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An Empirical Analysis of Stock Market Volatility in India Using GARCH Models

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ABSTRACT

The study analyses stock market volatility in India, including the NIFTY 50 index. The research problem is grounded in the reality that stock price movements and uncertainties are growing and threaten investment decisions and portfolio management and are a concern at the macro level of the economy (financial stability). In a significant part, the main aim of this study is to explore the volatility patterns and, at the same time, to find out how different variables (e.g., the volume of trading, currency price fluctuations, and the performance of major stock markets in the world) relate to one another to influence the stock market. The quantitative research approach used in the article will rely on second-hand information obtained from official and genuine sources, including the NSE, RBI, and Yahoo Finance, during the period of 1st April 2024 to 31st March 2025. Econometric techniques such as the GARCH (1, 1) model and the EGARCH model determine the underlying volatility differentials. The correlation regression of the Augmented Dickey-Fuller (ADF) test, the Granger causality tests are also performed to check the stability of the data and to examine the relations between the variables. The study finds that the stock market volatility in India is changing rapidly, and the key drivers of the domestic and international major markets, which means that there is a high need to develop advanced stock market models to devise strategies for reducing risks efficiently.

Keywords: *Stock Market Volatility, GARCH (1,1) Model, NIFTY 50, Trading Volume, Exchange Rate.*

Introduction

Volatility of a stock market is one of the most basic and easy to understand notions in financial economics that can be described as the extent of fluctuations in the price of a stock over a specified duration of time. It not only measures the level of uncertainty but also the risk entailed in the financial markets, and it is a very important parameter to spark investment decision-making. It becomes even more important in the case of emerging economies such as India, where volatility is already predetermined with such factors as the booming economic growth, the change of policies, and further integration of the financial markets in the world. The NIFTY 50 index is a collection of the largest traded companies on the National Stock Exchange and is a crucial measure of the market performance as well as the sentiments of the investors. The volatility of the stock market is a subject of study due to the many effects it brings about. The volatility can lead to the growth of ambiguity that will cause investors to lose their faith, and the financial markets may be destabilized.

Moreover, to an investor, the knowledge of volatility is essential in terms of portfolio diversification and risk management. In relation to the government or policymakers, volatility monitoring can be used to control financial markets and take effective regulatory actions. The traditional financial models are based on the assumption that the stock returns are constant in variance, yet real data from the stock market reveals that the volatility varies with time and is also skewed. E.g., an increase in volatility is normally accompanied by an increase. in volatility, in the same vein as a fall in volatility is preceded by a fall in volatility. Simple models fail to replicate this property of data, and, thus, other more sophisticated econometric models, including GARCH and EGARCH, have been created in order to address it.

Problem Statement

Though there are some very advanced econometric methods available, we still need to investigate the changing nature of stock market volatility in India and how different factors like the amount of trading, changes in the exchange rate, and movements in the global market affect it.

Research Objectives

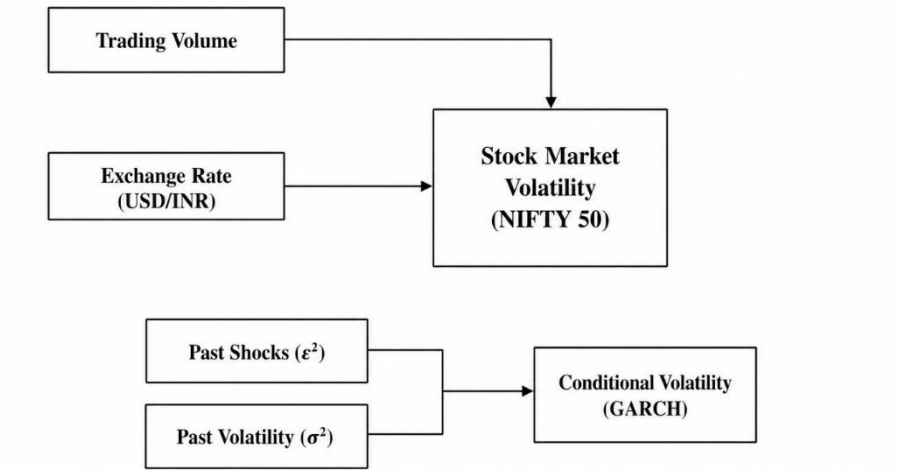
- To analyse the stock market volatility in India using GARCH models.
- To examine volatility clustering in NIFTY 50 returns
- To analyse asymmetric effects using EGARCH
- To study the impact of trading volume on volatility
- To analyse the impact of USD/INR exchange rate

Literature Review

Stock market volatility is one of the most studied topics in the financial literature, given its important role in risk measurement and investment decisions. According to the Efficient Market Hypothesis presented by Fama (1970), stock prices incorporate all the information that is currently available. Nevertheless, various empirical analyses have indicated that volatility is characterized by certain features like clustering and persistence, which go against the idea of a variance being constant at all times.

