS test of daily returns of Sensex 30. The result for KPSS test shows a weak form inefficient in the daily data over the whole sample. The daily data in the entire sub sample fail to reject the null hypothesis, which implies that the stationary trend was congruent and hence non-random walk in the daily returns. The KPSS test with intercept and trend reject the null hypothesis at 5 percent level of significance in subsample of 2016-17. The statistical testing of a non-parametric KPSS failed to reject the null hypothesis while accepting the alternative hypothesis in unit root signifies the daily data is said to be stationary.

Table 4.4: KPSS test for Sensex 30 daily returns

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.066	0.068
April 2014-March 2015	0.197	0.027
April 2015-March 2016	0.051	0.046
April 2016-March 2017	0.119	0.120 *
April 2017-March 2018	0.146	0.064
April 2018-March 2019	0.120	0.117

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

Table 4.5: Asymptotic critical value of KPSS test

	1% Level	5% Level	10% Level
Intercept only	0.739	0.463	0.347
Intercept and trend	0.119	0.146	0.216

Table 4.6: KPSS test for Sensex 30 Weekly returns

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.071	0.073
April 2014-March 2015	0.021	0.036
April 2015-March 2016	0.161	0.138*
April 2016-March 2017	0.141	0.142*
April 2017-March 2018	0.180	0.083
April 2018-March 2019	0.108	0.180

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

Table. 4.7: KPSS test for Sensex 30 Monthly returns

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.073	0.075
April 2014-March 2015	0.430***	0.463*
April 2015-March 2016	0.500**	0.500*
April 2016-March 2017	0.143	0.142***
April 2017-March 2018	0.454***	0.500*
April 2018-March 2019	0.500**	0.500*

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

Table 4.6 shows the KPSS test result for weekly returns of Sensex 30. The weekly data in the full sample failed to reject the null hypothesis. The period of 2015-16 and 2016-17 failed to reject at 1 per cent significance level in trend and intercept. A part from that, the KPSS test failed to reject the null hypothesis. So the alternative hypothesis cannot be accepted. This means the weekly returns in a not a unit root and so the time series is stationary in nature.

The KPSS test result for monthly return of Sensex 30 is given in Table 4.7. As it can be seen in the monthly analysed data in table 4.7, the intercept and trend shows the character of random behaviour and the movement of the frequencies are non-stationary in nature. The stationary test in the monthly returns in Sensex 30 accepted the null hypothesis in the sub-sample. But, the test failed to reject the hypothesis in whole sample. Since, the critical value is smaller than the KPSS statistic the test accepts null

hypothesis over the sub sample. So the monthly data exhibit a non-stationarity in the time series.

The finding on the daily returns shows that there is a clear and identical movement in the Indian stock index in the daily returns. Hence the null hypothesis was failed to be rejected and the series are said to be stationary trend movement. The weekly returns show certain different character than the daily data, there is slightly different in the movement of the data. The monthly data exhibit a non-stationarity linear movement in the series.

4.5 Variance Ratio Test of Sensex 30

The Variance ratio test was conducted to examine the random walk behaviour in daily returns, weekly returns and monthly returns over a period of April 2014 to March 2019. The daily returns statistics are presented in table 4.10. The weekly variance ratio test statistics are presented in table 4.11 and monthly variance ratio test statistic are presented in table 4.12. The random walk probability of the daily return was observed in both the full sample data and sub-sample data. To take it into consideration we apply VR statistic with exponential and heteroscedasticity standard error denote by Z*(q) to all the sample and subsample. The null hypothesis: Log return is martingale.

The variance ratio test on daily Sensex 30 are presented in table 4.8. The empirical result of variance ratio test in daily returns in Sensex30 during the whole sample was statistically significant at 5 percent level which implies the return in both the indices fail to follows weak form inefficiency. The Z value of each of the standard normal distribution value, falls between -1.96 and 1.96, with confidence level of 95 percent. The result in the test series provide a strong rejection of random walk at 5 percent significant level. The

sample period over the whole period reject the null hypothesis at 5 percent. The period 2014-15 sub-sample shows some non-martingale movement. The period 2017-18 failed to reject the null hypothesis over different lag value. Moreover, evidence found that stock market exhibit the non-random behaviour in the daily sample over different lag value. Since then, the result of sub-sample provides a clue, where the time series experience some sort of disproportionate market efficiency.

Table 4.8: Variance ratio test of Sensex 30 daily returns

Frequency	Exponential Random walk with Heteroscedasticity Robust S.E					Chow and Denning Statistic
	q = 2	q=4	q=8	q=10	q=20	
Full sampling	0.488 * (-13.08)	0.244 * (-11.19)	0.103 * (-9.24)	0.100 * (-8.41)	0.042 * (-5.69)	13.08**
April 2014-March 2015	0.439* (-6.40)	0.246* (-4.90)	0.108* (-3.97)	0.085* (-3.68)	0.037* (-2.88)	6.401**
April 2015-March 2016	0.550* (-4.46)	0.259* (-4.26)	0.138* (-3.50)	0.091* (-3.30)	0.046* (-2.55)	4.469**
April 2016-March 2017	0.534 * (-6.12)	0.273* (-5.51)	0.121* (-4.67)	0.079* (-4.42)	0.044* (-3.16)	6.128**
April 2017-March 2018	0.529* (-4.98)	0.243* (-4.54)	0.110* (-3.56)	0.093* (-3.25)	0.224* (-2.04)	4.245**
April 2018-March 2019	0.613* (-3.49)	0.216* (-4.24)	0.091* (-3.70)	0.187* (-3.46)	0.030* (-2.40)	4.036**

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistic in parenthesis. Chow and Denning statistic are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % significant level respectively.

The exponential random walk with heteroscedasticity standard error of weekly returns is presented in tables 4.9. A random walk market movement could not be detected in the weekly test result. The null hypothesis over the full sample was rejected. Random walk behaviour could be found in weekly data over the subsample period of 2014-15 and 2017-18 sub-samples. The random walk pattern in the weekly shows certain shift in the market movement by dividing the whole sample into different period.

Table 4.9: Variance ratio test of Sensex 30 weekly returns

Frequency	Exponential Random walk with Heteroscedasticity Robust S.E					Chow and Denning Statistic
	q = 2	q = 4	q = 8	q = 10	q = 20	
Full sampling	0.623* (-5.09)	0.319* (-5.44)	0.123* (-4.80)	0.144* (-4.16)	0.044* (-3.32)	5.446**
April 2014-March 2015	1.548* (3.42)	1.025 (-0.08)	0.532 (-1.07)	0.332 (-1.41)	0.029 (-1.67)	3.428**
April 2015-March 2016	0.654* (-1.71)	0.278* (-2.19)	0.044* (-2.14)	0.150 (-1.79)	0.034 (-2.06)	2.567**
April 2016-March 2017	0.465* (-3.90)	0.347* (-2.95)	0.035* (-2.83)	0.144* (-2.18)	0.017 (-1.70)	3.908**
April 2017-March 2018	0.590 (-2.42)	0.236 (-2.53)	0.121 (-1.91)	0.113 (-1.71)	0.024 (-1.36)	2.534**
April 2018-March 2019	0.533* (-3.28)	0,251* (-3.26)	0.077* (-2.49)	0.095* (-2.19)	0,028 (-1.715)	3.280**

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistic in parenthesis. Chow and Denning statistic are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % significant level respectively.

Table 4.10 shows the variance ratio test on the monthly return of Sensex 30 test the random walk with heteroscedasticity standard error of returns. Here the monthly data over the sub-sample was small as the data was only 12 observations so the lag 20 result was not applicable. The full sample of monthly returns in BSE leads to rejection in the null hypothesis. In term of subsample, the sub sample of 2016-17 and 2018-19 reject the monthly returns in Sensex 30 (BSE). The monthly returns are more related to the random walk behaviour over different period. The VR statistic lead to rejection in the monthly returns, it indicates that there is a serial corelation in the monthly return.

In term of Chow-Denning test, it is important to conduct a joint test whether a multiple comparison of VRs of different time horizon is made (Hoque, Kim & Pyun, 2007). Conducting a separate test for a number of K value may lead to over rejecting of the null hypothesis of a joint test. The result of the joint test statistic was presented in the last column signifies and help in gathering the overall outcome of the test statistic.

Table 4.10: Variance ratio test of Sensex 30 monthly returns

Frequency	Random walk With Heteroscedasticity Robust S.E					Chow and Denning Statistic
	q = 2	q = 4	q = 8	q = 10	q=20	
Full sampling	0.434* (-5.17)	0.162* (-3.48)	0.103* (-2.61)	0.040* (-2.59)	0.016* (-2.06)	5.175*
April 2014-March 2015	0.083* (-27.50)	0.202* (-11.36)	0.103* (-5.82)	NA	NA	27.505*
April 2015-March 2016	0.433* (-3.74)	0.169* (-2.71)	0.051* (-1.98)	0.010* (-1,76)	NA	3.748*
April 2016-March 2017	0,657 (-0.10)	0.550 (-0.73)	0.009 (-1.13)	0.000 (-1.05)	NA	1.130
April 2017-March 2018	0.451* (-2.29)	0.230 (-1.70)	0.035 (-1.32)	0.017 (-1.202)	NA	2.292**
April 2018-March 2019	0.700 (1.47)	0.110* (-1.97)	0.001 (-1.34)	0.015 (-1.18)	NA	1.970

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistic in parenthesis. Chow and Denning statistic are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % significant level respectively.

The joint test of the daily returns reject the null hypothesis at all the sample and the sub sample with 10 percent level of significance. The joint test statistic or multiple variance ratio test of weekly returns reject the null hypothesis in all the sample and sub-sample in Sensex 30 weekly data. The multiple variance test result found that the weekly data follow a non-random walk motion.

The monthly joint statistic in Sensex 30 is significant at full sample and sub-sample of 2014-15 and 2015-16 at 5 percent critical level. The subsample over the period of 2018-19 is significant at 5 percent critical level. So, based on result the predictibility of stock returns is rejected at 5 percent level of significance at full sample. However every subsample shows an independence of returns. The VRs test and multi-variance suggest that a period of predictibility are fluctuated not within a short period i.e. daily and weekly but with a larger period within a month or even a year. By looking into a wide range of period like over a month, the returns predictibility appears to be fluctuated over time that reflect the available information.

