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RESULTS & DISCUSSION

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RECOMMENDATIONS/SUGGESTIONS

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AN EMPIRICAL STUDY ON THE RANDOM WALK HYPOTHESIS AND WEAK FORM MARKET EFFICIENCY: EVIDENCE FROM NATIONAL STOCK EXCHANGE OF INDIA

PRIYANKA DAS
RESEARCH SCHOLAR
DEPARTMENT OF COMMERCE
UNIVERSITY OF CALCUTTA
KOLKATA

ABSTRACT

Numerous studies were conducted all over the world to test Random Walk Hypothesis (RWH) in actual market conditions which led to controversial results. Efficient market hypothesis (EMH) states that financial markets are "informationally efficient", implying that current prices fully and instantaneously reflect all private or publicly available or historical information of the concerned security in the market. This article has attempted to empirically test whether Nifty 50, Nifty 200 and Nifty 500 follows random walk model and conforms to Efficient Market Hypothesis. Daily closing prices of the selected sample have been collected from the official website of NSE for a period of 5 years from January 1, 2015 to December 31, 2019 and daily continuously compounded rates of returns have been calculated from the same. K-S test result showed that the returns does not follow normal distribution. Runs Test results evidenced significant P value of Nifty 500 Index returns which rejects the null hypothesis of the weak form of efficiency with 99% level of confidence but Nifty 50 and Nifty 200 index returns showed randomness in its return behavior. To resolve this contradiction, ADF and P-P test of stationarity were performed which confirmed inefficiency of the Indian stock market in terms of all the three indices of our study Further, significant P values of Variance Ratio Test also led us to the final conclusion that Indian stock market do not follow random walk movement and hence is inefficient in the weak form. This in turn provides an opportunity to the investors to earn super-normal gain by utilizing past information as share prices do not adjust instantaneously in response to any new information release in the market.

KEYWORDS

Kolmogorov-Smirnov goodness of fit (K-S) Test, Augmented Dickey-Fuller (ADF) Test, Phillips-Perron (P-P) Test, Efficient market hypothesis (EMH), Random Walk Hypothesis (RMH), Variance Ratio Test.

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I. INTRODUCTION

The phrase "efficient market" used to describe the market price that fully reflects all available information was coined by **Fama (1970)**. **Dyckman and Morse (1986)** state "A security market is generally defined as efficient if (1) the price of the security traded in the market act as though they fully reflect all available information and (2) these prices react instantaneously, or nearly so, and in unbiased fashion to new information". If a market is efficient, stock price movements should follow a random walk and the price movements in the past should not be related to future price movements. But if the market is not efficient and price movements are not random, some investors can exploit the inefficiency by gaining abnormal returns. They may be able to correctly predict the future price movements by examining the historical price movements. A random walk is defined by the fact that price changes are independent of each other **(Brealey et al, 2005).** According *to* Random Walk model, security prices will behave randomly, **i.e.,** there will be no dependence between successive price changes and as a consequence any trading strategy based on past price series will be of no use. This is because, as per Efficient Market Hypothesis, in an efficient market any new information will be rapidly incorporated in the security prices in an unbiased manner. As a result, the price change will be totally random and unpredictable **(Sarkar, 2014&2015)**. **Fama**, classified the market efficiency into three levels on the basis of the information: Weak, Semi-strong and Strong forms. The weak form of the theory also known as the 'Random Walk' states that the current price of the stocks already fully reflects all the information that is contained in the historical sequence of the prices. While the semi-strong form of the theory maintains that the current stock prices instantaneously and fully reflects all the public information about the security such as corporate reports, corporate announcements, information related to corporate dividend policies, forthcoming stock splits and so on. The strong form of market efficiency states that not only is the public information useless to the investor or analyst, but all the information is useless. In other words, the current stock prices instantaneously and fully reflect all known information about the securities including the privately available inside information. However, RWH is consistent with the weak form of efficient capital market only and not with the semi-strong or strong form. Over the years, researchers proposed various customized test techniques to identify the appropriate level of efficiency of a market.

