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Volatility Modelling of the Impact of Post Covid-19 Pandemic on Nigeria Stock Exchange

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ABSTRACT

This study investigated the impact of the post-COVID-19 period on the volatility behaviour of the Nigerian Stock Exchange (NSE) All-Share Index using monthly data from January 2018 to December 2023. The study aimed to examine volatility dynamics, assess volatility persistence, and forecast future market behaviour during the recovery phase following the COVID-19 pandemic. Logarithmic returns were computed from the NSE All-Share Index data and analysed using descriptive statistics, the Augmented Dickey-Fuller (ADF) unit root test, ARMA modelling, the ARCH-LM test, and GARCH-family models. Model estimation and forecasting were conducted using R statistical software. The results revealed that the original series was non-stationary but became stationary after logarithmic differencing. The ARCH-LM test confirmed the presence of significant ARCH effects, indicating volatility clustering and justifying the use of GARCH models. The initial Gaussian GARCH(1,1) model exhibited signs of misspecification and non-normal residuals; consequently, a Student-t error distribution was adopted to better capture the heavy-tailed nature of stock returns. The estimated model revealed substantial volatility persistence, suggesting that market shocks have prolonged effects before gradually dissipating. Furthermore, conditional volatility exhibited a declining trend throughout the study period, indicating that the Nigerian stock market progressively adjusted to pandemic-induced disruptions and moved toward greater stability. Forecast results showed a relatively flat, mean-reverting volatility pattern, suggesting that future market volatility is likely to converge toward its long-run equilibrium level. The study concludes that the Nigerian stock market has largely recovered from the volatility associated with the COVID-19 pandemic and entered a phase of relative stability. These findings provide useful insights for policymakers, investors, and financial institutions in designing strategies to strengthen market resilience and manage future financial risks.

***Keywords*— Nigerian Stock Exchange, COVID-19, Volatility Modelling, GARCH, Stock Market Returns**

I. INTRODUCTION

Volatility is a fundamental concept in financial markets and refers to the degree of variation in the price of an asset over a given period. It is widely recognized as a measure of financial risk, with higher volatility indicating greater uncertainty regarding future asset values. Highly volatile markets are characterized by

rapid price fluctuations and increased trading activity, which heighten the likelihood of substantial and often unpredictable changes in prices. In contrast, markets exhibiting lower volatility tend to be more stable and predictable. Volatility is commonly measured using statistical indicators such as standard deviation and conditional variance models, including the Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) frameworks developed for modelling time-varying financial market risk [1], [2]. The outbreak of the Coronavirus Disease (COVID-19) pandemic in late 2019 generated unprecedented disruptions across global economies and financial markets. The pandemic created widespread uncertainty among investors, disrupted business operations, weakened economic activities, and triggered significant fluctuations in stock markets worldwide. Financial markets responded sharply to the rapid spread of the virus, resulting in increased volatility, declining stock prices, and substantial capital outflows as investors sought safer investment alternatives. Several studies documented the adverse effects of the pandemic on global stock markets and reported heightened volatility across both developed and emerging economies [3], [4].

Africa recorded its first confirmed COVID-19 case in February 2020 following the initial outbreak in Wuhan, China. By February 2021, more than 123 million cases and approximately 2.7 million deaths had been reported globally, resulting in severe economic and social consequences. Beyond its public health implications, the pandemic caused widespread business closures, supply chain disruptions, trade restrictions, and job losses. According to the [5], Africa's economic growth declined sharply from 3.5% in 2019 to between –2.7% and –6.2% in 2020. Major economies such as Nigeria, South Africa, Kenya, Egypt, and Angola experienced significant economic contractions, which were reflected in the performance and volatility of their respective stock markets. In Nigeria, the pandemic intensified existing economic challenges and heightened uncertainty within the financial sector. The Nigerian Stock Exchange (now Nigerian Exchange Group, NGX) experienced notable fluctuations as investors reacted to changing macroeconomic conditions, government policy interventions, and evolving expectations regarding economic recovery. Understanding the behaviour of stock market volatility during and after the pandemic is therefore important for investors, policymakers, and financial institutions because it provides valuable insights into market resilience, risk management, and investment decision-making. Although numerous studies have examined the effects of COVID-19 on stock market performance across developed and emerging economies, relatively limited attention has been devoted to the volatility dynamics of the Nigerian stock market during the post-pandemic recovery period. Most existing studies focused on the immediate impact of the pandemic and short-term market reactions. Consequently, there remains a gap in understanding how volatility evolved as economies transitioned from crisis to recovery. Recent studies have