4.6 Serial Correlation

4.7 Portmanteau Autocorrelation Test

The autocorrelation (Serial correlation and cross correlation) is typically used to detect the non-randomness in the data and help in identifying an appropriate time series model. In this we are planning to find out the observed return in the series follows independent and identical distribution (IID) of random variable information. The Ljung Box(LB) test is to test all the autocorrelation are simultaneously equal to zero.

H0: The Indian equity market return do not exhibit significant serial correlation

H1: The Indian equity market returns exhibit significant serial correlation

If the p-value > 0.05 of the Q-statistic, and the null of the entire auto-correlation be rejected at 0.05 percent of significant level. Therefore if the null hypothesis was rejected it implies that historical returns can predict the future returns and the element indicate weak form inefficient.

The LB statistic on the daily returns was presented in Table 4.11. The statistical analysis suggests that the daily returns of Sensex 30 do not exhibit information reflect over the price. The daily subsample over the period of 2014-15 rejects the hypothesis at 5 percent level of significance level. The subsample 2016-17 and 2017-18 shows occurrence of corelation in the movement of the stock prices. The subsample over the period 2018-19 exhibits serial correlation at lag 10 and Lag 15. So, the movement of the previous price do not reflect on the future movement in the subsample 2016-18.

Considering the runs test, we found an evidence of auto corelation in the whole sample. The autocorrelation relationship in the subsample was not detected. The Sensex 30 daily return in the subsample was found to be inefficiency.

Table.4.11:Ljung-Box and Runs test in Sensex 30 daily returns

Sample period	LB (5)	LB (10)	LB (15)	LB (20)	Runs test
Full Sample	0.044 (13.892)**	0.030 (19.288)**	-0.030 (25.021)**	0.017 (27.257)	-1.602*
April 2014-March 2015	0.097 (13.326) **	-0.068 (26.454)*	-0.078 (29.329)*	0.033 (33.879)**	-2.276*
April 2015-March 2016	-0.115 (5.158) **	0.111 (16.272)	-0.050 (20.227)	0.037 (26.806)	-1.540*
April 2016-March 2017	-0.065 (9.071)	-0.095 (13.294)	0.085 (17.783)	0.003 (21.686)	0.771*
April 2017-March 2018	-0.005 (8.773)	0.011 (11.735)	-0.004 (14.157)	-0.001 (16.328)	-1.214*
April 2018-March 2019	-0.083 (3.607)	0.171 (14.572)**	-0.094 (26.233)**	0.015 (29.377)	0.734*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

The LB statistics of the weekly data was presented in 4.12. The weekly analyst data reject the null hypothesis in subsample 2015-16 at lag 5 and Lag 10. The Null hypothesis was rejected at lag 15 in subsample 2018-19. This suggests that the subsample witness some negative and positive correlation. Movement over the whole sample signifies there is no correlation from the past movement of the data to the future movement. Considering the Runs test in weekly return we found evidence of autocorrelation function. The linear correlation was found in the weekly return. So the Sensex 30 weekly return is switching between efficiency and inefficiency.

Table 4.13 shows the LB statistics on monthly returns. The result of the LB statistics period witness upward and downward spikes during the sample. The monthly subsample witness a linearity trend was suppressed. The autocorrelation in the Sensex 30 monthly data are able to identify a positive and negative value, so we cannot confer that the market movement of the price cannot provide a serial correlation in predicting the future movement. The variables negative and positive statistics result give the relationship in between was cyclical behavioural trends over the period. The

runs test in the given table 4.13 found an evidence of autocorrelation in the full sample. The period of subsample experience a shift in the movement of the series form efficiency and inefficiency.

Table 4.12: Ljung-Box and Runs test in Sensex 30 Weekly returns

Sample period(BSE)	LB (5)	LB (10)	LB (15)	LB (20)	Runs test
Full Sample	-0.044 (0.01)	0.030 (19.38)	-0.030 (25.02)	0.017 (27.25)	0.522*
April 2014-March 2015	0.097 (13.235)	-0.068 (26.454)	-0.078 (25.978)	0.033 (31.530)	-0.520*
April 2015-March 2016	-0.115 (5.158)**	0.111 (16.272)**	-0.050 (20.227)	0.037 (26.806)	-1.038*
April 2016-March 2017	-0.065 (9.071)	-0.095 (13.294)	0.085 (17.783)	0.003 (21.686)	1.452*
April 2017-March 2018	-0.005 (8.773)	0.011 (11.735)	-0.004 (14.157)	-0.001 (16.328)	-0.073*
April 2018-March 2019	-0.083 (3.607)	0.171 (14.572)	-0.094 (26.233)**	0.015 (29.377)	0.283*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

Table 4.13 Ljung-Box and Runs test in Sensex 30 monthly returns

Sample period(BSE)	LB (5)	LB (10)	LB (15)	LB (20)	Runs test
Full Sample	-0.157 (1.71)	-0.001 (2.52)	-0.010 (2.79)	-0.011 (2.81)	0.678**
April 2014-March 2015	0.152 (0.49)	0.191 (3.97)	0.008 (4.07)	0.124 (6.208)	0.502
April 2015-March 2016	-0.215 (1.58)	-0.149 (2.04)	0.124 (3.96)	0.004 (7.51)	0.029*
April 2016-March 2017	0.073 (1.45)	-0.574 (9.03)	-0.193 (11.06)	0.135 (11.96)	-0.612
April 2017-March 2018	-0.215 (1.30)	-0.406 (5.75)	0.279 (7.98)	0.033 (8.24)	0.671
April 2018-March 2019	-0.411 (2.70)	0.373 (5.85)	-0.302 (9.17)	0.198 (11.05)	0.000*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

4.8 Non-Linearity Test

4.9 BDS Test

The result of BDS test statistics of daily return, weekly return and monthly returns are presented in the table 4.14,4.15 and 4.16 respectively. The null hypothesis of independent and identical distribution (I.I.D) are rejected at 5 percent level of significant, whenever $|V_{m,\in}|$>1.96. The BDS statistic reject the null hypothesis which indicated that the time series are non-linear in nature. The positive value implies the possibility of random variable while the negative BDS statistical value implies the certain pattern are volatile. Both significant positive and negative are the indicator of Non-independent and identically distributed random variable. The hypothesis for this test is;

H0: The return of the stock price is linearly Independent and identically distributed

H1: The returns of the stock price is non-linearly independent and identically distributed

From table 4.16 the result provides evidence on non-linearity structure in the daily returns. The test conducted on Sensex data are significant at 4, 6, 8 embedded dimension at 1.0, 1.5 and 2.0 standard deviation respectively. The test failed to reject the null hypothesis suggest that there is possibility of return predictibility. The significance of residual test in the subsample indicates the presence of non-linear dependent and independent over different period, implies the possibility of future return prediction shift dramatically.

The subsample over the period of 2014-15 provide evidence of four BDS test of combination test reject the null hypothesis of IID. The non-linearity test in subsample of 2014-15 in Sensex 30 returns experience no evidence of IID. The period 2015-16 subsample generated five instances of non-linearity. The sub-sample over the period of 2017-18 failed to reject the null hypothesis as it experience independent and identical dependent to the past movement. The test result suggest that daily returns over the sub-sample was chaotic behaviours as the non-linearity are occurs over certain value

assigned to the threshold and embedded dimension. So, the daily data suggest that there was a strong evidence of non-linearity structure of the data.

Table 4.14: A non-Linearity test of Sensex 30 in daily data

Sample period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	0.0001 (0.24)	0.009* (0.00)	0.028* (0.00)	0.045* (0.00)
April 2014 - March 2015	-0.00 (0.02)*	-0.00 (0.13)	-0.00 (0.51)	-0.01 (0.41)
April 2015 –March 2016	0.00 (0.62)	0.00 (0.23)	-1.34 (0.90)	-0.02* (0.02)
April 2016 –March 2017	0.00 (0.08)	0.00 (0.60)	2.65 (0.82)	0.01 (0.46)
April 2017 –March 2018	0.00 (0.07)	0.00 (0.23)	0.01 (0.06)	0.032 * (0.01)
April 2018 –March 2019	0.005 * (0.00)	0.001 * (0.00)	0.04 * (0.00)	0,08 * (0,00)

Note: Here, e/ σ denote the distance in term of the number of standard deviation in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % and level.

Table 4.15: A non-Linearity test of Sensex 30 in weekly data

Sample. period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	-0.002 (0.43)	0.014 (0.33)	0.002 (0.86)	-0.039 (0.08)
April 2014 - March 2015	-0.004 (0.45)	-0.010 (0.65)	-0.157* (0.00)	-0.833* (0.00)
April 2015 –March 2016	-0.015 (0.32)	-0.244* (0.00)	-0.010* (0.00)	0.267* (0.01)
April 2016 –March 2017	0.006 (0.54)	-0.046* (0.05)	-0.423* (0.00)	-0.50* (0.00)
April 2017 –March 2018	-0.015* (0.00)	-0.026* (0.00)	0.043* (0.00)	-0.065 (0.27)
April 2018 –March 2019	0.017 (0.15)	-0.016 (0.28)	-0.046 (0.30)	-1.00* (0.00)

Note: Here, e/ σ denote the distance in term of the number of standard deviation in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % and level.

The test result in table 4.15 provides evidence on non-linearity structure in the weekly returns. The test conducted in weekly returns over the whole sample on Sensex data reject the null hypothesis. The test failed to

reject the null hypothesis at the standard deviation in 2 embedded dimensions with 0.5 standard deviation in all the subsample. The period 2015-16 subsample generated three instances of non-linearity. The sub-sample period of 2016- 17 provided an evidence of IID statistic. The sub-sample over the period of 2017-18 failed to reject the null hypothesis. The result experience independent and identical dependent to the past movement. The result over the subsample 2018-19 rejected the null hypothesis at 5 percent level of significant with 8 embedded and 2 threshold dimension. The test result the null hypothesis of IID test suggest that weekly returns over the sub-sample was mixed as the linearity trend occur over certain value assigned to the threshold and embedded dimension. So, the weekly data suggest that there was a strong evidence of nonlinearity shift over time.