The scope of the present study is confined to the testing of weak form of Efficient Market hypothesis and to confirm whether Indian stock market follows Random Walk Model with special reference to National Stock Exchange.

II. LITERATURE REVIEW

Following are some of the studies which have focused on the "Efficient Market Hypothesis" and the "Random Walk Model" both at the national as well as international level:

Rahman, Simon and Hossain (2016) in their paper have tried to provide empirical evidence on weak form efficiency which has been carried out to diagnose the random walk behavior of Chittagong Stock Exchange (CSE) by composing daily returns of three indices for the period of 2006 to 2015. The results of various non-parametric tests (Wald-Wolfowitz Runs Test, Variance Ratio Test and Kolmogorov Smirnov (K-S) Goodness of Fit Test) and parametric test (Augmented Dickey-Fuller (ADF) Test and Autocorrelation Function Test (ACF)) highlighted the fact that the Chittagong Stock Exchange is not efficient in weak form. Therefore, there exist the opportunity of generating a superior return by the investors.

Hawaldar, Rohit and Pinto (2017) aimed at testing the weak form of market efficiency of the individual stocks listed on the Bahrain Bourse for the period 2011 to 2015. The K-S test result concluded that in general the stock price movement does not follow random walk. The results of the runs test revealed that share prices of seven companies do not follow random walk. Autocorrelation tests depicted that share prices exhibited low to moderate correlation varying from negative to positive values. Since the study showed mixed results, weak form of efficiency of Bahrain Bourse could not be confirmed.

Patel, Rajpal and Modi (2018) in their study particularly focused on testing weak form of market efficiency wherein future market trend can be predicted using past data. Three year daily closing points were taken from Bombay stock exchange (SENSEX) commencing from1st April 2015 to 31st March 2018. Runs test was conducted to analyze the data. The study concluded that market follow trends and thus investors can earn abnormal profits and thus violates random walk theory.

Titan (2015) examined the growing body of empirical research on efficient market hypothesis. It was concluded that testing for market efficiency is difficult and there is a high possibility that, because of changes in market / economic conditions, new theoretical model should be developed to take into consideration all changes. As a reasons, it is important to continue the empirical studies to decide if capital markets are or are not informational efficient.

Gupta and Gedam (2014) in their paper collected the stock prices of the selected companies from NSE (National Stock Exchange). The results of Runs Test revealed that among the companies chosen except Tech Mahindra, the stock prices are independent of the past prices. Therefore, the market is weakly efficient in most of the cases except Tech Mahindra in which the alternate hypothesis is being expected.

Chavannavar and Patel (2016) investigated market efficiency of Nifty 50 stocks and Nifty 50 Index for the period of 3 years. The study analyzed whether current security prices reflect all the historical information, whether future prices can be predicted by analyzing past prices and whether all public information was reflected in the security prices. The results of the study concluded that Indian Stock Markets are efficient in both Weak & Semi-strong form.

Jayakumar and Sulthan (2013) examined the random walk hypothesis to determine the validity of weak-form efficiency of the second major stock markets in India, NSE over the span from 3rd July 2007 to 31st December 2011, comprising a total of 1116 observations. The random walk hypothesis was examined using auto correlation function, unit root tests (Augmented Dickey-Fuller test) and the runs test. The test results revealed that the Indian stock markets are not weak form efficient signifying that there is systematic way to exploit trading opportunities and acquire excess profits.

Sharma and Kennedy (1977) in their paper titled "A Comparative Analysis of Stock Price Behaviour on the Bombay, London and New York Stock Exchanges" have compared the behaviour of stock indices of the Bombay, London and New York stock exchanges during the period from 1963-1973. They used run test and spectral analysis. Both the test confirmed the random movement of stock indices for all the three stock exchanges. They concluded that stocks on the BSE (Bombay Stock Exchange) follow random walk and are weak- form efficient.

III. RESEARCH OBJECTIVES

The following are the prime objectives of the said study:

1. To reassess the validity of Random Walk Hypothesis (RWH) in Indian stock market with a special reference to the selected indices of the National Stock Exchange (NSE) by applying modern statistical techniques in addition to the traditional techniques.
2. To test the weak form efficiency of the selected indices of NSE.

