Journal of Statistical Sciences & Data Analytics (JOSSDA)
Volume 1, Issue 2, December 2026 | Print ISSN XXXX-XXXX | Online ISSN XXXX-XXXX
Daniel *et al.* 2026 **DOI**: 10.XXXXX/jossda.2026.1.1.008

JOURNAL OF STATISTICAL SCIENCES & DATA ANALYTICS
Department of Statistics, Ahmadu Bello University, Zaria, Nigeria | www.jossda.abu.edu.ng www.jossda.com.ng

Hybrid Deep Learning Framework for Multiscale Forecasting of Stock Price Dynamics in Nigerian Banking Stocks

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Abstract

Forecasting stock price movements and volatility is increasingly important in emerging financial markets such as Nigeria, where economic conditions, regulatory changes, and investor sentiment influence market performance. This study examined stock price dynamics and volatility in five selected Nigerian banks using a hybrid Recurrent Neural Network-Convolutional Neural Network–Long Short-Term Memory (RNN–CNN–LSTM) architecture. Daily stock price data for Fidelity Bank Plc, Stanbic IBTC Holdings Plc, United Bank for Africa (UBA) Plc, Wema Bank Plc, and Zenith Bank Plc were obtained from the Nigerian Exchange (NGX) for the period from 3 January 2014 to 31 December 2024. The hybrid model integrated RNN, CNN, and LSTM techniques to capture temporal dependencies, local patterns, and long-term relationships in stock-price movements. The model demonstrated strong predictive performance, achieving an RMSE of 0.1880 for Fidelity Bank and 0.4791 for UBA, with corresponding MSE and MAE values of 0.0353 and 0.1562 for Fidelity, and 0.2295 and 0.3911 for UBA compared to the standalone models. The findings identified three major phases: relative stability before 2020, heightened volatility during the COVID-19 period (2020–2021), and sustained recovery from 2022 onwards, particularly for Zenith Bank, UBA, and Fidelity Bank. Evidence of volatility clustering was also observed, indicating persistence in periods of high and low volatility. Overall, the study demonstrates the potential of the hybrid RNN–CNN–LSTM framework for forecasting stock price dynamics and volatility in Nigerian banking stocks, providing useful insights for investors, financial institutions, and policymakers.

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Keywords: Financial forecasting; volatility clustering; emerging markets; financial time series; prediction.

1. Introduction

Stock markets play a crucial role in economic development by facilitating capital formation and investment opportunities. Understanding stock price movements and daily return patterns is essential for investors, policymakers, and financial analysts, as these factors influence investment decisions and risk management strategies. The Nigerian banking sector, a vital component of the country's financial system, has witnessed significant stock price fluctuations over the years, driven by macroeconomic conditions, regulatory changes, and market sentiment (Asemota *et al*., 2017). The Efficient Market Hypothesis (Fama, 1970) suggests that stock prices fully incorporate available information, making it difficult for investors to achieve consistent excess returns. However, studies on emerging markets, including Nigeria, indicate that stock prices may not always reflect all information efficiently, leading to potential arbitrage opportunities (Emenike, 2008; Okpara, 2010). Furthermore, volatility clustering and return anomalies have been observed in Nigerian banking stocks, raising questions about market efficiency and the underlying drivers of stock price movements (Ajayi *et al*., 2017; Osazevbaru & Oboreh, 2014). This study investigates the stock price movements and daily return patterns of selected Nigerian banks over the period from 2014 to 2024 using a hybrid Recurrent Neural Network, Convolutional Neural Network and Long Short-Term Memory (RNN–CNN–LSTM) model. Joshi *et al*. (2025) investigated a hybrid LSTM–CNN architecture for stock-market prediction and reported improved forecasting performance compared with standalone models, demonstrating the benefit of combining temporal modelling with feature extraction. Similarly, recent research on hybrid financial forecasting has demonstrated that combining econometric models with machine-learning and deep-learning techniques can improve forecasting and trading performance across different market conditions. Stempień and Ślepaczuk (2025) found that appropriately constructed hybrid models combining statistical and AI techniques can outperform individual component models and conventional investment benchmarks.

The hybrid architecture combines the strengths of RNN, CNN, and LSTM to learn both short-term fluctuations and long-term trends in stock prices while automatically identifying complex patterns embedded in historical market data. The findings will contribute to a deeper understanding of market dynamics and offer practical implications for investors and financial regulators.

