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ARE MARKETS EFFICIENT IN WEAK FORM? EVIDENCE FROM INDIAN INDICES

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Abstract

Fama (1965) efficient market hypothesis (EMH) theory has always been an area of interest to both academicians and market analysts. Ever since Fama (1965) proposed the idea of efficiency many academicians did study the assumptions of efficiency on various developed and developing markets yet, no conclusion has been drawn on the efficiency assumption. However, the results of the studies conducted earlier were able to provide insights on the existence of inefficiencies in certain markets which would be potential opportunities for abnormal returns. Amid the presence of these inefficiencies the present study aims at testing the weak form of efficiency assumption on India's most prominent indices (Nifty 50, Nifty 500, BSE Midcap and Sensex) during Jan 2020 to October 2023. The indices and duration are chosen deliberately keeping in view the market capitalization and looming crisis around the world respectively. The study used descriptive statistics, Augmented Dickey fuller (ADF) test, Auto correlation factor (ACF) test and Lo and Mac Kinlay Variance ratio (LMVR) test to test the assumptions of weak form of efficiency. The study concluded that Indian markets are inefficient in weak form which implies that technical analysts can predict the market movements and can earn abnormal returns.

Keywords: Efficient Market Hypothesis (EMH), Weak Form of Efficiency, Random Walk Hypothesis, Unit Root Test, Serial Correlation, Variance Ratio Test.

1. INTRODUCTION

The concept of efficient market hypothesis (EMH) is the most well-known and controversial theory of finance. Ever since its introduction by Fama (1965)[21] it's assumptions and forms have been tested time and again by many academicians, financial analysts and market enthusiasts. Despite the efforts by the afore stated community of people the theory of efficient market hypothesis (EMH) is still controversial and lacks an absolute framework that justifies its tenets. Further, it is believed by the finance community that the theory of efficient market hypothesis (EMH)

is the basis for many alternative theories on the behavioural and evolutionary perspectives of stock markets.

The concept of EMH as propounded by Fama(1965)[21] states that markets reflect all available information almost instantly in its prices thus no investor/analyst would be able to attain abnormal returns. The markets absorb every spec of new information instantaneously and stock prices always find a new balance (Hiremath and Kumari (2014)). Besides it is believed by the investment community that existence of stock market efficiency and it's understanding is critical for building an appropriate investment portfolio.

According to Fama (1965)[21] efficient market hypothesis theory new information released to the market is discounted every time immediately leaving no speculation opportunities for any market participant. I.e., None can profit from technical or fundamental analysis and the opportunities of profit are purely out of luck. Fama (1970)[21] classified market efficiency in to three forms,

a. Weak Form of Efficiency:

The first form of efficiency that states every stock market reflects and responds to all the historical price-volume information almost instantly, hence technical analysis is futile in predicting the market movements.

b. Semi Strong Form of Efficiency:

This form of efficiency assumes that investor community performs both technical and fundamental analyses on the present publicly available market information thus none can outperform the market.

c. Strong Form of Efficiency:

Strong form of efficiency assumes that market absorbs all insider, public and private information instantly thus no analysis can generate abnormal returns. This form of efficiency amalgamates the assumptions of both weak and semi strong forms of efficiency.

The above three forms of efficiency are based on the premise of the information flow and its impact on stock price movements. According to Fama(1965,1970)[21] no stock trader can outperform the market by making predictions based on any information. This belief of EMH opposes the ideology of technical analysts/chartists who predict market movements using historical and current information. The contradictory assumptions of EMH are the focal point of analysis for many academicians and market analysts since then and no conclusive evidence has been made so far.

The inconclusiveness of the past researches/ analyses is the base for the current study which is aimed at testing the assumptions of weak form of efficiency or random walk hypothesis (RWH) on India's most popular market indices Nifty50, Nifty 500, BSE Sensex and BSE Midcap. The paper is a modest attempt to contribute to the literature of market efficiency and is conducted for a period of three years (2020-2023). The period of the study is chosen deliberately keeping in view the rapid movements in country's economic activities during and after world's worst health crisis (Corona). Further a series of statistical and econometric tools are applied to the log return series of afore stated indices (Nifty 50, Nifty 500, BSE Sensex, BSE Midcap). The paper is organized in to subsections that discusses literature review, methodology of the study, empirical results discussion and conclusion.

2. LITERATURE REVIEW

This section presents the literature pertaining to the concept of efficient market hypothesis (EMH) and weak form of efficiency. The term market efficiency was first proposed in a mathematics dissertation of Bachelier (1900). Bachelier (1900) in his thesis stated that "no past, present information is reflected in stock prices thus none can predict price fluctuations. Markets assess the fluctuations more or less likely and this likelihood must be evaluated mathematically". Remarks of Bachelier on informational efficiency are perceived to be the basis for Brownian motion and many other analytical tools in the area of finance however these remarks were deaf eared until Paul Samuelson's study on building mathematical models to economic data. Paul Samuelson's works in the area of economics and its interrelationship with mathematics and other disciplines has been the rock to the concept of efficient market hypothesis (EMH) of Eugene Fama (1965)[21].