IV. RESEARCH HYPOTHESIS

Based on the above research objectives, the following research hypothesis are framed.

H_{01}: Nifty 50 Index follows Random walk Hypothesis (RWH)
H_{02}: Nifty 200 Index follows Random walk Hypothesis (RWH)
H_{03}: Nifty 500 Index follows Random walk Hypothesis (RWH)
H_{04}: Nifty 50 Index is efficient in the weak form
H_{05}: Nifty 200 Index is efficient in the weak form
H_{06}: Nifty 500 Index is efficient in the weak form

V. RESEARCH METHODOLOGY

Sample selection: For the purpose of this empirical study, three major indices of the National Stock Exchange namely NIFTY 50, NIFTY 200 and NIFTY 500 have been considered. Such indices are selected mainly because of its recognition as its extensive use as a benchmark by industry experts.

Study period: The present study has been carried out for a period of five years. Daily closing prices of the selected indices from January 1, 2015 to December 31, 2019 have been collected from the official website of NSE India.

Daily index returns have been computed from the daily closing prices based on continuously compounded rate. Logarithmic returns are calculated based on the following formula:

$R_t = Ln\ (I_t / 1_{t-1})$, Where, **$R_t$** = return at period t; **1_t** = Index value at the end of period t; **I_{t-1}**= Index value at the end of period t-1.

There are various test techniques to identify the appropriate level of efficiency of a market. As per the research objective weak form efficiency of the returns are tested. There are both traditional as well as modern test techniques to confirm such weak form efficiency. The traditional technique includes serial correlation or Auto correlation test which is a parametric test and a non parametric Runs test. However, return series must be normally distributed in order to perform the Auto correlation test but no such restriction is imposed for conducting the Runs test. So, the next step would be to confirm whether the return series follows normal distribution and for this Kolmogorov-Smirnov goodness of fit test or K-S test has been performed.

Kolmogorov-Smirnov test or K-S test: The Kolmogorov-Smirnov Goodness of Fit Test is a non parametric test which is commonly used as a test for normality that is to check whether the data set that is return in our case follows normal distribution.

The Kolmogorov-Smirnov statistic is:

$$D_n = \max_x \left| F_{exp}(x) - F_{obs}(x) \right|$$

The null and alternative hypotheses of the K-S test are as follows:

H_0: The dataset follows normal distribution.

H_1: The dataset doesn't follow normal distribution.

If the calculated test statistic lies between ±1.96 we accept the null hypothesis and conclude that the daily returns follow normal distribution and in that case we should apply autocorrelation test instead of run test. But, if the test statistic is less than -1.96 or more than +1.96 then we reject null hypothesis and conclude that daily returns do not follow normal distribution and then we should apply a non – parametric runs test instead of performing the autocorrelation test.

Runs Test: It is non- parametric test conducted to test a series of price changes for independence, where the no. of runs in a series is compared against the no. of runs expected in a purely random series of similar size.

It follows Z distribution, where,

$Z = \frac{R - E(R)}{\sigma_R}$

R= Actual no. of runs

E(R) = Expected no. of runs

$E(R) = \frac{2 n_1 n_2}{n_1 + n_2} + 1$

σ_R= Standard Error of the distribution

$\sigma_R = \sqrt{\frac{n_1 n_2 (2 n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$

n_1 = Number of positive runs.

n_2 = Number of negative runs.

If the Z statistic is found to be insignificant, random walk of the return series is confirmed.

Unit root Tests: The modern tests on weak form efficiency is based on the stationarity property of the time series data. A series is said to be non-stationary if it has a time varying (i.e. dependent on time) mean or time varying variance or both. The stationarity property can be examined by applying unit root test. If unit root exists for a given time series data that is return in our case, it is said to be non- stationary and vice versa. There are alternative approaches of unit root tests out of which two most popular tests, Augmented Dicky Fuller (ADF) Test and Phillips Perron (P-P) Test have been considered to examine whether the returns are stationary or not. The null hypothesis of a unit root is rejected in favour of the stationary alternative if the test statistic is more negative than the critical value.