2. Materials and Methods

This study investigates the stock price movements and daily return patterns of selected Nigerian banks over the period from 2014 to 2024 using a hybrid Recurrent Neural Network, Convolutional Neural Network and Long Short-Term Memory (RNN–CNN–LSTM) model. The hybrid architecture combines the strengths of RNN, CNN, and LSTM to learn both short-term fluctuations and long-term trends in stock prices while automatically identifying complex patterns embedded in historical market data. By integrating these deep learning techniques, the model is able to detect periods of high and low market volatility, capture the

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persistence of volatility over time, and produce more accurate forecasts of future stock price movements. This approach offers a deeper understanding of the behaviour of Nigerian bank stocks by revealing underlying market trends, sudden price changes, and recurring volatility patterns, thereby providing valuable insights for investors, financial institutions, and policymakers. For this study, five banks were identified for research analysis, namely: Fidelity Bank Plc, Stanbic IBTC Holdings Plc, United Bank for Africa (UBA) Plc, Wema Bank Plc and Zenith Bank Plc. The data used for this analysis are secondary data obtained from the Nigerian Stock Exchange (NSE), which exhibited Brownian motion. Furthermore, graphical representations and statistical analyses will be provided to illustrate the trends and patterns in Nigerian stock market data for the period of 3rd January 2014 to 31st December 2024

3. Results and Discussions

Evaluation of the Performance of the Hybrid Model using Standard Metrics.

Table 1. Analysis of the model for Fidelity Bank

MODEL	MSE	RMSE	MAE
LSTM	0.0599	0.2447	0.1852
1DCNN	0.1668	0.4084	0.3016
RNN	0.0484	0.2200	0.1753
Hybrid-model	0.0353	0.1880	0.1562

Table 1 presents a comparative evaluation of four deep learning models: LSTM, 1DCNN, RNN, and Hybrid-model based on their predictive performance on pre-COVID Fidelity Bank data using three error metrics: Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). Among the models, the hybrid Hybrid-model architecture yields the lowest error values across all metrics (MSE: 0.0353, RMSE: 0.1880, MAE: 0.1562), indicating superior accuracy and robustness in capturing temporal dependencies and nonlinear patterns in the financial time series.

Table 2. Analysis of the hybrid model for Stanbic Bank

MODEL	MSE	RMSE	MAE
LSTM	159.4053	12.6255	12.3514
1DCNN	134.2007	11.5845	11.2101
RNN	11.9404	3.4554	2.7955
Hybrid-model	4.7250	2.1737	1.7346

Table 2 provides a comparative analysis of four deep learning models: LSTM, 1DCNN, RNN, and Hybrid-model, based on their predictive performance on pre-COVID STANBIC Bank data using standard error metrics: Mean Squared Error (MSE), Root Mean Squared

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Error (RMSE), and Mean Absolute Error (MAE). The hybrid model exhibits the lowest error values across all metrics (MSE: 4.7250, RMSE: 2.1737, MAE: 1.7346).

Table 3. Analysis of the hybrid model for UBA

MODEL	MSE	RMSE	MAE
LSTM	1.0297	1.0147	0.7464
1DCNN	0.5394	0.7344	0.5510
RNN	0.7959	0.8921	0.7070
Hybrid-model	0.2295	0.4791	0.3911

Table 3 presents a comparative analysis of four deep learning architectures: LSTM, 1DCNN, RNN, and the hybrid Hybrid-model based on their predictive accuracy for pre-COVID UBA Bank data using standard error metrics: Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). The Hybrid model outperforms all others, achieving the lowest error rates (MSE: 0.2295, RMSE: 0.4791, MAE: 0.3911).

Table 4. Analysis of the hybrid model for Wema Bank

MODEL	MSE	RMSE	MAE
LSTM	0.0154	0.1243	0.1038
1DCNN	0.0122	0.1107	0.0824
RNN	0.0112	0.1062	0.0895
Hybrid-model	0.0091	0.0954	0.0748

Table 4 presents a comparative evaluation of four deep learning models: LSTM, 1DCNN, RNN, and the hybrid Hybrid-model based on their predictive performance for pre-COVID WEMA Bank data using standard error metrics: Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). The Hybrid model achieves the lowest error rates across all metrics (MSE: 0.0091, RMSE: 0.0954, MAE: 0.0748).

