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UNVEILING VOLATILITY AND LONG-TERM DRIFTS – A STUDY OF BSE SENSEX

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ABSTRACT
This paper examines the long-term behaviour of the Bombay Stock Exchange (BSE) Sensex over 15 years, from 2010 to 2024, to understand its volatility and distributional features using statistical tools. The data was collected from the BSE official website and analysed to measure the comprehensive pattern and variability of index performance. The result shows a moderately right-skewed distribution, indicating that the Sensex tends to experience exceptional index values more frequently, while the negative kurtosis suggests a flatter-than-normal distribution, implying fewer extreme variations. To gauge the reliability of the figures over time, the Augmented Dickey-Fuller (ADF) test has been done to check for stationarity. The outcomes of the ADF test discovered a non-stationary time series, indicating that the statistical characteristics of the Sensex such as its mean and variance, have altered across the observed period, making long-term prediction less reliable without changes. This study contributes to a better knowledge of market behaviour in the framework of a developing economy and delivers insights into the Sensex's reaction to macroeconomic and basic developments over time. The findings of the study are assumed to help various stakeholders in order to take decisions regarding savings and investments.

Keywords: Sensex, BSE, ADF, Volatility, Stationarity

1. Introduction

Financial markets play a key role in keeping economic effectiveness and growth. They perform at both national and international stages by assembling savings, helping investment activities, and delivering liquidity over the easy change of assets into cash. Amongst them, the stock market is specifically important, as it allows the exchange of shares and serves as an indicator of economic strength. It reflects the performance of listed businesses and discloses investor sentiment. The chattels of stock market activities are not limited to a single region but highlight the unified nature of the global economy. As Liu and Tse (2012) note, stock markets are very vulnerable to external shocks which have produced substantial disturbances, mainly in developing countries.In a developing country like India, the consequences of the stock have a robust and direct connection with the country's economy as the prices of stock are mostly affected by various macroeconomic variables like inflation, interest, exchange rates, gross domestic product and national income (Tripathi & Seth, 2014; Dasgupta, 2012). Yet, the decisions in trading are mostly affected by past trends and sometimes with incomplete information, and even the stock market decisions are influenced by human activities. Most of the time, overconfidence among investors increases the volatility and transaction costs, specifically in developing countries like India (Mushinada & Veluri, 2018). These make the financial market more complex to understand and create a difficult pattern to analyse.

To understand the patterns in the stock market, various techniques were developed by the policy makers and researchers to make reliable decisions and easy to comprehend. The statistical models were used to understand, analyse and interpret the raw data so that key features of the dataset are identified. To realise the trends and volatility, the Augmented Dickey-Fuller (ADF) test provides the details about the stationarity, which is important for future prediction (Dadhich, Chouhan, & Adholiya, 2019). By combining both approaches, it helps to comprehend the precariousness and stationarity of the market and also provides an in-depth characterisation of the financial market.In India, the Bombay Stock Exchange (BSE) has been the earliest stock exchange in Asia, which was established in 1875 and is also the most indispensable organisation in the Indian economy. BSE is providing a place where companies and investors invest money and earning a profit. In the BSE, Sensex is the benchmark index, as Sensex is the reference point based on which the performance of the market is measured. Sensex was introduced in 1986 and includes the top 30 companies from various sectors of the economy. Sensex acts as a gauge of the performance of the financial market in India. A minor variation in the Sensex specifies the effect of change in the policy, earnings of the businesses and influence of different shocks either in the country or outside the country (Bhoi & Dhal, 1998). Sensex is closely monitored by the government, companies and stakeholders. The researchers used different techniques to predict the performance of the index, and before that, a stationarity test was essential to understand the volatility of the dataset (Perwej, Yadav, Sood, & Perwej, 2018).

2. Literature Review

As has been outline above that the performance of financial markets is object of captivation and examination. The economic downturn from the 2008 global financial crisis to the recent COVID-19 pandemic, that truly exaggerated the need to comprehend how stock markets react to uncertainty (Bellalah et al., 2012; Padhan & Sujit, 2013; Madheswaran et al., 2024). Carry this out, researchers transformed into a mixture of descriptive statistics and difficult econometric techniques like the Augmented Dickey-Fuller (ADF) test, making experimental lenses to observe the shocks under the surface of market indices.

Likewise, Bellalah et al. (2012) referred to the stock market of China to analyse the connection between macroeconomic variables and stock prices. ADF test was used in the study as a gatekeeper to show that the data were perfect for time-series modelling for using any kind of analysis. The findings of the study revealed that before 2008 crisis, there is a scrawny relationship between economic forces and stock prices, but the scenario has drastically changed post crisis and the forces tend to express stronger effect in the long run.

Early works started with a fundamental interest on the performance of market during crisis. Padhan and Sujit (2013), explaining stock market integration pre-recession and post-recession of 2008, relied on descriptive statistics to set the benchmark behaviour and employed the ADF test to measure the stationarity of the series, an important requirement for most time-series models. The analysis displayed that while stock prices looked random outwardly, using first differences revealed constancy and stationarity, signifying a fundamental order under the volatility.

