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Author’s contribution
The sole author designed, analysed, interpreted and prepared the manuscript.

ABSTRACT
This research work studied the autoregressive integrated moving average (ARIMA) model that best fitted monthly stock market returns of the Nigerian Stock Exchange between January, 2008 to September, 2018. The study collected secondary data from Central Bank of Nigeria (CBN) Statistical Bulletin 2018 on monthly stock market index of NSE to compute the monthly stock market returns. The Box-Jenkins ARIMA modeling was adopted for this work. The series was tested for stationarity using Augmented Dickey Fuller test. Several ARIMA (p, d, q) models were applied to the monthly stock market returns to ascertain the best fit model for the series. The ARIMA (2, 0, 3) model was selected as the best fit for the data since it has minimum values of Akaike Information Criteria and Mean Squared Errors. The forecasted period showed a market with an unstable monthly stock market returns. Therefore, investors were advised to weigh the risks before venturing into the market to invest.

Keywords: Stock market; ARIMA; model adequacy; forecast.

1. INTRODUCTION
Globally investors seek avenues to derive maximum return on their investments. Hence, the stock market provides one such platform for investment returns. Stock market return maybe defined as returns that accrue to investors for investing through a stock market. These returns
could be in the form of dividends declared by companies to shareholders or profit taking by trading in equities at the exchange market.

In Nigeria, the Nigerian Stock Exchange (NSE) was established in 1960 as Lagos Stock Exchange which started operation in 1961. It is one of the major stock markets in sub-Saharan Africa. Nevertheless, one of the principal objectives for establishing the Nigerian Stock Exchange is to provide an avenue for investors to buy and sell securities.

However, within the last decade the behavior of the market has become unpredictable as a result of dwindling economic growth thereby affecting investors’ confidence to continuously invest in the stock market. The scope of this work, from January 2008 to September 2018 revealed investor’s apathy.

Fig. 1 shows the indexes of the Nigerian Stock Exchange within the period of interest. It depicts moments from high investors’ confidence to low investors’ confidence in the market. Equally, the index is still exhibiting a continuous downward trend implying less attraction of investors to the market. Accordingly, average monthly stock market returns from the Nigerian Stock Exchange show high volatility. This makes it highly imperative for investors in that market to embrace a high degree of risk management.

![Fig. 1. The time series plot of monthly stock market indexes of the Nigerian stock exchange from January, 2008 to September, 2018. Source: Author’s computation and Minitab output](image1)

![Fig. 2. The time series plot of monthly stock market returns of the Nigerian stock exchange from January, 2008 to September, 2018. Source: Author’s computation and Minitab output](image2)
2. LITERATURE REVIEW

There are so many literatures abound in ARIMA modeling on stock market returns in several countries. [1] worked on Stock Price Prediction Using ARIMA Model. They applied ARIMA model to build a stock price predictive model using published data from New York Exchange and Nigerian Stock Exchange. Their Research showed that the ARIMA model was strong for short term prediction of stock prices.

Also, [2] studied the Prediction of Returns on All-Share Index of Nigerian Stock Exchange using monthly return share index from 1985 to 2014. They applied Box-Jenkins approach to evaluate the data. Their research revealed that ARIMA (1, 1, 2) model fitted the data and residuals from the estimated model appeared uncorrelated.

Likewise, [3] research on forecasting Croatian Stock Market: Cobrex. The research work used weekly data of Croatian stock market index Cobrex on Zagreb Stock Exchange from 1st January, 2011 to 1st January, 2013. Their work revealed that ARIMA model suits the behavior of the market in an exceptionally number of competing models.

In addition, [4] analyzed the Nigerian Stock Exchange All Share Index. They used data obtained from the Statistical Bulletin of Central Bank of Nigeria for the period of January, 1985 to September, 2014. The results from their research showed that Autoregressive model of order two AR (2) after differencing fitted the data. It also revealed that ARIMA (2,1,0) was adequate to define the optimal of Nigerian Stock Exchange All Share Index.

Moreover, [5] on Forecasting Stock Market Series with ARIMA Model studied to identify ARIMA models that can predict stock prices in Botswana and Nigeria. The applied standard model selection criteria to select the best ARIMA model for predicting stock prices in each of the countries they investigated. The result showed that ARIMA (3, 1, 1) and ARIMA (1, 1, 4) models were best forecast models for Botswana and Nigeria respectively during the period of consideration.

Additionally, [7] in his research paper, Forecasting Nigerian Stock Exchange Returns: Evidence from Autoregressive Integrated Moving Average (ARIMA) modeled stock prices of the Nigerian Stock Exchange using ARIMA (p, d, q) model. He used NSE data from January 1985 to December, 2018. ARIMA (1, 1, 1) was selected as the best fit model after several diagnostic test. The selected model predicted the index point well.

3. METHODOLOGY

The Box-Jenkins methodology for Autoregressive Integrated Moving Averages (ARIMA) models was adopted for this study and more so, the data were obtained from the Statistical Bulletin of Central Bank of Nigeria. It covered the period of January, 2008 to September, 2018 and the series descriptive statistics were calculated. In line with the Box-Jenkins method, the data were subjected to a stationarity test using Augmented Dickey – Fuller test. In addition, the parameters of the potential models were estimated and best model was selected using suitable criterion of Akaike’s Information Criterion (AIC) and Mean Squared Errors (MSE). Furthermore, the adequacy of the selected model was tested by using residuals of the model. The partial autocorrelation function (PACF) and autocorrelation function (ACF) of the residuals were checked and also, a portmanteau test was carried on the residuals by applying the Ljung-Box Q’ Statistic test. Lastly, the selected model was used to forecast for 12 month period ahead.

