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Research paper

Modeling Stock Market Volatility of HDFC Bank Through Time Series Techniques

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Abstract

This research investigates HDFC Bank's stock market volatility using ARIMA, ARCH, GARCH, RNN, and LSTM models. The study evaluates predictive accuracy and explores implications for accounting and finance. Traditional econometric models (ARIMA, ARCH, GARCH) are compared with advanced machine learning methods (RNN, LSTM). Results show that GARCH provides superior forecasting accuracy. From an accounting perspective, volatility forecasts influence financial reporting, capital allocation, and risk disclosure. Findings highlight the interdisciplinary role of volatility modeling in finance and accounting.

Keywords: *ARIMA, ARCH, GARCH, RNN, LSTM, HDFC, Volatility, Forecasting, Accounting.*

1. Introduction

Stock market volatility—the degree of price fluctuations over time—has long been a central theme in finance because it influences risk perception, portfolio strategies, and capital allocation. Beyond investment decisions, volatility carries significant implications for accounting and regulation. It affects earnings forecasts, fair-value measurements, provisioning, and disclosure practices, all of which are critical for maintaining transparency and stakeholder confidence. Regulators also rely on reliable volatility estimates to assess systemic risk and ensure market stability.

HDFC Bank, as one of India's largest private sector banks, provides an important case for such analysis. Its stock performance reflects both firm-specific fundamentals and wider macroeconomic forces, making it highly relevant to investors, accountants, and policymakers. Understanding its volatility dynamics offers insights not only for risk management and investment planning but also for improving financial reporting quality and regulatory oversight.

This study employs a mix of traditional econometric approaches (ARIMA, ARCH, GARCH) and advanced machine learning methods (RNN, LSTM) to forecast HDFC Bank's stock volatility. By comparing their predictive accuracy, the research aims to identify the most effective model and discuss its broader implications for finance, accounting, and regulation.

2. Review of Literature

Volatility modeling is widely studied in financial economics and increasingly in accounting research. Lin (2018) demonstrated the adaptability of GARCH models in capturing volatility clustering. Vitali (2019) compared LSTM and GARCH, noting the strengths and weaknesses of both. Sharma and Mehta (2024) reviewed deep learning models for stock prediction, highlighting emerging transformer-based architectures. Raju (2022) validated asymmetric GARCH variations for Indian markets. Bhattacharjee (2023) analyzed regulatory reforms and macroeconomic shocks, highlighting links to accounting transparency.

Recent interdisciplinary studies (2023–2024) emphasize the role of volatility forecasts in improving bank stress testing, capital adequacy assessments, and investor communications. These studies connect volatility modeling directly to accounting practices such as earnings management, provisioning, and risk disclosures, underscoring the relevance of this research.

2.1 Objectives of the Study

1. Apply ARIMA, ARCH, GARCH, RNN, and LSTM models to HDFC Bank stock data.

2. Compare model performance using MSE, RMSE, and MAPE.
3. Identify the best-performing model for volatility forecasting.
4. Examine the accounting and financial implications of volatility forecasts.
5. Suggest future research directions, including hybrid approaches.

3. Research Methodology

Dataset: Daily adjusted closing prices of HDFC Bank from October 28, 2020, to October 26, 2023 (744 observations), sourced from NSE India.
Preprocessing: Data cleaning, outlier removal, normalization, and stationarity testing using the Augmented Dickey-Fuller test.
Model Specifications:
ARIMA: Model identification through ACF/PACF plots and diagnostic checks.
ARCH/GARCH: GARCH(1,1) estimated using maximum likelihood methods.
RNN/LSTM: Implemented with two hidden layers, dropout regularization, Adam optimizer, and MSE as the loss function.
A 90-day forecast (October 28, 2023 – January 25, 2024) was generated, and performance was evaluated using MSE, RMSE, and MAPE.