Over the period, stock price prediction has grown more challenging. The COVID-19 pandemic carried a unique disturbance to international markets, deep-rooted in general mental uncertainty. This flow in volatility stimulated economic expert and policymakers to re-examine and familiarize their econometric models.Sharma and Mahendru (2010) applied descriptive statistics to study the behaviour of stock prices in association with many factors. Their initial examination of volatility and loopholes in share prices and macroeconomic features provides a vital understanding of the data structure, highlighting the worth of descriptive statistics in policy making and financial analysis.

The significance of these approaches stretched beyond crisis-focused study. Hiremath and Kumari (2014), in their paper on the Adaptive Market Hypothesis (AMH), applied descriptive statistics to observe the developing effectiveness of Indian stock marketplaces over time. While stationarity tests like the Augmented Dickey-Fuller (ADF) were not the main focus, they maintained the authors' time-series division. Their answers established that markets adjust and grow, resonating with earlier explanations that statistical belongings may move but continue present throughout crises.

Dadhich, Chouhan, and Adholiya (2019) showed a widespread study of seven main BSE indices. By means of the Augmented Dickey-Fuller (ADF) test, they identified that the initial time-series data were non-stationary, but taking first differencing reduced the data to stationary. The study emphasized that economic time-series data frequently require such alterations to develop meaningful forecasts. Along with descriptive

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statistics, their study discovered interdependences between the indices, showing the growing difficulty of financial market in India.

Bora and Basistha (2021) analysed the instability of the BSE Sensex and NSE Nifty 50 at the opening of the COVID-19 pandemic with a similar method. They applied descriptive statistics together with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to measure the stationarity of the series. The outcomes maintained previous results but also displayed that the market had become more subtle and volatile to bad news.

From the same perspective, Dadhich et al. (2021) addressed the same market from a predictive outlook. Their analysis was also authenticated with the ADF test to identify stationarity and after confirming non-stationarity in the raw data, they had taken differencing to make the series fit for ARIMA modelling. Once stationarity was attained, the models were capable of providing accurate short-term forecasts, authenticating that descriptive tools and Augmented Dickey-Fuller based preprocessing continue to be an important step before constructing predictive models.

Madheswaran, Lingaraja, and Duraisamy (2024) focused on the experience by examining stock price behaviour on the BSE Sensex during and before the outbreak of Covid 19. To comprehend the circumstantial evidence of return from the stock prices, the study used descriptive statistics. However, it was found that the descriptive statistics alone were not enough to analyse the observed patterns and Augmented Dickey-Fuller was also needed to predict the behaviour. Despite of high volatility during COVID-19, the findings indicated that the series remain largely static across both the periods.

3. Objectives

As mentioned in the beginning, our main objective of the study is unveiling the volatility in the BSE Sensex over a period of time. Specifically, we have studied the following:

a. To examine the reasons for volatility and behaviour in the BSE Sensex.
b. To analyse the stationarity of the BSE Sensex data.

4. Methodology

The study depends on secondary data covering the period 2010–2024, obtained directly from the official Bombay Stock Exchange (BSE) website to safeguard data consistency. While the data were originally logged on a daily basis, they were changed into yearly averages for each calendar year to simplify analysis. This alteration summarizes short-term differences and highlighted long-term drifts over the period of 15 years.

4.1 General Statistical Methods: Several statistical methods were employed to measure the original relations amongst the study variables, carried out in two steps. First, descriptive statistics were used to examine the features and instability of the BSE Sensex data, offering understandings into its dispersion, scattering, and loopholes. Volatility was restrained using modification, while skewness and kurtosis emphasized deviations from regularity. Secondly, the Augmented Dickey-Fuller (ADF) test was showed to regulate the stationarity of the time series, an essential step in most econometric analyses. The ADF test recognizes the existence of a unit root, representing whether the data are stationary or non-stationary, most common feature in financial time series dataset.

5. Data Analysis and Interpretation

This part of the paper shows a complete statistical analysis of the BSE Sensex index, based on annual average values from 2010 to 2024. The analysis contains two important segment which are discussed below:

5.1 Characteristics and Volatility in BSE Sensex: The study included descriptive statistical measures to examine the characteristics and volatility of the BSE Sensex data. This will provide an initial consideration of the dataset. It contributes to summarize and define the basic characteristics of a series in a in a valuable manner, providing insights into patterns, behaviour and irregularities in the data before using more difficult statistical models. The evaluation was carried out by taking into account the yearly average of the BSE Sensex data from 2010 to 2024. The results are reported in the table mentioned below:

Table 1: Calculated Statistical Value of the BSE Sensex

Name of Measures	Value
Mean	36468.40
Median	30929.00
Standard Error	4798.240191
Standard Deviation	18583.50435
Sample Variance	345346634
Kurtosis	-0.010429323
Skewness	0.965529547