Engle (1982), by presenting the model of Autoregressive Conditional Heteroskedasticity (ARCH) first, where the variance of one period depends on the past periods' variances, made it possible for the variance to change with time. Bollerslev (1986) took the model a step further and came up with the Generalized Autoregressive Conditional Heteroskedasticity (GARCH), which not only considers previous shocks but also previous volatilities. This model for GARCH has become one of the fundamental methods for describing financial time series data. Nelson (1991) revisited the EGARCH model, where the volatility reaction to bad news is larger than the reaction to good news.

Conceptual Framework



In fact, empirical research has demonstrated the presence of volatility clustering not only in the developed markets but also in the emerging ones. Studies on the emerging markets indicate that besides these markets' returns, changes in macroeconomic variables like exchange rates, inflation, interest rates, and global market trends significantly explain most of the variations or volatility of emerging market indices. At the same time, in the Indian context, the empirical results confirm that the stock market volatility is affected by the trading volume, foreign institutional investment, and global indices. Nevertheless, most of these earlier studies were limited to the factors they considered and didn't analyse the combined effect of multiple variables in a model. Therefore, the issue of trading volume, exchange rates, and global market indices jointly impacting stock market volatility appears as a gap in the literature.

Dependent Variables: Stock Market Volatility.

Independent variables: Trading Volume, Exchange Rate, Global Market Index.

Measurement of Variables:

- Dependent Variables: Stock market volatility (based on returns)
- Independent Variables:
  - Trading Volume
  - USD/INR Exchange Rate

Hypotheses

H_1: Trading volume significantly affects stock market volatility.

H_2: Exchange rate movements significantly influence volatility.

H_3: Global market indices significantly impact stock market volatility.

Research Methodology

Research Design

- This research is quantitative in nature. It mainly concerns empirical analysis of financial time-series data.
- The research method is analytical because the author intends to find out the correlation between the variables and test the hypotheses with the help of statistical models.

Data Collection – Secondary Data

- National Stock Exchange (NSE) – NIFTY 50 Data
- Reserve Bank of India (RBI) – Exchange Rate Data
- Yahoo Finance – Global Index (S&P500)

Instruments Used

- Calculation of logarithmic returns to normalize the data of stock prices.
- GARCH (1,1) model to study volatility clustering and persistence.
- EGARCH model to estimate asymmetric effects.

Reliability and Validity

The Augmented Dickey-Fuller (ADF) test is implemented to determine if the data are stationary, a necessary condition for time series modelling that will yield accurate results. The use of standard econometric models such as the GARCH and theEGARCH makes the results credible.

Data Analysis Techniques

Statistical analysis of the study was conducted using Metric Gate. These are some of the methods employed:

- GARCH (1,1) model
- EGARCH model
- Correlation Analysis
- Regression Analysis
- ADF test for stationarity

Results & Discussion

The research study analyses stock market volatility in India with the help of econometric models and assesses the effects of various factors like volume and exchange rate. The discussion is broken down into objective-wise based on empirical results.

To examine volatility clustering in NIFTY 50 returns

GARCH (1,1) Model Results

The GARCH (1,1) model was employed to study the volatility pattern in NIFTY 50 returns, based on 249 observations, assuming a normal distribution.