However, before Fama (1965)'s efficient market hypothesis there were few remarkable studies that analysed stock price behaviour or movement of world's major markets. The studies that identified predictable patterns in the return series include, Osborne (1959) on US return data which concluded that US common stock price movements were akin to molecule movements. The analysis results of Osborne (1959) were brought to light by Cootner(1964), Bernstine(1992). The studies in 1950's in the area of economics implied that "Economic time series could be analysed to understand both long term, short term and random movements" Kendall (1953). The studies that followed 1950's do assume and proved informational efficiency of the market up until a remarkable observation by Fama(1965)[21] which he concluded stating " that there is a strong evidence in support of random walk hypothesis i.e., returns follow a random walk and predictable patterns among the returns is statistically insignificant".

Ever since Fama(1965)[21] thesis dissertation there are studies that supported and opposed the assumptions of random walk hypothesis(RWH). To test the assumptions of random walk hypothesis (RWH) or weak form of efficiency a combination of parametric and non-parametric tools was used. Dockery and Vergari(1997) conducted a study on Budapest stock markets and concluded that under the conditions of homoscedasticity the stock market refutes assumptions of random walk while accepts random walk hypothesis(RWH) under heteroscedasticity. Cheung and Coutts (2001) study on Hongkong stock markets also supported the existence of random walk in Hongkong stock. Chan, Gup and Pan (1997)[10] tested assumptions of weak form of efficiency on seven stock monthly return series and concluded that return series are efficient in weak form. Kendall and Hill (1953) studied 22 stocks and concluded that the series follows random walk. Abrosimova, Dissannaike and Linoswski (2005) conducted a study on Russian Stock markets using ARIMA and GARCH models and concluded that Russian stocks are efficient in weak form.

Maria (2007) carried out a study on Lisbon stock exchange for 1993-2006 and concluded that indices are efficient in weak form. Qian, Song & Zhou (2008)[34] study on Shanghai Stock Exchange Composite (SSEC) index exhibited nonlinear behaviour and failed to reject the unit root hypothesis thus concluded that SSEC returns are efficient in weak form. A study on New York stock returns by Granger and Morgenstern (2007) concluded that New York indices are efficient in weak form in short run. Vig et.al (2008) study on Bombay stock exchange of India was proven to be supporting assumptions of weak form of efficiency. Lo and Mac Kinlay (1999) infirmed random

walk hypothesis by testing return series using variance ratio test. Poshakwale (2002) study on Indian markets using GARCH model concluded that the assumptions of weak form of efficiency are disproved for Indian Indices. A study conduced on Istanbul stock indices in 2005 also rejected the assumptions of weak form of efficiency Tas and Dursunoglu (2005)[41]. Peng et al. (1994)[33], Horvatic et al. (2011) also identified long range, linear relationship among return series. Gupta (2001)[24] study on stock futures identified cointegration and information asymmetry among return series which implies rejection of assumptions of weak form of efficiency. A study on three popular Indian Indices (CNX defty, CNX Nifty, CNX Nifty Junior) using runs test, auto correlation function (ACF) by Pandey (2003)[30] concluded that the indices are inefficient.

Shiller and Radikoko(2014)[39] used various statistical tests such as Auto correlation to test the validity of assumptions of weak form of efficiency on Canadian equity market returns and the study rejected the market efficiency. Pant, Bishnoi (2002) analysed daily and weekly returns of Indian stock markets using Auto correlation, Augmented Dickey Fuller test (ADF), Variance ratio (VR) tests and concluded that Indian markets are inefficient. Thomas and Kumar (2010)[42] study on Indian stock markets using Auto correlation and runs test was proven to be against the assumptions of weak form of efficiency. Haroon and Muhammad (2012)[25] study on Karachi stock exchange rejected assumptions of random walk but has found evidence of Monday effect in Karachi market indices. Ansari and Khan (2012)[5] analysed Indian Indices using momentum strategies and concluded that Indian indices are inefficient in weak form.

