



## Testing the Adaptive Market Hypothesis and Time-Varying Efficiency in the Indian Equity Market

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### Abstract

The study examines the adaptive market hypothesis (AMH) as an evolutionary principle of the alternative efficient market hypothesis in the Indian stock market (Sensex and Nifty50) on the daily return from April 2014 to May 2020. Based on AMH, investors behave, learn, and adapt to market conditions. This distinction of dynamic market conditions is divided into bull and bear market classifications. We apply three variations of the variance ratio test and the returns have been whitened using the Autoregressive model with generalized autoregressive conditional heteroskedasticity (AR-GARCH) approach to examine the nonlinear predictability test. Further, we evaluate a fixed-length subsample window framework to detect the time-varying predictability and examine whether market conditions affect stock return predictability and market condition. The study confirms inefficient market behaviour during crises, fear, panic, macroeconomic events and each market adapts differently to certain market conditions. Furthermore, the return series exhibits significant periods of efficiency and inefficiency consistent with the adaptive market hypothesis. The evidence of our findings sheds light on efficient market behaviour in dynamic market conditions and market environments for researchers, investors in investment strategies and policy intervention in risk containment measures and control market manipulation.

**Keywords:** Adaptive Market Hypothesis, Market Efficiency, Time-Varying Predictability, Indian Stock Market, Market Conditions

Received:  
21 June 2023

Accepted revised version:  
19 March 2024


Published:  
30 June 2024

Suggested citation: Sing, N. B. & Singh, R. G. (2024). Testing the adaptive market hypothesis and time-varying efficiency in the Indian equity market. *Colombo Business Journal*, 15(1), 105-135.

DOI: <https://doi.org/10.4038/cbj.v15i1.172>

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## **Introduction**

The return predictability and efficient market (Fama, 1970) on the stock markets are considered one of the utmost consciousnesses for investors, investment institutions and academicians. The efficient market hypothesis (EMH) based on a “random walk” on stock price states that the price of assets reflects all the available information that suggests the market behaves rationally to its intrinsic value (Fama, 1965a, 1965b, 1970, 1990). This gained substantial attention among academic researchers and economists. Numerous studies aimed at better understanding the validity of the EMH revealed various challenges. The notion of efficient market in financial economics is not ideally efficient (Sornette & Cuypers, 2004) and unrealistic in real-world stocks (Grossman & Stiglitz, 1980). Further, the debate remains a tranquil and unsolved issue in the field of finance (Dash, 2019). The challenges to the EMH have further arisen from various observations; anomalies (Bondt & Thaller, 1987; Auer, 2019), mean reversal (Poterba & Summers, 1988; Cochran & DeFina, 1994), noise (Black, 1986; Zargar & Kumar, 2019), irrational exuberance due to investor sentiment and psychological biases (Shiller, 2000, 2015) that leads to a potential outperformance to generate abnormal return. There is widespread debate among academics over the efficiency market hypothesis. Even though many of these studies attempt to better understand the efficiency market hypothesis in the context of the Indian stock market, a large portion of these studies assume that market efficiency remains in disagreement. In the more recent empirical literature, some studies claim that EMH can be treated as an ‘all-or-nothing condition’ (Kumar, 2018; Dash, 2019), while some other studies accept the presence of EMH (Jain & Jain, 2013; Gupta & Gedam, 2014; Mishra et al., 2015; Kumar et al., 2020). However, some studies reject it (Harper & Jin, 2012; Kumar & Jawa; 2017; Malafeyev et al., 2019; Yadav & Arora, 2020).

There has been no consensus on the emergence of behavioural finance and its validity in the financial market. Consequently, a more comprehensive theory is needed to evaluate whether the market is efficient or inefficient. In this regard, Lo (2004) suggests the Adaptive Market hypothesis (AMH), an alternative theoretical framework that challenges conformist thinking in a wider forum and reconciles modern finance with behavioural finance. Lo (2004) states “price reflects as much information as dictated by the combination of environmental conditions and the number and nature of species in the economy” known as a “complex dynamics market”. Moreover, AMH is based on the concept of evolutionary principles (Nelson & Winter, 1982; Andersen, 1994) and bounded rationality (Simon, 2000). Further, Lo (2005) states the financial market is grounded on the dynamic ecology (Farmer &

Lo, 1999; Farmer, 2002) of market factors – competitors, availability of profit opportunity, and adaptableness of market participants. The changing market conditions (Lo, 2005; Charles et al., 2012) provide profit opportunities that arise and disappear allowing investors to make optimal dynamic allocations to the market. However, the notion that adaptability is driven by evolutionary principles, human innovation, and psychological response is the way ahead of an open-ended solution. In the context of testing the Adaptive Market Hypothesis (AMH), the existing literature has employed two primary approaches: Time-varying models (Ito and Sugiyama; Kim et al., 2011; Urquhart and Hudson, 2013) and Moving window analysis (Lo, 2004; Lim et al., 2013). However, a limitation identified in the previous studies, as highlighted in the work of Lo (2004), Kim et al. (2011), and Shah & Bahri (2019), is the lack of a clear specification or indication of the underlying market conditions. Building on this backdrop, the present study aims to extend the existing research by providing a more comprehensive examination of time-varying market efficiency, dynamics of market behaviour, and market conditions in the Indian equity market.

The Indian stock exchange is one of the oldest stock exchanges in Asia, with activity having started in 1875. In the early days of Indian trading, 318 traders formed a group of brokers that became an official organisation called the Native Share and Stock Brokers Association, which we now know as the Bombay Stock Exchange. There are seven recognised stock exchanges in India, but the two most active are the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE). BSE and NSE portray themselves as synonyms for the Indian stock market. Sensex, a composite index of 30 stocks, was created in 1986. A new milestone was reached in 1990 when it crossed the 1000 mark for the first time. Nifty 50, a weightage average of 50 of the largest Indian companies was launched in 1996. The market turnover and market capitalisation of listed companies have grown tremendously in post-liberalisation era. According to the metric on the website, the average listed share over the study period was 7430 in the indices. The number of traded volumes increased from 363 million to 550 million over the study period. The total market capitalisation came from 1622 billion USD to 2043 billion USD1 from Q1 of 2014 to Q2 of 2020. With 57.8% and 68.8% of market capitalisation, the Nifty<sup>2</sup> and Sensex<sup>3</sup> indices represent the benchmarks of the Indian economy. The Indian stock market is mostly dominated by small investors and noise trading. All the NIFTY stocks are affected by noise traders

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<sup>1</sup> [https://www.bseindia.com/markets/keystatics/Keystat\\_maktcap.aspx](https://www.bseindia.com/markets/keystatics/Keystat_maktcap.aspx)

<sup>2</sup> <https://www.nseindia.com/regulations/listing-compliance/nse-market-capitalisation-all-companies>

<sup>3</sup> <https://www.bseindia.com/markets/equity/EQReports/allindiamktcap.aspx>

on an everyday basis in their opening stock prices (Zargar & Kumar, 2019). Small investors make their investment decisions based on past share price movements or sentiments which leads to a greater degree of volatility (Brzeszczyński et al., 2015). Secondly, some studies suggest that these markets are characterised by some idiosyncratic phenomena; speculative and market bubbles, mean reversion of stock price, informationally weak-inefficient, and non-randomness of return (Ahmed et al., 2010; Goudarzi, 2013; Shaik & Maheswaran, 2018; Dash, 2019; Yadav & Arora, 2020; Kanvinde & Shaik, 2022). Based on the above discussion, we are expecting to produce a unique intuition regarding the time-varying market efficiency, dynamics of market behaviour, and market conditions in the Indian equity market.