Table 5. Analysis of the hybrid model for Zenith Bank

MODEL	MSE	RMSE	MAE
LSTM	3.5465	1.8832	1.6307
1DCNN	4.4066	2.0991	1.8503

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RNN	1.4098	0.9264	0.7753
Hybrid-model	0.8582	0.9264	0.7753

Table 5 provides a comparative assessment of four deep learning models: LSTM, 1DCNN, RNN, and the hybrid Hybrid-model applied to pre-COVID Zenith Bank data using error metrics: Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). The Hybrid model demonstrates the strongest performance, achieving the lowest MSE (0.8582) and matching the RNN in RMSE (0.9264) and MAE (0.7753).

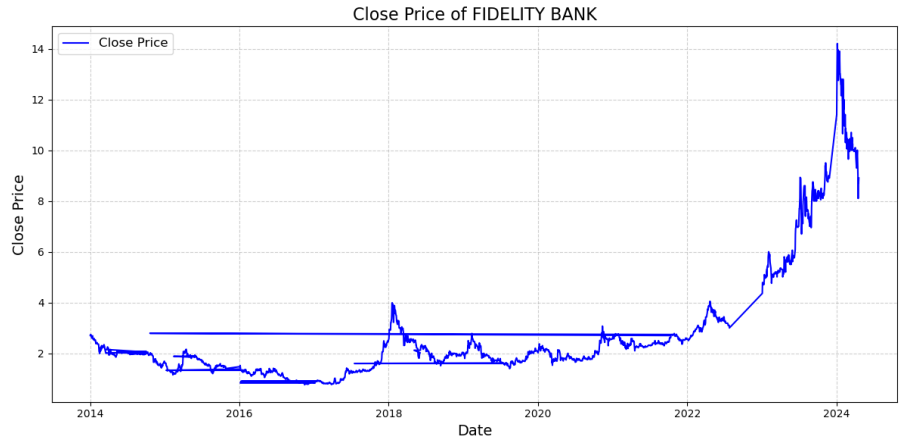

Figure 1: Closing Price of Fidelity Bank

Figure 1 presents the daily closing stock price of Fidelity Bank from 2014 to 2024, revealing a dynamic trend with distinct phases. Initially, the stock price exhibited relatively low volatility and a plateau around 2.5 NGN, suggesting a period of stability or limited growth. A significant surge began in late 2022, culminating in a peak of approximately 14 NGN by early 2024, indicating substantial market confidence or fundamental changes in the bank's performance.

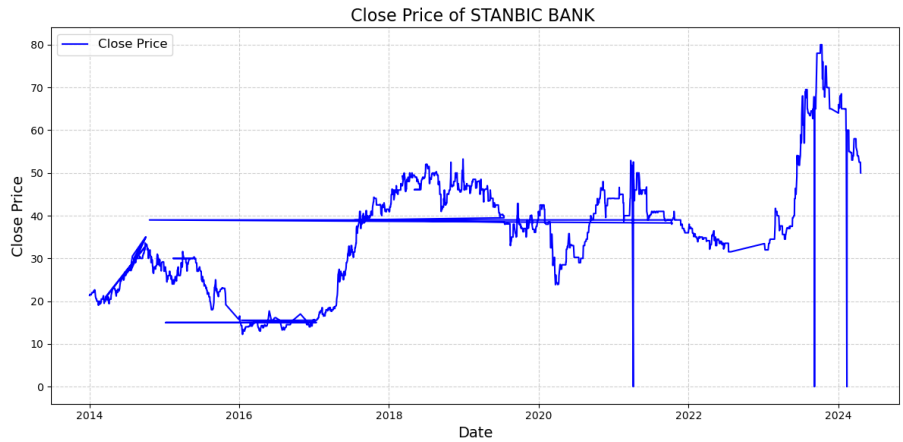

Figure 2: Closing Price of Stanbic Bank

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Figure 2 shows Stanbic Bank's daily closing stock price from 2014 to 2024, highlighting a volatile pattern. The stock experienced gradual growth with fluctuations, followed by a surge around 2017–2018, possibly due to strong financial performance or market optimism. A decline and stagnation from 2020 to 2022 suggest market corrections or internal challenges. Sharp vertical anomalies indicate potential data errors or trading halts. The recent upward trend toward 2024 calls for further analysis of market dynamics, regulatory changes, or strategic shifts driving this growth.

