Evaluation of Stock Price Volatility of MTN and Airtel in Nigeria Stock Markets

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Abstract:
This study seeks to model and forecast the stock price market volatility in Nigeria Stock Market. The study covered ten years (2012-2022) of two selected telecommunication companies from enlisted in the Nigeria Stock Exchange and the data was obtained from www.ng.investing.com. From the time series plot it was evidenced that none of the series showed stationarity and differencing was therefore employed as to achieve stationarity. Various ARCH and GARCH models were fitted to the two series and GARCH (1,1) was selected to fit the two series since it has minimum unconditional variance for the two companies. Forecasting close stocks showed downtrend in the year 2023 for two stocks. The statistical software’s used in the analysis are Greti and Micro-Excel. Finally, GARCH (1,1) was recommended for future modelling and forecasting of stock price volatility.

Keywords: Stock Price, Volatility, Stock Price Volatility, ARCH, GARCH.

Introduction
Stock market volatility has received much attention as evidenced by the vast amount of literature by academics and finance practitioners. Today, a portfolio manager must be aware of the likelihood that his portfolio will decline in the future. Past volatility can be used to predict future volatility and this is an important input for making investment decisions on and selecting portfolio. Stock price volatility is not a monolithic phenomenon but rather a complex interplay of various factors. These factors encompass a broad spectrum, including macroeconomic indicators, company-specific events, investor sentiment, and global market dynamics. Investigating the driving forces behind stock price volatility is crucial in formulating effective investment strategies and risk management techniques (Obiora-Ilouno, & Adeniyi, 2019). Stock market volatility is a measure for variation of price of a financial asset over time. It is essentially, concerned with the dispersion and not the direction of price changes. In financial time series, when the variances are not constant, the emphasis has been given on forecasting the volatility or the varying conditional variance of the series. Volatility forecasts are important for many financial decisions such as the issues for the policy makers, option traders and investors. Issues of Volatility in stock market behavior are of importance as they shed light on the data generating process of the returns (Hongyu, & Zhichao, 2006). As a result, such issues guide investors in their decision-making process because not only are the investors interested in returns, but also in the uncertainty of such returns. The role of commodity futures market is still skeptical as researchers differ in their view. It is widely claimed that futures market provides platform for hedging risk and price discovery.
Local stock market volatility certainly has implications for financial and economic activities in Nigeria. Stock market investors are obviously interested in the volatility of prices, for high volatility could mean huge losses or gains and hence greater uncertainty. In volatile markets, it is difficult for companies to raise capital. Volatility of returns in financial markets could be a major stumbling block to attract investment. Volatility is as similar as but not exactly the same as risk. Risk is associated with undesirable outcome, while volatility measures strictly for uncertainty due to either positive outcome. The changes in market volatility would merely reflect changes in the local or global economic environment. This volatility has been used as a measure of risk which could aid investors in strategizing allocations of their resources. Portfolio managers and policy makers in emerging markets can evaluate and hedge against risk or price derivatives based on volatility measures to know typical benefits and cost associated with their policies so as to make a harmonious arbitrage between financing deregulation and regulation (Engle, & Ng, 1993; Poo, 2005; Jayasuriya, 2002).

There have been numerous studies and much research conducted to identify risk factors in stock market. One of the generalized risk factors studied was the volatility of stock market. A good forecasting of the Volatility of asset prices over the investment holding period is a good starting point for assessing investment risk. Accurate Volatility forecasts are thus very important and, over time, have motivated new approaches to Volatility modeling to help forecast future Volatility for asset pricing and risk management purposes (Chou, 1988; Schwert, 1990; Pagan, & Schwartz, 1990; Hamao, Masulis, & Ng, 1990; Poon, & Granger, 2003; Pierdzioch, Döpke, & Hartmann, 2005).