The motive of the study is to examine whether the Indian equity market experiences AMH or not. The study in the Indian major market is a prime motivation for this study as the non-linearity test was negligible in the previous studies (Hiremath & Kumari, 2014). The present study has been conducted using both linearity and non-linearity. Moreover, no such study has been found on the stock return predictability concerning macroeconomic events in the selected period. We also adopt a rolling window scheme in a regression model to detect the dynamic market characteristics of market efficiency. For this, we use the daily closing prices of Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) for a period of six years from 1st April 2014 to 30th May 2020. A selection of overlapping sub-samples of market efficiency can provide insights into the dynamic market characteristics of market efficiency (Kim & Shamsuddin, 2008; Kim et al., 2011; Urquhart & McGroarty, 2016). A statistical test on linearity and non-linearity has been conducted, and a mere rejection of linear dependence does not infer that the market is efficient without the presence of non-linear dependence. The result of the findings suggest that the Indian stock market experienced inefficiency in the aggregate stock market. However, the level of market efficiency appears to be substantial over time when the dataset is separated into distinct subsamples. The dynamic Indian equities market is found to behave significantly differently under different macroeconomic conditions. Though predictability of stock return appears over time, this return predictability does not provide a long memory and it reverses over a certain period. We find the relevance of time-varying return predictability to market conditions that support Lo's (2004) adaptive market hypothesis.

The study contributes to the existing literature in three ways. First, empirical evidence is added to the existing literature on the theory of adaptive market hypothesis in emerging markets. Secondly, unlike other studies, we further look at

the dynamics of the market such as economic, behavioural, regulatory and institutional change that impact the return predictability and market efficiency. Finally, we address the issue of time-bound market efficiency over time on the returns that will help managers in their investment strategies to guide the investment community.

The remainder of this paper is organised as follows. The next section provides related studies on the AMH and it is followed by a section that describes the methodology of predefined statistical tools used for the study. The section after that contains the empirical findings and the analysis. The final section summarises the findings and provides a conclusion.

## **Review of Literature**

Bachelier's (1900) work on the theory of speculation gained recognition in the field of finance. Bachelier's work was overlooked by Working (1934) and Cowles and Jones (1937), thus showing some random patterns of stock movement and other economic action. Fama's contribution to modern financial economics (Fama, 1965a, 1965b), defines the behaviour of stock prices as "informationally efficient". Fama (1970) formulated a model that presumed a rational and scientific explanation for the decisive paper on the EMH. Existing research and studies on market efficiency have been conducted using models other than traditional models with improved statistical tools. At the same time, no consensual statements could be made on whether the market is efficient, inefficient, or mixed (Karemera et al., 1999; Gupta & Yang, 2011; Shahid & Sattar, 2017; Huang, 2019). Existing literature suggests that market efficiency is a static phenomenon (Sharma & Kenedy, 1977; Karemera et al., 1999; Chuluun et al., 2011; Malafeyev et al., 2019). In reality, market efficiency is a dynamic phenomenon with evolving market frictions over time due to behavioural biases (Kim et al., 2011; Charles et al., 2012; Urquhart & Hudson, 2013; Shah & Bahri, 2019; Almail & Almudhaf, 2017; Zhu, 2019; Obalade & Muzindutsi, 2020). This perspective challenges the notion of market efficiency and rationality, suggesting that various psychological and behavioural factors can lead to deviations from rational decision-making. These factors include herd behaviour during turbulence market conditions under a period of crisis and uncertainty events (Shiller & Pound, 1989; Prechter & Parker, 2007; Baddeley, 2011; Chiang & Zheng, 2010), the presence of heuristic behavioural biases in financial markets (Kahneman & Tversky, 1979), noise trading (Black, 1986; Zargar & Kumar, 2019), overreaction or underreaction to information (Daniel et al., 1998; Kaestner, 2006) and culminating irrational behaviour among market participants.

However, behavioural finance implies that investors behave irrationally, but irrational behaviours are highly predictable due to market bubbles (Shiller, 2000, 2015; Malkiel, 2003; Dale et al., 2005), anomalies (Bondt & Thaller, 1987; Auer, 2019), and mean reversals (Poterba & Summers, 1988; Lipe & Kormendi, 1994). As a result, Campbell et al. (1998) proposed an ‘all or nothing’ view on the market, an approach that determines a market's efficiency over a period of time as an all-or-nothing proposition, implying that markets are relative to each other in the sense of their efficiency. However, this approach utilised many conventional efficiency study approaches (Lo & Mackinlay, 1988). Amid the behavioural finance proponents and advocates of the EMH, investor rationality is at the core of the debate. Lo (2004), provides a new theoretical framework, the adaptive market hypothesis (AMH), which reconciles the behavioural aspect of finance with EMH. The AMH borrowed the concept from evolutionary biology (competition, mutation, reproduction, and natural selection) and bounded rationality that affects the rational behaviour of the stock (Lo, 2004; Simon, 2000). It states that, in the presence of rational and satisfying individuals, actions of the individual associated with learning, natural selection, and competition may drive stock prices to efficient values. The market may not be fully efficient, and there could be instances where assets are priced differently from their intrinsic values, allowing for potential arbitrage opportunities. As existing anomalies are exploited and wane, new opportunities may emerge. This does not necessarily mean that all arbitrage opportunities will be eliminated, as new inefficiencies may continually emerge. Furthermore, events like financial crises, booms, crashes, and regulatory interventions affect the psychological process of market participants that change market conditions (Charles et al., 2012). However, individuals adapt to the environment and learn from their mistakes in the market ecology creating opportunities to survive in dynamic market conditions (Lo, 2005). In AMH, the predictability of security returns can vary over time due to changes in market conditions, market participants, and financial institutions. So, a comprehensive view of the efficient market, market environment, and market participants is required to provide whether AMH is appropriate in explicating the behaviour of stock returns (Sing & Singh, 2019).

