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Examining the Distributional Characteristics of Daily Returns of Nifty 50: Normality Assessment and Implications

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ABSTRACT: This paper investigates the distributional characteristics of daily returns of the Nifty 50 index, a benchmark index comprising 50 large-cap stocks traded on the National Stock Exchange of India. Utilizing historical data spanning a specified time period, we conduct normality testing to assess the adequacy of the normal distribution assumption underlying many financial models. Our analysis provides insights into the departure from normality. As a result of departure from Normality, it may affect the tail behaviour, and volatility dynamics of Nifty 50 daily returns, offering implications for risk management, option pricing, portfolio management, and market efficiency. By synthesizing empirical findings with theoretical considerations, this research contributes to a deeper understanding of the statistical properties of Nifty 50 daily returns and informs practitioners in finance about the challenges associated with Modeling and analysing stock market data.

KEYWORDS: Daily Returns, Financial Modeling, Normal Distribution, Normality Assessment, Nifty 50.

INTRODUCTION

The Nifty 50 index, a key barometer of the Indian equity market, encompasses 50 large-cap stocks representing various sectors traded on the National Stock Exchange of India. Investors and practitioners widely rely on the Nifty 50 index as a benchmark for performance evaluation, portfolio construction, and risk management. Central to many financial models and strategies is the assumption of a normal distribution of daily returns, which underpins critical concepts such as risk-neutral pricing, portfolio optimization, and option valuation. However, empirical evidence suggests that real-world financial data often exhibit departures from normality, prompting the need for rigorous examination of the distributional characteristics of daily returns of Nifty 50.

In this context, this paper endeavors to analyse the distributional properties of daily stock returns of the Nifty 50 index. By employing statistical techniques for normality testing, we aim to scrutinize the validity of the normal distribution assumption and explore potential deviations from this theoretical framework. Our investigation encompasses a comprehensive time series dataset covering a specified period (1st January 2019 till 31st December 2023), past five years), enabling us to capture the dynamics of Nifty 50 daily returns and elucidate insights into their statistical behaviour.

The implications of our analysis extend across various domains within finance. Departures from normality can have profound ramifications for risk management practices, as inaccurate assessments of risk may lead to suboptimal investment decisions and heightened exposure to market volatility. Furthermore, deviations from a normal distribution can impact option pricing models, portfolio allocation strategies, and assessments of market efficiency. By elucidating the statistical properties of Nifty 50 returns, this research aims to provide practitioners with valuable insights into the challenges and opportunities inherent in Modeling and analysing stock market data.

Normality testing involves utilizing statistical procedures to assess whether a dataset conforms to a normal distribution. Evaluating normality typically entails employing a blend of graphical and mathematical methods, as each approach may provide unique insights into the distributional properties of the data.

1) Box Plot:

A box plot (also known as a box-and-whisker plot) provides a graphical representation of the distribution of the data.

The box in the plot represents the interquartile range (IQR), with the median depicted as a line within the box. The "whiskers" stretch to cover the data points that lie within 1.5 times the interquartile range (IQR) from the first and third quartiles, thus including the minimum and maximum values within this range. Points beyond the whiskers are considered outliers.

A symmetric box plot with a median line in the centre suggests normality. Skewed or asymmetric distributions may indicate non-normality.

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2) Q-Q Plot (Quantile-Quantile Plot):

A Q-Q plot compares the quantiles of the observed data with the quantiles of a theoretical distribution (e.g., normal distribution). If the data are normally distributed, the points in the Q-Q plot will fall along a straight line. Deviations from the straight line indicate departures from normality.

A straight diagonal line in the Q-Q plot suggests that the data are normally distributed. Departures from the diagonal line signify deviations from normality.

3) Shapiro-Wilk Test:

The Shapiro-Wilk test is a statistical test used to assess whether a sample of data comes from a normally distributed population. It calculates a test statistic based on the correlation between the data and the corresponding expected values under the null hypothesis of normality.

The test results in a p-value. If the p-value is greater than a chosen significance level (e.g., 0.05), we fail to reject the null hypothesis of normality, indicating that the data are consistent with a normal distribution. A smaller p-value suggests evidence against normality.

4) Kolmogorov-Smirnov Test:

The Kolmogorov-Smirnov test is a non-parametric test used to compare the empirical cumulative distribution function (ECDF) of the data with a specified theoretical distribution (e.g., normal distribution).

It calculates a test statistic representing the maximum absolute difference between the ECDF of the data and the corresponding theoretical distribution.

The test results in a p-value. Similar to the Shapiro-Wilk test, if the p-value is greater than a chosen significance level, we fail to reject the null hypothesis of normality. A smaller p-value suggests evidence against normality.

These methods provide complementary approaches for assessing the normality assumption in statistical analysis, and researchers often use multiple methods to gain a comprehensive understanding of the distribution of their data.

