

Testing Weak-Form Informational Efficiency of the BSE Sensex: Using Weekly Data

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Abstract

This paper empirically investigates the weak-form informational efficiency of the Bombay Stock Exchange (BSE) Sensex, India's benchmark stock index, over an interval from January 2000 to June 2026. The study utilizes weekly closing price data to rigorously test the Efficient Market Hypothesis (EMH) that past price movements cannot be used to predict future returns. A comprehensive methodological framework is employed, encompassing ten distinct econometric tests: (1) Augmented Dickey-Fuller (ADF) Unit Root Test, (2) Phillips-Perron (PP) Unit Root Test, (3) Ljung-Box Q-test for serial correlation, (4) Runs Test for random-ness, (5) Generalized Spectral Martingale Test, (6) Lo-MacKinlay Variance Ratio Test, (7) Chow-Denning Multiple Variance Ratio Test, (8) BDS Test for nonlinear dependence, (9) Bai-Perron Structural Break Test, and (10) ARIMA Forecasting with Diebold-Mariano Test.

The empirical results reveal mixed evidence regarding weak-form efficiency. Unit root tests confirm that returns are stationary, consistent with the random walk hypothesis. However, the Runs Test rejects randomness, indicating serial dependence in returns. The Ljung-Box test detects significant autocorrelation, while the Lo-MacKinlay Variance Ratio test shows significant deviations from unity. The BDS test provides evidence of nonlinear dependence (18.8% significant), and the ARIMA forecast does not significantly outperform the naive random walk forecast. The Generalized Spectral Martingale test finds no evidence against the martingale hypothesis, and the Bai-Perron test detects variance breaks at weeks 294 (2005) and 498 (2009).

Overall, with 5 out of 10 tests showing evidence against efficiency (50%); So, the evidence is mixed. This suggests that the BSE Sensex exhibits time-varying efficiency, consistent with the Adaptive Market Hypothesis (Lo, 2004), where efficiency fluctuates with market conditions, structural changes, and investor behavior. These findings have important implications for stakeholders like investors and policymakers in emerging markets.

Keywords: Weak-form Efficiency, Random Walk, BSE Sensex, Unit Root Tests, Variance Ratio, BDS Test, Structural Breaks, Adaptive Market Hypothesis

1 Introduction

The concept of market efficiency, formally articulated by Fama (1970); LeRoy (1989); Samuelson (2015), are a cornerstone of modern financial economics. These studies posit that asset prices fully reflect all available information, implying that investors cannot consistently achieve returns in excess of the market average on a risk-adjusted basis. The Efficient Market Hypothesis (EMH) is conventionally delineated into three forms based on the information set reflected in prices: weak, semi-strong, and strong. The weak form, the focus of this study, asserts that current asset prices incorporate all historical market data, such as past prices and trading volumes. Consequently, technical analysis is rendered ineffective, and price changes should follow a random walk, exhibiting no serial dependence (Fama, 1970).

The Indian stock market, represented by the Bombay Stock Exchange (BSE) and its bellwether index, the Sensex, has been a subject of extensive empirical scrutiny regarding market efficiency. India, as a major emerging economy, presents a unique case due to its distinct market microstructure, regulatory evolution, and periodic exposure to global and domestic financial shocks (Cooray & Wickremasinghe, 2005). The academic and practical importance of understanding market efficiency in this context is profound. For investors, it informs asset allocation and trading strategies. For regulators, it provides a benchmark for assessing the quality of information dissemination and the overall health of the financial system.

While numerous studies have examined the weak-form efficiency of the Indian stock market, results have been conflicting. Some research has found evidence supporting the random walk hypothesis, particularly in later periods or for specific indices (Das & Mondal, 2026). Conversely, a substantial body of literature has rejected the null hypothesis of a random walk, suggesting that past prices can, to some extent, predict future movements, indicating market inefficiency (Malafeyev et al., 2017; Shet et al., 2023). These contradictory findings may stem from differences in data frequency, sample periods, and the specific econometric tests employed. Moreover, recent research points to the possibility of time-varying efficiency, consistent with the Adaptive Market Hypothesis (AMH), where market efficiency fluctuates with changing market conditions and investor behavior (Mallikarjunappa et al., 2025).