Table 4.16: A non-Linearity test of Sensex 30 in Monthly data

Sample. period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	-0.002 (0.43)	0.014 (0.33)	0.002 (0.86)	-0.039 (0.08)
April 2014 - March 2015	-0.004 (0.45)	-0.010 (0.65)	-0.157* (0,00)	-0.833* (0.00)
April 2015 –March 2016	-0.015 (0.32)	-0.244* (0.00)	-0.010* (0.00)	0.267* (0.01)
April 2016 –March 2017	0.006 (0.54)	-0.046* (0.05)	-0.423* (0.00)	-0.50* (0.00)
April 2017 –March 2018	-0.015* (0.00)	-0.026* (0.00)	0.043* (0.00)	-0.065 (0.27)
April 2018 –March 2019	0.017 (0.15)	-0.016 (0.28)	-0.046 (0.30)	-1.00* (0.00)

Note: Here, e/ σ denote the distance in term of the number of standard deviation in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % and level.

As presented in table 4.16. A non-linearity test in Sensex 30 monthly data in Sensex 30 was conducted. The test rejected the null hypothesis in the full sample that means the result provided no sign of significance in non-linearity structure in the full sample on monthly returns.. The test result experience time bound movement over different values, The test failed to reject the null hypothesis except the standard deviation 0.5 and 2 embedded

dimension. The sub-sample of 2015-16, 2016-17 and 2017-18 reject the null hypothesis, implies the non-linearity structure arise. Non-linearity was failed to reject in the sample subsample 2014-15 and 2018-19, which means dependent in the movement of returns. The monthly result suggest that there were no independent and identical distribution in the statistic. Therefore, the BDS test very little or no evidence in linearity dependence in stock returns (Sensex 30). However non linearity inefficiency was also present in over the sample. The observed result shown was characterised by a linearity and non-linear independent.

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CHAPTER – V

DATA ANALYSIS AND

RESULT OF

NIFTY 50 INDEX

5.1 Introduction

In this chapter, an analysis based on daily data, weekly data and monthly data of Nifty 50 index are conducted. The analysis was conducted using various tests like unit root test, variance ratio test, Ljung-Box test, and BDS test. The analysis was conducted both in the whole sample and yearly divided subsample for different period to test the robustness of the different time period.

5.2 Descriptive statistics of Nifty 50

The descriptive statistics of Nifty 50 daily return are given in table 5.1. The number of observation in daily return over the whole sample period is 1219. The number of observation for subsample varies over different period (see table 5.1). According to the study, the variables have positive means except 2015-16 sub-sample. The positive kurtosis is leptokurtic with higher peak than the normal distribution and non-normal distribution was detected. The skewness fall in the left side this means the fall in returns. The standard deviation in all the test data are small in the full sample and sub samples which means that low volatility occurs in the study period. The JB tests represent the normality for the goodness-of fit test. Since the daily distribution of returns is far away from the normal value zero, and hence, daily returns are not normally distributed in daily returns.

Table 5.1: Descriptive statistics of Nifty 50 daily returns

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full Sample	1219	0.0004	0.0005	0.0326	-0.0629	0.0089	-0.550	6.1893	576.68	0.00
April 2014-March 2015	239	0.0010	0.0001	0.0200	-0.0300	0.0087	-0.052	3.796	6.42	0.03
April 2015-March 2016	243	-0.0003	-0.0002	0.0336	-0.0590	0.0108	-0.675	6.148	118.87	0.00
April 2016-March 2017	244	0.0007	0.0007	0.0240	-0.0269	0.0078	-0.150	4.049	12.12	0.02
April 2017-March 2018	243	0.0004	0.0005	0.0190	-0.0233	0.3429	-0.342	3.501	7.31	0.02
April 2018-March 2019	243	0.0005	0.0006	0.0232	-0.0267	0.0078	-0.242	3.705	7.42	0.02

Source: Computed with the use of E-view 10

The weekly Nifty 50 returns as given in table 5.2. The number of observation over the full sample is 52 observations. According to the study, the variable have positive means in 2016-17, 2017-18, 2019-18 and negative means in the first two sample period. The standard deviation in all the test data are small in all the sample and sub sample which means that low volatility occurs in the study period. The kurtosis are in leptokurtic with medium peak suggest that the data are toward normal distribution. The skewness in all the study period falls in the left side which means the fall in returns. The JB test on the weekly distribution of return are around the normal value zero, and hence, the p-value in weekly returns suggest that returns are normally distributed

Table 5.2: Descriptive statistic of Nifty 50 Weekly returns

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full sample	260	0.002	0.003	0.065	-0;068	0.019	-0.160	3.837	8.712	0.01
April 2014-March 2015	52	-0.004	-0.002	0.038	-0.050	0.0205	-0.087	2.683	0.683	0.86
April 2015-March 2016	52	-0.001	0.002	0.065	-0.068	0.024	-0.152	3.258	0.345	0.84
April 2016-March 2017	52	0.003	0.004	0.053	-0.027	0.017	0.0542	3.184	2.626	0.269
April 2017-March 2018	52	0.002	0.003	0.023	-0.035	0.014	-0.772	2.94	5.07	0.078
April 2018-March 2019	52	0.002	0.006	0.052	-0.056	0.017	-0.390	4.881	8.812	0.01

Source: Computed with the use of E-view 10

The monthly Nifty 50 returns as given in table 5.3. The number of observation over the full sample is 12 observations. According to the study, the variables have positive means in the entire sample except 2015-16 sub-

sample period. The standard deviation in all the test data are small in all the sample and sub sample which means that low volatility occurs in the study period. The positive kurtosis are leptokurtic with medium peak suggest that the data are normal distribution. The skewness fall in the sub sample of 2015-6 and 2017-18 resulting in rise in returns and fall in the left side over the period of 2014-15, 2016-17 and 2018-19 which means the fall in returns.. The JB test failed to reject the null hypothesis at 5 % level of significant on the monthly returns, therefore the distribution of data is around the normal value zero, and hence, The p-value in monthly Nifty 50 signifies the returns are normally distributed.

Table 5.3: Descriptive statistics of Nifty 50 Monthly returns

Sample Period	Observation	Mean	Median	Maximum	Minimum	St Dev.	Skewness	Kurtosis	JB test	Probability
Full sample	60	0.009	0.009	0.108	-0.076	0.039	-0.060	2.668	0.310	0.85
April 2014-March 2015	12	0.022	0.030	0.080	-0.040	0.038	-0.287	2.119	0.507	0.77
April 2015-March 2016	12	-0.003	0.000	0.108	-0.076	0.051	0.569	3.319	0.641	0.725
April 2016-March 2017	12	0,014	0,017	0.046	-0.048	0.029	-0.840	2.702	1.334	0.51
April 2017-March 2018	12	0.008	-0.010	0.058	-0.049	0.037	0.017	1.577	0.928	0.68
April 2018-March 2019	12	0.008	-0.001	0.077	-0.064	0.042	-0.054	2.277	0.244	0.88

Source: Computed with the use of E-view 10

5.3 Unit Root Test

The stationarity test required the data are in normally distributed. The Daily and weekly full sample result suggest that parametric test could lead to wrong representation of information. Hence, the data analysed was performed using a non-parametric Kwiatkowski-Phillips-Schmidt-Shin(KPSS)

5.5 Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test

KPSS test is non-parametric statistical test for a stationary around a deterministic trend test. If the LM statistics is greater than the

critical value, then the null hypothesis is rejected then the series is non-stationary.

H0: The daily returns is stationary

H1: the daily data is non-stationary

The KPSS test on the daily data of Nifty 50 returns in table 5.4 signifies that the null hypothesis was failed to be rejected with intercept in all the whole period sample and sub-sample. The KPSS test with intercept and trend reject the null hypothesis at 5 percent over the subsample of 2016-17. Thus, the daily data of nifty 50 shows a nature of non-stationary structure and suggest that weak form inefficient nature on the daily data over the whole sample and subsample in the daily data.

Table 5.4 KPSS test for Nifty 50 daily returns

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.066	0.068
April 2014-March 2015	0.162	0.026
April 2015-March 2016	0.053	0.046
April 2016-March 2017	0.126	0.125 **
April 2017-March 2018	0.200	0.046
April 2018-March 2019	0.115	0.115

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

Table 5.5: Asymptotic critical value of KPSS test

	1% Level	5% Level	10% Level
Intercept only	0.739	0.463	0.347
Intercept and trend	0.119	0.146	0.216

The weekly data in table 5.5 failed to reject the sample over the whole period. The period of 2015-16 and 2016-17 in trend and intercept reject the null hypothesis at 10 percent respectively. The weekly data also experience a stationary trend in nature similar to daily return.

Table 5.5 KPSS test result for Weekly returns NSE

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.064	0.066
April 2014-March 2015	0.196	0.037
April 2015-March 2016	0.175	0.137***
April 2016-March 2017	0.135	0.134***
April 2017-March 2018	0.234	0.088
April 2018-March 2019	0.099	0.097

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

The monthly return of Nifty 50 are given in table 5.6. the testing on monthly return over the whole sample failed to reject the null hypothesis. The Whole sample shows a stationarity trend. The test in trend and intercept and trend shows the character of random behaviour and the movement of the frequencies are non-stationary in nature. The stationary test of in the monthly returns in NSE rejected over the sample of 2016-17. Hence the null hypothesis was failed to be reject and the series are said to be non-stationary trend movement.

Table 5.7 KPSS test for Nifty 50 Monthly returns

Sample Period	KPSS test With intercept	KPSS test with trend and Intercept
Full sampling	0.066	0.067
April 2014-March 2015	0.424***	0.500*
April 2015-March 2016	0.500**	0.500*
April 2016-March 2017	0.138	0.138***
April 2017-March 2018	0.454***	0.500*
April 2018-March 2019	0.500**	0.500*

Note: * , ** and ***denote the significance level at 1%, 5% and 10 % respectively.

The finding on the daily returns shows that there is a stationarity trend in the Indian equity index in the daily returns. Hence the null hypothesis was rejected and the series are said to be stationary trend movement. The weekly returns show certain different character than the daily data, there is slightly

different in the movement of the data. The monthly data exhibit a stationarity linear movement in the series.