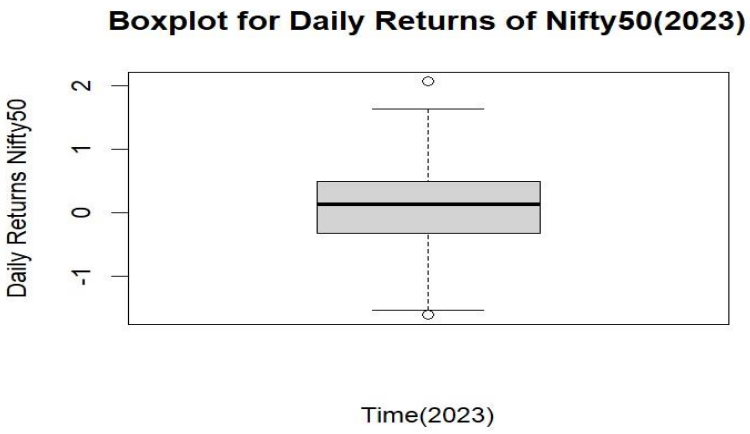
METHODOLOGY

The data on Nifty 50 daily returns for the period 1st January 2019 till 31st December 2023), is used for the analysis. Using R and various packages in R the historical financial data is fetched and daily returns are calculated. One popular package for fetching financial data is "quantmod" and for data manipulation and analysis, its "dplyr". The statistical software R is used for the assessment of Normality. The data are considered in two sets viz. Set 1: 1st January 2019 to 31st December 2023(Long Duration) and Set 2: 1st January 2023 to 31st December 2023 (Short Duration). Box Plot, Q-Q Plot, Shapiro Wilk Test and Kolmogorov Smirnov Test are applied for detecting Normality of daily Returns of Nifty 50 for both the datasets.

RESULTS AND DISCUSSION

Case I) Small Duration: 1 Year-2023

i) Box Plot: Figure 1



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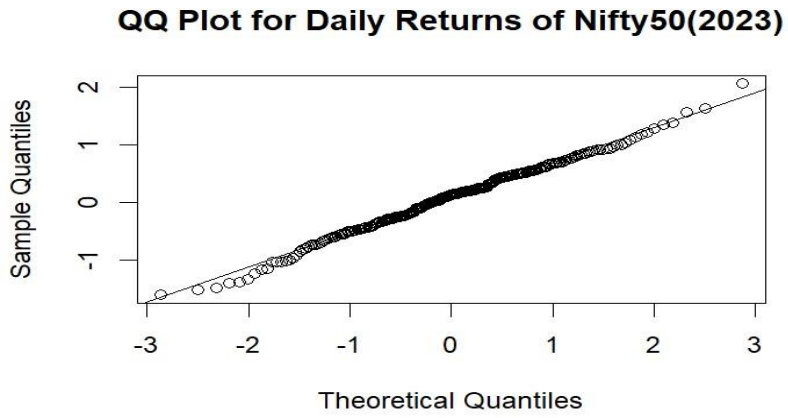
ii) Q-Q Plot: Figure 2



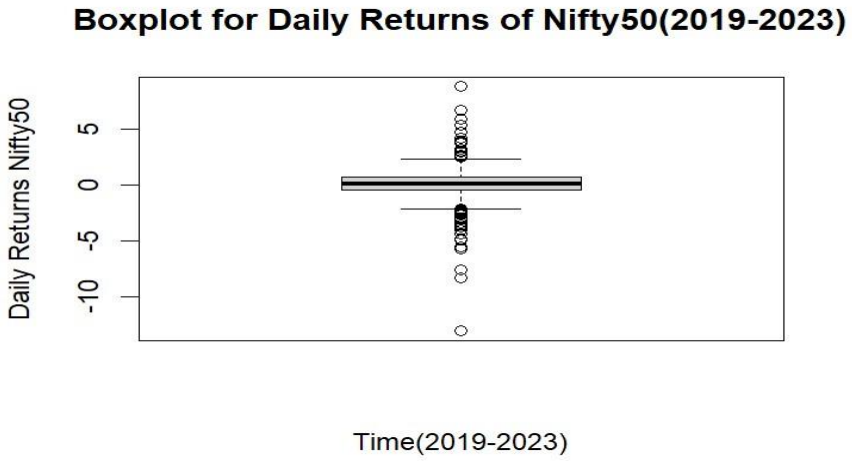
iii) Shapiro-Wilk Test-Small Duration-1 Year 2023
Test Statistic = W = 0.9946 p-value = 0.5431

iv) Lilliefors (Kolmogorov-Smirnov) normality test - Small Duration-1 Year 2023
Test Statistic = D = 0.0394 p-value = 0.4683

Conclusion: Box Plot shows that whiskers are of equal length and median is equidistant from Q1 and Q3. So, the Daily Nifty 50 returns may be normally distributed.
Q-Q plot also shows linearity.
Shapiro-Wilk Test and K-S Test both result in p-value > 0.05, resulting in retaining H_0, where H_0 is the daily Nifty returns are Normally distributed.
Hence it is concluded that the Nifty 50 daily returns are Normally distributed for small duration (Period of 1 Year).