The AMH has gained substantial attention among researchers and academic literature. Recent studies viz. Ghazani and Araghi (2014) in the Tehran stock market; Noda (2016) in the Japanese stock market; Xiong et al. (2019) in the Chinese market; Akhter and Yong (2019) in the Dhaka Stock exchange; Trung and Quang (2019) in Vietnam stock market provide evidence in favour of the AMH in Asian regions. Studies such as Ito and Sugiyama (2009) in the US stock market, Popović et al.

(2013) in Montenegro equity market, Kinnunen (2013) in Russian stock market, Madhavan and Arrawatia (2016) in Group of Eight (G8) countries, Almail and Almudhaf (2017) in UK stock market, Ndubuisi and Okere (2018) in Nigerian capital market, Rojas et al. (2017) in Mexican stock exchange, Soteriou and Syenssor (2017) in Stockholm stock exchange, and Shahid et al. (2019) in Pakistan stock exchange also provide supportive evidence for AMH. The U.S. market (Ito & Sugiyama, 2009; Kim et al., 2011) shows time-varying predictability of stock return. Urquhart and Hudson (2013) suggest that the efficiency in the US, UK, and Japanese stock markets are varying and the behaviour of the overall market can be best described as AMH. Obalade and Muzindutsi (2020) claim that South Africa is adaptive in nature as opposed to showing static behaviour. Arendas and Chovancová (2015) suggests that the share markets in Brazil, Russia, India, and China (BRIC) exhibit periods of both weak-form efficiency and inefficiency, indicating that technical and fundamental analysis can generate superior returns. Charles et al. (2012) use AVR, GS-test, and DL consistent tests to examine the exchange rate return of Australia, Canada, Japan, the United Kingdom, and Switzerland stock exchanges to signify the occurrence of AMH depending on specific market conditions and environment. However, stock market efficiency does not fluctuate with market conditions over time, especially in developed countries (Kumar, 2018; Kılıç, 2020). So, testing the adaptive market behaviour in the emerging market is a cause of concern in the study.

A significant gap in the literature on adaptive market behaviour is the lack of emphasis on nonlinear predictability (Urquhart & McGroarty, 2016). Specifically, in the context of the Indian market, studies on nonlinear predictability have been scarce, and the implications of nonlinearity have been largely overlooked or considered negligible (Nair & Thenmozhi, 2011; Jain & Jain, 2013; Hiremath & Kumari, 2014; Kumar 2018; Bhuyan et al., 2020). In emerging stock markets, such as India, AMH provides a better description than EMH, and the Indian stock market shows time-varying predictability that switches between efficiency and inefficiency (Hiremath & Kumari, 2014). Hiremath and Narayan (2016) examine the persistence of AMH in an Indian equity market using long-run Hurst exponential and they found that the market shows a tendency to revert to or cluster to the mean in a dynamic and adaptive manner. Moreover, the degree of market efficiency tends to be higher in external shocks such as financial crises. Khuntia and Pattanayak (2017) provide clues in supporting adaptive markets in the Indian stock exchange. This implies that the predictability of the stock market occurs within a time span for a certain period and thus depends upon the market conditions (Kumar 2018; Dash, 2019). Khuntia et al.

(2018) study the Indian foreign exchange market in comparison with four major currencies (US dollar, Japanese yen, and UK sterling pound) and suggest that AMH is a better elucidation of the Indian currency market. Earlier evidence on AMH was found to be significant in different sectors across the globe and not limited to the equity market. Existing literature on the bond market (Nair & Thenmozhi, 2011), cryptocurrency (Chu et al., 2019; Khurshed et al., 2020), foreign exchange (Kumar, 2018), crude oil prices (Ghazani & Ebrahimi, 2019), planetary economics on energy and climate change (Hall et al., 2017), precious metals (Shahid et al., 2020) and agricultural commodities (Coronado-Ramirez et al., 2015) use AMH as better explanation to understand the behaviour of the respective markets. Given the practical importance of the AMH in financial research, the existing literature on its examination in the context of the Indian financial market is quite limited. Moreover, the exploration of nonlinearity, which is a crucial aspect of the AMH, has been relatively neglected compared to studies conducted in developed markets. The absence of literature regarding the examination of how macroeconomic developments and changes affect the predictability of stock market returns highlights the need for a more thorough investigation into the dynamic market condition of the stock in association with macroeconomic events. Addressing this gap would provide valuable insights into the complexities of the Indian stock market and its responsiveness to evolving market dynamics along with the broader economic landscape. The present study examines the evolving dynamic market condition in the emerging Indian equity market to fill the gap

## **Data and Methodology**

### ***Description of Data***

Daily stock prices have been used for a period of 6 years from 1<sup>st</sup> April 2014 to 30<sup>th</sup> May 2020 in this paper. The period covers events like demonetisation, Chinese stock turbulence, global risk trade-off, and the initial covid-19 pandemic. The data source of the study comprises major stock indices of India such as the Bombay Stock Exchange's Sensex and the National Stock Exchange's Nifty. The choice of the data is due to its market capitalisation and the fact that both indices are considered barometers of the Indian economy. Sensex consists of 30 stocks and Nifty comprises 50 stocks with high cap and financially sound companies. The data are obtained from the official database of BSE<sup>4</sup> and NSE<sup>5</sup> websites.

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<sup>4</sup> [https://www.bseindia.com/market\\_data.html](https://www.bseindia.com/market_data.html)

<sup>5</sup> <https://www.nseindia.com/reports-indices-historical-index-data>



The returns of the stock price are calculated using Equation (1).

$$r_t = \ln \frac{p_t}{p_{t-1}} \quad (1)$$

where,  $r_t$  is return of the adjusted price of the index,  $p_t$  is the adjusted closing value of the index at period t and  $p_{t-1}$  is the adjusted previous closing value of the index at period t-1.

The summary of the descriptive statistics of the variables used in the study is given in Table. 1. The mean values show the same positive value in the entire sample period. The standard deviation values show that Sensex is more volatile than Nifty. The two return series show a negative skewness indicating a long left tail. A positive leptokurtic kurtosis, a higher peak than the normal distribution was found in the samples. The JB test in the return series shows a 1% level of significance which implies an abnormal distribution. The ARCH-LM test is applied to each series of returns in order to examine the ARCH (auto-regressive conditional heteroscedasticity) effect in the residual of the AR model using an auxiliary regression. The lag length of ARMA (2, 3) was selected based on the Akaike information criterion (AIC). The return series provides significant evidence for conditional heteroscedasticity at a 1% level of significance.