Results:

Parameter	Value	Interpretation
Mean (μ)	0.000400	Very small positive average return
Omega (ω)	0.000042	Low base level of volatility
Alpha (α_1)	0.228541	Moderate impact of past shocks
Beta (β_1)	0.181166	Moderate persistence of volatility
α + β	0.4097	Low persistence → quick mean reversion

Measure	Value
Last-period volatility	0.1207 (12.07%)
Forecast volatility	0.1178 (11.78%)

Volatility Estimates:

Formula:

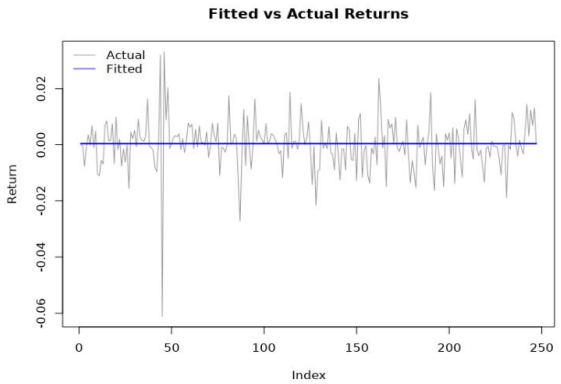
$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

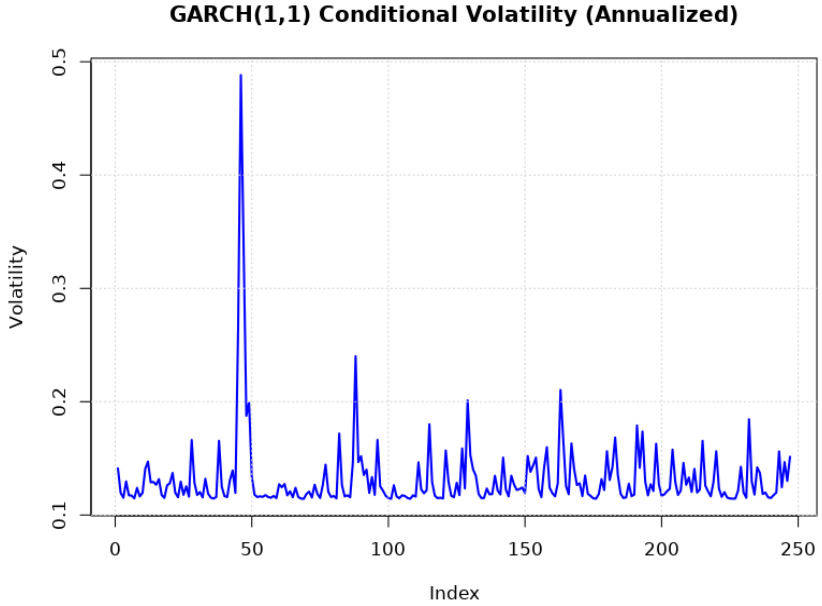
Where:

- σ_t^2 → Current period volatility (conditional variance)
- ω → Constant (long-term variance level)
- α → ARCH term (impact of past shocks/news)
- ϵ_{t-1}^2 → Previous period error squared
- β → GARCH term (persistence of volatility)
- σ_{t-1}^2 → Previous period volatility

Explanation:

The GARCH (1,1) model findings show that volatility clustering exists in the Indian market. The ARCH coefficient (α_1 = 0.2285) suggests that past shocks have a relatively small effect on current volatility, and the GARCH coefficient (β_1 = 0.1812) indicates that past volatility affects current volatility.





But the sum of coefficients (α + β = 0.4097) is much smaller than one, suggesting that shocks to volatility do not persist and that the volatility quickly reverts to its mean. This implies that shocks to volatility are temporary and quickly fade away. The findings confirm the theoretical notion of GARCH Model, which describes time-varying volatility. The low persistence found in this study suggests a stable market during the period of study.

To Analyse Asymmetric Effects using EGARCH

EGARCH Model Results

The EGARCH model helps us identify not only volatility clustering but also the asymmetric effects of shocks on volatility.

Results:

Parameter	Value	Interpretation
Mean (μ)	0.000677	Small positive return
Omega (ω)	-5.210950	Log variance constant (acceptable)
Alpha (α_1)	-0.060685	Weak magnitude effect
Beta (β_1)	0.454210	Moderate persistence
Gamma (γ_1)	0.557253	Strong asymmetric (leverage) effect

Volatility Estimates:

Measure	Value
Last-period volatility	12.28%
Forecast volatility	11.99%

Formula:

$$\ln(\sigma_t^2) = \omega + \alpha_1(|z_{t-1}| - E|z_{t-1}|) + \gamma_1 z_{t-1} + \beta_1 \ln(\sigma_{t-1}^2)$$

