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Assessing random walk of returns in select stock exchange: Evidence from India

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Abstract
The Indian capital market has emerged as one of the fastest growing economies in the world. In recent years due to secured regulatory monitoring system and digital transformation has lead to increased stock market participation among retail traders. The most liquid and one of the largest stock exchanges named National Stock Exchange playing an important role in shaping the capital market of India. The study investigates whether the Indian market follows a random pattern by analysing daily returns of the indices of National Stock Exchange (NSE). The research is based on secondary data which was collected for the period of ten years to examine any major changes in market behaviour. The study employs both parametric and non-parametric methods to test the randomness of stock returns. The parametric methods include the Autocorrelation Test and Variance Ratio Test, while the non-parametric method is the Runs Test. The results reveal that the Indian stock market does not completely follow a random walk pattern which implies that past stock prices may predict the future returns. Therefore, the study concludes that the Indian stock market was not fully efficient during the study period potentially due the impact of the recent global pandemic.
JEL Classification: C12, C58, D53, G14

Keywords: Indian Stock Market, Random Walk Hypothesis, Variance Ratio Test, Autocorrelation Test, Runs Test

Introduction

The Efficient Market Hypothesis (EMH) is a key idea that helps explain how stock markets work and how the cost of investing in stocks is determined. It says that stock prices include all the important information that's available to everyone. This idea started with Samuelson (2016) [13], who noted that stock prices move up and down randomly around their true value, making it hard to guess what they'll do next. Fama (1970) [3] built on this and said a market is efficient when prices always show all the information out there. EMH talks about three types of efficiency: weak, where past prices are already part of today's stock prices, so looking at old prices won't help predict future ones; semi-strong, where prices quickly update when new public information, like company earnings or stock splits, comes out; and strong, where even insiders with private information can't predict prices better than anyone else.

Thanks to globalization and technology, financial markets around the world have grown a lot (Bakhtiyorovich, 2024) [1]. EMH suggests that because prices include all information, it's tough to consistently beat the market (Fama, 1970) [3]. Weak-form efficiency means past price data can't help predict future prices, so tools like technical analysis don't work well (Maasdorp, 2015) [8]. This means prices should move randomly, like a "random walk" (Malkiel, 2003) [9].

But in emerging markets like India, this idea is questioned because these markets can be more unpredictable, have many small investors, and less strict rules (Sarkar, 2019) [14]. These factors might create patterns in prices that could allow some predictions (Lo & MacKinlay, 1988) [7]. India's stock market, run by the BSE and NSE, is one of the biggest and fastest-growing emerging markets (BSE, 2024; NSE, 2024) [17, 18]. It has seen more companies and trading, but it's still affected by ups and downs and possible inefficiencies. This study looks into how efficient India's stock market really is.

Literature Review

Market efficiency refers to how well prices reflect all relevant information. According to Fama (1970) [3], efficient markets incorporate all available information into prices, limiting opportunities for above-average returns through active trading.

Jethwani and Achuthan (2013) [4] examined weak-form efficiency in the Indian stock market using data from January 1, 1996, to December 31, 2012. The study employed parametric tests (autocorrelation, variance ratio) and non-parametric tests (Kolmogorov-Smirnov, Runs Test) to assess efficiency before, during, and after the financial crisis. Results showed that the market was not weak-form efficient across all periods, though efficiency improved post-2002.

Khanal *et al*. (2025) [6] investigated weak-form efficiency in the Nepalese stock market from 2013 to 2022, using the Kolmogorov-Smirnov test, Runs Test, and Hurst exponent. Their findings rejected the null hypothesis of weak-form efficiency across all sectors, indicating that the Nepalese market does not follow a random walk.

Samuel and Princewill (2024) [12] studied the Nigerian Stock Exchange's weak-form efficiency using monthly data from January 2013 to December 2022. Employing the Runs Test, they found that stock returns were not random, suggesting that the market is not weak-form efficient.

Yaya *et al*. (2024) [16] analyzed stock market efficiency in Vietnam and other Asian countries using a GARCH-based unit root test, accounting for heteroskedasticity and structural breaks. Their results indicated inefficiency in 14 countries' markets, but efficiency in China, Hong Kong, Japan, and South Korea.

Olawale (2024) [11] explored the impact of capital market performance on Nigeria's economic growth from 1981 to 2019, using a multiple regression model. Statistical tests, including the Augmented Dickey-Fuller test, confirmed that 97.9% of real GDP variation was explained by capital market indicators.

Smerkolj and Jeran (2023) [15] tested emerging market efficiency using the Runs Test on weekly and monthly stock index returns. Significant results in three indices suggested violations of weak-form efficiency, though the Indian BSE Sensex 30 Index showed insignificant results, indicating efficiency.

Faisal *et al*. (2022) [2] assessed weak-form efficiency in the Indonesian Stock Exchange from 2011 to 2021, dividing the period into pre-COVID (2011–2019) and COVID-19 (2020–2021) phases. Using unit root, serial correlation, and regression tests, they found evidence of weak-form efficiency in some periods.