Source: Calculated by the author using the secondary data

The study analyses the tracks of BSE Sensex from 2010 to 2024. The figures reveal a story that is both stable progress and random swings. The mean value of 36,468.40 reveals a middle point, signifying that the index, on normal, remained well above the 30,000 level. This explains a strong growth over the years during 2010 to 2024. The mean value hides the facts that in some years the value is much higher while in some years the value is much lower as revealed from the standard deviation value of 18583.50435 which is a much higher signifying the variations in the Sensex.The median value of 30,929.00 is slightly lower than the mean indicating that a few very high years dragged the average upward, strengthening the picture of a market that has sometimes jumped far ahead. The positive skewness of 0.965529547 verifies this description well, presenting that the distribution rests towards more common high values, signifying stockholder confidence and bull market have overshadowed extended recessions. Interestingly, the negative kurtosis of 0.010429323 tell us that the market distribution has been slightly flatter than the bell curve, showing that volatility exists, extreme high values or crashes have been less common than one might think of in a developing economy.In conclusion, the descriptive statistics disclose that the BSE SENSEX has showed overall growth, but with significant each year volatility, and a distribution outline that is slightly skewed but mainly normal. This knowledge is important, as it explains the requirement to investigate the stationarity of the dataset to know its appropriateness for predictive modelling.

5.2 Augmented Dickey-Fuller (ADF) Test: The Augmented Dickey-Fuller (ADF) test was applied to verify whether the BSE Sensex data persist over time regarding its average and inconsistency which is known as stationarity. The test is significant because stationarity shows whether a time series continues a constant pattern, which moves how the data is understood and analysed over long time periods.

The Augmented Dickey-Fuller (ADF) test was carried out on the data extracted from BSE official website and the result is reported in Table 2.

Table 2: Augmented Dickey-Fuller (ADF) test

Name of the Test	Value
ADF Test Statistic	1.8042
p-value	0.9984
Lags used	5
Number of observations	9
Critical Values:	
1% level	-4.4731
5% level	-3.2899
10% level	-2.7724

Source: Calculated by the author using the secondary data

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The Augmented Dickey-Fuller (ADF) test was applied to examine whether the BSE Sensex data from 2010 to 2024 follows a steady pattern over time or if it varies in a way that makes it difficult to forecast. The value of ADF test statistic is 1.8042, which exceeds the critical values at the 1% (−4.4731), 5% (−3.2899), and 10% (−2.7724) stages. As the result is higher than all these critical values, representing that the dataset is non-stationary.

The ADF test formed a p-value of 0.9984, which is above the standard 0.05 significance level, validating that the BSE Sensex data is non-stationary in nature. In a non-stationary series, the mean and variance transform in course of time rather than remaining constant. The Sensex, therefore, does not vary around a static mean but reacts to worldwide events, investor sentiment, and unexpected shocks like the COVID-19 pandemic.

The test employed 5 lags to show for past index activities, with 9 observations after lag change. Even after including these old effects, the data still showed non-stationarity, representing that the Sensex acts like a moving target, with drifts and instability growing over time, making long-term forecasting based on raw data.

6. Volatility in BSE Sensex

As mentioned earlier, the main objective the study is to see the volatility in BSE Sensex from 2010 to 2024. Based on the analysis conducted on the BSE SENSEX yearly average data from 2010 to 2024, the study presents the following important findings:

i. **Volatility Identified:** The descriptive statistics discovered that the BSE SENSEX showed significant volatility over the 15-year time frame. The high standard deviation and variance show clear fluctuations in the value from year to year, showing the market's response to macroeconomic variables, and worldwide economic events.

ii. **Irregularity in Distribution:** The positive skewness shows that the distribution of BSE SENSEX values is not regular. This advises that there were some years which exceptionally high and pulled the mean value upward. The negative kurtosis value additional showed that the dataset had flatter tails, indicating that there were some extreme activities than predicted in a normal distribution.

iii. **Stationarity of Data:** The outcomes of the Augmented Dickey-Fuller (ADF) test proved that the BSE SENSEX data is non-stationary. The ADF test statistic surpassed all the critical values, and the p-value was much higher than 0.05. This indicates that the mean and variance in the data change over time, which is normal in dynamic and growing financial markets.

7. Conclusion

This study analyses the statistical behaviour of the BSE SENSEX value over the period of 15 years from 2010 to 2024, concentrating on three essential objectives: studying volatility using descriptive statistics, analysing stationarity through the Augmented Dickey-Fuller (ADF) test, and assessing the complete behaviour of the index over time. The findings of the study show that in India, the stock market faces a noticeable change during the 15-year time period, which is verified by seeing changes in the volatility, irregularity and non-stationary features.

The results from the descriptive statistics display substantial year-to-year fluctuations, which is supported by a high amount of deviation and variance, showing that Sensex is affected by various internal and external factors, including government rules and regulations, economic events and stakeholder sentiment. The skewness value revealed a right-skewed distribution, showing a few years of exceptional performance that dragged the mean upward. The negative value of the kurtosis showed a flatter than normal distribution, which indicates that there are fewer extreme ups and downs during this period. At the outset, it can be said that the stock market in India, that signifies through Sensex, presents a dynamic behaviour rather than statistical stability during the long-term trend analysis.

Statement and Declaration

- **Funding Statement:** Both authors received no funding for this work.
- **Competing Interest:** Both authors have no competing interests.

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