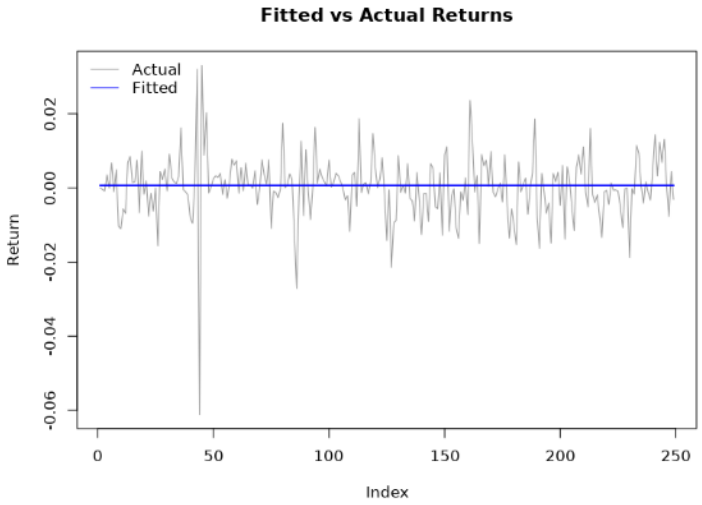
Where:

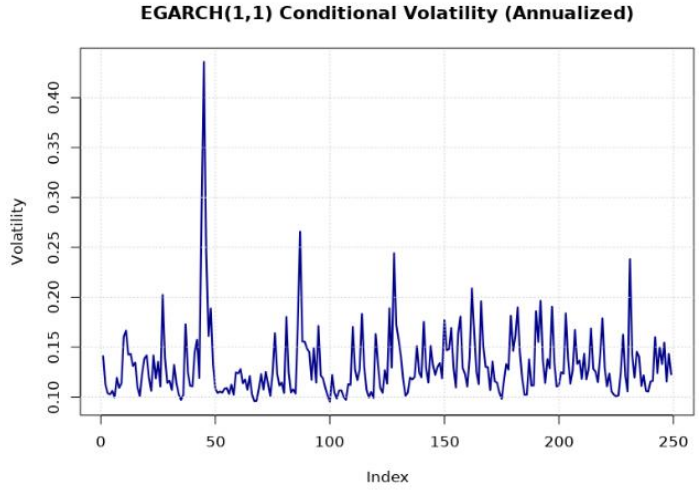
- $\ln(\sigma_t^2)$→ Log of current volatility (variance)
- ω→ Constant term
- α_1→ Measures impact of magnitude of shocks

- $| z_{t-1} |$→ Absolute value of previous standardized shock
- $E | z_{t-1} |$→ Expected value (used for centering)
- γ_1→ Captures asymmetry (leverage effect)
- β_1→ Measures persistence of volatility
- $\ln (\sigma_{t-1}^2)$→ Past volatility

Explanation

The EGARCH model supports the presence of asymmetric volatility in the stock market. The gamma coefficient (γ_1 = 0.5573) is significant and positive, implying the presence of leverage effects, with different impacts of shocks on volatility. The alpha coefficient (α_1 = -0.0607) implies that shocks are not very influential, and the beta coefficient (β_1 = 0.4542) implies that volatility has moderate persistence. These findings are in line with the EGARCH Model that allows for non-linear dynamics in financial time series. The results suggest that volatility is not only time-varying but also dependent on the type of market information.