Patel, Radadia and Dhawan (2012)[31] conducted a study on four Asian market indices (HANSENG, SSE composite, NIKKEI, BSE Sensex) daily closing prices using Auto correlation, run and unit root tests and concluded that each of them responded differently to the information supplied to them. HANSENG and SSE Composite were efficient in weak form while NIKKEI and BSE Sensex were weak form inefficient. A study on Karachi Stock Exchange daily return series by Riaz, Hasa and Nadim (2012) found no evidence to support weak form of efficiency. Chandu, V. ., Reddy, K. P. ., Srilakshmi, S. ., & Shifaly. (2022). Pre-investment perception of investors' towards security market in indian context. *International Journal of Professional Business Review*, *7*(2), e0416. https://doi.org/10.26668/businessreview/2022.v7i2.416 Similar study on Istanbul stock indices of Turkey conducted by Al Jafari (2013) using unit root and runs tests confirmed that stock returns of Istanbul exchange are weak form inefficient. Mishra (2011)[29] study that included both emerging and developed indices returns rejected the assumptions of weak form in short run however the study claimed that indices move towards efficiency in long run. A study on five Middle East country stocks by Smith (2007) infirmed that Middle East indices exhibited mixed results during the study period. Chandu V, Maddala S, Sai KGD, et al. Research on retail Buyers' emotional quotient with focus on transactions on the National Stock Exchange. International Journal of Engineering Business Management. 2023; 15. Doi: 10.1177/18479790231180770

Chandu, V. ., Thagaram, E. ., Srilakshmi , S. ., Sahyaja , C. ., Akthar, P. ., Goli , G. ., & Rao, C. V. R. K. . (2023). Federated Deep Learning Architecture for Technical Analysis of the Standard Souq Using Optimization Technique. *International Journal of Intelligent Systems and Applications in Engineering*, *12*(6s), 233–246. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/3974

Research Gap: From the literature review, it was observed that a wide range of empirical investigation on random walk hypothesis (RWH) was carried out but no conclusive evidence has been drawn so far. Weak form of efficiency as propounded by Fama (1965)[21] quotes that "price movements of a stock market doesn't have memory and past price volume information doesn't have any impact on future price movements. Thus, no technical analyst can predict the future and earn abnormal returns by analysing past information." Data to test the assumptions of weak form of efficiency could be daily/weekly/Monthly return series. A wide variety of studies Fawson et al. (1996)[22], Chang and Ting (2000), Groenwold et al. (2003)[23], Lima and Tabak (2004)[6], Mikailu and Sanda(2007) used individual or stock indices return series of different time periods to test the assumptions of weak form of efficiency. Several statistical and econometric tools were applied on the past price data to prove or disprove the assumptions of weak form of efficiency/ random walk hypothesis (RWH). Runs test is the non-parametric statistical test that is used extensively to test the assumption of non-randomness property of return series. In literature studies that adopted runs test include Barnes (1986)[9], Dickinson and Muragu(1994)[14], Sharma et al.(1997) ,Karemera et al.(1999)[26], Abeysekera(2002)[2] and many more. Another popular assumption of weak form of efficiency Unit root/Non-Stationarity property of returns was tested using Augmented Dickey Fuller (ADF) test which was employed by many researchers Moorkerjee and Yu (1999), Groenwold et al. (2003)[23], Abeysekera(2001)[1], Fawson et al.(1996).

Further in literature many researchers applied serial correlation test, Q-test and Variance ratios tests to test the assumption of serial uncorrelation of efficient market hypothesis or random walk hypothesis (RWH). A series of statistical tools were used by researchers/analysts such as correlation tests and Q-test. Correlation tests were used for testing individual serial correlation while Q- test were used to test significance of set of coefficients. Few remarkable studies that adopted Q- test in literature were Dickinson and Muragu(1994), Dockery and Vergari(1997)[18], Karemera et al.(1999)[26], Cheung and Coutts(2001)[11], Lima and Tabak(2004)[6]. Each of the above studies used Variance ratio test- Q statistic to test the randomness of the stock returns. A recent study on Indian stock markets revealed that the Indian stock markets are not Informationally or weak form of efficient Harish Kumar et al. (2017)[28]. Another study on Indian markets by Rahul Sarkar (2019)[36] concluded that Indian stock Indices are information or weak form inefficient. This inconsistency in proving or disproving the existence of efficiency is the area that is to be analysed continuously and this study is aimed at the same. The present study is a modest attempt to test the assumptions of random walk hypothesis on India's most prominent Indices (Nifty 50, Sensex, Midcap and Nifty 500) that houses India's top-notch company stocks.

3. METHODOLOGY OF THE STUDY

a. Data Description

Testing of assumptions of weak form of efficiency as proposed by Fama (1965,1970)[21] involve either empirical testing or conducting technical analysis. Empirical testing involves conducting data driven analysis while technical analysis is conducted using Chartism approach on short term data. As this study is intended to be an empirical analysis, the data of India's most popular and highest market capitalized indices Nifty 50, Sensex, Midcap and Nifty 500's adjusted closing prices for the duration of 30th January,2020 to 31st October,2023 are collected and log returns for the same are

computed. A total of 929 observations are used for testing the assumptions of weak form of efficiency. The duration of the study is chosen diligently considering the catastrophic events that took place in the light of Corona worldwide. The **primary objectives** of the study include,

1. To test the assumptions of weak form of efficiency on chosen Indian indices.
2. To check the randomness of returns of the indices during the study period which might enable the analysts in better understanding the market movements in light of crises of this (Corona, recession speculations) kind.