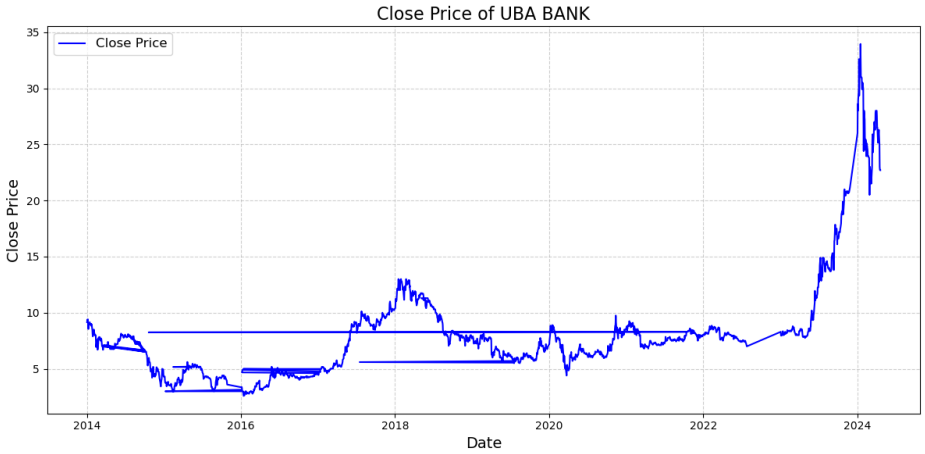

Figure 3: Closing Price of UBA Bank

Figure 3 shows UBA Bank's daily closing stock price from 2014 to 2024. The stock remained relatively stable between 2 and 12 NGN until late 2022, indicating limited growth. However, from late 2022 onward, prices surged dramatically, peaking at around 35 NGN by early 2024. This sharp rise suggests potential influences like improved financial performance, market expansion, or macroeconomic factors in the Nigerian banking sector

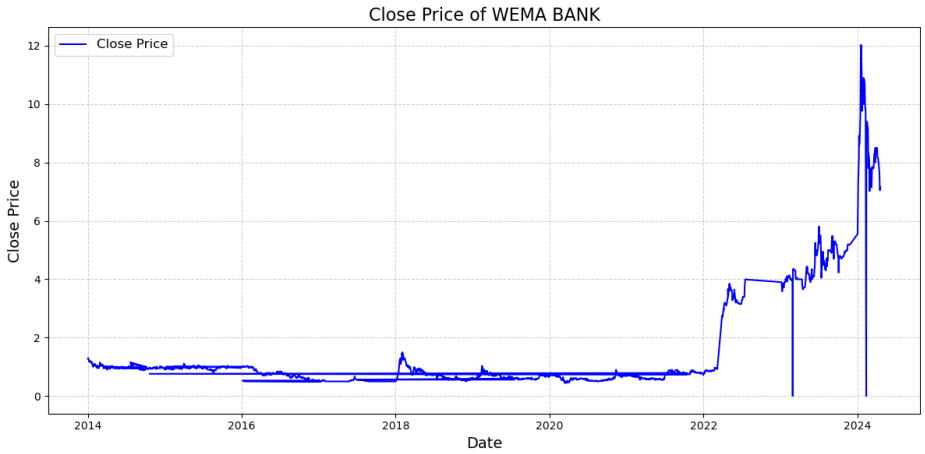

Figure 4: Closing Price of WEMA Bank

Figure 4 presents the daily closing stock price of Wema Bank from 2014 to 2024, revealing a prolonged period of low volatility followed by a dramatic late-stage surge. The

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stock price remained consistently below 2 NGN for the majority of the period, indicating a phase of stagnant growth or limited market activity. This stability was punctuated by brief, minor fluctuations, suggesting potential small-scale market adjustments or internal operational changes. However, starting in late 2022, a significant upward trend is observed, culminating in a peak of approximately 12 NGN by early 2024.