emphasized the importance of examining volatility persistence and market resilience in the post-pandemic era to better understand long-term financial market adjustments [6], [7]. This study addresses this gap by examining the volatility behaviour of the Nigerian Stock Exchange All-Share Index from January 2018 to December 2023, covering both the pre-pandemic and post-pandemic periods. Using ARCH and GARCH modelling techniques, the study evaluates volatility persistence, investigates the effects of COVID-19-related shocks on market behaviour, and provides forecasts of future market volatility. The findings contribute to the growing literature on financial market resilience and offer valuable insights for policy formulation, risk management, and investment decision-making in the Nigerian capital market.

II. METHODOLOGY

A. Data Description

This study utilized monthly Nigerian Stock Exchange (NSE) All-Share Index data covering the period from January 2018 to December 2023, encompassing both the pre-pandemic and post-pandemic periods. The data were obtained from the Nigerian Stock Exchange as secondary data. To avoid the problems associated with non-stationary price levels, logarithmic returns were computed prior to volatility modelling. The return series was subsequently employed for all statistical analyses, including descriptive statistics, stationarity testing, ARMA modelling, ARCH-LM testing, GARCH estimation, and volatility forecasting. All analyses were conducted using R statistical software.

B. Model Specification

The modelling procedure consisted of four stages:

1. Stationarity Analysis: Graphical inspection and the Augmented Dickey-Fuller (ADF) unit root test were used to determine the stationarity properties of the return series [4].
2. Mean Equation Specification: The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) were employed to identify the appropriate ARMA specification for the conditional mean equation [5].
3. ARCH Effect Test: The ARCH-LM test was performed to determine the presence of volatility clustering in the return series [6].
4. Volatility Modelling: GARCH-family models were estimated to capture time-varying volatility and generate forecasts of future market behaviour. Model selection was based on Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and diagnostic tests. Because the residuals departed from normality, the final model adopted a Student-t error distribution.
5.

III. RESULTS

A. Descriptive Statistics

Table 1 presents the descriptive statistics of the NSE All-Share Index over the study period. The dataset consists of 72 monthly observations with an average index value of 39,798.21. The relatively large standard deviation indicates considerable variability in market performance during the study period. The distribution is approximately symmetric, as indicated by the skewness coefficient of –0.07, while the negative kurtosis value (–1.47) suggests a platykurtic distribution.

B. Stationarity Analysis

Figure 1 presents the time plot of the NSE All-Share Index from 2018 to 2023. The original series exhibited an upward trend and level shifts, suggesting non-stationarity. The Augmented Dickey-Fuller (ADF) test confirmed the presence of a unit root (ADF = –2.079, p = 0.5431). Consequently, the series was transformed using first-differenced logarithmic returns, resulting in a stationary series suitable for volatility modelling.