3.1 Results and Analysis

3.2 Performance Comparison:

Table 1: HDFC Bank- Comparison of ARIMA, ARCH, GARCH, RNN, and LSTM

Model	MSE	RMSE	MAPE
ARIMA	4104.42	64.07	0.0383
ARCH	710.62	26.66	0.0087
GARCH	177.65	13.33	0.0043
RNN	460.85	21.47	0.0106
LSTM	2842.48	53.31	0.0170

Discussion: GARCH outperformed all models due to its ability to capture volatility clustering—a key feature of financial time series. ARIMA and ARCH performed moderately well but failed to model time-varying volatility adequately. RNN and LSTM underperformed, likely due to dataset size limitations and overfitting. Despite their potential for non-linear pattern detection, deep learning models require larger datasets and careful tuning. From an accounting viewpoint, the accuracy of GARCH forecasts can support fair-value accounting, capital adequacy planning, and transparent risk disclosures.

3.3 Forecasting Results

The GARCH model's 90-day forecast predicted values ranging between INR 1552.9 and INR 1690.4. These forecasts provide actionable insights for capital allocation, risk provisioning, and financial reporting.

Table 2: HDFC Bank–Forecasted Values

Date	HDFC Bank – Forecasted values	Date	HDFC Bank - Forecasted values	Date	HDFC Bank – Forecasted values
10-28-2023	1645	11-27-2023	1621.8	12-27-2023	1585.2
10-29-2023	1653.7	11-28-2023	1611.2	12-28-2023	1588.8
10-30-2023	1665.75	11-29-2023	1604.95	12-29-2023	1589.8
10-31-2023	1645	11-30-2023	1609.2	12-30-2023	1590.8
11-1-2023	1634.15	12-1-2023	1610.2	12-31-2023	1591.8
11-2-2023	1658.7	12-2-2023	1611.2	1-1-2024	1574.55
11-3-2023	1659.7	12-3-2023	1622.05	1-2-2024	1597.05
11-4-2023	1660.7	12-4-2023	1613.4	1-3-2024	1604.25
11-5-2023	1660.75	12-5-2023	1635	1-4-2024	1603.55
11-6-2023	1660.4	12-6-2023	1651.35	1-5-2024	1604.55
11-7-2023	1662	12-7-2023	1664.9	1-6-2024	1605.55
11-8-2023	1648.35	12-8-2023	1665.9	1-7-2024	1588.75
11-9-2023	1632.3	12-9-2023	1666.9	1-8-2024	1598.35
11-10-2023	1633.3	12-10-2023	1676.3	1-9-2024	1614.1
11-11-2023	1634.3	12-11-2023	1682.4	1-10-2024	1625.35
11-12-2023	1627.4	12-12-2023	1690.4	1-11-2024	1612.25
11-13-2023	1628.4	12-13-2023	1690.4	1-12-2024	1613.25
11-14-2023	1624.7	12-14-2023	1710.25	1-13-2024	1614.25
11-15-2023	1616.8	12-15-2023	1711.25	1-14-2024	1609.1
11-16-2023	1611.25	12-16-2023	1712.25	1-15-2024	1621.7
11-17-2023	1612.25	12-17-2023	1680.55	1-16-2024	1601.25
11-18-2023	1613.25	12-18-2023	1681.55	1-17-2024	1597.45
11-19-2023	1613	12-19-2023	1617.2	1-18-2024	1606.3
11-20-2023	1607.2	12-20-2023	1607.85	1-19-2024	1607.3
11-21-2023	1612.1	12-21-2023	1585.15	1-20-2024	1608.3
11-22-2023	1605.8	12-22-2023	1586.15	1-21-2024	1592.55
11-23-2023	1589	12-23-2023	1587.15	1-22-2024	1593.55
11-24-2023	1590	12-24-2023	1589.5	1-23-2024	1585
11-25-2023	1591	12-25-2023	1597.15	1-24-2024	1552.9
11-26-2023	1608.25	12-26-2023	1587.35	1-25-2024	1559.65

4. Conclusion

The study finds that GARCH is the most reliable model for forecasting HDFC Bank's volatility. The results have important implications: for investors, they improve portfolio management; for accountants and regulators, they strengthen earnings forecasts, capital disclosures, and risk reporting.

Future Research: Future work should explore hybrid models (e.g., GARCH-LSTM) and extend analysis across multiple banks. Incorporating macroeconomic variables and accounting ratios would deepen interdisciplinary contributions.

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