Karemera *et al*. (1999) [5] used the Variance Ratio Test to examine 15 emerging markets, finding that most exhibited weak-form efficiency based on local and U.S. dollar-based returns.

Mobarek *et al*. (2008) [10] studied the Dhaka Stock Exchange from 1988 to 2000, using parametric (autocorrelation, AR, ARIMA) and non-parametric (Kolmogorov-Smirnov, Runs Test) methods. Their findings rejected weak-form efficiency, as returns showed significant autocorrelation.

Objectives of The Study

- To examine whether the Indian stock market follows a random walk pattern.
- To assess whether investors can consistently earn abnormal returns using historical price data.

Research Methodology

The empirical analysis in this study uses daily market returns of the National Stock Exchange (NSE). The study has been conducted for the period of 1st April 2015 till 28th March 2025. Secondary data has been used for the study to determine the randomness of the stock market. The study employs parametric test like autocorrelation, variance ratio test and non-parametric test named runs test has been used. The details of tests are mentioned below:

The Variance Ratio Test: is a statistical test used to assess the efficiency of financial markets, particularly in the context of the Random Walk Hypothesis (RWH) and Efficient Market Hypothesis (EMH). The idea behind the test is to check if the variance of returns over different time horizons behaves as would be expected under the assumption of a random walk or market efficiency.

H_0: The stock return series follows a random walk.

H_1: The stock return series does not follow a random walk.

Let r_t be the return at time t. Compute the variance of 1-period (e.g., daily) returns

$VAR(1) = Var(r_t)$

Aggregate returns over k periods (e.g., 2-day, 4-day, etc.):

$r_t^{(k)} = r_t + r_{t-1} + r_{t-k+1}$

Compute the variance of the aggregated returns:

$VAR(k) = Var\ (r_t^{(k)})$

Calculate Variance Ratio (VR):

Under the random walk assumption, the k-period variance should be k times the 1-period variance.

$$VR\ (k) = \frac{VAR(k)}{k\ \times VAR\ (1)}$$

If VR (k) = 1, returns are consistent with a random walk.

If VR (k) = <1, it suggests mean reversion (negative autocorrelation).

If VR (k) = >1, it suggests momentum (positive autocorrelation)

Estimate the Variance of the VR ($\varphi(k)$)

Estimate the variance of the variance ratio under the null hypothesis (i.e., assuming the data follows a random walk):

$\varphi(k)$ = Estimated variance of VR (k)

Compute the Z-Statistic

Standardize the test statistic to evaluate how far the VR is from 1

$$Z\ (k) = \frac{VR(k) - 1}{\sqrt{\boldsymbol{\varphi}(\mathbf{k})}}$$

Determine the p-value associated with the Z-statistic to evaluate the null hypothesis:

If $p < 0.05$: reject the random walk hypothesis (returns are not i.i.d.).

If $p \geq 0.05$: fail to reject the random walk hypothesis.

Autocorrelation measures the relationship between a variable and its lagged values.

For returns:

$ACF\ (k) = Corr\ (r_t, r_{t-k})$

Where:

r_t: return at time t

k: lag

Autocorrelation analysis is a foundational tool for testing market efficiency. Existence of no autocorrelation supports random walk whereas significant autocorrelation leads the chance of predictability.

Runs Test

Calculate Number of Positive (n_1) and Negative (n_2) Signs

Let:

n_1 = number of + signs

n_2 = number of − signs

R= number of runs in the sequence

Calculate Expected Number of Runs

$$E\ (R) = \frac{2n_1n_2}{n_1 + n_2} + 1$$

Calculate Variance of Runs

$$VAR\ (R) = \frac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1 + n_2)^2(n_1 + n_2 - 1)}$$

Compute Z-statistic

$$Z\ (k) = \frac{R - E(R)}{\sqrt{Var(R)}}$$

Use the Z-value to determine whether to reject H_0

H_0: Returns are random indicating market is efficient

H_1: Returns are not random indicating market is not efficient

Finding & Analysis

Table 1: Variance Ratio Test

	return	2-day return	4-day return	8-day return
VAR(1)	0.0001082	0.00021169	0.000423834	0.000855497
VAR(k)		0.00010591	0.000106491	0.000108567
VR(k)		0.48960003	0.246139563	0.125468718
φ(k)		0.00040371	0.001413	0.003532499
sqrtφ(k)		0.02009264	0.037589887	0.05943483
Z(k)		-25.402335	-20.05487377	-14.71412108
P-value		0	0	0

Source: Authors' own calculation

The Variance Ratio (VR) test is a method used to examine whether a time series follows a random walk, a core assumption of weak-form market efficiency.