Table 1: Descriptive Statistics of NSE All-Share Index

Statistic	Value
Number of Observations	72
Mean	39,798.21
Standard Deviation	9,295.89
Median	41,038.91
Minimum	13,793.64
Maximum	74,773.77
Skewness	–0.07
Kurtosis	–1.47

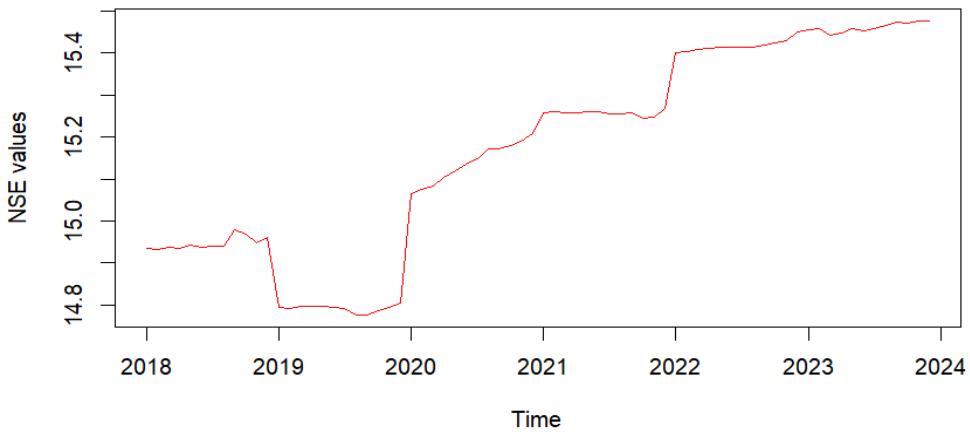

Figure 1: Time Plot of Nigeria Stock Exchange (2018–2023)

C. ARCH Effect Test

Prior to volatility estimation, the ARCH-LM test was conducted. The test produced a Chi-square statistic of 30.859 ($p = 0.00207$), indicating significant ARCH effects and confirming the presence of volatility clustering in the return series.

D. GARCH Model Estimation

The ACF and PACF analyses suggested an ARMA(1,1) specification for the conditional mean equation. An ARMA(1,1)-GARCH(1,1) model was initially estimated (Figure 2). However, the Gaussian specification produced insignificant ARCH and variance parameters, while the Adjusted Pearson Goodness-of-Fit test rejected the assumption of normally distributed residuals.

Consequently, the model was re-estimated using a Student-t error distribution. Alternative GARCH specifications were also evaluated using AIC and BIC criteria. The final model produced a statistically significant GARCH coefficient (β_1), indicating high volatility persistence.

E. Model Diagnostic Tests

Model adequacy was assessed using the Weighted Ljung-Box Test and ARCH-LM tests on standardized residuals. The Ljung-Box statistics produced p-values greater than 0.05 across all lag structures, indicating the absence of serial correlation. Likewise, the ARCH-LM tests on squared residuals showed insignificant p-values, confirming that no remaining ARCH effects existed after model estimation.