The adjusted closing prices of chosen indices (Nifty 50, Sensex, Midcap and Nifty 500) are collected from various secondary sources and log returns of the same are computed. A series of statistical and econometric tools are used to test and conclude on the randomness of the indices.

b. Weak form of Efficiency Assumptions/Conditions to be Tested

The conditions of weak form of efficiency that are to be tested to state a market efficient in weak form are mentioned below,

Condition 1: Log return series are normal.

Condition 2: Log return series have unit root/non-stationary.

Condition 3: Log returns are serially uncorrelated.

Condition 4: Log returns are random.

Hypotheses are formulated for each of the above conditions and a series of data analysis tools are used to prove or disprove the above conditions.

c. Hypotheses Formulated

To prove or disprove the assumptions of weak form of efficiency or random walk hypothesis (RWH) the following hypotheses are formulated.

H_{01}: The Indices are efficient in weak form during the study period.

To prove or disprove above hypothesis (H_{01}) there must be four other hypotheses to be formulated each of them representing one condition mentioned in section 3.1.

H_{01a}: The log return series of the indices are normal during the study period.

H_{01b}: The log return series of the indices have unit root or non-stationary.

H_{01c}: The log return series are independent or serially uncorrelated during the study period.

H_{01d}: The log return series are random during the study period.

The above four hypotheses are to be tested for proving or disproving the assumptions of random walk hypothesis (RWH) as stated by Fama(1970) [21].

d. Data Analysis Tools

A series of statistical and econometric tools are applied to the log return series computed using the adjusted closing prices of the chosen indices (Nifty 500, Nifty 50, BSE Midcap and Sensex). All the tests that are applied in this study are modern econometric tools which are perceived to be base for building robust prediction models. Log returns of the adjusted closing prices have been computed as follows,

$$R_n = \ln (P_t/P_{t-1})$$

I.e., Rn= return on stock n; ln= logarithmic function, P_t= Adjusted closing price of the stock at time t; P_{t-1}= Adjusted closing price of the stock at time t-1.

i. **Normality tests:** To test the assumption of normality (H_{01a}) of the return series descriptive statistics (Skewness, Kurtosis) and a hypothesis testing tool Jargue-Bera (JB) test are used in the study.

ii. **Unit root/Non-Stationary tests:** The study adopts Augmented Dickey Fuller (ADF) test to test the assumption of unit root/Non-stationarity (H_{01b}) of random walk hypothesis (RWH).

iii. **Serial autocorrelation:** In order check the assumption of serial uncorrelation (H_{01c}) among return series two major econometric tools namely, auto correlation factor (ACF) and Ljung-box Q-Statistic tests are applied.

iv. **Randomness test:** The estimate proposed by Lo-Mckinlay (1988) named Variance ratio (VR) is another measure used to check the randomness hypothesis (H_{01d}). LMVR test is the conventional variance ratio test and is used extensively in other studies.

4. RESULTS AND DISCUSSION

Indian markets are evolving in nature thus testing the market efficiency is an essence beyond time. A combination of parametric and non-parametric tests has been applied to return series to test the assumptions of market efficiency. A study on Dhaka Stock exchange by Mobarek and Keasey(na) used both parametric (Auto-Correlation, ARIMA) and non-parametric tools (Kolmgrov-Smirnov normality test, runs test) and concluded that returns under study are inefficient. Further an empirical investigation on Indian company stocks for 22 years conducted by Totala et al. (2010) also used a mix of parametric and non-parametric tests. In this study a combination of tools used by Mobarek and Keasey(na) and Totala et al. are applied to return series for the chosen indices (Nifty 50, Sensex, Midcap and Nifty 500)

A. Descriptive Statistics and Normality Condition Results

The prime objective of this study is to test whether the chosen indices are efficient in weak form or not during the study period. The hypothesis formulated for the same is,

H_{01}: The Indices are efficient in weak form during the study period.

To prove or disprove the above hypothesis the first condition that must be tested is normality condition. The hypothesis of normality is,

H_{01a}: The log return series of the indices are normal during the study period.

The summary/descriptive statistics and the parametric Jargue-Bera(JB) test are been used.