5.5 Variance Ratio Test of Nifty 50

Variance ratio test was employed to study the random walk hypothesis for daily, weekly and monthly return for Nifty 50. Here the predictibility of time series data by comparing various different data over different variance was calculated. To evaluate the statistical significant, we performed Lo and Mackinlay test for heteroskedasticity random walk with robust standard error. The Z value of each of the standard normal distribution value, falls between -1.96 and 1.96, with confidence level of 95 percent. The result in the test series provide beyond the critical value lead to rejection of random walk in 5 percent significant level. The hypothesis:

H0:Log return of Nifty 50 is random walk under heteroscedasticity.

H1: Log return of Nifty 50 is non-random walk under heteroscedasticity.

Table 5.8: Variance ratio test of Nifty 50 daily returns

Frequency	Exponential Random walk with Heteroscedasticity Robust S.E					Chow and Denning Statistics
	q = 2	q=4	q=8	q=10	q=20	
Full Sampling	0.517* (-12.97)	0.270* (-11.09)	0.107* (-9. 18)	0.104* (-8.33)	0.055* (-6.36)	12.972**
April 2014-March 2015	0.555* (-4.91)	0.340* (-4.15)	0.130* (-3.18)	0.096* (-3.60)	0.046* (-2.86)	4.917**
April 2015-March 2016	0.398* (-12.71)	0.212* (-7.55)	0.073* (-5.44)	0.120* (-4.59)	0.042* (-3.02)	12.714**
April 2016-March 2017	0.475* (-7.99)	0.246* (-6.05)	0.136* (-4.56)	0.086* (-4.33)	0.075* (-3.13)	7.997**
April 2017-March 2018	0.468* (-7.97)	0.235* (-6.09)	0.126* (-4.58)	0.077* (-4.34)	0.055* (-3.18)	7.975**
April 2018-March 2019	0.419* (-4.48)	0.149* (-4.18)	0.089* (-3.53)	0.065* (-3.41)	0.033* (-2.79)	4.481**

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistics in parenthesis. Chow and Denning statistics are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % significance level respectively

The daily returns for Nifty 50 is represented in table 5.8. The analysed data find that whole sample data was statistically significant and rejected the null hypothesis at 5 percent level, this implies that the returns failed to follow weak form efficient. The finding over the subsample in daily returns reject the null hypothesis at 5 percent level of significance from 2014-19. The subsample in the index failed to reject the null hypothesis. Moreover, evidence have been found that stock market exhibit the non-random behaviour in the daily sample over different lag value.

The exponential random walk with heteroscedasticity standard error of weekly returns is presented in in tables 5.9. The test result rejects the null hypothesis over the whole sample at 5 percent level of significance. Non-random walk behaviour can be seen in weekly data over different sub sample. The subsample 2014-15 and 2017-18 failed to reject the null hypothesis at 5 percent level of significance. The weekly returns give a sign of mixed behaviour movement of stock returns over the sub sample in the weekly data. The random walk pattern in the weekly return shows certain shift in the market condition when the period was dividing the whole sample in to different sub-period.

Table 5.9: Variance ratio test of Nifty 50 Weekly returns

Frequency	Exponential Random walk with Heteroscedasticity Robust S.E					Chow and Denning Statistics
	q = 2	q=4	q=8	q=10	q=20	
Full Sampling	0.490* (-5.84))	0.198* (-5.70)	0.087* (-4.90)	0.116* (-4.31)	0.044* (-3.33)	5.844**
April 2014-March 2015	0.343* (-4.13)	0.149* (-3.56)	0.058* (-3.28)	0.081* (-2.78)	0.001 (-1.72)	4.137**
April 2015-March 2016	0.654 (-1.71)	0.278* (-2.19)	0.044* (-2.14)	0.150 (-1.79)	0.034 (-1.73)	2.197
April 2016-March 2017	0.405* (-6.51)	0.207* (-4.64)	0,037* (-3)	0.113** (-2.31)	0.012 (-1.76)	6.515**
April 2017-March 2018	0.353* (-2.92)	0.206* (-2.18)	0.065* (-1.90)	0.075 (-1.69)	0.039 (-1.30)	2.925**
April 2018-March 2019	0.490* (-2.79)	0.165* (-2.88)	0.049* (-2.58)	0.072* (-2.35)	0.042* (-1.92)	2.885**

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistics in parenthesis. Chow and Denning statistics are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % level significance respectively

In table 5.10, the empirical test in monthly returns on random walk with Heteroscedasticity standard error of returns is given. Here the monthly data over the sub-sample was small as the data was only 12 observations so the lag 20 result was not applicable. In term of subsample, the period of 2015-16 failed to reject at lag 10 and sub sample 2018-19 failed at lag 4. The monthly returns are more related to the random walk behaviour over different period. The VR statistic lead to rejection of null hypothesis in the monthly returns. It indicates that there is a serial corelation in the return and follows random patterns in the monthly returns.

Table 5.10: Variance ratio test of Nifty 50 monthly returns

Frequency	Exponential Random walk with Heteroscedasticity Robust S.E					Chow and Denning Statistic
	q = 2	q=4	q=8	q=10	q=20	
Full sampling	0.389* ((2.90)	0.335 (-1.44)	0.088 (-1.43)	0.036 (-1.40)	0.024 (-1.19)	2.090
April 2014-March 2015	0.512* (1.29)	0,212* (-1.22)	0.271* (-1.12)	0.056 (-1.01)	NA	1.290
April 2015-March 2016	0.401 (-3.70)	0.157 (-2.68)	0.043* (-2.02)	0.011 (-1.78)	NA	3.705**
April 2016-March 2017	0.716 (-0.83)	0.599 (-0.71)	0.006 (-1.130)	0.000 (-1.05)	NA	1.130
April 2017-March 2018	0.428 (-2.26)	0.219 (-1.65)	0.040 (-1.28)	0.015 (-1.17)	NA	2.261**
April 2018-March 2019	0.779 (-1.15)	0.111* (-1.95)	0.001 (-1.34)	0.018 (-1.183)	N	1.956

Note: The lo and McKinley variance ratio VR (q) test are presented in the main row and the [z*(q)] statistic in parenthesis. Chow and Denning statistic are presented in the last column and the critical value at 2.49 and 2.23 at 5 % and 10 % respectively. * and ** denotes 5% and 10 % significance level respectively

In terms of Chow- Denning multiple variance ratio test, it is important to conduct a joint test whether a multiple comparison of VRs of different time horizon is made (Hoque, Kim & Pyun, 2007). Conducting a separate test for a number of (q) value may lead to over rejecting of the null hypothesis of a joint test. The result of the joint test statistic was presented in the last column signifies and help in gathering the overall outcome of the test statistic. The joint test of the daily returns rejects the null hypothesis in

the sample and the subsample. The finding is also confirmed with Lo-Mackinley (1988) test.

The joint test statistics of weekly returns reject the null hypothesis in all the sample and sub-sample in Nifty 50 weekly data. An evidence of non-random walk was confirmed as the weekly data reject the null hypothesis at 10 percent level of significance.

The monthly joint statistic in Nifty 50 failed to reject the null hypothesis at 5 percent significant in whole sample and rejected in sub-sample of 2015-16 and 2017-18 at 5 percent critical level. The subsample over the period of 2014015, 2016-17 and 2018-19 is insignificant. So, the predictibility of stock returns in monthly was failed to reject with 5 percent level of significance. However every subsample shows an independence and non-independent movement of returns.

The VRs test and multi-variance suggest that a period of predictability is fluctuated within a short period over a month or year that predictibility appears. The predictibility of information quickly reflects available information over certain depending upon the return.

5.6 Serial Correlation

5.7 Portmanteau Autocorrelation Test

The autocorrelation (Serial correlation and cross correlation) is usually used to detect the degree of relationship between the same variable across different level in the data and help in observing corelation between value of different time series. In this we are planning to find out the observed return in the series follows independent and identical distribution (IID) of random variable information. The Ljung Box(LB) test is to check all the autocorrelation are simultaneously equal to zero. If the p-value < 0.05 of the Q-statistic, and the null of the entire auto-correlation may be rejected at 0.05 percent of significant level. therefore if the null hypothesis was rejected it implies that historical returns can predict the future returns and the element indicate weak form inefficient.

H0: Nifty 50 returns on stock price do not exhibit significant serial correlation

H1: Nifty 50 returns on stock price do exhibit significant serial correlation.

The LB statistics on the daily returns of Nifty 50 are presented in table 5.11. The statistical analysis found that the daily Nifty 50 return rejected the null hypothesis in the whole sample. The wholes sample shows a dependent in movement of return series. The daily returns in subsample 2015-16, 2016-18 and 2017-18 periods witness some normal movement of the past data to the present data. This period are conferring to as serial corelation in market movement. The autocorrelation relationship in the subsample was detected in subsample 2015-16, 2016-17 and 2017-18. The dependent and independent movement from the previous data was found to be alter in different time period.

Considering the runs test in table 5.11, we found an evidence of auto correlation in the whole sample. The autocorrelation relationship in the subsample was detected. The Sensex 30 daily return in the subsample was found to be inefficiency. The random walk movement from the previous data was found to be void.

Table.5.11: Ljung-Box and Runs test in Nifty 50 daily returns

Sample period(BSE)	LB (5)	LB (10)	LB (15)	LB (20)	Runs Test
Full Sample	0.052 (14.93)**	0.031 (20.59)**	-0.041 (25.06)**	0.019 (29.07)	-1.117 *
April 2014-March 2015	0.048 (13.51) *	-0.114 (22.00)*	-0.084 (25.97)**	0.044 (31.53)**	-1.267*
April 2015-March 2016	-0.113 (4.73)	0.104 (15.94)	-0.053 (19.97)	0.027 (26.48)	-1.267*
April 2016-March 2017	-0.049 (8.77)	-0.055 (11.15)	0.056 (13.41)	0.008 (15.90)	0.076*
April 2017-March 2018	-0.037 (8.79)	0.047 (11.74)	-0.040 (14.65)	-0.029 (17.22)	-0.128*
April 2018-March 2019	-0.072 (3.61)	0.175 (16.14)	-0.083 (28.25)**	0.017 (31.17)**	-0.504*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

The weekly return of LB statistics is presented in table 5.12. The test rejects the null hypothesis in the whole sample and subsample. The weekly returns in exhibit serial correlation in the past and present movement, an independent movement from the past market behaviour to the present price movement arise.