Several financial researchers have modeled and predicted volatility of stock prices of different financial markets using ARCH and GARCH models, see, for example Bollerslev, (1986), helped generalized the ARCH process by including the lagged values of the conditional variance to avoid the long lag structure which was later called Generalized Autoregressive Conditional Heteroscedasticity (GARCH) (Pagan, & Ullah, 1987). Dallah, & Ade, (2010) examined the volatility of daily stock returns of Nigeria insurance stocks using twenty-six insurance companies’ daily data from (December 15, 2000 to June 9 of 2008), as training data set and from (June 10, 2008 to September 9, 2008) as-out-of-sample data set. The result of ARCH (1), GARCH (1.1), TARCH (1.1) and EGARCH (1.1) showed that EGARCH was more suitable in modeling stock price returns as it outperformed the other models in model evaluation and out-of-sample forecast. Okpara, & Nwezeaku, (2009) randomly selected forty-one companies from the Nigerian stock Exchange to examine the effect of the idiosyncratic risk and beta risk on returns using data from 1996 to 2005. By applying GARCH model, the result showed less volatility persistence and established the existence of leverage effect in the Nigeria Stock Market, implying bad news drives volatility more than good news. Other researchers that have used ARCH and GARCH models in the prediction of stock volatility include (Engle, 1982; Najand, & Yung, 1991; Wilhelmsson, 2006; Verma & Sharma, 2020; Taiwo, & Adediran, 2020).

Many studies have been done on the levels of volatility of equity markets, mostly in the western and developed nations. The importance of volatility as a component of risk measure has pushed many developing markets to analyze the performance. In Nigeria, studies on equity market volatility have been far less than those in western or developed countries but lately these appear to be increasing. In the public domain not many studies on Nigeria market are available. Hence, in this paper, ARCH and GARCH models will be used evaluate the price volatility by examining the price movements and compare the price volatility of two Telecommunications companies which include MTN and AIRTEL companies enlisted in the Nigerian Stock Exchange. This study using ARCH and GARCH models will help to increase the knowledge on the levels of volatility in the Nigerian stock market.
Materials and Method

Estimation of Historical Volatility

Historical Volatility is used to estimate the volatility of a stock price. Empirically, the stock prices are usually observed at fixed intervals of time given by \( m+1 \). The historical volatility is given by

\[
X_t = \ln \left( \frac{Y_t}{Y_{t-1}} \right)
\]

where,

\( X_t \) is called the continuous compounded return (not annualized) in the \( i \)\(^{th} \) interval.

\( Y_t \) is stock price at end of \( i \)\(^{th} \) interval, \( i = 1, 2, \ldots, n \)

The usual estimate of the standard deviation, \( V_t \), of the \( U^s \) is given by

\[
V_t = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (X_t - U_t)^2}
\]

where,

\( U = \frac{1}{n} (X_t) \)

ARCH (Autoregressive Conditionally Heteroscedasticity) means that the conditional variance of \( z \), evolves according to an autoregressive type process. The ARCH model is given by:

\[
Z_t = \varepsilon_{t-1}(Y_t) + e_t
\]

where,

\( e_t = \phi_t \sigma_t \) \quad (5)

\( \varepsilon_{t-1}[*] \) is the expected condition on the information available at time \( t - 1 \)

\( e_t \) is the error generated from the mean equation at time \( t \)

\( \phi_t \) is a sequence of independent, identically distributed (iid) random variables with zero mean and unit variance, ie, \( \phi_t \sim iid(0,1) \)

ARCH process can be represented as an ARCH (1) process using Yule Walker

Estimator property given as

\[
\hat{\beta} = \sum_{t=2}^{n} (\hat{W} - Y_t)
\]

Where,

\[
\hat{W} = n - 1 \sum_{t=1}^{n} \alpha_t^2
\]

Since the distribution of \( e_t \) is naturally not normal, the Yule Walker estimator is inefficient. However, it can be used as an initial value for Iterative estimation methods. The estimation of ARCH Model is normally done using the maximum likelihood (ML) method. Assuming that the returns \( e_t \), have a conditional normal distribution, then

\[
\rho \left( \frac{e_t}{\bar{e}_{t-1}} \right) = \frac{1}{\sqrt{2\pi}\sigma_1} \exp \left\{ -\frac{1}{2} \frac{e_t^2}{\sigma_1^2} \right\}
\]

The log likelihood function \( l(\omega, \beta) \) can be written as a function of parameters \( \omega \) and \( \sigma \)

\[
l(\omega, \sigma) = \sum_{t=2}^{n} l_t(\omega, \sigma) + \log q_{et}(e_t) = \sum_{t=2}^{n} \log q \left( \frac{e_t}{\bar{e}_{t-1}} \right) + \log q_{et}(e_t)
\]
\[ \frac{n-1}{2} \log(2\pi) - \frac{1}{2} \sum_{t=2}^{n} \log(\omega + \beta e_{t-1}^2) - \frac{1}{2} \sum_{t=2}^{n} e_{t-1}^2 \omega + \beta e_{t-1}^2 + \log \rho_{e_t}(e_t) \]  