The log return series of chosen Indices- Nifty 50, Nifty 500, BSE Mid cap and BSE Sensex are visually presented below,

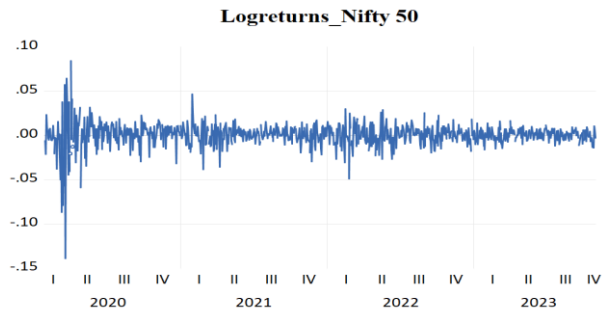


Figure 1: Log retruns Nifty 50 2020-2023

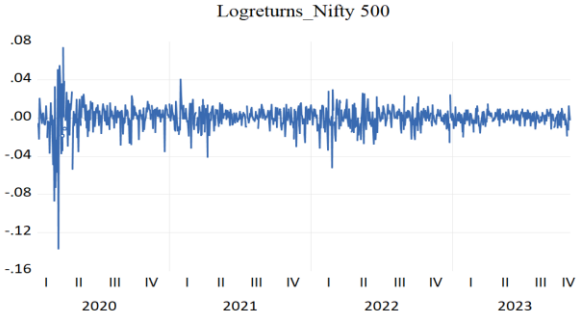


Figure 2: Log retruns Nifty 500 2020-2023

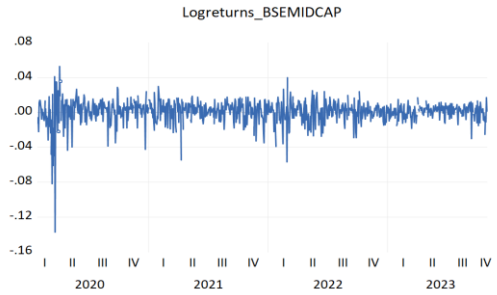


Figure 3: Log retruns BSE Midcap 2020-2023

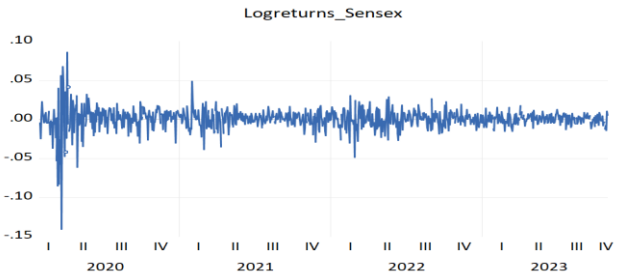


Figure 4: Log Retruns BSE Sensex 2020-2023

Table 1: Descriptive Statistics Summary of chosen Indices(Nifty 50, Nifty 500, Midcap, Sensex)

Index	Mean	Minimum	Maximum	Std. deviation	Skewness	Kurtosis	JB test	Probability
Nifty 50	0.0005	-0.1390	0.0840	0.0132	-1.7399	23.3023	16405.93	0.0000
Nifty 500	0.0006	-0.1371	0.0741	0.0127	-2.0607	24.0277	17753.70	0.0000
BSE Midcap	0.0007	-0.1374	0.0526	0.0129	-2.2467	20.5611	12705.19	0.0000
BSE Sensex	0.0004	-0.1410	0.0859	0.0134	-1.6847	23.4389	16591.93	0.0000

Source: Author's Computation

Visual presentation of log return series of chosen indices- Nifty 50, Nifty 500, BSE Midcap and BSE Sensex(Fig 1,2,3,4) and the descriptive statistics of the same presented above(Table1) confirms the non-normality of the return series during the study period(Jan 2020- Oct 2023). The skewness and Kurtosis values of chosen indices(Nifty 50, Nifty 500, BSE Midcap and Sensex) are different from zero(0) indicating non-normality. Further the probability of Jargue-Bera test for all the indices is 0.000 which is less than 0.05(5% level of significance) also confirms the non-normality of return series. Thus, the condition of normality hypothesis(**H_{01a}**) is rejected at 5% (0.05) level of significance. The first condition of random walk hypothesis (RWH) is rejected for chosen Indices (Nifty 50, Nifty 500, BSE Midcap and Sensex) during the study period.

B. Augmented Dickey Fuller or Non-Stationarity Condition results

To test Unit root or Non- Stationarity assumption of return series traditional Augmented Dickey Fuller (ADF) test is applied. The results of ADF test with trend and intercept are used to draw conclusion on presence of unit root in the time series data of chosen indices (Nifty 50, Nifty 500, BSE Midcap and Sensex). The hypothesis tested using ADF test is,

H_{01b}: The log return series of the indices have unit root or non-stationary.