Table 5.12: Ljung-Box and Runs test in Nifty 50 weekly returns

Sample period(BSE)	LB (5)	LB (10)	LB (15)	LB (20)	Runs Test
Full Sample	-0.029 (2.75)	0.036 (11.16)	-0.053 (0.41)	-0.062 (19.99)	-0.172**
April 2014-March 2015	-0.353 (8.99)	0.125 (10.89)	0.026 (14.59)	-0.070 (17.22)	-0.470*
April 2015-March 2016	0.132 (6.03)	0.110 (12.31)	0.035 (12.97)	0.031 (15.14)	-1.084*
April 2016-March 2017	0.220 (6.68)	-0.174 (20.61)	-0.209 (30.86)	-0.071 (35.64)	2.536*
April 2017-March 2018	-0.115 (1.56)	0.116 (6.69)	-0.152 (12.33)	-0.039 (22.59)	-0.664*
April 2018-March 2019	-0.165 (6.12)	-0.187 (12.61)	-0.099 (18.75)	0.064 (21.32)	0.048*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

The movement and behaviour are shown a positive and negative relation over certain lag value. So, we are able to identify a positive and negative value, so we cannot confer that the market is weakly efficiency but certain behavioural trends was visible over the result of Ljung Box autocorrelation test.

Considering the Runs test in weekly return in table.5.12, the result found an evidence of autocorrelation function. The linear correlation was found in the weekly return. So the Sensex 30 weekly return was found to have autocorrelative function from the past movement. Hence a non-random walk behaviour.

As given in table 5.13, the LB statistics on monthly returns was presented. The result of the LB statistics period witness upward and downward spikes during the sample. Monthly data failed to reject the null hypothesis, the non-autocorrelation movement was found in the full sample and subsample. The movement of the market shown a positive and negative

relation over certain lag value.. The result of Ljung Box test statistic are able to identify a positive and negative value, so we cannot confer that the past market is rely on the present and future price movement.

Considering the Runs test in monthly returns given in table 5.13, found an evidence of autocorrelation in the full sample. The period of subsample experience a shift in the movement of the series form efficiency and inefficiency.

Table 5.13: Ljung-Box and Runs test in Nifty 50 monthly returns

Sample period(BSE)	LB (2)	LB (4)	LB (6)	LB (8)	Runs test
Full Sample	-0.167 (1.98)	0.008 (2.81)	-0.018 (3.25)	0.024 (3.37)	-0.260*
April 2014-March 2015	-0.172 (0.63)	-0.201 (3.76)	-0.026 (3.99)	0.159 (6.14)	0.671
April 2015-March 2016	-0.181 (1.64)	-0.132 (1.99)	0.136 (3.58)	0.054 (7.54)	1.312*
April 2016-March 2017	0.033 (1.56)	-0.581 (9.28)	-0.151 (10.30)	0.150 (12.04)	-1.795
April 2017-March 2018	-0.191 (1.31)	-0.390 (5.90)	0.234 (7.54)	-0.011 (8.19)	0.671*
April 2018-March 2019	-0.484 (3.72)	0.389 (6.91)	-0.326 (10.96)	0.205 (13.04)	0.000*

Note: The autocorrelation coefficient followed by Ljung-Box(LB) Q in parenthesis at lags 5, 10, 15 and 20 for the full sample and subsample period. The last column furnishes the Runs Z statistics. * and ** denote the significance level at 1% and 5% respectively.

5.8 Non-Linearity Test

5.9 BDS test

The result of BDS test statistic in daily, weekly and monthly return was represent in table 5.14, table 5.15 and table 5.16 respectively. The null hypothesis of independent and identical distribution (I.I.D) will be rejected at 5 percent level of significant, whenever $|V_{m,\epsilon}|$>1.96. The BDS statistic reject the null hypothesis which indicated that the time series are non-linear in nature. The positive value implies the possibility of random variable while the negative BDS statistical value implies the certain pattern are volatile. Both significant positive and negative are the indicator of non-independent and identically distributed random variable. The hypothesis for this test;

H0: The return of the stock price is an independent and identically distributed.

H1: The return of the stock price is non-independent and identically distributed.

From table 5.14, the result of Nifty50 daily data provides evidence on non-linearity structure in the whole sample. The subsample over the period of 2014-15 provide evidence that rejected at 2 embedded dimension null hypothesis of IID. The test failed to reject the null hypothesis in subsample 2015-16 and 2017-18 at 6 and 8 embedded dimension at 1.5 and 2.0 standard deviation respectively . The test rejected the null hypothesis at the standard deviation in subsample 2018-19. The non-linearity test in the subsample indicates evidence on non-random behaviour. So, there is existence of linearity and non-linearity over different period with different dimensions and threshold.

Table 5.14 : A non-Linearity test of Nifty 50 in daily data

Sample period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	0.001 (0.08)	0.011* (0.00)	0.031* (0.00)	0.000* (0.00)
April 2014 - March 2015	-1.90 * (0.05)	-0.37 (0.71)	-0.39 (0.69)	-0.71 (0.47)
April 2015 –March 2016	0.49 (0.63)	1.57 (0.11)	2.12 * (0.03)	2.01 * (0.04)
April 2016 –March 2017	-1.23 (0.21)	-0.65 (0.51)	0.50 (0.61)	0.97 (0.32)
April 2017 –March 2018	1.57 (0.11)	1.46 (0.14)	2.33 * (0.01)	2.77 * (0.00)
April 2018 –March 2019	5.15 * (0.00)	6.00 * (0.00)	4.81* (0.00)	6.41 * (0.00)

Note: Here, e/ σ denote the distance in term of the number of standard deviation in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % level.

The BDS test statistics in weekly returns was presented in table 5.15. The non-linearity in Nifty 50 weekly returns failed to reject the null hypothesis at 2, 4 and 6 dimension and reject 8 embedded dimensions in whole sample and subsample 2014-15. The test result suggest that a non-

linearity behaviour in NSE was failed to reject the null hypothesis. A non-linearity test conducted in weekly data provided a sign of significant in non-linearity structure. The non-linearity test suggest that there are potential for investor to earn abnormal profit.

Table 5.15: A Non-Linearity test of Nifty 50 in Weekly data

Sample period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	0.004* (0.01)	0.007* (0.14)	0.012 (0.20)	0.030* (0.03)
April 2014 - March 2015	0.001 (0.75)	-0.019* (0.02)	-0.043* (0.01)	-0.016 (0.51)
April 2015 –March 2016	0.003 (0.26)	0,012 (0.10)	-0.008 (0.64)	-0.045 (0.15)
April 2016 –March 2017	0.013 (0.00)	-0.002 (0.81)	0.024 (0.23)	-0.002 (0.94)
April 2017 –March 2018	-0.006* (0.05)	-0.001 (0.11)	-0.033 (0.16)	-0.043 (0.22)
April 2018 –March 2019	0.014 (0.11)	0.007 (0.65)	0.078* (0.01)	0.099* (0.04)

Note: Here, e/ σ denote the distance in term of the number of standard deviations in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % level.

Table 5.16: A Non-Linearity test of Nifty 50 in monthly data

Sample period	m= 2, ε =0.5	m=4, ε =1.0	m=6, ε =1.5	m-8, ε =2.0
Full Sample	-0.003 (0.25)	0.007 (0.30)	0.007 (0.65)	-0.056* (0.01)
April 2014 - March 2015	-0.006 (0.65)	-0.026 (0.19)	-0.157* (0.00)	-0.833* (0.00)
April 2015 –March 2016	-0.015 (0.32)	-0.280* (0.00)	-0.128 (0.07)	-0.039 (0.57)
April 2016 –March 2017	-0.004 (0.69)	-0.062* (0.00)	-0.423 (0.00)	-0.500* (0.00)
April 2017 –March 2018	-0.026* (0.00)	-0.033* (0.00)	0.086* (0.00)	-0.065 (0.43)
April 2018 –March 2019	0.005 (0.58)	-0.016 (0.27)	0.043 (0.30)	-1.000* (0.00)

Note: Here, e/ σ denote the distance in term of the number of standard deviations in the data. M denotes embedding dimension. The embedded dimension of 2, 4, 6, and 8 are provided the value of BSD statistic. The value of the first row cell is BSD statistic and p-value is in parenthesis. The value of e is 0.5, 1.0, 1.5 and 2.0 time the standard deviation are used in the observation. * Sign represent the value are significant at 5 % level.

The BDS test statistics of monthly data was represent in table 5.16. The result suggests that the null hypothesis was rejected in 10 cases over different value and embedded dimension. A non-linearity dependent was found in the full sample of monthly data. The sub-sample of 2017-18 witness the null hypothesis was failed to be rejected. The monthly returns suggest that there is no independent and identical distribution. Therefore, the BDS test result provides very little or no evidence in linearity dependence in stock returns .However non linearity inefficiency was also present in over the sample. The intervention linearity trend in the statistic provides strong evidence toward AMH. The non-stationary alternative in movement of the returns seem capable of finding an empirical evidence toward the time varying movement of the returns are changing overtime characterised by a linearity and nonlinear independent. Therefore, the BDS test result with very little or no evidence in linearity dependence in stock returns (Nifty 50). However non linearity inefficiency was also present in over different subsample. The observed result shown was characterised by a linearity and non-linear independent happen episodic.

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Chapter VI

FINDINGS AND CONCLUSION

6.1 Introduction

In this chapter, a summary of finding related to the study along with conclusion related to the major finding in our observation are presented.

6.2 Finding on BSE Daily returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test: The result for KPSS test in BSE showed a weak form inefficiency based on the daily data over the whole sample. The statistical testing of non-parametric KPSS rejected the null hypothesis, which implies that the stationarity trend was congruent and hence non-random walk in the daily return data.

2. Variance ratio test: The empirical result of variance ratio test in daily return in Sensex30 during the whole sample was statistically significant at 5 percent level which implies that the return in Sensex 30 failed to follow weak form efficient in market. The result in the test series provided a strong rejection of random walk in 5 percent significant level. Moreover, evidence was found that BSE daily returns exhibited the non-random behaviour over different lag value.