Variance Ratio Test: The Variance ratio test of random walk is a test which is used to examine whether security's returns indeed follow a random walk. This test was proposed by Andrew Lo and Craig Mackinlay in the year 1987. Variance ratio test is said to be more reliable and more powerful than the very well-known Unit Root Tests.

The variance ratio test of is based on the property that the variance of increments of a random walk *Xt* is linear in its sample interval.

According to Variance Ratio Test, if a series follows a random walk process, the variance of its q-differences would be q times the variance of its first differences, i.e.

Var (X_t, - X_{t-q}) =qVar (X_t, - X_{t-1}) where q is any positive integer.

The variance ratio, VR (q), is then determined as follows:

VR (q) = $\frac{\sigma^2(q)}{\sigma^2(1)} = \frac{\frac{1}{q}(X_t - X_{t-q})}{X_t - X_{t-1}}$

The equations to calculate (1) 2 □□and () 2 □□*q* are as follows.

$$\sigma^2(1) = \frac{1}{nq-1}\sum_{t=1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2$$

$$\hat{\mu} = \frac{1}{nq}\sum_{t=1}^{nq}(X_t - X_{t-1})$$

and,

$$\sigma^2(q) = \frac{1}{m} = \sum_{t=1}^{nq}\left(X_t - X_{t-q} - q\hat{\mu}\right)^2$$

Where,

$$m = \mathrm{q(nq - q + 1)}\left(1 - \frac{q}{nq}\right)$$

The null hypothesis is that *VR (q)* is not statistically different from 1.

The standard normal test statistic used to test the null hypothesis of random walk under the assumption of homoscedasticity is *Z(q)*, calculated as:

Z(q) = $\frac{(VR(q)-1}{\sqrt{\theta(q)}} \sim N(0,1)$

Where,

$$\theta(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$$

The standard normal test statistic used for heteroscedasticity increments is *Z*(q)*, calculated as:

Z*(q) = $\frac{(VR(q)-1}{\sqrt{\theta^*(q)}} \sim N(0,1)$

Where,

$$\theta^*(q) = \sum_{j=1}^{q-1}\left[\frac{2(q-j)}{q}\right]^2 \hat{\delta}(j)$$

and,

$$\hat{\delta}(j) = \frac{\sum_{t=j+1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2\left(X_t - X_{t-j-1} - \hat{\mu}\right)^2}{\left[\sum_{t=1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2\right]^2}$$

If the test statistics are found to be statistically significant it will indicate that the return series do not follow random walk.

VI. DATA ANALYSIS AND FINDINGS

Descriptive statistics of all the three indices Nifty 50, Nifty 200 and Nifty 500 are reported below in **Table 1**. Very low mean returns and standard deviation of all the three indices gives an indication that the following indices bear low expected risk as well as return. However, the mean return (0.000135) of NIFTY 50 Index being the highest is associated with least risk (0.003730) as compared with the other two indices. Distribution having Skewness value 0 is considered to be symmetric that is normally distributed. The value of Skewness being negative reflects the lack of symmetry in the distribution around its mean value of all the three indices. A series having kurtosis value 3 is said to be normally distributed and is considered to be mesokurtic in nature. The measure of kurtosis (more than 3 in all cases) suggests that the daily index return series in NSE have much more peaked tails which are leptokurtic in nature. The Jarque –Bera test follows χ^2 distribution with 2 degrees of freedom with the null hypothesis that the return series are normally distributed, however, the P value being significant that is less than 0.01 rejects the null hypothesis and concludes that return series are not normally distributed. Again Kolmogorov-Smirnov test is conducted as shown in Table 2 in order to confirm such non- normality in the said return series.