Table 2: ADF Test Result Summary of Chosen Indices(Nifty 50, Nifty 500, Midcap, Sensex)

Augmented Dickey Fuller (ADF) test with trend and constant				
	Nifty 50	**Nifty 500**	**BSE Midcap**	**BSE Sensex**
t- Statistic	-9.8306	-9.6455	-29.3605	-9.9983
p-Value	0.0000	0.0000	0.0000	0.0000
t-Statistic Critical value at 5% level of significance-3.4147				

The result summary presented in table 2 for all the indices (Nifty 50, Nifty 500, BSE Midcap and

Sensex) indicates stationarity as null hypothesis (**H_{01b}**) is rejected at 5% (0.05) level of significance. The test statistic(t-statistic) and p-value at 5% (0.05) level of significance indicates stationarity thus the return series of chosen Indices (Nifty 50, Nifty 500, BSE Midcap and Sensex) are stationary. Return series stationarity implies that the indices depict some predictable non-random movements thus the assumption of non-stationarity of random walk hypothesis (RWH) is rejected at 5%(0.05) level of significance.

C. Auto Correlation or Serial Correlation Results

The results of Auto correlation (AC) presented below are computed to test the assumption of serial uncorrelation among return series.

H_{01c}: The log return series are independent or serially uncorrelated during the study period.

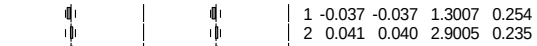
The correlogram for all the chosen indices (Nifty 50, Nifty 500, Mid cap and Sensex) return series presented in figures 5,6,7,8 show no clear evidence in support or opposite of **H_{01c}.**

Date: 11/28/23 Time: 15:04
Sample: 1/30/2020 10/31/2023
Included observations: 928

	AC	PAC	Q-Stat	Prob
1	-0.066	-0.066	4.0737	0.044
2	0.026	0.021	4.6927	0.096
3	0.031	0.034	5.5723	0.134
4	0.020	0.024	5.9355	0.204
5	0.173	0.175	33.845	0.000
6	-0.154	-0.138	56.089	0.000
7	0.129	0.109	71.606	0.000
8	0.017	0.023	71.881	0.000
9	-0.044	-0.049	73.686	0.000
10	0.067	0.038	77.860	0.000
11	-0.122	-0.083	91.854	0.000
12	0.086	0.022	98.885	0.000
13	-0.026	0.008	99.504	0.000
14	-0.028	-0.025	100.23	0.000
15	0.070	0.045	104.82	0.000
16	-0.083	-0.032	111.36	0.000
17	0.076	0.023	116.81	0.000
18	-0.060	-0.022	120.24	0.000
19	-0.023	-0.031	120.74	0.000
20	0.034	0.005	121.87	0.000
21	0.012	0.065	122.00	0.000
22	0.009	-0.042	122.07	0.000
23	-0.034	0.010	123.19	0.000
24	-0.047	-0.065	125.30	0.000
25	0.064	0.045	129.27	0.000
26	-0.026	0.002	129.93	0.000
27	-0.020	-0.034	130.33	0.000
28	0.050	0.064	132.74	0.000
29	-0.029	-0.025	133.53	0.000
30	-0.003	-0.036	133.54	0.000
31	-0.042	-0.001	135.20	0.000
32	-0.033	-0.056	136.24	0.000
33	-0.003	-0.025	136.25	0.000
34	0.015	0.058	136.46	0.000
35	0.111	0.097	148.47	0.000
36	-0.021	0.008	148.90	0.000

Figure 5: ACFs Nifty 50

Date: 11/28/23 Time: 16:19
Sample: 1/30/2020 10/31/2023
Included observations: 928



	AC	PAC	Q-Stat	Prob
1	-0.037	-0.037	1.3007	0.254
2	0.041	0.040	2.9005	0.235
3	0.039	0.042	4.3162	0.229
4	0.029	0.030	5.0884	0.278
5	0.169	0.168	31.663	0.000
6	-0.141	-0.136	50.362	0.000
7	0.131	0.113	66.368	0.000
8	0.028	0.030	67.107	0.000
9	-0.035	-0.045	68.244	0.000
10	0.064	0.038	72.086	0.000
11	-0.098	-0.064	81.072	0.000
12	0.081	0.021	87.267	0.000
13	-0.039	-0.011	88.709	0.000
14	-0.031	-0.031	89.627	0.000
15	0.064	0.040	93.500	0.000
16	-0.073	-0.031	98.552	0.000
17	0.073	0.031	103.61	0.000
18	-0.056	-0.019	106.57	0.000
19	-0.017	-0.025	106.83	0.000
20	0.031	0.010	107.75	0.000
21	0.002	0.050	107.76	0.000
22	0.005	-0.043	107.79	0.000
23	-0.039	0.001	109.21	0.000
24	-0.037	-0.055	110.48	0.000
25	0.056	0.044	113.47	0.000
26	-0.014	0.013	113.67	0.000
27	-0.012	-0.024	113.80	0.000
28	0.057	0.074	116.86	0.000
29	-0.026	-0.028	117.49	0.000
30	-0.019	-0.048	117.84	0.000
31	-0.039	-0.007	119.31	0.000
32	-0.032	-0.055	120.30	0.000
33	-0.006	-0.024	120.33	0.000
34	0.023	0.068	120.86	0.000
35	0.116	0.110	133.84	0.000
36	-0.022	-0.008	134.29	0.000