**Table 1: Descriptive Statistics of Sensex and Nifty Daily Return**

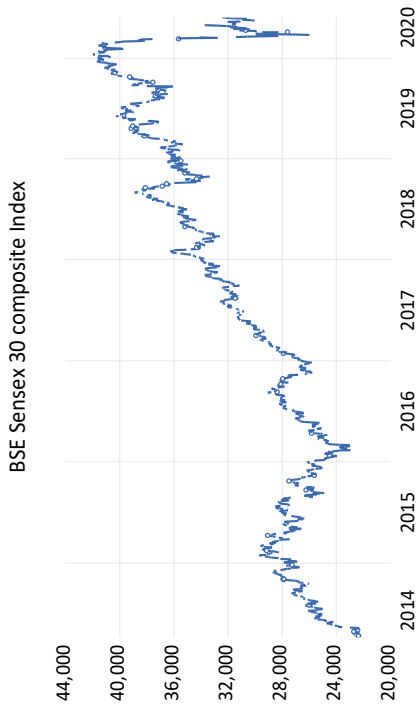
	Obs.	Mean	SD	Skewness	Kurtosis	JB	ARCH-LM
Sensex	1515	0.00024	0.0112	-1.6989	29.6368	45517.31***	444.53***
Nifty 50	1515	0.00024	0.0111	-1.6887	28.3476	41278.06***	431.41***

Notes: 1. \*\*\*, \*\* and \* denote  $p < .1$ ,  $p < .05$  and  $p < .01$  respectively.

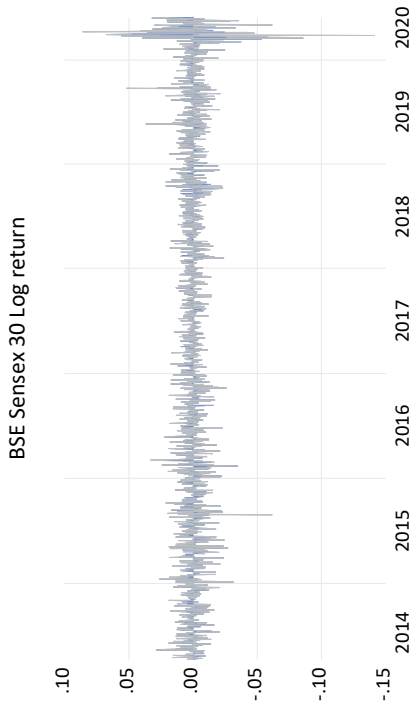
2. ARCH-LM stands for Lagrange Multiplier test for Autoregressive conditional heteroscedasticity.

The trend of the two indices and their log returns are depicted in Figure 1 and Figure 2, respectively. As shown in the figures, the pattern of the two markets intuitively indicates an abnormal distribution of value in price and return and shows evidence of widespread volatility clustered, providing a strong rationale for time-varying dynamics in market returns.

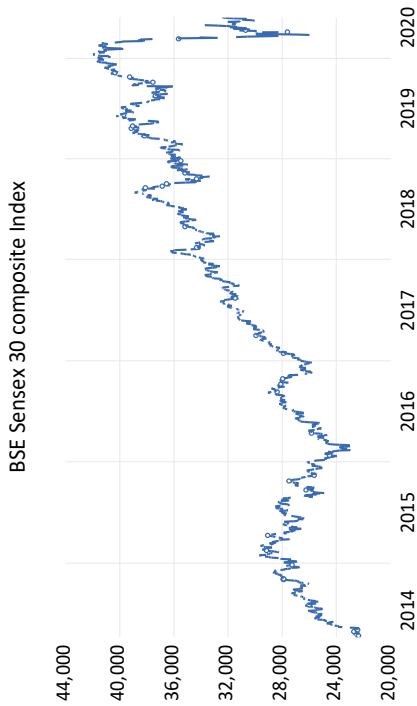
**Figure 1(a): Composite Price of the BSE Sensex**



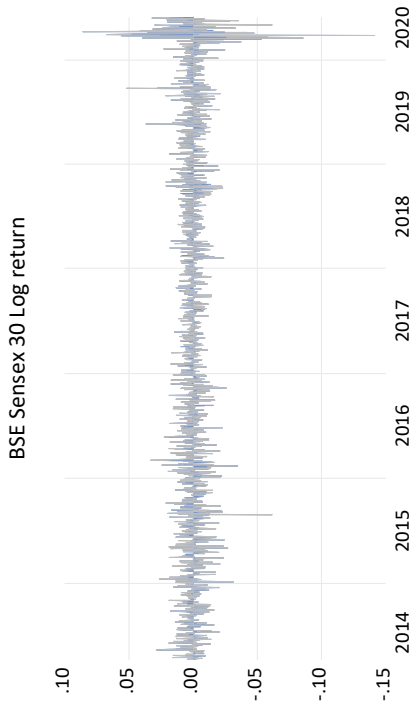
**Figure 1(b): Log Return of BSE Sensex**



**Figure 2(a): Composite Price of the Nifty 50**



**Figure 2 (b): Log Return of the Nifty 50**



## Methodology

To investigate market predictability and evaluate the presence of potential inefficiencies, this study employs a comprehensive set of linearity and non-linearity tests. Specifically, the linearity tests employed include the Chow and Denning variance-ratio test, Wright's (2000) rank and sign test, and the popular non-linearity BDS test. By employing this comprehensive battery of tests, the study aims to provide a thorough examination of market predictability and efficiency. As suggested by Urquhart and Hudson (2013) and Urquhart and McGroarty (2016), linear autocorrelation must be removed before estimating the non-linear BDS test. Consequently, we whiten the returns using an AR-GARCH process to investigate non-linear predictability. After whitening the returns through the AR-GARCH approach, any remaining non-linear predictability cannot be attributed to conditional heteroscedasticity (Lim & Hooy, 2013). Statistical testing is quantified and evaluated using a  $p$ -value. If the  $p$ -value is less than or equal to a 10% level of significance, we reject the null hypothesis and indicate significance in support of the alternative hypothesis of return predictability. Following Kim et al. (2011), Urquhart and Hudson (2013), Urquhart and McGroarty (2016), Mandacı et al. (2019), we use 60-days rolling windows (approximately 2.5 months) to obtain the time-varying predictability. In order to calculate the test statistics, the data for the first trading day of April 2014 is used through the end of May 2020, and then the window is moved forward two months covering the period from June 2014 to August 2014. As a result of this procedure, we were able to generate enough data to evaluate the time-varying return predictability of returns.