Tostudy the impact of trading volume on volatility

Correlation Analysis

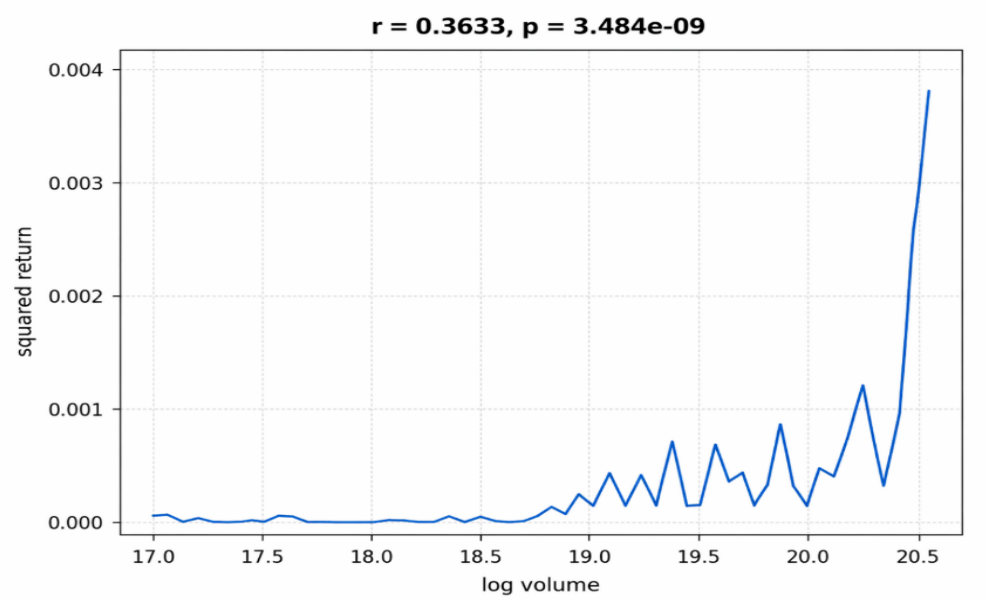
Results:

Parameter	Value	Interpretation
Pearson r	0.3633	Moderate positive relationship
R^2	0.1319	13.19% variation explained
p-value	3.48×10^{-9}	Highly significant

p-value < 0.05 is statistically significant.

Formula:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \cdot \sum(y_i - \bar{y})^2}}$$



Where:

- r= Correlation coefficient
- x_i= Individual values of variable X
- y_i= Individual values of variable Y
- $\bar{x}$= Mean of X
- $\bar{y}$= Mean of Y

Regression Analysis

Results:

Parameter	Value	Interpretation
Intercept (β_0)	-0.005431	Base level (not practical)
Slope (β_1)	0.000283	Positive impact on volatility
R^2	0.1320	Moderate explanatory power
F-statistic	37.5579	Model significant
p-value	3.48×10^{-9}	Highly significant

P-value < 0.05 is a significant predictor.

Formula:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon$$

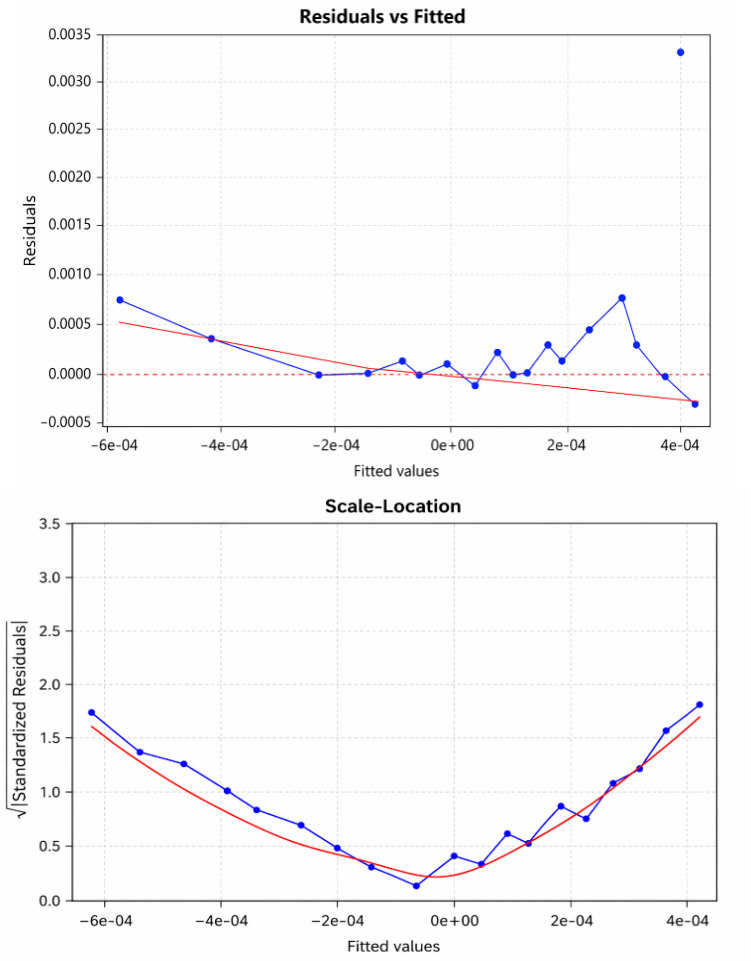
Where:

- Y= Dependent variable (e.g., volatility)
- $X_1, X_2, \ldots, X_n$= Independent variables (predictors)
- β_0= Intercept (constant term)
- $\beta_1, \beta_2, \ldots, \beta_n$= Regression coefficients
- ε= Error term

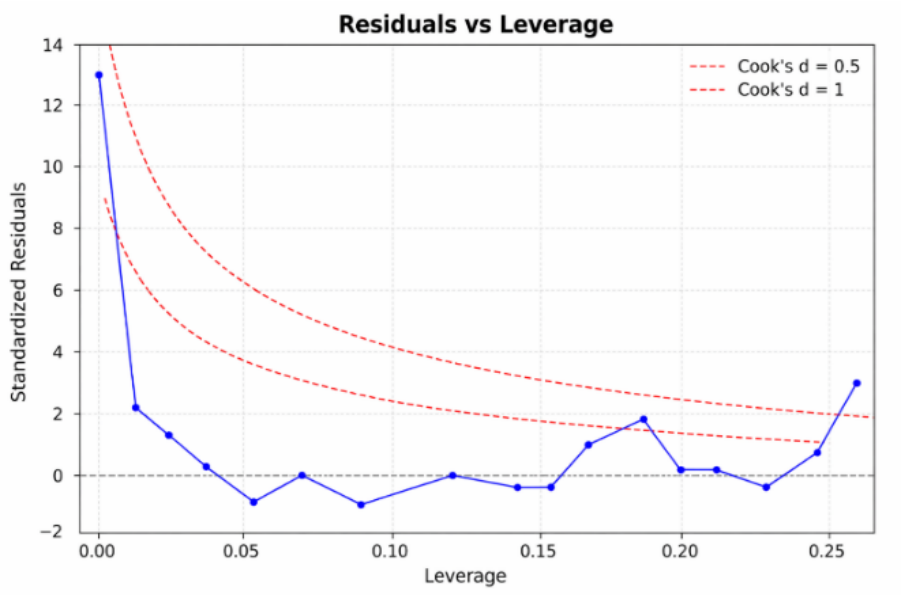
Explanation:

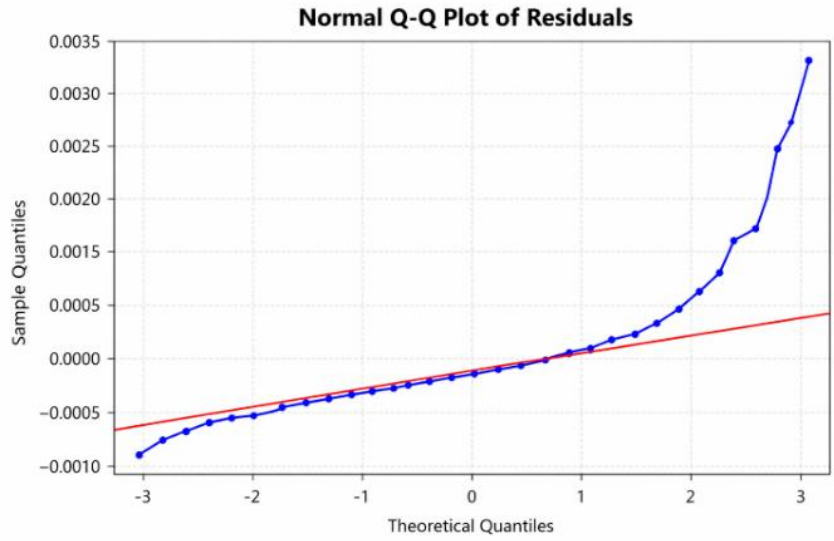
The correlation results show a moderate positive correlation between trading volume and volatility (r = 0.3633), significant at the 5% level (p < 0.05). This means that as trading volume increases, so does volatility.

The regression analysis also confirms this association, with trading volume positively and significantly impacting volatility (β_1 = 0.000283). But the coefficient of determination (R^2 = 0.132) suggests that trading volume accounts for only 13.2% of the volatility.