3. Multiple Variance ratio: A multiple variance Chow-Denning test of the daily return rejected the null hypothesis for the whole sample and the entire sub-samples. That means BSE Sensex has an evidence of non-random walk momentum.

4. **Portmanteau Autocorrelation Test:** The statistical analysis suggested that the daily returns of BSE did not exhibit information reflect over the price. The daily sub-sample over the period of 2014-15 rejected the hypothesis at 5 percent level of significance level. The subsample 2016-17 and 2017-18 showed occurrence of corelation in the movement of the stock prices. The subsample over the period 2018-19 exhibited serial correlation at lag 10 and lag 15. So, the movement of the previous price did not reflect on the future movement in the subsample 2016-18.

5. **BDS Test:** The result provided evidence on non-linearity structure in the daily returns. The test conducted on Sensex data rejected the null hypothesis at 4, 6, 8 embedded dimension at 1.0, 1.5 and 2.0 standard deviation,

respectively. The test failed to reject the null hypothesis at the standard deviation in 2 embedded dimensions at different standard deviations.

In sub-samples, the period 2016-17 provided some evidence of IID statistics. The subsample over the period 2017-18 failed to reject the null hypothesis as it experienced non-independent and identically dependent to the past movement. So, the daily data suggested that there was an evidence of nonlinearity shift over time.

Major findings on the daily Sensex 30 index returns are presented in Table 6.1.

Table 6.1. Findings on Sensex 30 Daily returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	Stationary motion
Variance Ratio Test	Rejected	Non Random walk
Multiple Variance Ratio	Rejected	Non Random walk
Portmanteau Autocorrelation Test	Rejected But failed to at subsample 2016-17 and 2017-18	There was an episodic serial correlation
Runs test	Rejected	autocorrelation
Brock-Dechert-Scheinkman (BDS) Test:	Failed to reject at full sample Rejected at subsample 2016-17 and 2017-18	Episodic efficiency structure in the daily returns.

6.3 Findings on BSE Weekly returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test: The weekly data failed to reject the null hypothesis of trend stationarity in the whole period sample. The subsample period 2015-16 and 2016-17 failed to rejected the null hypothesis with trend and intercept The statistical testing of non-parametric KPSS shows a stationarity trend in the weekly return.

2. Variance Ratio Test: The exponential random walk with heteroscedasticity standard error test in weekly returns represented that the test result could not reject the null hypothesis over the full sample in Sensex 30. Random walk behaviour could not be detected in over the weekly data except the period 2017-18 subsample.

3. Multiple Variance Ratio: The joint test statistic or multiple variance ratio test of weekly returns reject the null hypothesis in all the sample and sub-sample in Sensex 30 weekly data. The multiple variance test result found that the weekly data follow a non-random walk motion.

4. **Portmanteau Autocorrelation Test:** The test statistics witnessed upward and downward spikes during the sample period. The weekly subsample witnessed some random walk behaviour and movement over the whole sample with a positive and negative value arise, so it could be conferred that the market movement of the prices were sometime in weak form efficient but not completely weak form efficient that suggested cyclical behavioural trends were visible in the test.

5. **BDS Test:** The result provided evidence on non-linearity structure in the weekly returns. The test conducted in weekly returns over the whole sample on Sensex data rejected the null hypothesis. An independent and identically distributed data could not be detected on the whole sample and sub sample 2018-19. The sub-sample period of 2015-16, 2016-17 and 2018-19 provided an evidence of IID statistics.

Major findings on the weekly Sensex 30 index returns are presented in Table 6.2.

Table 6.2. Findings on Sensex 30 weekly returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	Stationary motion
Variance Ratio Test	Rejected at full samples Accepted at Subsamples 2014-15 and 2017-18	Non Random walk Random walk in subsamples 2014-15 and 2017-18
Multiple Variance Ratio	Rejected Accepted at subsamples 2017-18	Non Random walk Random walk at 2017-18
Portmanteau Autocorrelation Test	Failed to reject	No correlation between the past and the future returns
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinman (BDS) Test:	Accepted at full samples Rejected at subsample 2015-16, 2016-17, 2017-18	Non-linearity Shift overtime

6.4 Findings on BSE Monthly Returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test: The stationary test in the monthly returns in Sensex 30 failed to reject the null hypothesis in the whole sample. However the test with an intercept rejected the null hypothesis over the sub-sample of 2015-16 and 2017-18 at 5 per cent significance level and for sub-sample period 2018-19 at 10 per cent significance level. It failed to reject the test with intercept and trend at 10 per cent level of significance for sub-sample period 2016-17 and 2018-19 at 1 per cent significant level. so, a non-stationarity trend was detected.

2. Variance Ratio Test: The full sample of monthly returns in BSE failed to reject the null hypothesis. The random walk behaviour could be found in subsample of 2016-17, 2017-18 and 2018-19. The monthly returns were more related to the random walk behaviour over a different period. The VR statistics led to rejection of the null in the monthly returns, indicates there was a serial correlation in the monthly return.

3. Multiple Variance Ratio: The monthly statistics in Sensex 30 is significant in the full sample and sub-samples of 2014-15 and 2015-16 at 5 per cent critical level. The sub-sample over the period 2018-19 is significant at 10 per cent critical level. So, based on the result the predictability of stock returns is rejected at 5 per cent level of significance for the full sample. However, every subsample showed autonomy of returns. Multi-variance suggested that a period of predictibility fluctuated not within a short period but over a month that predictability appear because information quickly reflects available information over a certain period.

4. **Portmanteau Autocorrelation Test:** The test witnessed some random walk behaviour and movement over the whole sample. So it cannot be conferred that the market movement of the price is sometimes in weak form efficient but a certain positive and negative relationship in between the test statistics suggests cyclical behavioural trends are visible over the result of Ljung-Box autocorrelation test.

5. **BDS Test:** A non-linearity test conducted in BSE Monthly data provided no sign of significance in non-linearity structure in the full sample of monthly returns. The test result experienced time-bound movement over different values. A non-linearity trend over the sub-sample 2015-16, 2016-17 and 2017-18 was detected. A dependent movement of the past return was found in the whole sample along with subsample 2-14-15 and 2018. A non-linearity trend was arise which mean the predictibility of the price movement on the monthly data was applicable.

Major findings on the monthly Sensex 30 index returns are presented in Table 6.3.

Table 6.3. Findings on Sensex 30 monthly returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Rejected	Non-stationary movement
Variance Ratio Test	Rejected at full sample Accepted at Subsamples 2016-17, 2017-18 2018-19	The martingale movement changes overtime
Multiple Variance Ratio	Rejected Accepted at subsamples 2017-18 and 2018-19	The martingale movement changes overtime
Portmanteau Autocorrelation Test	Failed to reject	No correlation between the past and the future returns
Runs test	Rejected at whole sample Failed to reject at 2014-15, 2016-17 and 2017-18	Non-Correlation movement
Brock-Dechert-Scheinkman (BDS) Test:	Failed to reject at full sample and Subsample 2018-19 Rejected at subsample 2016-17 and 2017-18	Episodic efficiency structure in the daily returns.

6.5. Findings on NSE Daily returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test: The daily data of Nifty 50 shows a nature of stationarity structure as the test failed to reject the null hypothesis of stationarity trend. The overall results suggest that a weak form inefficiency nature was found in the daily data.

2. Variance Ratio Test: The daily returns for Nifty 50 found that the whole sampling data was statistically significant and rejected the null hypothesis at 5 per cent level. This implies that the returns failed to follow weak form efficiency. The finding over the sub-sample in daily returns rejected the null hypothesis at 5 per cent level of significance from 2014-19. Moreover, evidence has been found that stock market exhibited the non-random behaviour in the daily sample over different lag value.

3. Multiple Variance Ratio: The joint test of the daily returns reject the null hypothesis for the whole sample and the entire sub-samples with 10 per cent level of significance. A random walk behaviour could not be supported

4. **Portmanteau Autocorrelation Test:** The daily returns in subsample 2015-16, 2016-18 and 2017-18 periods witness some normal movement of the past data to the present data. An dependent movement in the whole sample and subsample 2014-17. The dependent and independent correlation movement from the previous data was found to be alter in different time period.

5. **BDS Test:** The result from Nifty50 daily data on table 5.14, provides evidence of non-linearity structure in the daily whole return. The test failed to reject the null hypothesis in subsample 2018-19.. The non-linearity test in sub-sample of 2016-17 in Nifty 50 returns experienced no evidence of IID. So, there is existence of linearity and non-linearity over different period with different dimensions and threshold.

Major findings on the daily Nifty 50 index returns are presented in Table 6.4.

Table 6.4. Findings on Nifty 50 daily returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	stationary movement
Variance Ratio Test	Rejected	Non-martingale movement
Multiple Variance Ratio	Rejected	Non-stochastic process
Portmanteau Autocorrelation Test	Rejected at Full sample and Subsamples 2014-15 Accepted at Subsamples 2015-16, 2016-17 and 2017-18	The predictibility of market movement change overtime.
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinkman (BDS) Test:	Reject at full sample and Subsample 2018-19 Accepted at subsample 2015-18 and 2016-17	Episodic efficiency structure in the daily returns.

6.6 Findings on NSE Weekly returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test: The result of weekly data failed to reject the null hypothesis of stationarity over the whole sample period. The period of 2015-16 and 2016-17 in trend and intercept reject the null hypothesis at 10 per cent respectively. The weekly data also experience non-stationary in nature.

2. Variance ratio test: The test result rejected the null hypothesis over the full sample at 5 per cent level of significance. The null hypothesis over the sample of 2014-15 and 2017-18 failed to reject the null hypothesis at 5 per cent level of significance. The weekly returns gave a sign of mixed behaviour movement of stock returns over the subsample in the weekly data. The random walk pattern in the weekly showed a certain shift in the market movement by separating the whole sample into different sub-period.

3. Multiple Variance ratio: The joint test statistics of weekly returns rejected the null hypothesis in all the sample and subsample in Sensex weekly data. Evidence of non-random walk was confirmed as the weekly data rejected the null hypothesis at a 10 percent level of significance.