Case II) Long Duration (5 Years Data-2019-2023)

i) Box Plot: Figure 3



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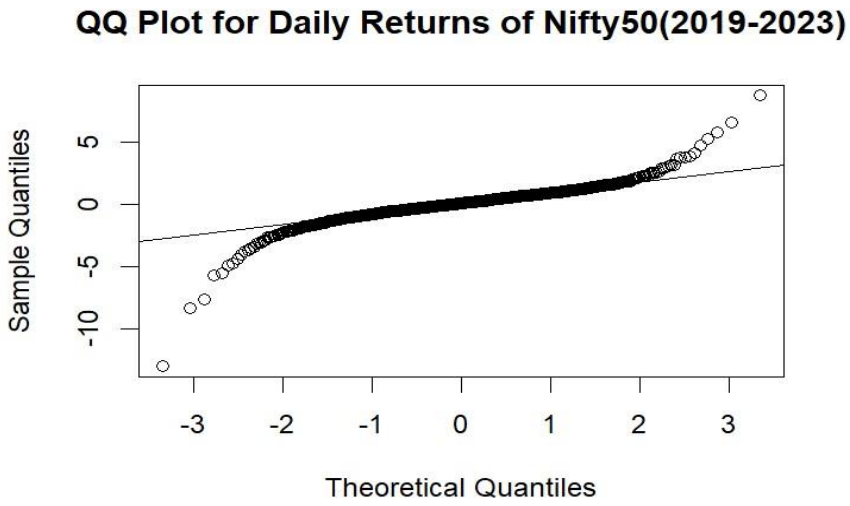
ii) Q-Q Plot: Figure 4



iii) Shapiro-Wilk Test-Long Duration-5 Years (2019-23)
Test Statistic = W = 0.8548 p-value = 0.00

iv) Lilliefors (Kolmogorov-Smirnov) normality test – Long Duration-5 Years (2019-23)
Test Statistic = D = 0.0929 p-value = 0.00

Conclusion: Box Plot shows that whiskers are of equal length and median is equidistant from Q1 and Q3. So, the Daily returns of Nifty 50 may be normally distributed.
However, Q-Q plot does not show linearity.
Shapiro-Wilk Test results in p-value which is very small approximately Zero, resulting in rejecting H_0, where H_0 is the daily returns of Nifty 50 are Normally distributed.
K-S Test results in p-value is very small approximately Zero, resulting in rejecting H_0, where H_0 is the daily Nifty returns are Normally distributed.
Hence it is concluded that the Nifty 50 daily returns are **NOT** Normally distributed for long duration (Period of 5 Years).

DISCUSSION

This study examined the normality of Nifty 50 daily stock returns over varying durations from 2019 to 2023, employing four statistical methods: Box Plot, Q-Q Plot, Shapiro-Wilk Test, and Kolmogorov-Smirnov (K-S) Test. The analysis yielded distinct observations across different durations, highlighting nuances in the distributional characteristics of the data.
For the small duration (1 Year -2023), the daily returns on Nifty 50 exhibited characteristics of a normal distribution according to all four methods examined. This suggests that within shorter time frames, the assumption of normality may be reasonably upheld for Modeling purposes.
In the long duration, results from all the statistical methods Q-Q Plot, Shapiro-Wilk Test, and K-S Test concurred in indicating the data to be non-normally distributed. This suggests that over longer periods, the assumption of normality may not hold, and alternative distributional assumptions or Modeling techniques may be warranted for more accurate financial Modeling.
While normality assessment is a fundamental step in financial Modeling, the duration of data plays a critical role in its interpretation. Understanding the nuances revealed by various statistical methods and adapting Modeling approaches accordingly can enhance the accuracy and reliability of financial analyses and decision-making processes.

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Instead of assuming normality, one can explore alternative distributional assumptions such as the student's t-distribution, skewed distributions (e.g., log-normal or Weibull), or heavy-tailed distributions (e.g., Cauchy distribution). These distributions may better capture the characteristics of financial data, especially over longer durations where non-normality is prevalent.

The findings underscore the importance of considering the duration of data when assessing normality for financial Modeling. While shorter durations may exhibit characteristics of normality, longer durations may necessitate alternative Modeling approaches to account for non-normality adequately.

Incorrect assumptions regarding the distribution of returns can lead to biased estimates and flawed risk assessments. Recognizing non-normality in longer-duration data is crucial for accurate risk management and portfolio optimization.

Algorithms designed based on assumptions of normality may perform sub optimally when applied to data exhibiting non-normality. Incorporating more robust Modeling techniques capable of capturing the true distributional characteristics of the data is essential for algorithmic trading strategies.

Investors relying on traditional models assuming normality may misjudge investment opportunities and risk profiles. Incorporating insights from non-normal distributions can lead to more informed investment decisions and improved portfolio performance.

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Data Source: Finance.Yahoo.Com (Yahoo Finance)