This suggests that although trading is a significant factor, much of the variability in volatility is also driven by other factors including market sentiment, news events and other shocks. These results are consistent with financial theory, which posits that trading activity increases with more information flowing, causing a greater variance in price





To analyse the impact of USD/INR exchange rate

Augmented Dickey–Fuller test (ADF Test)

We have conducted the ADF test for both the NIFTY 50 returns and the USD/INR exchange rate.

Results

Variable	ADF Statistic	p-value	Result
NIFTY Returns	-6.2372	0.01	Stationary
USD/INR	-6.4558	0.01	Stationary

P-value < 0.05

As the value of P is less than the 5% level of significance, the hypothesis that there is a unit root is rejected.

Formula:

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{j=1}^{k} \gamma_j \, \Delta y_{t-j} + \varepsilon_t$$

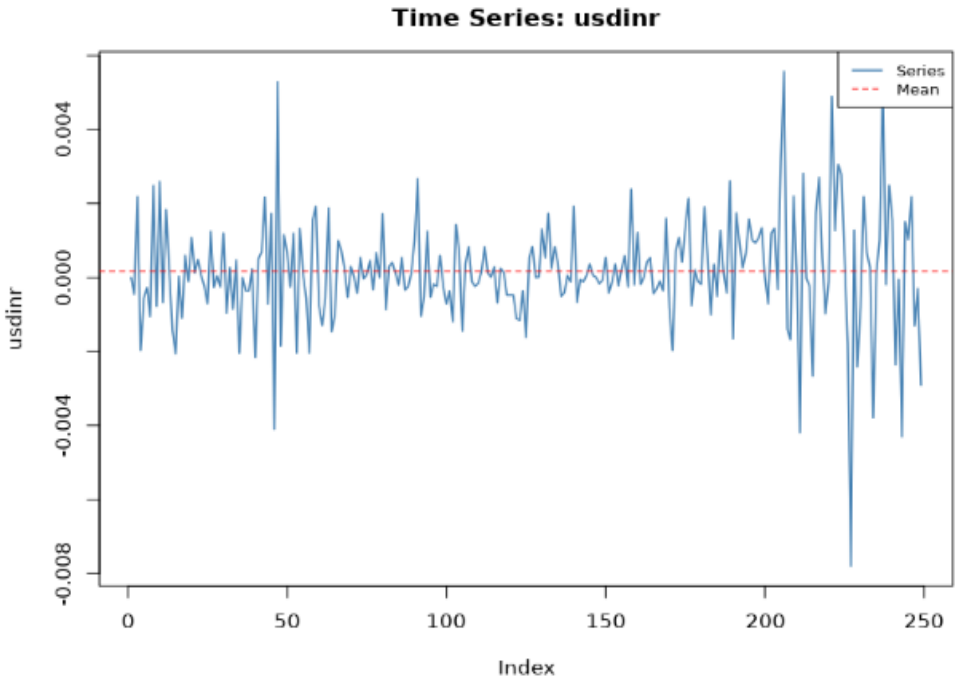
Where:

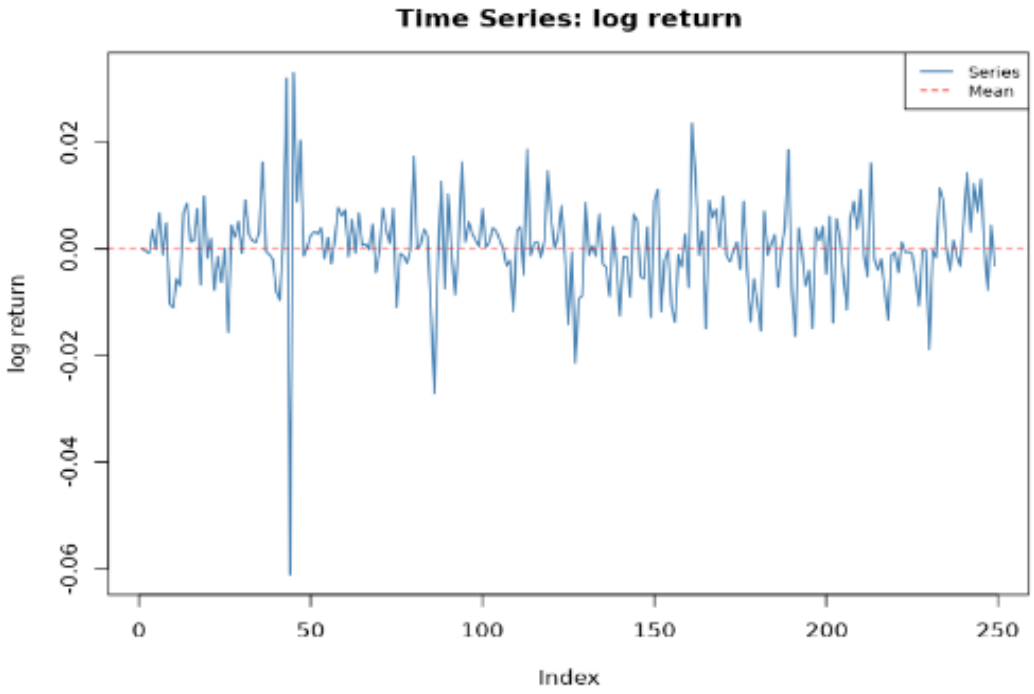
- Δy_t= First difference of the series $(y_t - y_{t-1})$
- α= Constant (intercept)
- β= Coefficient used to test stationarity
- y_{t-1}= Lagged level of the series
- γ_i= Coefficients of lagged differences
- k= Number of lag terms
- ε_t= Error term