### *Measure of Return Predictability*

There is a wide array of research that provides statistical tools to test the adaptive behaviour of return predictability based on the past price. Among the alternatives, the variance ratio test has been widely used to test the weak form efficiency in the financial market. Within this category, we select Chow and Denning (1993) an extended Lo-MacKinlay's (1988) conventional variance ratio test and a non-parametric variance ratio test using rank and sign method (Wright, 2000). Further, the BDS test has been employed to avoid the nonlinear character in the return series. Next few subsections provide a brief description of each statistical test adopted in the study.

#### *Chow and Denning (CD) Test*

According to the random walk hypothesis, the variance ratio for all holding periods should equal unity, and the test should be done concurrently over many holding periods (Hiremath & Kumari, 2014). To overcome the problem, Chow and

Denning (1993) offered a multivariate ratio test to assess whether the number of distinct holding periods is jointly equal to one in order. Further, the multivariate ratio is more powerful than the test against ARIMA (1,1,1) and ARIMA (1,1,0).

In the Lo-McKinley test, the null  $VR(q) = 1$ , but in multiple variance ratio test,  $M_r = (q_i) = VR(q) - 1 = 0$  which is generalised to set of  $m$  variance ratio test as;

$$\{M_r(q_i) | i = 1, 2, \dots, m\} \tag{2}$$

Under the random walk null hypothesis, there are multiple sub-hypotheses.

$$H_{01}: M_r(q_i) \neq 0 \text{ for any } i = 1, 2, \dots, m \tag{3}$$

Rejection in  $H_{01}$  means rejection of the random walk null hypothesis. The heteroscedasticity of Chow and Denning statistic in Equation (4)

$$CD = \sqrt{T} \text{Max } |Z^*(q_1)| \tag{4}$$

where,  $Z^*(q_1)$  is heteroskedasticity robust test statistics. Studentised Maximum Modulus,  $SMM(\alpha, m, T)$ , distribution with  $m$  parameters and  $T$  degrees of freedom is used in the Chow-Denning test. If the value of the standardised test statistic  $CD$  is more than the  $SMM$  critical significant value, the random walk is rejected.

#### Wright Rank and Sign Test

Further, we conduct a non-parametric variance ratio test using rank and sign by Wright (2000). The rank and sign test is a non-parametric alternative to the conventional VR test that addresses the issues of biased and right-skewed samples and makes them more robust to issues in non-normality data. The tests have a higher power against a model demonstrating serial correlation and are more effective than the Lo-MacKinlay (1988) VR test. The sign-based test is exact against a wide range of models with serial correlation, even when conditional heteroscedasticity is present, while the rank-based test exhibits low-size distortion when heteroscedasticity is present (Belaire-Franch & Contreras, 2004). Wright's proposed  $R_1$  and  $R_2$  in Equations 6 and 7 are defined for  $T$  observations of first differences of a variable stock price  $\{y_1, \dots, y_T\}$ . The test statistic based on the rank test is given in Equation (5).

$$R_j(k) = \left( \frac{\frac{1}{Tk} \sum_{t=k}^T (r_{jt} + \dots + r_{jt-k+1})^2}{\frac{1}{t} \sum_{t=1}^T r_{jt}^2} - 1 \right) \left( \frac{2(2k-1)(k-1)}{3kT} \right)^{-1/2} \tag{5}$$

where,

$$R_{1t} = \frac{[r(rt) - (T + \frac{1}{2})]}{\sqrt{(T-1)(T+1)/12}} \quad (6)$$

$$R_{2t} = \frac{\varphi^{-1}r(r_t)}{T+1} \quad (7)$$

where,  $\varphi^{-1}$  is the inverse of the standard normal cumulative distribution function.

The test statistic based on the sign test for the observation is given in Equation (8):

$$S_j(k) = \left( \frac{(TK)^{-1} \sum_{t=k}^T (S_t + \dots + S_{jt-k+1})^2}{T^{-1} \sum_{t=1}^T S_{jt}^2} - 1 \right) \left( \frac{2(2k-1)(k-1)}{3kT} \right)^{-1/2} \quad (8)$$

where,  $s_t = 2u(y_t, 0)$  and  $u(y_t, 0)$  is 1/2 if  $y_t$  is positive and -1/2 otherwise. Under the assumption that  $r_t$  is a no-drift martingale difference sequence,  $s_t$  is an i.i.d. sequence with zero mean and unit variance, and the critical values can be calculated by simulating its sampling distribution.

#### BDS Test

The Brock-Dechert-Scheinkman (1987) or BDS test was initially designed for time-based dependent series (Hiremath & Kumari, 2014). The BDS test is the most powerful nonlinearity test because it does not require adjustment to a correction when applied to residuals (Brito-Cervantes et al., 2018). We fit an AR-GARCH (2,3) to the return based on the Akaike information criterion (AIC) and the standardised residuals are then checked for independent and identically distributed variance using the BDS test.

Let  $\{u_t\}$  be the stochastic process with value of embedding dimension  $m$ , which is determined in the following process:

$$u_t = (u_t, u_{t+\tau} \dots \dots \dots, u_{(t+m-1)\tau}) \quad (9)$$

where  $t = 1, 2, \dots, N-m+1$  and  $\tau$  is a delay time.

The correlation integral at the embedded dimension,  $m$ , for  $\epsilon > 0$ , is estimated by Equation (10):

$$C_{m,\epsilon} = \left( \frac{1}{T} \right) \sum_{1 < s < t < T} \sum I_{\epsilon}(u_t^m, u_s^m) \quad (10)$$

where  $\underline{T} = T - (M - 1)$ ,  $I_{\epsilon}(\dots)$  is the symmetric indicator kernel.  $I_{\epsilon}(z, \omega = 1)$ , otherwise zero.

If  $\{u_t\}$  is an i.i.d. process with a non-degenerate cumulative distribution F, then for fixed  $\epsilon > 0$  and  $m=1,2,\dots$ .  $C_{m,\epsilon} \rightarrow C(\epsilon)^m, T \rightarrow \infty$ , with a probability of one, where,

$$C(\epsilon) = \int \{F(Z+\epsilon) - F(Z-\epsilon)\}dF(Z) \tag{11}$$

Brock, Dechert, and Scheinman (1987) defined the BDS statistic in Equation (12):

$$V_{m,\epsilon} = \frac{\sqrt{T} C_{m,\epsilon} - C(\epsilon)^m}{S_{m,\epsilon}} \tag{12}$$

where,  $S_{m,\epsilon}$  is a constant estimator of the asymptotic standard deviation,  $\sigma_{m,\epsilon}$ , of  $\sqrt{T}C_{m,\epsilon} - C(\epsilon)^m$ , and the null hypothesis  $\{u_t\}$  is i.i.d,  $V_{m,\epsilon} \sim N(0,1) \forall \epsilon > 0$ , and  $m=2,3,4,\dots,n$ .