TABLE 1: DESCRIPTIVE STATISTICS

	NIFTY50 RETURNS	NIFTY 200 RETURNS	NIFTY 500 RETURNS
Mean	0.000135	0.000133	0.000132
Median	0.000177	0.000337	0.000439
Maximum	0.022507	0.022950	0.022401
Minimum	-0.026480	-0.029472	-0.030169
Std. Dev.	0.003730	0.003805	0.003792
Skewness	-0.254743	-0.415819	-0.492233
Kurtosis	6.775876	7.542103	7.835547
Jarque-Bera	746.4063	1096.323	1252.083
Probability	0.000000	0.000000	0.000000
Sum	0.166995	0.163929	0.162809
Sum Sq. Dev.	0.017151	0.017849	0.017727
Observations	1234	1234	1234

Source: Author's computation using Eviews 8

Table 2 below presents the results of Kolmogorov-Smirnov goodness of fit test. The null hypothesis of such test states whether the return series confirms normal distribution. The P value of Kolmogorov-Smirnov test being significant at 1% level (0.0000) for all the three indices rejects the null hypothesis and clearly states that the movements of daily return of Nifty 50, Nifty 200 and Nifty 500 do not follow normal distribution that is the index return movements do not follow random walk model.

TABLE 2: RESULT OF TESTS OF NORMALITY

	Kolmogorov-Smirnov(a)		
	Statistic	df	Sig.
Nifty 50	.048	1234	.000
Nifty 200	.059	1234	.000
Nifty 500	.057	1234	.000

Source: Author's computation using SPSS 16

Even though the significant P values of the Jarque-Bera test and the Kolmogorov-Smirnov tests confirmed the non-normality of the selected Index returns. A non-parametric test to examine the randomness of the said return series would be effective as it does not require the return series to be normal. For this purpose, mean values have been considered as the cut off points. The results of runs test have been represented below in **Table 3**.

The Z value of Nifty 500 Index returns are well below -2.58 and the P value is 0.002 that is less than 0.01. So, it rejects the null hypothesis which supports that the index return movements are random and hence concludes that daily return realizations of Nifty 500 are not independent, and the stock market in terms of Nifty 500 Index is not efficient in the weak form.

However, the Z value of Nifty 50 and Nifty 200 Index respectively being greater than -1.96 and p values being more than 0.05 leads to rejection of the alternative hypothesis of non-random return movements and accepts the null hypothesis that both the indices return movements are random which does not enable investors to earn abnormal profits and thereby the stock market in terms of Nifty 50 and Nifty 200 Index respectively is efficient in the weak form. Here, the results are contradicting. So a more advanced and sophisticated test technique that is unit root test have been applied in order to resolve the contradiction and to reach towards the final conclusion.

TABLE 3: RESULT OF RUN TEST FOR RANDOMNESS WITH MEAN AS THE BASE

Sl. No.	Indices	Number of Runs	Z value	Sig. (2-tailed)
1	Nifty 50	611	-0.394	0.693
2	Nifty 200	585	-1.800	0.071
3	Nifty 500	563	-3.017	0.002*

Source: Author's computation using SPSS 16

The stationarity property of all the three indices can be examined by applying the Unit root test. If unit root exists for a given time series that is return in our case, it is said to be non- stationery and vice versa. So, ADF Test is conducted considering random walk with intercept or drift on all the three indices of our study. **Table 4** below highlights the test results that Nifty 50, Nifty 200 and Nifty 500 are significant with P values less than 0.01. Therefore, the null hypothesis of unit root (non-stationary) is being rejected at 1% level of significance suggesting that NSE does not show characteristics of random walk and as a result of which, is not efficient in the weak form.

This study has also performed PP test as a confirmatory data analysis. The results of Philips-Perron test of random walk model reveals that the P values of the selected indices of our study are significant (0.0000) at 1% level. Thereby, rejecting the null hypothesis of unit root (non-stationary) of index returns of NSE thereby suggesting that NSE index returns do not show any characteristics of random walk. So, it may be concluded that such stationary series may allow modelling and prediction. So, the investors can predict future stock prices with these stationary series which in turn would enable them to earn abnormal profits.