Explanation

The Augmented Dickey-Fuller (ADF) test shows that both the returns of NIFTY (ADF = -6.2372) and the USD/INR exchange rate (ADF = -6.4558) are stationary at level (p-value < 0.05).

Stationarity is an important assumption for time series modelling, as it guarantees that the mean and variance of the series are time-invariant. This justifies the use of GARCH and regression models in the research. While the exchange rate series is stationary and can be analysed, the findings suggest that it does not play a substantial role in stock market volatility. This implies that volatility was not significantly affected by the exchange rate in the period under consideration.





Overall Discussion

This study suggests that stock market volatility in India is time-varying, with features of volatility clustering and asymmetry The persistence of volatility is low, suggesting that the market is quick to incorporate information and is stable. Among the factors considered, trading volume has a significant effect on volatility while exchange rate fluctuations have a negligible effect. This suggests the impact of domestic market factors. In summary, the study demonstrates that advanced econometric models such as GARCH and EGARCH are able to capture the dynamic behaviour of stock markets and also provide valuable insights to investors and policy makers.

Conclusion

The current research has studied the characteristics and factors affecting stock market volatility in India, particularly the NIFTY 50 index. Using sophisticated econometric techniques like the GARCH Model and EGARCH Model, this study offers empirical evidence about volatility characteristics for the period April 2024 to March 2025.

The result shows that stock market volatility in India is time-dependent and displays volatility clustering, characterised by high volatility following high volatility and low volatility following low volatility. But the persistence at a relatively lower level ($\alpha + \beta = 0.4097$) suggests that the volatility shocks are transitory and mean-reverting, implying a stable stock market during the period under study.

The EGARCH also reveals that the volatility is asymmetric with leverage effects. This suggests that the impact of shocks on volatility is not symmetric, and non-linear models should be taken into account when studying financial markets.

It is also found that trading volume significantly increases stock market volatility, meaning that active trading results in more volatility in prices. But the low R^2 value indicates that other factors besides trading volume contribute to volatility.

On the other hand, the study of the USD/INR exchange rate reveals that while the series is stationary and can be modelled, it has no significant impact on stock market volatility over the period of analysis. This suggests that the exchange rate did not significantly contribute to volatility in the Indian stock market.

In summary, the research shows that the stock market volatility in India is mainly driven by its own dynamics and is not significantly affected by external factors like exchange rates. The use of GARCH-type models is successful in modelling the dynamics of financial time series, and offers insights for investors, portfolio managers and policy makers.

The results of this research add to the understanding of volatility dynamics in emerging markets and emphasise the need for the use of suitable econometric methods for appropriate risk analysis and management.

Limitations and Future Research

Limitations

- The study is limited to a short period (April 2024 - March 2025).
- It only investigates two factors (trading volume and exchange rate).
- Used secondary data, which may not be perfect.
- This may not be sufficient to capture market behaviours (e.g., GARCH model, EGARCH model).

Future Research

- A longer time period can be considered.
- Other factors such as inflation, interest rates, and global developments can be considered.
- Use more complicated models/machine learning models.
- Cross-market studies can also be conducted.

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