## Empirical Findings

### *Efficient and Dynamic Return Predictability*

The estimates for the entire sample period help in determining the static or absolute efficiency for selected stock exchanges in India. The joint test statistics in Table 2 indicate that no linear dependence for both the sample period and the BDS test statistics signifies the sample periods are independently and identically distributed, with no non-linearity forecasting technique. So, the estimation of the whole sample indicates predictability of the Indian stock markets in both indices is not possible.

**Table 2: Joint Test and BDS Statistics for the Full Sample**

	<b>CD</b>	<b>JR</b>	<b>JS</b>	<b>BDS</b>
BSE	4.455***	16.210***	11.102***	6.287***
NSE	4.530***	16.226***	10.999 ***	6.287***

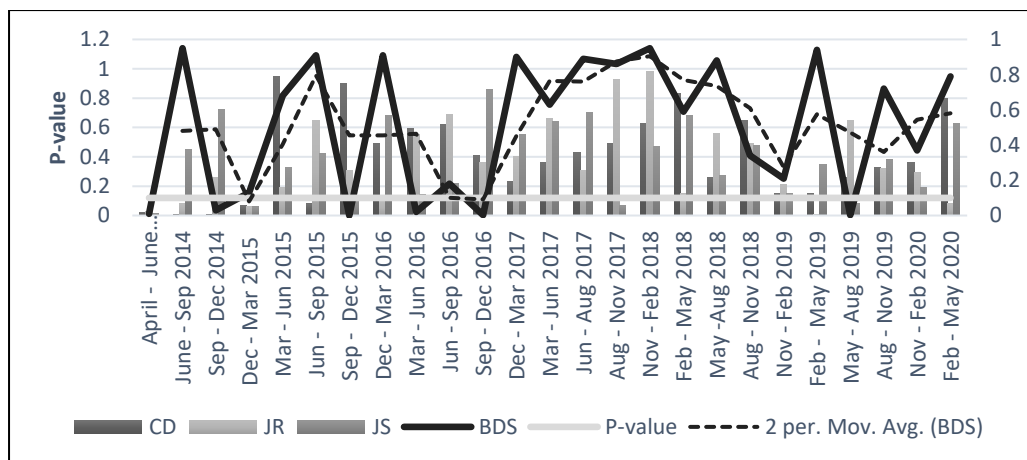
Notes: 1. CD = Chow-Denning statistic, JR = Joint Rank statistic, JS= Joint sign statistic and BDS = Brock-Dechert-Scheinkman statistic.

2. \*\*\*, \*\* and \* denote  $p < .1, p < .05$  and  $p < .01$  respectively.

Interpreting or depicting a financial market in an overall sample as efficient or inefficient may not only lead to inaccurate conclusions but also be practically futile. For this testing, the rolling window allows us to investigate the event with the level

of efficiency. Following Kim et al. (2011), Urquhart and McGroarty (2016), Figure 3 and Figure 4 present the estimated output of a fixed-length rolling 60-day window for Sensex and Nifty 50, respectively.

**Figure 3: The Dynamic Market Behaviour of BSE (SENSEX) Stock Return**

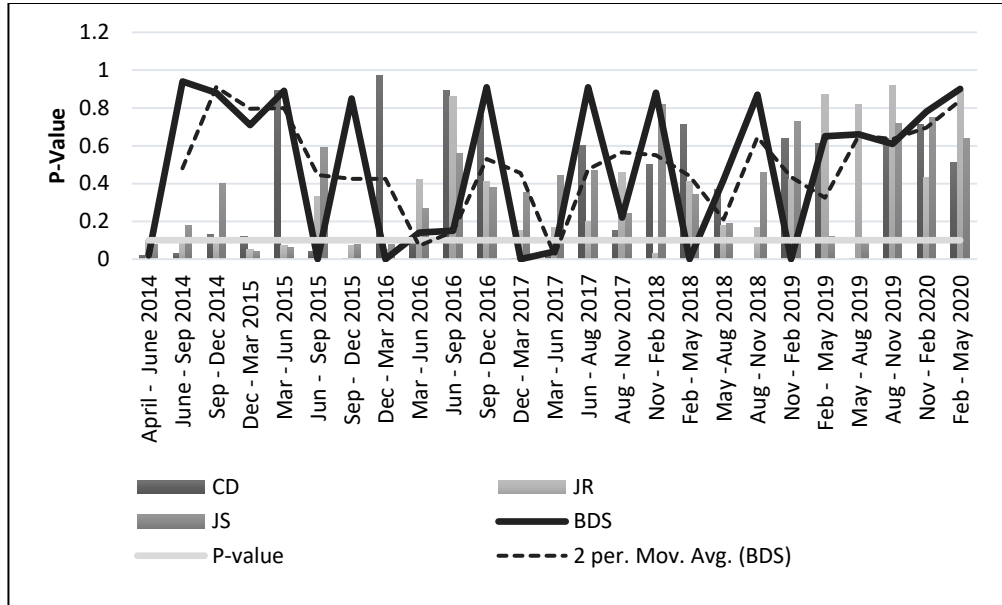


- Notes: 1. The figure depicts the behaviour of BSE stock return using linear method i.e. three variance ratio Joint test and a non-linear test using BDS test using daily return with 3-month windows moving average.  
2. The horizontal line is a representation of the 10% significance level.

The variance ratio  $p$ -value for the Nifty in Figure 3 exhibits a time-varying return predictability. The sample period from June 2014 to March 2015, December 2016 to March 2017, August to November 2018, May to August 2019, and the initial period of the COVID-19 pandemic show a market inefficiency that implies predictability of stock returns are found to be significant. However, the samples from other periods are insignificant at a 10% level of significance, and the stock returns in those periods are unpredictable. The period of significance varies over a period within a short period after 2015. There is clear evidence of return predictability that changes over time which is consistent with the AMH. Our finding is congruent with the findings of Hiremath and Kumari (2014) and Khuntia and Pattanayak (2017). The results of BDS test statistics for subsample periods from April 2014 to June 2014, September 2014 to December 2014, September 2015 to December 2015, March 2016 to June 2016, September 2016 to December 2016 and May 2019 to August 2019 are statistically significant which implies predictability of stock return. From December 2017 to May 2019, all the  $p$ -values are statistically insignificant indicating that stock returns are unpredictable. The BDS statistic suggests that there is a transition of predictability and unpredictability simultaneously. Our finding is similar to earlier findings on the

time-variation in expected return (Conrad & Kaul, 1988; Ito & Sugiyama, 2009; Kim et al., 2011; Rojas et al., 2017; Shah & Bahri, 2019).