VR test was conducted using lag intervals of 2-day, 4-day, and 8-day returns as showcased in the above table 1. The computed variance ratios were 0.4896, 0.2461, and 0.1255 respectively and the corresponding Z-statistics were -25.40, -20.05, and -14.71, with p-values equal to zero in all cases, suggesting a high level of statistical significance. These results provide strong evidence against the random walk hypothesis. Therefore, the researchers' reject the null hypothesis that market follows random walk.

Table 2: Autocorrelation Test

Correlation			-0.0271661		
no. of periods			5		
Weight Matrix	1	2	3	4	5
1	1	-0.02717	0.000738	-2E-05	5.45E-07
2	-0.0271661	1	-0.02717	0.000738	-2E-05
3	0.000738	-0.02717	1	-0.02717	0.000738
4	-2.005E-05	0.000738	-0.02717	1	-0.02717
5	5.446E-07	-2E-05	0.000738	-0.02717	1
Variance				0.0001081	
Variance (independent)				0.0005406	
Variance (autocorrelation)				0.0005176	
Scaling factor				4.7870197	
Variance (autocorrelation)				0.0005176	
stdev (independent)				0.0232518	
stdev (autocorrelation)				0.0227512	

Source: Authors' own calculation

From the above table 2 it can be observed that autocorrelation was measured across five time lags. The first-order autocorrelation coefficient was found to be -0.02717, indicating a slight negative correlation between successive returns. The value is slightly negative, suggesting a weak tendency toward mean reversion (i.e., a return today is slightly negatively related to yesterday's return). However, the magnitude (≈ -0.03) is very small and likely not statistically significant on its own.

The variance under autocorrelation is lower, indicating some negative serial dependence. The difference is modest, so autocorrelation is present but not strong.

Your stock returns show weak negative autocorrelation, suggesting a mild mean-reverting pattern.

However, the magnitude is small, so while there's a slight deviation from random walk, it is not strong enough to imply inefficiency or exploitable predictability.

Table 3: Runs Test Result

-1	negative runs ends
1	positive runs starts
Positive Runs	571
Negative Runs	570
Total Runs	1141
Positive Days	1340
Negative Days	1137
Total Days	2477
expected runs	1234.168758
run variance	615.1708567
run stdev	24.8026381
z-stat	-3.756405154
p-value	99.99%

Source: Authors' own calculation

The runs test is a non-parametric (Mobarek *et al*. 2008) [10] statistical tool used to detect randomness in a time series by examining the occurrence and sequence of consecutive positive and negative returns, known as "runs" (Karemera *et al*. 1999) [5] under the market efficiency study, asset prices are assumed to follow a random walk, implying that price changes are independent of one another. If the sequence of returns exhibits a pattern or dependency, it may suggest predictability and inefficiency in the market.

From the above table 3 it can be observed that the runs test was applied to a dataset of 2477 daily return observations. The test identified 1141 actual runs, whereas the expected number of runs under the null hypothesis of randomness was 1234.17. The calculated Z-statistic was -3.756, with a corresponding p-value of less than 0.01. This significant result indicates a substantial deviation from the expected number of runs, pointing to non-randomness in the return sequence.

The outcome of the runs test suggests that the returns exhibit serial dependence and fail to follow a purely random pattern. Consequently, the null hypothesis of randomness is rejected.

Table 4: Overall Results of all the tests performed

Period	Variance Ratio Test	Autocorrelation Test	Runs Test
2015-2025	Not Random	Not Random	Not Random

Source: Authors' own calculation

The overall result has been showcased in the above table 4 which indicates that the stock market return in the study period replicates non randomness which implies that the market is not efficient and it may be predicted.

Conclusion

The study explores whether the Indian stock market moves randomly, using daily return from the indices of national stock exchange (NSE) covering a period of ten years. Three tests have been conducted, that is variance ratio, autocorrelation, and runs tests, to observe whether stock prices follow a random pattern or not, which is a key part of market efficiency.

The results revealed that the Indian stock market doesn't move randomly in the study period. The variance ratio test gave very low p-values (0), meaning stock prices don't follow a random walk. The runs test found fewer patterns than expected, also showing non-random behaviour. The autocorrelation test showed a slight connection between past and current prices, but it is too weak to predict much. Together, these findings suggest the market is not fully efficient, as prices seem to follow some patterns.

This non-randomness might come from India's market being less stable, with many small investors and less strict rules. These patterns could help investors guess future prices a bit, but they are not strong enough to always make extra profits. Investors should use both price trends and company performance to make smart choices.

The study's results suggest that investors should be cautious about depending only on historical price data for investment choices, as the Indian stock market does not show complete randomness. Although some patterns and trends exist, they don't ensure steady profits. Therefore, combining technical analysis (looking at price movements) with fundamental analysis (evaluating a company's financial health) is recommended for smarter decisions. Regulators and policymakers should focus on improving market transparency and supporting investor education to boost market efficiency and shield participants from false information. Additionally, future studies could explore specific industries or different timeframes to better understand the Indian stock market's behaviour and efficiency.

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