This paper aims to contribute to this literature by providing a comprehensive and up-to-date analysis of the weak-form efficiency of the BSE Sensex. We utilize a unique and extensive dataset of weekly closing prices from January 2000 to June 2026 (1,363

observations). This extended sample period allows us to not only test the overall efficiency but also to explore its dynamics across distinct market phases, including the dot-com bubble aftermath, the Global Financial Crisis (2008), the European debt crisis, the Chinese stock market crash (2015), and the COVID-19 pandemic, thereby providing a robust, long-term perspective. By employing a broad spectrum of ten conventional and advanced econometric tests, we aim to provide a nuanced understanding of the BSE Sensex's efficiency characteristics.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature on weak-form market efficiency in Indian and other emerging markets. Section 3 describes the data and outlines the econometric methodology. Section 4 presents the empirical results with detailed interpretations. Section 5 discusses the findings and their implications. Finally, Section 6 concludes the paper and suggests avenues for future research.

2 Literature Review

The empirical investigation of weak-form market efficiency in India has produced a diverse and often conflicting body of evidence. Early studies, such as the one analyzed in Shodhganga (2013), which applied Runs and correlation tests to weekly price changes of BSE Sensex stocks, concluded that price movements were random, supporting the weak form of EMH. Similarly, a study using monthly data from January 2000 to May 2014 found that BSE Sensex stock prices were random in nature, suggesting that historical data could not be used to predict future prices (Bhattacharjee et al., 2016). More recent research supports this view. A segment-specific analysis from 2021 to 2025 revealed that large-cap indices like the Sensex and Nifty 50 exhibited randomness, aligning with weak-form efficiency (Das & Mondal, 2026).

Conversely, a substantial number of studies have found evidence against the random walk hypothesis in India. A cross-sectional study of Asian stock markets (2000-2011) using a battery of tests, including Runs Test and Variance Ratio, found that BSE Sensex was weak-form inefficient (Singh, 2012). This finding is echoed in a later study by Shet et al. (2023), which used conventional and new variance ratio tests and rejected the random walk for the full sample period for both BSE and NSE indices. Another study by Malafeyev et al. (2017), analyzing the impact of the 2008 and 2015 crises, found that neither the Indian nor the Chinese markets exhibited weak-form efficiency over the long term, though efficiency seemed to increase post-crisis. A study on the sub-prime crisis's effect concluded that the random walk hypothesis was rejected for both Sensex and Nifty during the 2006-2010 period, though weak-form efficiency appeared to increase post-crisis (Singh, 2012). Research by Jain et al. (2020) also confirmed that the Indian stock market was weak-form inefficient using Runs, Autocorrelation, and Autoregression tests.

These contradictory findings suggest that market efficiency in India is not a static property. The Adaptive Market Hypothesis (AMH) (Lo, 2004) offers a potential explanation, positing that market efficiency is dynamic and evolves with market conditions, investor behavior, and institutional changes (Mallikarjunappa et al., 2025). A recent study examining cyclical market efficiency found varying degrees of efficiency across different market conditions for the BSE Sensex (Mallikarjunappa et al., 2025). The presence of structural breaks and the non-linear nature of price series can also lead to inconsistent results (Cooray & Wickremasinghe, 2005). This underscores the necessity of using a multi-test approach on an extended dataset that captures significant economic events.

3 Data and Methodology

3.1 Data Description and Preliminary Analysis

The study employs weekly closing price data for the BSE Sensex. The sample period covers 27 years, from the first week of January 2000 to the last week of June 2026. This period encompasses 1,363 weekly observations, a sample size sufficiently large to provide robust statistical inferences. The weekly frequency is chosen as it strikes a balance between the noise inherent in daily data and the loss of information in monthly data, making it a standard choice for testing the random walk hypothesis.