**Figure 4: The Dynamic Market Behaviour of NSE (NIFTY 50) Stock Return**



- Notes: 1. The figure depicts the behaviour of NSE stock return using linear method i.e. three variance ratio Joint test and a non-linear test using BDS test using daily return with 3-month windows moving average.  
 2. The horizontal line is a representation to the 10 % significant level.

The variance ratio  $p$ -value for the Nifty in Figure 4 also exhibits a time-varying return predictability. The sample period from June 2014 to March 2015, December 2016 to March 2017, August 2018 to November 2018, and May 2019 to August 2019 show a market inefficiency that implies predictability of stock return as the  $p$ -values in those periods are statistically significant. However, the sample from other periods is insignificant at a 10% level of significance, and the stock returns in those periods are unpredictable. The period of significance varies over a period within a short period after 2015. There is clear evidence of return predictability that changes over time which is consistent with earlier evidence on AMH (Kim et al., 2011; Urquhart & Hudson, 2013; Urquhart & McGroarty, 2016; Xiong et al., 2019). The  $p$ -value of the BDS test statistic for the Nifty 50 index is shown as a line graph in Figure 4. The rejection of the null hypothesis in the BDS test indicates that the data is not independently and identically distributed (IID). This means that the stock returns do not follow a purely random and uncorrelated process. So, historical price can be leveraged to predict future stock price movements. The predictability of the stock



returns shows a significant nonlinear dependence from June 2015 to September 2015, December 2015 to March 2016, December 2016 to March 2017, March 2017 to June 2017, February 2018 to May 2018, and November 2018 to February 2019. The presence of non-linear dependence and independence over certain periods implies that the return prediction shifts over numerous sub-periods. The unpredictability in the stock return occurred over a wide span of the period from February 2019. Stock market efficiency and in-efficiency transition occurred in the whole sample. The period of predictability in the stock return happens more often but the behaviour fluctuates between predictability and unpredictability. Our finding is similar to the earlier finding on the nonlinearity during the fear of stock market turbulence and crisis (Urquhart & Hudson, 2013) and outflow of Foreign Institute Investor (FII) and Foreign Portfolio Investor (FPI) and trade-wars (Hiremath & Kumari, 2014).

### ***Market Condition and Return Predictability***

Lo (2004) suggests that a market's predictability varies over time as market conditions change but does not provide specific references or assumptions regarding the relationship between market efficiency and market conditions (Kim et al., 2011). This study examines market conditions using monthly sample data spanning 75 months. Following the methodologies of Fabozzi and Franchise (1977) and Urquhart and Hudson (2013), the data is categorised into bull and bear markets. Months with non-negative average returns are defined as "UP" (bull) periods, while months with negative average returns are classified as "DOWN" (bear) periods. Additionally, the study incorporates the classification method proposed by Klein and Rosenfeld (1987), a modified version of Fabozzi and Franchise's (1977) approach. In this method, a bull market period is defined as 'when the market's return exceeds one-half of the market's standard deviation for that period', and a bear market is defined inversely. This approach allows for an evaluation of market predictability and efficiency across distinct market regimes without considering underlying trends. Classification of market conditions and descriptive statistics are presented in Table 3.

To detect the predictability of certain market conditions, we regress the market condition with a dummy 60-day rolling widow return predictability. This exertion is consistent with the prior work of Urquhart and McGroarty (2016). The regression results of the market conditions and the different events on stock return predictability are reported in Table 4. Throughout a market downturn, the Sensex shows a significant negative relationship with the joint sign test, whereas the BDS test suggests a high degree of predictability during the downturn. Similarly, Nifty 50 results on the joint-rank test and joint-sign test show a significantly high level of

predictability during the down period. Moreover, according to the Chow-Denning test, the result in the bear period shows a higher level of return predictability in Nifty50. Our finding is similar to the findings of Urquhart and McGroarty (2016) in the S&P 500 and NIKKEI 225 stocks.

**Table 3: Classification of Market Conditions and Descriptive Statistics**

	BSE Sensex				NSE Nifty 50			
	UP	Down	Bull	Bear	UP	Down	Bull	Bear
Market condition	42	33	22	53	41	34	28	47
Mean	0.006	-0.033	0.054	-0.042	0.032	-0.029	0.054	-0.060
Maximum	0.137	0.038	0.139	0.059	0.096	-0.001	0.1371	0.059
Minimum	-1.181	-0.264	0.029	-1.182	0.001	-0.078	0.029	-0.078
SD	0.192	0.049	0.025	0.162	0.023	0.024	0.025	0.035
Skewness	-5.953	-3.149	1.813331	-6.257	1.035	-0.376	1.813	-0.390
Kurtosis	37.36	15.69	6.31	42.82	3.877	1.948	6.311	2.530

**Table 4. Regression Results of The Predictability Test and the Market Condition**

	Market Condition	CD	JR	JS	BDS
BSE (SENSEX)	UP	0.01286	-0.03119	-0.00582	0.04462
	Down	0.03583	-0.02585	-0.0472***	0.0196***
	Bull	-0.03791	0.03002	-0.02479	0.00748
	Bear	0.01721	0.00989	-0.02298	0.06531
NSE (Nifty 50)	UP	0.02729	0.01556	0.00554	0.00081
	Down	0.00518	-0.0658***	0.0794**	-0.0387
	Bull	-0.00644	-0.00931	0.03757	0.00419
	Bear	0.0468***	-0.02588	-0.0079***	0.01495

Notes: 1. CD = Chow-Denning statistic, JR = Joint Rank statistic, JS= Joint sign statistic and BDS = Brock-Dechert-Scheinkman statistic.

2. \*\*\*, \*\* and \* denote  $p < .1$ ,  $p < .05$  and  $p < .01$  respectively.

### ***Robust Check for an Event Around Market Inefficiency/Predictability***

We examine the relationship between major economic events and stock market inefficiency during the study period. We identify events in which the trend in the BDS test is found to be inefficient in the market during the estimated window. The inefficiency observed during the period of 2014 is associated with a reform agenda

'Make in India' movement led by the National Democratic Alliance (NDA) government that aims to boost the macro-economic indicators such as GDP growth and reduce inflation. The period also experienced a positive capital market response to Sensex and Nifty with 30% year to date (YTD). The Reserve Bank of India (RBI) announced a fight against inflation in 2014 to curb market volatility and encapsulate the financial scenario. In the year 2014, market inefficiency occurred as investors were optimistic about the government reforms, reform push in e-commerce businesses, and expectation for a new government.