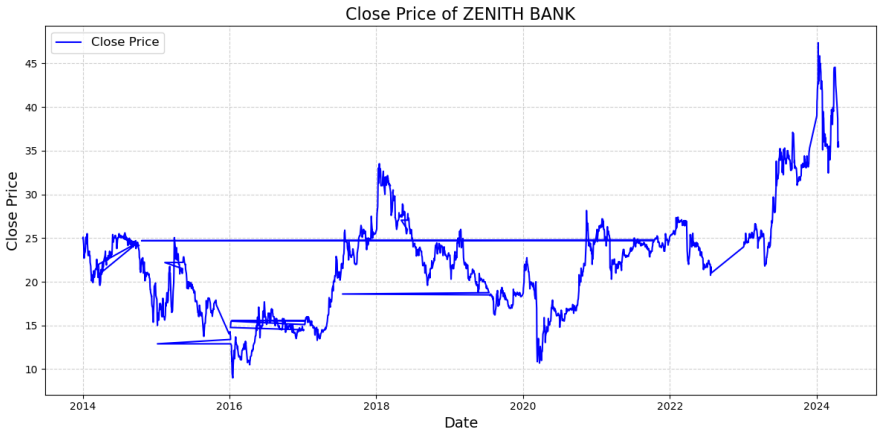

Figure 5: Closing Price of Zenith Bank

Figure 5 presents the daily closing stock price of Zenith Bank from 2014 to 2024, revealing a pattern of fluctuating volatility with a notable late-stage surge. The initial period shows moderate volatility, with the stock price oscillating between 10 and 25 NGN, indicating a phase of active trading and potential market adjustments. A subsequent period of relative stability around 2018-2022 is observed, suggesting potential consolidation or a period of consistent performance. However, starting in late 2022, a significant upward trend is evident, culminating in a peak of approximately 45 NGN by early 2024.

Before (2014–2019), the market was relatively steady, with stock prices following predictable patterns and only moderate fluctuations. Then came the pandemic (2020–2021), which brought uncertainty and sent stock prices tumbling. Investors pulled back, trading activity slowed, and volatility soared. However, from 2022 onward, the market bounced back. Stocks, especially those of UBA, Fidelity, and Zenith Bank, experienced a strong surge, thanks to renewed investor confidence and financial sector reforms.

Among the banks studied, UBA and Zenith Bank had the largest market capitalisations, standing at ₦1.25 trillion and ₦1.96 trillion, respectively. This reflects their strong positions in the market. Fidelity and Wema had more modest valuations in comparison. When it came to trading volume, Zenith Bank led the way, with an impressive 22.92 million shares changing hands.

From 2014 to 2024, the selected Nigerian banking stocks experienced three main phases: relative stability before 2020, increased volatility during 2020–2021, and strong recovery from late 2022 onwards. UBA recorded one of the most notable increases, rising from approximately ₦12 to ₦35 by early 2024, representing an estimated 191.7% increase. Fidelity also rose from about ₦2.5 to ₦14 (460% increase), while Wema increased from below ₦2 to approximately ₦12 and Zenith reached about ₦45. These movements demonstrate the strong post-2022 recovery in selected banking stocks. The clustering of large

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price fluctuations followed by calmer periods provides evidence of volatility clustering. This pattern was particularly evident during periods of market disruption and the post-2022 recovery, supporting the use of volatility-sensitive models alongside the proposed hybrid deep-learning architecture.

4. Conclusion

This study investigated the stock price movements and volatility dynamics of selected Nigerian banking stocks between 2014 and 2024 using a hybrid Recurrent Neural Network–Convolutional Neural Network–Long Short-Term Memory (RNN–CNN–LSTM) architecture. The findings show that the hybrid model is highly effective in capturing the complex and dynamic behaviour of stock prices in the Nigerian banking sector. By combining the strengths of the RNN in learning sequential patterns, the CNN in extracting meaningful features, and the LSTM in retaining long-term information, the model successfully learned both short-term price fluctuations and long-term market trends. This integrated approach resulted in more accurate and reliable forecasts of stock price movements and market volatility than could be achieved using the individual models alone.

The results also revealed that the Nigerian banking sector experienced three major phases during the study period. Between 2014 and 2019, stock prices remained relatively stable with moderate fluctuations, reflecting a period of steady market performance. This was followed by the COVID-19 pandemic between 2020 and 2021, when uncertainty in both the domestic and global economy led to heightened market volatility and significant price swings. From 2022 onwards, the banking sector witnessed a strong recovery, with most of the selected banks recording sustained increases in stock prices as investor confidence gradually returned. These patterns suggest that the performance of Nigerian banking stocks is strongly influenced by macroeconomic conditions, regulatory policies, global economic events, and changes in investor sentiment. The study also found clear evidence of volatility clustering, where periods of high volatility were likely to be followed by further market instability, while calmer periods tended to persist. This behaviour confirms that volatility in the Nigerian stock market is not random but follows identifiable patterns that can be effectively captured by advanced deep learning models such as the proposed hybrid RNN–CNN–LSTM architecture.

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