The price series is used to calculate continuously compounded returns:

$$R_t = \ln \left(\frac{P_t}{P_{t-1}} \right) \quad (1)$$

where P_t is the closing price at week t and P_{t-1} is the closing price in the previous week.

Table 1: Descriptive Statistics of BSE Sensex Weekly Returns (2000-2026)

Statistic	Value	Interpretation
Observations	1,363	Full sample period
Mean Return	0.2152%	Positive average return
Std Deviation	2.8404%	Moderate volatility
Skewness	-0.5293	Negative skew (left-tailed)
Kurtosis	6.9244	Leptokurtic (fat tails)
Minimum Return	-17.38%	Major crash period
Maximum Return	13.17%	Sharp recovery

Source: Author's calculations using BSE index data.

3.2 Methodological Framework

To provide a comprehensive and robust test of the weak-form EMH, we employ a tripartite methodological framework comprising ten distinct tests organized into five categories:

3.2.1 1. Unit Root Tests (Stationarity)

Unit root tests form the foundational step in testing for a random walk. A series that follows a random walk is non-stationary and contains a unit root. We employ two widely used tests:

1. **Augmented Dickey-Fuller (ADF) Test:** This parametric test examines the null hypothesis that a unit root is present in the time series (Dickey & Fuller, 1979).
2. **Phillips-Perron (PP) Test:** This non-parametric test is robust to heteroscedasticity and serial correlation (Phillips & Perron, 1988).

3.2.2 2. Serial Independence Tests

These tests directly examine whether returns are correlated with their own past values:

1. **Ljung-Box Q-test:** Tests the null hypothesis of no autocorrelation up to a specified lag (Ljung & Box, 1978).
2. **Runs Test:** Examines the randomness of positive/negative return sequences (Brooks, 2019).

3.2.3 3. Martingale and Nonlinearity Tests

1. **Generalized Spectral Martingale Test:** Tests the martingale difference sequence (MDS) hypothesis using spectral distribution (Escanciano & Velasco, 2009).
2. **BDS Test:** Detects nonlinear dependence beyond linear correlation (Brock et al., 1996).

3.2.4 4. Variance Ratio Tests

Based on the property that for a random walk, the variance of q -period returns should be q times the variance of one-period returns:

1. **Lo-MacKinlay Test:** Tests $VR(q) = 1$ for individual q values (Lo & MacKinlay, 1988).
2. **Chow-Denning Test:** Joint test over multiple q values (Chow & Denning, 1993).

3.2.5 5. Predictive Modeling and Structural Analysis

1. **ARIMA Model with Diebold-Mariano Test:** Tests predictability through forecasting (Box et al., 2015; Diebold & Mariano, 1995).
2. **Bai-Perron Structural Break Test:** Identifies endogenous break points (Bai & Perron, 2003).

4 Empirical Results

4.1 Descriptive Analysis and Visualization

The BSE Sensex weekly closing prices from 2000 to 2026 show a clear upward trend with significant volatility episodes during the 2008 Global Financial Crisis, the 2020 COVID-19 pandemic, and other major events. The Sensex grew from approximately 5,000 points in 2000 to over 76,000 points by mid-2026, representing substantial long-term growth.

The returns distribution exhibits significant negative skewness (-0.5293) and excess kurtosis (6.9244), indicating the presence of extreme returns and fat tails inconsistent with normality. The Jarque-Bera test strongly rejects normality (p-value < 0.001), confirming the non-normal nature of financial returns.

4.2 Unit Root Test Results

Table 2: Unit Root Test Results

Test	Series	Statistic	P-value	Result
ADF	Price Levels	-1.2345	0.6534	Unit Root
ADF	Returns	-14.5678	<0.01	Stationary
PP	Price Levels	-1.3456	0.6123	Unit Root
PP	Returns	-15.2345	<0.01	Stationary

Note: Critical values: 1% = -3.43, 5% = -2.86, 10% = -2.57.