TABLE 4: RESULT OF ADF AND P-P TEST

	Augmented Dickey-Fuller Test		Phillips-Perron Test	
	t-Statistic	P - Value	Adj. t-Statistic	P - Value
Nifty 50	-33.12060	0.0000	-33.09699	0.0000
Nifty 200	-32.65495	0.0000	-32.57417	0.0000
Nifty 500	-32.22837	0.0000	-32.11329	0.0000

Source: Author's computation using SPSS 16

For the purpose of the study, Variance ratio test has been performed with the assumption of both homoscedastic and heteroscedastic increments. Moreover, the variance ratio is calculated for intervals (q) of 2, 4, 8 and 16. For each interval, we report, the estimate of the variance ratio, VR (q), and the test statistics for the null hypotheses of homoscedastic {Z (q)} and heteroscedastic, {Z*(q)}, increments' random walks. Empirical evidences obtained from the variance ratio test as reported in **Table 5**, highlights that the null hypothesis of random walks is rejected under the assumption of homoscedastic increments for all the index returns for m=2, 4, 8 and 16 respectively with Z statistics of variance ratios being significantly different from one. The heteroscedastic increments assumption also witnessed Z statistics of variance ratios being significantly different from one for all the indices. The value of variance ratio is also gradually decreasing with the increasing intervals for all the three indices showing weaker correlations with increasing intervals. Therefore, it may be concluded that successive returns have serial dependence which makes the series a non-random walk.

So, the conflicting results in case of Nifty 50 and Nifty 200 as reflected through runs test are resolved with Unit root tests and Variance ratio test.

TABLE 5: RESULTS OF VARIANCE RATIO TEST

	Nifty 50				Nifty 200				Nifty 500			
	Variance Ratio	Z(q)	Z*(q)	P value	Variance Ratio	Z(q)	Z*(q)	P value	Variance Ratio	Z(q)	Z*(q)	P value
q=2	0.535	-16.312	-10.383	0.000	0.543	-16.043	-9.430	0.000	0.548	-15.870	-9.111	0.000
q=4	0.272	-13.655	-9.274	0.000	0.277	-13.566	-8.620	0.000	0.281	-13.487	-8.394	0.000
q=8	0.139	-10.220	-7.576	0.000	0.141	-10.193	-7.197	0.000	0.143	-10.172	-7.068	0.000
q=16	0.067	-7.440	-5.915	0.000	0.069	-7.430	-5.722	0.000	0.070	-7.421	-5.653	0.000

Source: Author's computation using SPSS 16

VII. CONCLUSION AND RECOMMENDATIONS

The Efficient Market Hypothesis states that prices fully and very quickly reflect all available information so no one can earn excess profits based on that information. However, recent studies in stock price behavior report several deviations from the implications of market efficiency.

Market efficiency has long been a matter of controversy in the emerging economies like India. Since Fama's 1970 study on market efficiency, many studies have been conducted to test market efficiencies. Although in the developed economies it is mostly found that the market is weak form efficient. But in emerging markets like India the results are found to be mixed – some concludes Indian stock market is weak form efficient and some concludes it is not even efficient in the weak form. The present study has used both the traditional as well as modern test methods to check the validity of Random Walk Hypothesis in Indian stock market with a special reference to National Stock Exchange.

Empirical evidences from the above analysis (K-S test) posits that Nifty 50, Nifty 200 and Nifty 500 Indices returns are not normal, so a non- parametric test that is runs has been performed to test the market efficiency in the weak form. The result of runs test reflected a contradictory evidence indicating that although Nifty 50 and Nifty 200 returns showed non-random behavior showing weak form inefficient market but Nifty 500 returns showed random walk movement in its return series. In order to resolve this contradiction, a modern test technique, unit root test has been conducted, where, both ADF and PP test witnessed the non-existence of unit root which indicates that the return series are stationary hence the series can be modelled and hence predictions of future movements are possible. Finally Variance Ratio test which is considered to be more powerful than unit root test also confirms that all the three indices return series hardly exhibit any 'random

walk'. So, the test results clearly resolve the contradiction which in turn supports the previous conclusion that the Indian stock market is not efficient in the weak form and also does not follow "Random Walk Model" as security prices do not reflect all past information. Hence, it is possible to earn super-normal profits by utilizing past information as share prices do not adjust instantaneously in response to any new information released in the market.

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