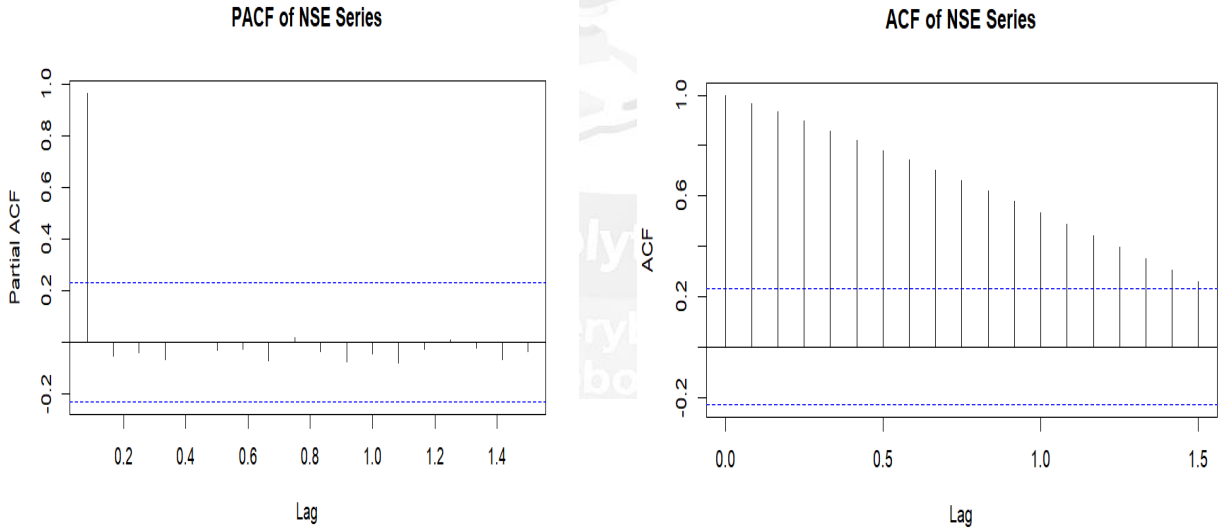

Figure 2: ACF and PACF of NSE Return Series

F. Goodness-of-Fit Assessment

The Adjusted Pearson Goodness-of-Fit results are presented in Table 2. The highly significant p-values indicate that the normal distribution assumption was violated, justifying the adoption of the Student-t error distribution.

G. Volatility Dynamics and Volatility Forecasting

Figure 3 presents the estimated conditional volatility obtained from the final GARCH model while Table 3 shows the GARCH volatility forecast. The estimated volatility shows a gradual decline throughout the study period, indicating that volatility moderated following the heightened uncertainty associated with the COVID-19 pandemic. Figure 4 also illustrates the historical observations together with the forecast generated by the GARCH model. The forecasted conditional standard deviation declines gradually from 0.02787 to 0.02653, suggesting convergence toward a stable long-run volatility level.

Table 2: Adjusted Pearson Goodness-of-Fit Test

S/N	Group	Statistic	P-value
1	20	134.7	1.899×10^{-19}
2	30	162.2	1.866×10^{-20}
3	40	165.8	1.442×10^{-17}
4	50	161.3	6.614×10^{-14}