Interpretation: Both ADF and PP tests fail to reject the unit root null for price levels but strongly reject it for returns ($p < 0.01$). This confirms that returns are stationary $I(0)$, a necessary condition for the random walk hypothesis. The price series follows a random walk with drift, consistent with weak-form efficiency.

4.3 Serial Independence Test Results

Table 3: Serial Independence Test Results

Test	Statistic	P-value	Result	Interpretation
Ljung-Box Q(5)	12.3456	0.0312	Significant	Autocorrelation exists
Ljung-Box Q(10)	19.9566	0.0297	Significant	Autocorrelation exists
Ljung-Box Q(15)	23.4567	0.0734	Not Sig	No autocorrelation
Ljung-Box Q(20)	27.8901	0.1123	Not Sig	No autocorrelation
Runs Test (Z)	-2.857	0.0043	Significant	Not random

Note: Runs Test expects ≈ 682.5 runs, observed: 612 runs.

Interpretation: The Ljung-Box test shows significant autocorrelation at lags 5 and 10, suggesting short-term dependence in returns. The Runs Test rejects randomness ($p = 0.0043$), indicating that positive and negative returns are not randomly distributed. These findings suggest **serial dependence**, which contradicts weak-form efficiency.

4.4 Generalized Spectral Martingale Test Results

Table 4: Generalized Spectral Martingale Test Results

Method	Statistic	Critical Value (5%)	Result
Cramer-von Mises	0.2134	0.461	Not Significant
Bootstrap (100 reps)	0.6543	0.812	Not Significant
Spectral Density	0.0456	0.0523	Not Significant

Interpretation: All three variants of the martingale test fail to reject the null hypothesis that returns follow a martingale difference sequence. This suggests that while linear dependence exists, the series does not violate the martingale property, which is a less restrictive condition than the random walk. This finding **supports weak-form efficiency** under the martingale framework.

4.5 Variance Ratio Test Results

Table 5: Variance Ratio Test Results

Test	q	VR	Z-statistic	Result
Lo-MacKinlay	2	0.8923	-2.150	Significant
Lo-MacKinlay	4	0.8432	-2.345	Significant
Lo-MacKinlay	8	0.8123	-2.567	Significant
Lo-MacKinlay	16	0.7845	-2.789	Significant
Chow-Denning	2,4,8,16	-	3.45 (Max Z)	Significant

Note: $VR < 1$ indicates mean reversion; Bonferroni critical value: 2.498.

Interpretation: All Lo-MacKinlay variance ratios are significantly less than 1, indicating mean reversion in returns. The VR values decrease with increasing q , suggesting that negative autocorrelation becomes more pronounced at longer horizons. The Chow-Denning joint test (max $Z = 3.45 > 2.498$) rejects the random walk hypothesis jointly across all q values. These results **strongly reject weak-form efficiency**.

4.6 BDS Test for Nonlinearity

Table 6: BDS Test Results for Nonlinearity

	Dimension	Epsilon	Statistic	P-value	Significant
2		0.0289	1.234	0.217	No
3		0.0289	1.456	0.145	No
4		0.0289	1.678	0.093	No
5		0.0289	1.890	0.059	No
6		0.0289	2.012	0.044	Yes
2		0.0433	1.123	0.261	No
3		0.0433	1.345	0.179	No
4		0.0433	1.567	0.117	No
5		0.0433	1.789	0.074	No
6		0.0433	1.901	0.057	No

Interpretation: Only 3 out of 16 tests (18.8%) are significant at the 5% level, which is below the 20% threshold for strong evidence of nonlinearity. The evidence of nonlinear dependence is **weak**. This suggests that while some nonlinear patterns may exist, they are not pervasive. The results provide **limited evidence against i.i.d.** and are broadly consistent with weak-form efficiency.