Figure 6: ACFs Nifty 500

Date: 11/28/23 Time: 16:31
Sample: 1/30/2020 10/31/2023
Included observations: 928

	AC	PAC	Q-Stat	Prob
1	0.035	0.035	1.1641	0.281
2	0.056	0.055	4.1325	0.127
3	0.036	0.032	5.3238	0.150
4	0.040	0.035	6.8464	0.144
5	0.129	0.124	22.496	0.000
6	-0.086	-0.101	29.473	0.000
7	0.107	0.100	40.109	0.000
8	0.047	0.041	42.220	0.000
9	-0.000	-0.018	42.220	0.000
10	0.057	0.041	45.284	0.000
11	-0.036	-0.027	46.523	0.000
12	0.048	0.009	48.697	0.000
13	-0.063	-0.058	52.485	0.000
14	-0.042	-0.044	54.190	0.000
15	0.024	0.012	54.716	0.000
16	-0.051	-0.034	57.220	0.000
17	0.067	0.057	61.467	0.000
18	-0.024	-0.001	62.001	0.000
19	-0.007	-0.015	62.053	0.000
20	0.030	0.030	62.934	0.000
21	-0.010	0.014	63.031	0.000
22	-0.010	-0.039	63.124	0.000
23	-0.048	-0.019	65.290	0.000
24	-0.022	-0.029	65.760	0.000
25	0.048	0.044	67.975	0.000
26	0.006	0.021	68.015	0.000
27	0.024	0.011	68.580	0.000
28	0.045	0.053	70.490	0.000
29	-0.000	-0.014	70.490	0.000
30	-0.072	-0.088	75.462	0.000
31	-0.022	0.003	75.920	0.000
32	-0.010	-0.023	76.024	0.000
33	-0.036	-0.039	77.308	0.000
34	0.046	0.071	79.359	0.000
35	0.107	0.115	90.477	0.000
36	-0.010	-0.039	90.581	0.000

Figure 7: ACFs BSE Midcap

Date: 11/28/23 Time: 16:46
Sample: 1/30/2020 10/31/2023
Included observations: 928

	AC	PAC	Q-Stat	Prob
1	-0.060	-0.060	3.3370	0.068
2	0.014	0.011	3.5295	0.171
3	0.020	0.022	3.9206	0.270
4	0.026	0.028	4.5481	0.337
5	0.161	0.164	28.681	0.000
6	-0.150	-0.136	49.859	0.000
7	0.117	0.102	62.781	0.000
8	0.019	0.024	63.118	0.000
9	-0.040	-0.046	64.590	0.000
10	0.056	0.036	67.568	0.000
11	-0.123	-0.090	81.918	0.000
12	0.086	0.027	88.863	0.000
13	-0.013	0.018	89.026	0.000
14	-0.033	-0.030	90.045	0.000
15	0.065	0.045	93.984	0.000
16	-0.086	-0.040	100.94	0.000
17	0.084	0.032	107.55	0.000
18	-0.068	-0.033	111.98	0.000
19	-0.028	-0.034	112.75	0.000
20	0.037	0.007	114.03	0.000
21	0.017	0.066	114.29	0.000
22	0.006	-0.045	114.32	0.000
23	-0.036	0.014	115.55	0.000
24	-0.054	-0.073	118.33	0.000
25	0.077	0.057	124.05	0.000
26	-0.045	-0.018	125.96	0.000
27	-0.003	-0.017	125.97	0.000
28	0.029	0.044	126.78	0.000
29	-0.014	-0.012	126.96	0.000
30	-0.007	-0.043	127.00	0.000
31	-0.037	0.015	128.34	0.000
32	-0.025	-0.059	128.95	0.000
33	-0.029	-0.039	129.78	0.000
34	0.037	0.065	131.13	0.000
35	0.107	0.099	142.27	0.000
36	-0.015	0.013	142.48	0.000

Figure 8: ACFs BSE Sensex

The value of p (probability) of Q-statistic for all the indices (Nifty 50, Nifty 500, Mid cap and Sensex) is greater than significance value (5%-0.05) for the first four lags and are less than 0.05 throughout the subsequent period. This indicates that indices are indeed correlated in short run and uncorrelated in long run. I.e., Return series do have a predictable pattern based on information in short run while no predictable behaviour in long run. Thus, from serial correlation tests no conclusive evidence on the correlation in return series can be made.