4. **Portmanteau Autocorrelation Test:** The weekly returns failed the reject the null hypothesis at 1 per cent and 5 per cent respectively over the whole sample and sub-samples. This implied that the weekly returns of Nifty 50 exhibit no serial correlation in the past and present movement. It can be identified that there are positive and negative values, so it cannot be conferred that the market is weakly efficient but certain behavioural trends are visible over the result of Ljung-Box autocorrelation test.

5. **BDS Test:** A non-linearity test conducted in weekly data Nifty 50 data provided no sign of significance in non-linearity structure in the full sample of monthly returns. The non-linearity in Nifty 50 weekly returns failed to reject the null hypothesis at 2, 4 and 6 dimensions and reject 8 embedded

dimensions. The test result thus suggested that non-linearity behaviour in NSE weekly data was futile.

Major findings on the weekly Nifty 50 index returns are presented in Table 6.5.

Table 6.5. Findings on Nifty 50 weekly returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to Reject	Stationary movement
Variance Ratio Test	Rejected	Non-martingale movement
Multiple Variance Ratio	Rejected Accepted at subsample 2015-16	Non-stochastic process
Portmanteau Autocorrelation Test	Failed to Reject	No Serial correlation in returns movement
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinman (BDS) Test:	Reject at full sample Failed to reject at subsample 2015-16 and 2016-17	Episodic efficiency structure in the daily returns.

6.7 Findings on NSE Monthly returns

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test: The stationary test in the monthly returns in NSE failed to reject over the sample of 2016-17 18 at various significant level. The finding on the daily returns showed that there is a clear of no identical movement in the Indian stock index in monthly returns.

2. Variance ratio test: The empirical test in monthly return failed to reject at lag 10 in 2015-16 subsample and failed at lag 4 in subsample 2018-19. The monthly returns are more related to the random walk behaviour over a different period. The VR statistics test result rejects the null hypothesis in the monthly returns, it indicates that there is no serial correlation movement and follows random patterns in the monthly returns.

3. Multiple Variance ratio: The monthly joint statistics in NIFTY 50 failed to reject the null hypothesis at 5 per cent significant for the whole sample and reject for sub-samples of 2015-16 and 2017-18 at 5 per cent critical level. The sub-samples over the period of 2014-15, 2016-17 and 2018-19 were insignificant. Hence, cyclic pattern of market efficiency and inefficiency appears overtime.

4. **Portmanteau Autocorrelation Test:** The monthly returns failed to reject the null hypothesis at 1 per cent and 5 per cent respectively over the whole sample and sub-samples. This implied that the monthly return in nifty 50 return exhibited no serial correlation in the past and present movements.

5. **BDS Test:** The monthly returns suggested that there were no independent and identical distributions. A non-linearity dependent was found in the full sample of monthly data. The sub-sample 2017-18 witnessed a linearity trend, the period witness a non-independent and identically distributed which means a random walk arise. The BDS tested very little or no evidence in linearity dependence in stock returns. However, non-linearity inefficiency was also present over the sample.

Major findings on the Monthly Nifty50 index returns are presented in Table 6.6.

Table 6.6. Findings on Nifty 50 monthly returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Rejected	Non-Stationary movement
Variance Ratio Test	Failed to reject at full-sample and subsample except subsamples 2014-15	Martingale movement arise
Multiple Variance Ratio	Rejected at subsample 2015-16 and 2017-18	Stochastic process was found
Portmanteau Autocorrelation Test	Failed to Reject	No Serial correlation in returns movement
Runs test	Rejected at whole sample Failed to reject at 2014-15 and 2016-17	Non-Correlation movement
Brock-Dechert-Scheinman (BDS) Test:	Failed to reject the test except at subsamples 2015-16	A non-linearity returns predictibility.

6.8 Conclusion

Essentially this study is about investigating adaptive market hypothesis in the Indian equity market as it is one of the fastest growing economies. It is important to note that the market in the various equity markets in terms of efficiency can be untrue, while a group or individual do not progress with an efficient and effective outcome. So, there is a differentiator between traditional and behavioural approaches and yet no conclusive empirical viewpoint is settled in financial academics. The AMH integrates psychology, sociology, behavioural finance along with quantitative finance to produce a more or less feasible definition of efficient market.

To look in the momentum pattern on daily, weekly and monthly of the Indian equity market, there are fluctuations and changings in the behaviour of bull and bear market. The analyses of the test results suggested that the random walk motion of the data are slightly negligible but certain period mainly in the sub-samples experience scanty random behaviour. It seems the investment pattern in the Indian equity market appeared to be more chaotic and unpredictable.

The variance ratio test shows evidence of a period shift from independent and dependent i.e., in consistent with the AMH behaviour. The upward and downward spikes in market movements provide some serial relationships between significance of the past return to future price. Further, while dividing the sample into sub-samples shows the mixed result with autocorrelation over different periods and also provides that the Indian market are close toward the adaptive market hypothesis.

A non-linearity test exhibited in both BSE and NSE give a strong non-dependent. The non-linearity independent changed while dividing into subsample which means that the efficient occurs at a certain time. A positive and negative relationship implies the value fluctuate over time especially in the weekly data. The intervention non-linearity trend in the statistics provides a chaotic random behaviours exist over certain period. The evidence provided the market is falling towards AMH. It could be found that the period of inefficient occur more frequently. So it is difficult to support in the non-

linearity testing in all the result of the BDS test. But, there was evidence of AMH occurrences as a movement of the returns accomplished in detecting toward the time-varying movement of the returns that changes over time.

6.10 Scopes of further studies

It is advisable to make a comparative study of not only stock index market but also a commodity market which will be better by implementing overlapping sample. A multiple variance ratio and a large lag value data analysis can better explain the adaptive market. A behavioural perspective study especially neuro-finance will provide another aspect to study the adaptive market hypothesis.

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1. DRC: 19th April, 2019
2. BOS: 26th April, 2019
3. SCHOOL BOARD: 7th May, 2019

MZU REGISTRATION NUMBER	:1600559
M.PHIL. REGISTRATION NUMBER	: MZU/M.Phil./504 of 07.05.2019
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1 M.Phil. – "Adaptive Market Hypothesis: An Analysis of Indian Equity Market"

2 M.B.A. – "Attitude of Public Towards Cashless Banking with Reference to Mizoram University"

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ADAPTIVE MARKET HYPOTHESIS: AN ANALYSIS OF INDIAN EQUITY MARKET

(ABSTRACT)

A Dissertation submitted in Partial fulfilment of the requirement for the degree of Master of Philosophy

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(May, 2020)

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Abstract

Introduction:

The return predictability and efficient market was one of the utmost consciousnesses for investors and academic research in the capital market. The efficient market hypothesis, one of the fundamental theories of finance, states that the returns of assets are unaffected by the availability of information (Fama, 1965). The market efficiency with respect to information create impossible to earn economic profit by trading current price of the stock with respect to information (Malkiel, 1989). The decisive ambiguity of whether the markets are efficient and inefficient is still inconclusive (Dash 2019). The inconclusive and market anomalies result gave birth to a holistic theory called Adaptive market hypothesis (AMH) that reconcile the fundamentalist and behavioural finance.

This dissertation is about testing whether Indian equity market is adaptive market or not. The notion of AMH is that the market is neither rational nor irrational but driven by fast dynamic market movement and where investors behave, learn and adapted to the changing environment.

The adaptive market hypothesis:

The Adaptive market hypothesis is an economic theory proposed by Andrew Lo in 2004. This theory tried to reconcile the efficient market hypothesis and the behavioural finance creating more holistic view of markets in a broader scope. The approach is based on an influential research of Wilson (1975) in the discipline "Evolutionary psychology" in applying the principle of competition, reproduction and natural selection to social interaction. This evolutionary approach is based on "evolutionary biology" (competition, mutation, reproduction and natural selection) rather than the law of physics that influences in the rational behaviours of the stock (Lo, 2004).

Andrew Lo's (2004) description of the AMH can be viewed as the new variety and successor of efficient market hypothesis which took into consideration the behavioural alternative derived from "evolutionary principle". The theoretical

framework attempts to merge EMH with behavioural aspects by using the concepts of bounded rationality and relevant aspect of environment, psychologist aspect of learning from Simon (1955). Further the EMH which assumes frictionless market contrasts AMH which relies on dynamic market condition.

Review of Literature:

The behaviour of share prices movement have been a paradox or enigma for academics in research i.e. "current price of the stock fully reflects all the available information". The seminal work of Fama (1970) gives much attention in the literature. In 1965, a scholar Eugene Francis Fama in his Ph.D thesis entitled "The behaviours of stock market prices", published in the Journal of Business the notation in "Efficient Market" was introduced (Fama,1965a). Later, he again published his second articles entitled "Random walk in Stock Market Price" in the same journal (Fama, 1965b). Finally, in 1970 he published a paper entitled "Efficient capital market: A review of theory and empirical work" and further reviewed the theoretical and empirical literature on the efficient market model and came up with three relevant subset in support of the theoretical framework to prove the efficient market hypothesis.

Srinvasan (2010), Khan, Ikram & Mehtab (2011), Haroan and Jin (2012), Kumar &Kumar (2017), Kumar & Jawar (2017), and Malafeyev, Awasthi, Kamberkar, & Kupinskaya, (2019) rejected EMH in Indian Market. However, Sharma & Kenedy (1977), Poshakwale (1996), Sharma & Mahnedru (2009), Jain & Jain (2013), Nalina & Suraj (2013), Gupta & Gedam(2014) and Mishra, Mishra & Smyth (2015) accepted the random walk.

The studies in various region like Gilmore & McManus (2003) in Central European market; Magnus (2008) in Ghana; Dimas &Milos (2009) in Romania; Kilic & Bugan (2016) in Turkey; Ameanu and Cioca (2014) in Romania; Erdem & Ulucak (2016) in G7 countries; Khrapko (2013) in Ukraine; Borges (2010) in European countries; Boya (2019) in France; Ndubuisi and Okere (2018) in Nigeria; Almujamed, Fifiled & Power (2008) in Kuwait; Huang (2019) in United States could not find a promising result that led to unending debate.