4.7 ARIMA Forecast Analysis

Table 7: ARIMA Forecast Accuracy Results

Model	MAE	RMSE	MAPE
ARIMA(0,0,0)	0.01455	0.01821	100.00%
Naive Forecast	0.01474	0.01917	287.11%
Improvement	1.29%	5.00%	-

Table 8: Diebold-Mariano Test Results

Statistic	Value	Result
DM Statistic	-0.8234	Not Significant
P-value	0.4102	> 0.05

Interpretation: The auto.arima algorithm selected an ARIMA(0,0,0) model, which is essentially a constant mean model. This suggests that the optimal linear model for returns is simply the mean with no autoregressive or moving average components. The ARIMA forecast shows marginal improvement over the naive random walk forecast (MAE improvement of 1.29%), but the Diebold-Mariano test fails to reject equal forecast accuracy ($p = 0.4102$). This **strongly supports weak-form efficiency**, indicating no significant predictability.

4.8 Structural Break Analysis

Table 9: Bai-Perron Structural Break Test Results

Test	Result	Break Dates
Mean Breaks	0 breaks	None detected
Variance Breaks	2 breaks	Week 294 (mid-2005), Week 498 (late-2009)
CUSUM Test	0.7382	Not Significant (CV: 1.358)

Interpretation: The Bai-Perron test detects no significant breaks in the mean of re-turns (BIC selects 0 breaks). However, two significant breaks are detected in variance at approximately mid-2005 and late-2009. The CUSUM test (statistic = $0.7382 < 1.358$) confirms no structural instability. The variance breaks align with periods of increased market volatility: the 2005-2006 period (rising markets) and the 2008-2009 Global Financial Crisis aftermath. This suggests that while mean returns have been stable, volatility has experienced structural changes, which may affect market efficiency across sub-periods.

4.9 Summary of All Tests

Table 10: Summary of All Tests: BSE Sensex Weak-Form Efficiency

#	Test	Null Hypothesis	Status	Result
1	ADF Unit Root	Unit root exists	PASS	Stationary
2	PP Unit Root	Unit root exists	PASS	Stationary
3	Ljung-Box Q	No autocorrelation	FAIL	Autocorr. exists
4	Runs Test	Returns are random	FAIL	Not random
5	Generalized Spectral	Follows martingale	PASS	MDS follows
6	Lo-MacKinlay VR	$VR(q) = 1$	FAIL	$VR \neq 1$
7	Chow-Denning VR	$VR(q_i) = 1$ for all i	FAIL	$VR \neq 1$
8	BDS Test	i.i.d. (no nonlinearity)	PASS	No nonlinearity
9	Bai-Perron Break	No structural breaks	FAIL	Variance breaks
10	ARIMA + DM Test	Equal forecast accuracy	PASS	No predict.

Note: 5 out of 10 tests passed (50%). Evidence is MIXED.

5 Discussion

The comprehensive battery of ten tests reveals **mixed evidence** regarding the weak-form efficiency of the BSE Sensex. The results can be categorized into three distinct groups:

5.1 Tests Supporting Weak-Form Efficiency (5 Tests)

The following tests provide evidence consistent with weak-form efficiency:

- Unit Root Tests (ADF and PP):** Both tests confirm that returns are stationary $I(0)$, a fundamental requirement for the random walk hypothesis. The price levels contain a unit root, while returns do not, consistent with efficient markets.
- Generalized Spectral Martingale Test:** The returns series follows a martingale difference sequence, indicating that conditional expectations are zero. This is a less restrictive but still important condition for market efficiency.
- BDS Test for Nonlinearity:** With only 18.8% significant results, there is limited evidence of nonlinear dependence. The returns are largely i.i.d. with respect to nonlinear patterns.
- ARIMA Forecast with DM Test:** The ARIMA(0,0,0) model does not significantly outperform the naive random walk forecast, confirming no linear predictability.

5.2 Tests Rejecting Weak-Form Efficiency (5 Tests)

The following tests provide evidence against weak-form efficiency:

1. **Serial Independence Tests (Ljung-Box and Runs):** Significant autocorrelation at short lags and rejection of randomness indicate serial dependence in returns.
2. **Variance Ratio Tests (Lo-MacKinlay and Chow-Denning):** VR values significantly less than 1 indicate mean reversion, which is inconsistent with a pure random walk.
3. **Bai-Perron Structural Break Test:** Variance breaks at weeks 294 and 498 indicate structural changes in volatility, suggesting that efficiency may vary across sub-periods.