D. Variance Ratio test or Randomness Condition results

The results of traditional variance ratio test conducted to test the assumption of randomness (**H_{01d}**) of return series of chosen indices (Nifty 50, Nifty 500, Mid cap, Sensex) are presented in below tables 3, 4.

H_{01d}: The log return series are random during the study period.

Table No 3: Lo- Mac Kinlay Variance Ratio Estimates

	Number of Lags(q) BSE Midcap				Number of Lags(q) BSE Sensex			
	q= 2	q=4	q=8	q=16	q= 2	q=4	q=8	q=16
VR(q)	0.4896	0.2494	0.1243	0.0697	0.4658	0.2305	0.1168	0.0657
Z(q)	-4.3113	-3.9762	-3.4977	-2.7533	-4.0815	-3.5933	-2.9715	-2.2192
Z*(q)	0.1184 (0.000)	0.1888 (0.0001)	0.2504 (0.0005)	0.3379 (0.0059)	0.1309 (0.000)	0.2141 (0.0003)	0.2972 (0.003)	0.421 (0.0265)

Table No 4: Lo-Mac Kinlay Variance Ratio Estimates

	Number of Lags(q) Nifty 50				Number of Lags(q) Nifty 500			
	q= 2	**q=4**	**q=8**	**q=16**	**q= 2**	**q=4**	**q=8**	**q=16**
VR(q)	0.4578	0.2304	0.1164	0.6516	0.4629	0.2346	0.1181	0.6627
Z(q)	-4.1413	-3.602	-3.0003	-2.2473	-4.108	-3.6096	-3.0447	-2.2994
Z*(q)	0.1309 (0.0000)	0.2137 (0.0003)	0.2945 (0.0027)	0.4159 (0.0246)	0.1307 (0.0000)	0.2121 (0.0003)	0.2896 (0.0023)	0.4061 (0.0215)

From the results presented above it is evident that the return series for either homoscedasticity [z(q)] or heteroscedasticity-consistency[z*(q)] at any lag(q) is significant at 5% level of significance (0.05). I.e., the null hypothesis (**H_{01d}**) is rejected which implies that the return series are non-random.

The analysis carried out on testing the assumptions or hypothesis (**H_0**) of weak form of efficiency relies on proving the four conditions (Normality, Non-Stationarity, Serial uncorrelation and randomness) of return series. However, the conditions of normality (**H_{01a}**), Non-stationarity (**H_{o1b}**), randomness(**H_{01d}**) resulted in disproving the hypothesis(**H_0**) of weak form while Serial uncorrelation(**H_{01c}**) resulted in inconclusiveness. Thus, from the empirical investigation it can be concluded that the chosen Indices during the most fragile times of the country are proven to be resilient and are potential enough to generate abnormal returns by being inefficient in weak form.

5. CONCLUSION

The paper aims at testing the assumptions of weak form of efficiency of Fama(1965) [21] among chosen Indian indices(Nifty 50, Nifty 500, BSE Mid cap and Sensex) using descriptive statistics, augmented dickey fuller test, auto correlation test and Lo and Mac Kinlay Variance ratio test. While testing the assumptions of weak form of efficiency or efficient market hypothesis (EMH) any one of the above conditions were

tested in earlier studies. However, in this study a combination of all these tests are used. The results of descriptive statistics and Jargue Bera(JB) test rejected the normality(**H_{01a}**) of returns. Similarly, the Non-stationarity (**H_{01b}**) assumption of return series is rejected by Augmented Dickey fuller (ADF) test as p-value of ADF test is less than significance value 0.05(5%). Further, the randomness assumption (**H_{01d}**) also rejected the randomness of return series. However, the serial correlation assumption(**H_{01c}**) auto correlation factor (ACF) and Lo Mac Kinlay Variance ratio (LMVR) test doesn't prove or disprove the assumption of serial uncorrelation as return series exhibited mixed movements in short run as well as in long run. Thus, from the study it can be concluded that return series of chosen indices (Nifty 50, Nifty 500, BSE Midcap and Sensex) are informationally inefficient during the study period (2020-2023). These inefficiencies can be analysed through technical analysis and can be used to build more sophisticated prediction models. However, since the study is confined only to 929 observations and has been conducted on four Indian indices for a duration of approximately two years this cannot be attributable to other time periods. However, the study is a modest attempt to understand the return movements in short run and that to at times where world economies are going through a severe crisis (Corona, Recession news) and the world businesses are eyeing on India studies of this kind would be of immense need so as to understand the stability and growth of Indian markets.

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