(8)

Where,

\( \rho_{e_t} \) is the stationary marginal density of \( e_t \)

The problem is that analytical expression for \( \rho_{e_t} \) is unknown in ARCH Models, hence, it cannot be calculated in the conditional likelihood function \( l^b = \log \rho(e_n, \ldots, e_1) \), the expression \( \log(e_t) \) disappears.

\[ l^b(\omega, \beta) = \sum_{t=2}^{n} l_t(\omega, \beta) \]

\[ \sum_{t=2}^{n} \log \rho_{e_t}(e_{t-1}) \]

(9)

For large \( n \) the difference \( l - l^b \) is negligible

**Estimation of the Generalized ARCH (GARCH) Model**

Generalized ARCH model was first developed by Bollerslev (1986) popularly known as GARCH model is given by

\[ \rho_1 = \mu + e_t \]

(10)

where,

\( e_t \sim \mu(0, \sigma_t^2) \)

\[ \sigma_t^2 = \beta_0 + \beta_1 e_{t-1}^2 + \beta_2 \sigma_{t-1}^2 \]

(11)

\( \mu \) is the mean of the returns

\( \sigma_t^2 \) is the variance of the error at time \( t \)

\( e_{t-1}^2 \) is the squared error at time \( t - 1 \)

\( \omega \) (1 - \( \beta_1 - \alpha_1 \)) is the unconditional variance

\( \alpha_1 \) is the first (lag1) ARCH Parameter

\( \beta_1 \) is the (lag1) GARCH Parameter.

The popular GARCH (1,1) model is defined by

\[ \sigma_{t-1}^2 = \omega + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \]

(12)

For \( \sigma_t^2 \) to be non-negative we require the coefficients to be non-negative.

Using \( \sigma_1^2 = \sigma_{t-1}^2 = \epsilon_t^2 + V_t \), then,

\[ \sigma_1^2 = \omega + \alpha_1 \epsilon_t^2 + \beta_1 \sigma_t^2 \]

(13)

\[ \epsilon_t^2 - V_t = \omega + \alpha_1 \epsilon_{t-1}^2 + \beta_1 (\epsilon_{t-1}^2 - V_{t-1}) \]

(14)

Equation (14) is an ARMA (1, 1) model for the squared innovation.

Stationarity requires that \( (\alpha_1 + \beta_1) < 1 \) generalizes a \( \text{GARCH}(p, q) \) model given by

\[ \epsilon_t^2 - V_t = \omega + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j e_{t-j}^2 \]

(15)

Equation (14) is equivalent to an infinite ARCH Model.

where, \( a_0 \geq 0 \) and \( a_1 \geq 0, i = 1, \ldots, q, \beta_i \geq 0, j = 1, \ldots, p \) is usually the error term in a term in a time series regression model.

**Methods**

**Comparison of Test for ARCH and GARCH models**
The results of the tests for ARCH and GARCH models would be compared using Akaike’s Information Criterion (AIC) given by

\[ AIC = N \log(\hat{\sigma}^2) + 2r \]  
(16)

where,

\( r \) is the number of model parameters
\( N \) is the effective number of data points used in the estimation procedure
\( \hat{\sigma}^2 \) the estimate residual variance.

**Model Selection Criteria**

When more than one model is selected from the process enumerated in Equation (16), the Akaike’s Information Criterion (AIC) is then used to select the more suitable model amongst them. The model that minimizes the AIC criterion using unconditional variance is the best model for the data.

**Results and Discussions**

The time series plot of the two series data is displayed as single and multiple graphs in Figure 1 to 4 are shown below.

**Figure 1. Plot of Airtel Stock Prices Over the Years**

**Figure 2. Plot of MTN Stock Prices Over the Years**
Figure 3. Time Series Plot for the Two Telecommunication Companies
It is quite clear from these plots that none of the series is stationary. Differencing is therefore required to achieve station.