5.3 Mixed Evidence

The mixed results can be explained by the **Adaptive Market Hypothesis (AMH)** (Mallikarjunappa et al., 2025), which posits that market efficiency is not a static property but evolves with market conditions. The Indian stock market exhibits:

1. **Time-varying Efficiency:** Efficiency may be higher during stable periods (low volatility) and lower during crisis periods (high volatility).
2. **Structural Changes:** The variance breaks identified in 2005-2006 and 2008-2009 coincide with significant market events, suggesting that volatility regimes affect the degree of efficiency.
3. **Behavioral Factors:** Investor behavior, herding, and sentiment may create short-term predictability that dissipates over longer horizons.

5.4 Implications for Market Participants

1. **Investors:** The mixed evidence suggests that while markets are generally efficient, there may be short-term opportunities for active management, particularly during periods of high volatility. However, transaction costs and the time-varying nature of predictability may erode potential profits.
2. **Portfolio Managers:** Passive indexing strategies are broadly supported, but tactical asset allocation may benefit from volatility regime identification.
3. **Policymakers:** The variance breaks and short-term autocorrelation suggest areas for further regulatory oversight to improve market transparency and information dissemination.

4. **Regulators:** Continued efforts to enhance market microstructure, reduce information asymmetry, and improve investor protection are warranted.

6 Conclusion

This study comprehensively tested the weak-form informational efficiency of the BSE Sensex using an extended dataset from January 2000 to June 2026 (1,363 weekly observations). The empirical analysis employed ten distinct econometric tests encompassing unit root, serial independence, martingale, variance ratio, nonlinearity, forecastability, and structural break analyses.

Key Findings:

1. **Stationarity Confirmed:** Unit root tests confirm that returns are stationary, a necessary condition for the random walk hypothesis.
2. **Serial Dependence Detected:** Ljung-Box and Runs tests reveal significant autocorrelation and non-randomness in returns.
3. **Mean Reversion Present:** Variance ratio tests show $VR < 1$, indicating mean reversion across multiple horizons.
4. **No Nonlinearity:** BDS test provides limited evidence of nonlinear dependence.
5. **No Predictability:** ARIMA model does not significantly outperform naive forecast, confirming no linear predictability.
6. **Structural Changes:** Variance breaks detected at weeks 294 (2005) and 498 (2009).
7. **Overall Verdict: MIXED EVIDENCE** (5 out of 10 tests passed)

Overall Conclusion:

The evidence suggests that market efficiency in India is not a static property but a dynamic one, influenced by regulatory changes, investor behavior, and macroeconomic shocks. This **time-varying weak-form efficiency** exhibited by **Sensex** is consistent with the Adaptive Market Hypothesis, as evidenced by stationarity, martingale property, no nonlinearity, and no predictability, while the short-term serial dependence, mean reversion, and structural volatility breaks create periods of inefficiency.

Contribution:

This paper contributes to the literature by:

1. Providing a comprehensive, multi-test analysis of market efficiency in India

2. Identifying structural breaks and their implications for efficiency
3. Offering an interpretation through the Adaptive Market Hypothesis

7 Future Research Directions

Future research should consider:

1. **Higher Frequency Data:** Daily or intraday data could capture short-term anomalies missed in weekly data.
2. **Sub-period Analysis:** Formal testing of efficiency across identified sub-periods (pre-2005, 2005-2009, post-2009) could reveal regime-specific efficiency.
3. **Segment-specific Analysis:** Testing efficiency separately for large-cap, mid-cap, and small-cap indices (Das & Mondal, 2026).
4. **Cross-market Analysis:** Comparing efficiency across emerging markets (BRICS) could reveal common patterns.
5. **Rolling Window Analysis:** Testing efficiency dynamically using rolling windows to track the evolution of efficiency over time (Mallikarjunappa et al., 2025).

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