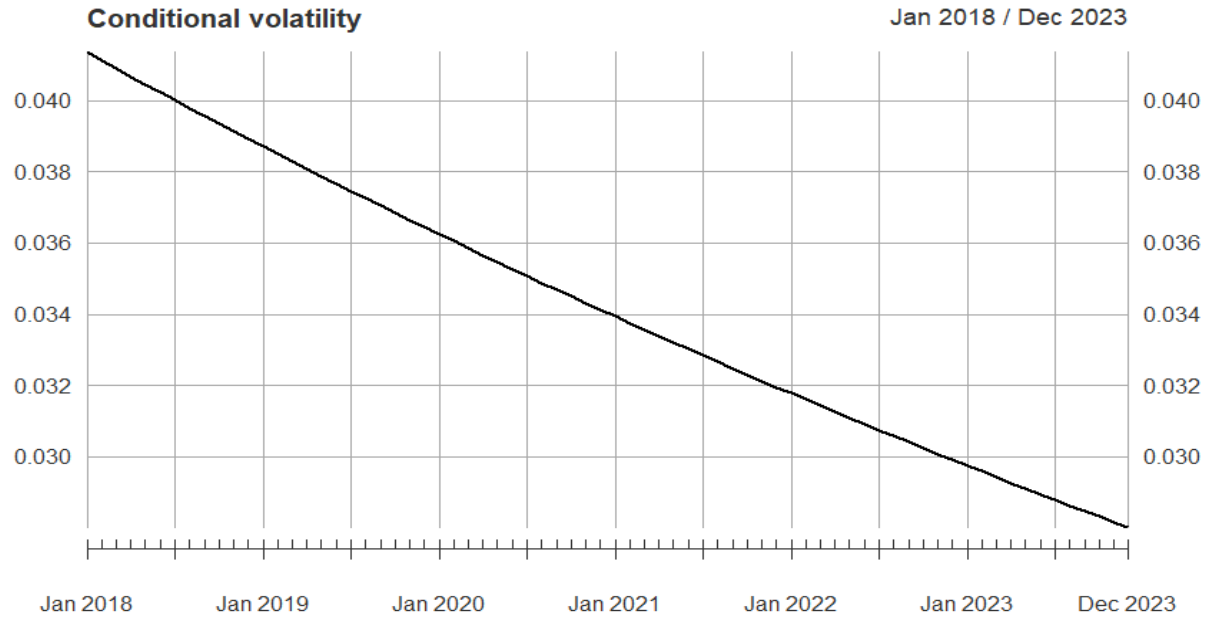

Figure 3: Estimated Conditional Volatility

Table 3: GARCH Volatility Forecast

Forecast Period	NSE Series	Sigma
T+1	15.48	0.02787
T+2	15.48	0.02771
T+3	15.48	0.02756
T+4	15.48	0.02741
T+5	15.48	0.02726
T+6	15.48	0.02711
T+7	15.48	0.02697
T+8	15.48	0.02682
T+9	15.48	0.02667
T+10	15.48	0.02653

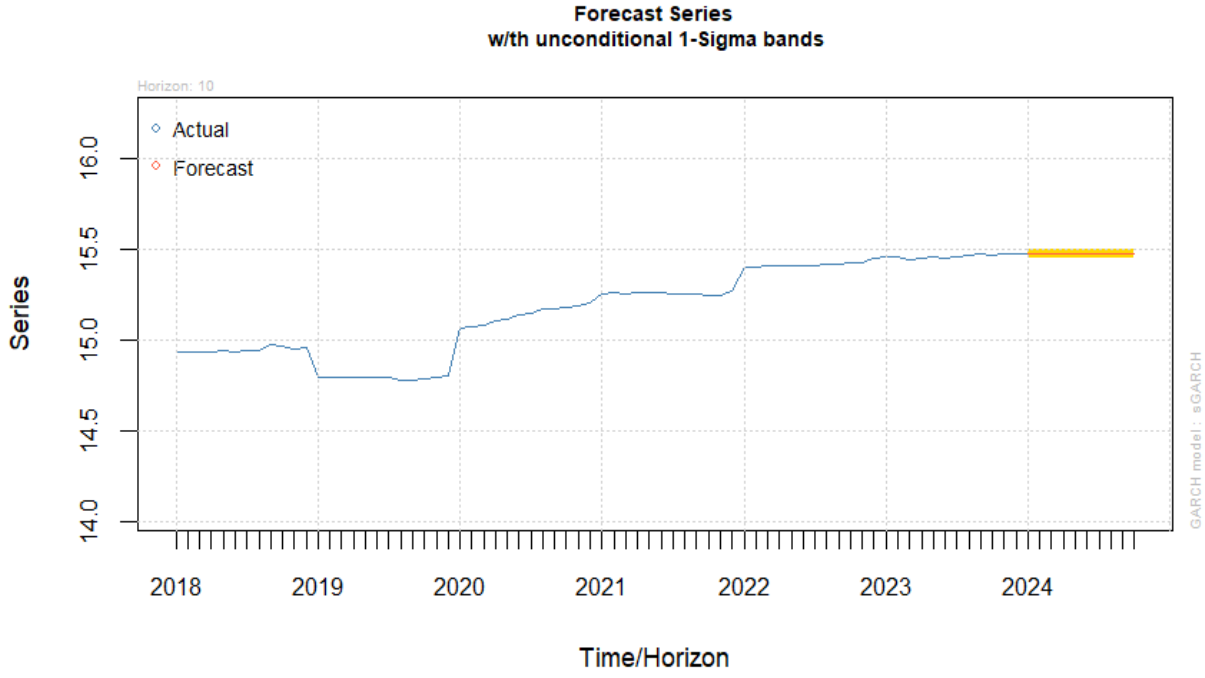

Figure 4: Forecast of NSE All-Share Index

IV. DISCUSSION

The descriptive statistics indicate substantial variability in the Nigerian stock market over the study period, reflecting the combined effects of economic fluctuations and the COVID-19 pandemic. Although the return distribution is approximately symmetric, the relatively flat kurtosis suggests departures from normality, a common feature of financial time series. The stationarity analysis confirms that the original NSE All-Share