Interestingly, the stock market from September 2015 to December 2015 and September to December 2016 displayed a market inefficiency. Major global events like Chinese stock market turbulence, the Greek crisis, the downward performance of the Dow Jones Industrial Average (DJIA) in August 2015, and 'Black Monday' by Chinese state media in August 2015 had a ripple impact on Indian equities in reaction to the global risk-off trade. In the first half of the financial year 2015-2016, the number of initial public offerings (IPOs) increased by more than nine-fold. The government intervened to slash interest rates to curb the weaker health of the banking sector in September 2015. The overreaction of the market after the announcement of the Brexit vote on 22 February 2016, as a result of the first trade day after the referendum on 22 June 2016, shows the Sensex lean to over 600 points and the Nifty bled to 180 points. A massive sell-off of domestic institutional investment (DIIs) and a dip toward foreign institutional investment (FII) happened in the month of June 2016. The announcement of the surgical strike in the month of September 2016 across the border of Pakistan reacts to the market into a tailspin. The year 2016 led to the overreaction of the market-led market volatility and experienced stock return predictability. The Indian stock markets show a market inefficiency and have had the worst performance so far in 2019 during our study period. The higher tax surcharge on foreign portfolio investors (FPI) announcement in the budget led to higher FPI selling in June 2019 and August 2019. This result reveals that FII and FPI are affected not only by the strategies of global investors but also by domestic policies in a liberalised economy. As such, it appears that business performance is affected by both local and global influences in a liberalised economy. The global pandemic that originated in China in 2020 created chaos, and instilled fear in investor behaviour resulting in market inefficiency.

Further, we examine the relationship between major macroeconomic events and stock market inefficiency during the study period. We regress the three variance ratio test statistics and BDS test statistic as dependent variables against a dummy event

Table 5: Major Stock Market and Economics Event for the Period 2014-20

Period	Events	Sensex 30			Nifty 50				
		CD	JR	JS	BDS	CD	JR	JS	BDS
2014	General election: the NDA form government, RBI fight against inflation	-0.430**	-0.396*	-0.150	-0.084	-0.285	-0.160	-0.226	-0.039
2015	Fear over the Chinese stock market turbulence and Greek debt crisis, Black Monday	-0.371*	-0.096	-0.143	-0.044	-0.230	-0.065	-0.041	-0.164
2016	NPA of Indian Bank, Demonetisation drive by Modi government	0.004	-0.216	0.387**	-0.107	0.555**	-0.025	-0.126	-0.064
2017	The introduction of GST bill into the Indian economy	0.174	0.239	-0.163	-0.384	0.580*	0.605**	0.204	-0.369*
2019	Higher tax surcharge on foreign portfolio investor's (FPI) announcement in the budget, FII and FPI are affected the global and domestic economy, Corporate tax cut, US-China trade war	-0.151	0.034	-0.153	-0.203	0.010	0.615**	0.054	0.116
2020	FY 2020-21 Union budget, The market panic, fear due to global breakdown of coronavirus	0.134	-0.266	0.027	0.016	0.300	0.405*	0.339*	0.321

Notes: 1. CD = Chow-Denning statistic, JR = Joint Rank statistic, JS = Joint sign statistic and BDS = Brock-Dechert-Scheinkman statistic.  
2. \*\*\*, \*\* and \* denote  $p < .01$ ,  $p < .05$  and  $p < .10$  respectively.

associated with the stock market environment. This is consistent with the work of Khuntia et al. (2018). The regression estimation result in Table 5 shows that the predictability of the stock market is associated with its market event. The weak form of market efficiency is not static and certain periods show inefficiency over time. This finding provides evidence of time-varying predictability of stock market aligning with macro-economic events, implying that the market predictability emerges from complex interactions and adaptations of the diverse market participants. The finding is congruent with Lo's (2004) adaptive market hypothesis.

## **Conclusion and Implications**

The paper investigates whether the evidence from the Indian stock market supports the adaptive market hypothesis (AMH) or not. The test for both return series shows that the degree of efficiency or in-efficiency varies over time. This result of the study provides evidence of market behaviour fluctuation and time-varying return predictability. This highlights that markets are adaptive in nature. There is a change in market condition from an inefficient to efficient market momentum within a short span of time i.e. a month and a year. Market conditions such as government intervention, global and domestic events, FIIs regulation, and boundary counter-attacks show an important role in the return predictability as investors quickly react to the market. The present study confirms the Indian market is more efficient but the inefficiency has shifted with changes in market conditions over different periods. The AMH framework, with its emphasis on the adaptive behaviour of market participants, provides a more robust and insight in defining the Indian stock market.

The results have implications for academics, institutional investment managers, retail investors, and policymakers in dealing with market behaviour, formulation of investment strategies, and investment strategies. For academics, adaptive markets, characterised by time-varying efficient markets, market conditions, and market responses to economic conditions, seem more conclusive in describing the behaviour of the financial market. It is advisable to come up with a model for the time-varying approach, a model that is capable of detecting market efficiency and inefficiency. From the aspect of formulation of investment strategies, our findings on time-varying efficiency in stock market performance remain significant. This implies that market timing, sectoral rotation, and security selection need to be used with specialised concepts as arbitrage opportunities are possible and may arise from time to time. In terms of investment strategies, the current study reveals that relying solely on a technical trading strategy to forecast the value and growth may not yield the intended results. So, quantifiable analysis of information related to news, macro-micro

economic structure and cross-sectional measures on investor population of investor preference with innovation is required to navigate the complexities of the Indian stock market for potential opportunities for generating abnormal profits. Policymakers, particularly the Securities and Exchange Board of India (SEBI) need to take proactive corrective measures in monitoring and addressing market manipulation and risk containment at the stock exchanges. The finding underscores major international events (market turbulence, debt crisis, Black Monday) that impact the integrity and stability of the Indian stock exchanges. Therefore, regulatory bodies need to enhance their oversight and introduce appropriate measures to mitigate the risks and prevent potential market manipulation during such periods of heightened volatility and external shock. For institutional investors, managers should prioritise survival strategies in addition to profit maximisation and need to analyse each market separately. For instance, one market can perform poorly while another performs well depending on the current market environment in which changes in market ecology interact.

Further research can be conducted to examine predictability in response to changing market conditions in sectoral indices, exchange-traded funds, or derivatives markets in developed, emerging and frontier markets. Detecting dynamic markets and time-varying return predictabilities with short-term memory data might be insignificant. A comparative study on monthly and weekly data with daily data using long memory models is advisable. Alternative approach or methodology, beyond the findings already presented may be to use panel-based approaches, trends in macroeconomic indicators, and consolidation of modern finance with a behavioural perspective.

### **Declaration of Conflicting Interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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