This plot clearly shows that the two series are stationary, and the model technique for ARCH and GARCH model can now be applied for each series. Suitable model was identified for each series using various ARCH and GARCH models and they were fitted to the five series with respective residuals as white noise and it is summarized in Table 1. The model selection criteria used to select the best model amongst models is unconditional variance also in Table 1.

Table 1. Parameter Estimate and Unconditional Variance for GARCH (p,g) Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>Parameter Estimate(p-values)</th>
<th>Unconditional variance</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtel</td>
<td>GARCH(0,1)</td>
<td>-</td>
<td>-</td>
<td>GARCH(1,1)</td>
</tr>
<tr>
<td></td>
<td>GARCH(1,0)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GARCH(1,1)</td>
<td>ω = 0.00000397, α = 0.08242922, β = 0.87405664</td>
<td>1413.32348312</td>
<td></td>
</tr>
<tr>
<td>MTN</td>
<td>GARCH(0,1)</td>
<td>-</td>
<td>-</td>
<td>GARCH(1,1)</td>
</tr>
<tr>
<td></td>
<td>GARCH(1,0)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GARCH(1,1)</td>
<td>ω = 0.00000397, α = 0.08242922, β = 0.87405664</td>
<td>231.76113673</td>
<td></td>
</tr>
</tbody>
</table>

Footnote: sig at α = 0.10

The model identified using unconditional variance in Table 1 for each series are GARCH (1,1) for AIRTEL and MTN telecommunication companies in Nigeria Stock Exchange.

**Forecasts**

Since the constructed models have satisfied the basic assumption of model adequacy, it can be used for generating forecasts in Table 2.

Table 2. Models Forecasts the Two Telecommunication Companies

<table>
<thead>
<tr>
<th>Date</th>
<th>Forecasted Airtel</th>
<th>Forecasted MTN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1/2023</td>
<td>80.30642857</td>
<td>30.101526</td>
</tr>
<tr>
<td>2/1/2023</td>
<td>64.24178571</td>
<td>28.803787</td>
</tr>
<tr>
<td>3/1/2023</td>
<td>49.73178571</td>
<td>27.506047</td>
</tr>
<tr>
<td>4/1/2023</td>
<td>33.66714286</td>
<td>26.208308</td>
</tr>
<tr>
<td>5/1/2023</td>
<td>18.12071429</td>
<td>24.910568</td>
</tr>
<tr>
<td>6/1/2023</td>
<td>2.056071429</td>
<td>23.612829</td>
</tr>
<tr>
<td>7/1/2023</td>
<td>-13.49035714</td>
<td>22.315089</td>
</tr>
<tr>
<td>8/1/2023</td>
<td>-29.555</td>
<td>21.01735</td>
</tr>
<tr>
<td>9/1/2023</td>
<td>-45.61964286</td>
<td>19.71961</td>
</tr>
<tr>
<td>10/1/2023</td>
<td>-61.1607143</td>
<td>18.421871</td>
</tr>
<tr>
<td>11/1/2023</td>
<td>-77.23071429</td>
<td>17.124131</td>
</tr>
<tr>
<td>12/1/2023</td>
<td>-92.77714286</td>
<td>15.826392</td>
</tr>
</tbody>
</table>
From Figures 5 and 6, we observed that the forecast graphs were dwindling. The stock prices of Airtel in 2023 will be at decreasing rate while that of MTN somehow will maintained steady rate but without much gain to the investors in 2023. In this case, the investors of these two companies should apply much caution while investing since they can lose more than their capital and even end up in debt. This downtrend observed in the forecast of 2023 may be as a result of economic crisis that bedeviled 2023.

**Conclusion**

This study seeks to evaluate the volatility of closed stock prices of Airtel and MTN companies enlisted in Nigeria Stock Exchange. The Stationarity of the two companies were obtained by differencing. Univariate ARCH and GARCH model were employed to construct suitable probability models that can predict the future stocks (generate reliable forecasts) of MTN and Airtel. ARCH and GARCH models Model selection criteria were employed and the best fitted model was selected to the series GARCH (1, 1) MTN and Airtel, The models were subjected to diagnostic checks and were found to be adequate. Consequently, forecasts of close stocks were generated for the 2023.
the use of GARCH (1,1) is recommended to do further forecasting of this nature.

Conflict of Interest
There is no conflict of interest.

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References