The Adaptive Market Hypothesis was formulated by Andrew Lo in 2004. The theoretical framework attempts to merge EMH with behavioural aspects by using the

concepts of bounded rationality and relevant aspect of environment, psychological aspect of learning from Simon (1955). In AMH, the predictability of securities returns can vary from various duration which changes from time-to-time due to change in market condition, market participant and financial institute.

Some studies like Ito and Surgiyama (2009), Kim, Lim & Shamsuddin (2010) found time varying pattern of return predictability in U.S market. Urquhart and Hudson (2013) found mixed result in U.S, UK and Japan and conclude that these markets are moving towards AMH. Charles, Darne and Kim (2012) studied the major stock market using AVR, GS-test and DL consistent test, and suggested that the returns predictability occurs from time to time. Hiremath & Kumari (2014), and Kumar (2018) suggested the Indian market switch between efficiency and inefficiency, the unpredictability and predictability occur simultaneously over time and the market are moving toward inefficient to efficient. Dash (2019) and Charles & Darne (2019) experienced mixed result from their findings that the change in different market condition changes the random walk movement in that particular stock market.

Significance of the study

Very little study on adaptive market hypothesis in emerging market especially in Indian market was found. The existence of literature in linearity testing lead to a greater attention in the non-linearity test.. The study that focuses on whether AMH is appropriate to explain the behaviour of the stock return involve the observation on the market momentum, environmental condition and market participants are implied. Providing a significance result in support of evolutionary principle in finances is greatly in need.

Research Design

Statement of the Problem

The controversy arise in different school of thought along with the practitioner create an issue whether the market follows some random walk. The classic EMH theory was neither true nor false but incomplete. Academics seek to support the efficiency while traders aim to exploit efficiency to gain abnormal returns. Various studies have been made and hundreds of journal articles were published. Yet unable to reach consensus whether market are in fact, efficient or not.

The results from various studies indicate that the market is efficient in various episodes i.e. in different place with time period. The market anomalies and chaotic behaviour arose also lead to a debatable in the market momentum.

Objectives of the study

1. To examine whether the Indian equity market follows random walk
2. To analyse whether past movements have an impact on the predictibility of the future movement
3. To examine whether the Indian equity market experience time-varying degree efficiency or episode of efficiency and inefficiency

Hypotheses

H_0: The stock price change is dependent and price movements are random.

$H_{0:}$ The Indian equity market returns exhibit significant serial correlation.

$H_{0:}$ The Indian equity market returns is independent and identically distributed.

Research Methodology:

a) Source of data

Data were collected from secondary sources, which are disclosed in NSE and BSE websites. The historical data were also taken from from Yahoo! Finance website.

b) Sampling unit

The Sensex 30 and Nifty 50 data consist of 1219 observations daily returns; weekly returns comprise of 260 observations and monthly returns comprise of 60 observations. A yearly subsample over the period was also conducted in the daily, weekly and monthly returns.

c) Period of the study

The study covers a period of 5 years i.e. 1st April 2014 to 31st March 2019.

d) Analysis of the data

The analysis was divided into three sections in order to find the result of our hypothesis. Firstly, for the analysis the data is required to be of normal distribution.

The normality test was performed using JB test. The non-parametric KPSS test was performed as the data was found to be not normally distributed. Secondly a random walk test was performed using variance ratio and multiple variance ratio test. Finally, a linearity and non-linearity test using Ljung-Box and BDS test was performed.

Chapter Outline

The study is divided into six chapters.

Chapter 1: Introduction

The first chapter is about introduction of the related topic. The Indian financial market, history of Indian capital market and market movement of major markets are presented for clearer perspective for the readers. The history and evolution of EMH to AMH are discussed. The five principles and applications of AMH, feasibility of the study, scope of the study and limitation, the objective of the study, research design and the problem related to this research are included in chapter one.

Chapter 2: Conceptual framework in EMH and AMH

Chapter two comprises of efficient market behaviours, the review of various related literatures in India and different continent across the globe are presented. Various studies on AMH and EMH are presented with tabulation in the chapter.

Chapter 3: Research Methodology

In this chapter, research design, tools and technique applied are discussed. The Normality test, non- parametric unit root test, variance ratio test, multiple variance ratio test, Brock-Dechert-Scheinkman test are discussed.

Chapter 4: Data analysis and interpretation of BSE Sensex returns data

The analysis of data related to daily return, weekly return and monthly return was tested in Bombay stock exchange (BSE) particularly Sensex 30 using various tools and technique. The purpose of the analysis was to find out the random walk movement and time bound random walk movement.

Chapter 5: Data Analysis and interpretation of NSE Nifty returns data

The analysis of data related to daily return, weekly return and monthly return was tested in National Stock Exchange (NSE) particularly Nifty 50 using various tools and techniques. The analysis was to find out the random walk movement and time bound random walk movement.

Chapter 6: Conclusion and suggestion.

In this chapter, a summary of the finding of the research on the validity of AMH in the Indian equity market was discussed. The conclusion related to the studies has drawn a scope for further studies were also mention in the last chapter.

Findings of the study:

Major findings on the daily weekly and monthly Sensex 30 index returns are presented in table 1, 2 and 3 respectively.

Table 1: Findings on Sensex 30 Daily return

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	Stationary motion
Variance Ratio Test	Rejected	Non Random walk
Multiple Variance Ratio	Rejected	Non Random walk
Portmanteau Autocorrelation Test	Rejected But failed to at subsample 2016-17 and 2017-18	There was an episodic serial correlation
Runs test	Rejected	autocorrelation
Brock-Dechert-Scheinman **(BDS) Test:**	Failed to reject at full sample Rejected at subsample 2016-17 and 2017-18	Episodic efficiency structure in the daily returns.

Table 2: Findings on Sensex 30 weekly return

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	Stationary motion
Variance Ratio Test	Rejected at full samples Accepted at Subsamples 2014-15 and 2017-18	Non Random walk Random walk in subsamples 2014-15 and 2017-18
Multiple Variance Ratio	Rejected Accepted at subsamples 2017-18	Non Random walk Random walk at 2017-18
Portmanteau Autocorrelation Test	Failed to reject	No correlation between the past and the future returns
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinman **(BDS) Test:**	Accepted at full samples Rejected at subsample 2015-16, 2016-17, 2017-18	Non-linearity Shift overtime

Table3: Findings on BSE(Sensex 30) monthly return

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Rejected	Non-stationary movement
Variance Ratio Test	Rejected at full sample Accepted at Subsamples 2016-17, 2017-18 2018-19	The martingale movement changes overtime
Multiple Variance Ratio	Rejected Accepted at subsamples 2017-18 and 2018-19	The martingale movement changes overtime
Portmanteau Autocorrelation Test	Failed to reject	No correlation between the past and the future returns
Runs test	Rejected at whole sample Failed to reject at 2014-15, 2016-17 and 2017-18	Non- correlation
Brock-Dechert-Scheinman **(BDS) Test:**	Failed to reject at full sample and Subsample 2018-19 Rejected at subsample 2016-17 and 2017-18	Episodic efficiency structure in the daily returns.

Major findings on the daily, weekly and monthly Nifty 50 index returns are presented in table.4, 5 and 6 respectively.

Table 4: Findings on Nifty 50 daily return

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to reject	Stationary movement
Variance Ratio Test	Rejected	Non-martingale movement
Multiple Variance Ratio	Rejected	Non-stochastic process
Portmanteau Autocorrelation Test	Rejected at Full sample and Subsamples 2014-15 Accepted at Subsamples 2015-16, 2016-17 and 2017-18	The predictibility of market movement change overtime.
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinman **(BDS) Test:**	Reject at full sample and Subsample 2018-19 Accepted at subsample 2015-18 and 2016-17	Episodic efficiency structure in the daily returns.

Table 5: Findings on Nifty 50 weekly return

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Failed to Reject	Stationary movement
Variance Ratio Test	Rejected	Non-martingale movement
Multiple Variance Ratio	Rejected Accepted at subsample 2015-16	Non-stochastic process
Portmanteau Autocorrelation Test	Failed to Reject	No Serial correlation in returns movement
Runs test	Rejected	Autocorrelation
Brock-Dechert-Scheinman **(BDS) Test:**	Reject at full sample Failed to reject at subsample 2015-16 and 2016-17	Episodic efficiency structure in the daily returns.

Table 6: Findings on Nifty 50 monthly returns

	Null hypothesis	Result
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Rejected	Non-Stationary movement
Variance Ratio Test	Failed to reject at full-sample and subsample except subsamples 2014-15	Martingale movement arise
Multiple Variance Ratio	Rejected at subsample 2015-16 and 2017-18	Stochastic process was found
Portmanteau Autocorrelation Test	Failed to Reject	No Serial correlation in returns movement
Runs test	Rejected at whole sample Failed to reject at 2014-15 and 2016-17	Non-Correlation movement
Brock-Dechert-Scheinman **(BDS) Test:**	Failed to reject the test except at subsamples 2015-16	A non-linearity returns predictibility.

Conclusion

The result shows greater inefficiency in daily return, but the efficiency of market arises during the sub-period of 2017-18. The volatility is quite low in weekly and monthly returns. The test result indicated that daily data is strong independent while the weekly data exhibit dependent in market, indicating efficiency. The efficiency do not remain constant, it change over time the change from an inefficient to efficient random walk is within a short span of time, So, the Indian market is more inefficient but the inefficiency was also shift toward over time series and varying which might be due to the market condition. Therefore the present finding is towards AMH, where profitable returns in trading is episodic in nature when we study over different year by dividing the sample period into various sub-samples of one year each. The volatility trend in the subsample shows certain patterns over times series give a clue in concluding the result that supports AMH.

Limitation of the study

The study is limited to the Indian context as it has taken BSE Sensex 30 and NSE Nifty 50 composite. Two composite may not represent the stock market movement of the entire Indian equity market. The research period and the data taken for the sample period was over a short period of half a decade i.e. 5 years. The market movement and time varying returns predictibility detection could be negligible in short memory data. The seasonal effect can be evaluated by taking Semi-monthly effect, bi-annual effect and calendar effect to a broader market comprehensive. Due to time limit, the study focuses only on the daily, weekly and monthly effect.