Index is non-stationary, necessitating logarithmic differencing before econometric modelling. The significant ARCH-LM test provides strong evidence of volatility clustering, indicating that periods of high volatility tend to be followed by similar periods. This justifies the application of GARCH-family models for modelling conditional variance [7]. The inadequacy of the Gaussian GARCH model and the rejection of residual normality highlight the importance of accounting for heavy-tailed return distributions. The Student-t specification provided a more appropriate representation of the data and improved estimation accuracy. The significant GARCH coefficient further demonstrates that volatility shocks in the Nigerian stock market are highly persistent, meaning that the effects of major economic events dissipate only gradually over time [8]. Diagnostic tests confirmed that the selected model adequately captured the dependence structure in the data, as evidenced by the absence of residual serial correlation and remaining ARCH effects. The estimated conditional volatility reveals that market uncertainty gradually declined after the peak disruptions associated with COVID-19, suggesting increased investor confidence and improved market resilience during the recovery period.

The volatility forecasts indicate that future market volatility is expected to converge toward its long-run equilibrium, consistent with the mean-reverting property of GARCH processes. The relatively flat forecast suggests that, in the absence of major external shocks, the Nigerian stock market is likely to maintain a stable volatility environment in the short term. Despite these findings, the study is limited by its reliance on monthly aggregate market data and the exclusion of macroeconomic variables such as inflation, exchange rates, interest rates, and oil prices.

This study is subject to certain limitations. The analysis was based solely on the Nigerian Stock Exchange All-Share Index and monthly observations, which may not fully capture sector-specific differences or short-term volatility dynamics observable in higher-frequency data. In addition, the study focused primarily on the impact of the COVID-19 pandemic and did not explicitly incorporate other macroeconomic and financial variables such as inflation, exchange rates, interest rates, oil prices, and geopolitical events that may influence stock market volatility. Furthermore, although GARCH models with Student-t innovations were employed, other advanced volatility models such as EGARCH, TGARCH, APARCH, and Markov-Switching GARCH may provide deeper insights into asymmetric volatility and structural changes in the market. The forecasting results are also based on historical data and model assumptions; therefore, unexpected economic shocks, policy changes, or global crises may cause future market behaviour to differ from the projected outcomes. Future studies should incorporate higher-frequency data, sectoral indices, relevant macroeconomic variables, and more advanced modelling approaches such as EGARCH, TGARCH, APARCH, and Markov-Switching GARCH to capture asymmetric responses and structural

changes to enhance understanding of volatility dynamics in the Nigerian capital market.

V. CONCLUSION

This study investigated the volatility behaviour of the Nigerian Stock Exchange (NSE) All-Share Index from January 2018 to December 2023, covering the pre- and post-COVID-19 periods. Using logarithmic returns and GARCH-family models, the study examined volatility clustering, persistence, and future market volatility. The results showed that the NSE series was initially non-stationary but became stationary after logarithmic differencing. The ARCH-LM test confirmed the presence of significant ARCH effects, validating the use of GARCH models. Due to evidence of non-normality and model misspecification in the initial Gaussian GARCH model, a Student-t error distribution was adopted, providing a more appropriate representation of stock return behaviour. The findings revealed substantial volatility persistence, indicating that market shocks have lasting effects before gradually dissipating. However, conditional volatility exhibited a declining trend between 2018 and 2023, suggesting that the Nigerian stock market progressively adjusted to the disruptions caused by the COVID-19 pandemic and moved toward greater stability. Forecast results further indicated that future volatility is likely to remain stable and converge toward its long-run equilibrium level.

Cumulatively, the study provides evidence that the Nigerian stock market has largely recovered from pandemic-induced volatility and entered a phase of relative stability. The findings underscore the importance of policies that promote macroeconomic stability, strengthen investor confidence, and enhance market resilience against future shocks.

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