3.1 Model Estimation

The ARIMA (p, d, q) to be estimated in this research study is:
4.1 Descriptive Analysis of the Variable

The monthly stock returns with the period under consideration shall be computed as:

\[ Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum \alpha_i \Delta Y_{t-i} + \epsilon_t \]  

The monthly stock market returns is a time series data. The error terms may be correlated; therefore the augmented Dickey Fuller test was applied to the model to check for unit root in the time series data using [9]:

\[ \Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum \alpha_i \Delta Y_{t-i} + \epsilon_t \]

\[ \Delta Y_{t-1} = Y_{t-1} - Y_{t-2}, \Delta Y_{t-2} = Y_{t-2} - Y_{t-3}. \]

The unit root test is carried out under the null hypothesis \( r = 0 \) against \( r < 0 \). The Dickey Fuller test statistic is:

\[ Q^* \text{ Statistic} = n(n+2) \sum_{k=1}^{h} (n-k)^{-1} r_k^2 \]

where \( n \) = number observation, \( h \) = maximum number of lag being considered and \( r \) = residuals. The data are white noise if the value of 0.6778% while, standard deviation from the mean for was 7.9049%. Distribution of the monthly stock market return is negatively skewed to the left. The kurtosis value of 4.8761 means that the curve of the monthly stock market returns is leptokurtic in nature.

4.2 Unit Root Test

Test interpretation:

\[ H_0: \text{There is a unit root for the series} \]

\[ H_1: \text{There is no unit root for the series. The series is stationary} \]
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis $H_0$, and accept the alternative hypothesis $H_1$. The risk to reject the null hypothesis $H_0$ while it is true is lower than 1.36%. Therefore, the monthly stock market returns is stationary at level and does not need differencing.

4.3 Model Estimation and Selection

Table 3 shows the mean squared error values of the estimated ARIMA $(p, d, q)$ models. The ARIMA $(2, 0, 3)$ model is the best since it has the least mean squared errors of 56.41. Some models were not able to be estimated by the computer program used; this means those models are not suitable for this analysis.

Table 4 shows the Akaike’s Information Criteria values of the estimated ARIMA $(p, d, q)$ models. The ARIMA $(2, 0, 3)$ model is the best since it has the least AIC of 894.81. Also, some the models could not able to be estimated by the computer program used; this means those models are not suitable for this analysis.

4.4 Parameters of the Best Selected Model

The ARIMA $(p, d, q)$ model with smallest values of MSE and AIC is ARIMA $(2,0,3)$. It is the ARIMA $(p, d, q)$ model that fitted the stock market returns from January, 2008 to September, 2018. Table 5 shows that estimated parameters of ARIMA $(2, 0, 3)$ model. Based on the table, parameters of the autoregressive (AR) are all significant; also parameters of the moving average (MA) part of the model are equally significant since all their p-values are less than the significance level of 0.05. The constant is not significant; its p-value is more than the significance value of 0.05.

The ARIMA $(2, 0, 3)$ model can be represented as stated in equations (1) and (2) to be:

\[ Y_t = -0.7683 Y_{t-1} - 0.5936 Y_{t-2} + \varepsilon_t \] (5)
\[ + 0.8807 \varepsilon_{t-1} + 0.8565 \varepsilon_{t-2} + 0.3931 \varepsilon_{t-3} \]
\[ (1 + 0.7683 B + 0.5936 B^2)Y_t \]
\[ = (1 + 0.8807 B + 0.8565 B^2 + 0.3931 B^3)\varepsilon_t \] (6)

4.5 Model Adequacy of the Best Selected Model

The residuals from the best selected model, ARIMA $(2, 0, 3)$ were checked if they are white noise. 

Table 6 shows the Ljung-Box Q Statistic test on residuals from ARIMA $(2, 0, 3)$ model. Since the P-values at different lags are more than the significance level of 0.05, it means the residual values are not significantly different from zero. Therefore, they are white noise.

In addition, spikes of PACF and ACF of the residuals are within the 5% significance limits as shown in Fig. 3 and Fig. 4. This equally means that the residuals are white noise.

4.6 Forecasts

The 12 month ahead forecast of monthly stock market returns from the Nigerian Stock Exchange shows there will be a rise in monthly stock market returns from October, 2018 to January, 2019. The monthly return is expected to fluctuate from February, 2019 to September, 2019.
Mean squared errors (MSE)

<table>
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<tr>
<th></th>
<th>q = 0</th>
<th>q = 1</th>
<th>q = 2</th>
<th>q = 3</th>
<th>q = 4</th>
<th>q = 5</th>
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<tbody>
<tr>
<td>p = 0</td>
<td>63.03</td>
<td>62.06</td>
<td>60.63</td>
<td>58.09</td>
<td>57.40</td>
<td></td>
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<tr>
<td>p = 1</td>
<td>62.98</td>
<td>62.58</td>
<td>62.09</td>
<td>58.99</td>
<td>58.05</td>
<td>57.77</td>
</tr>
<tr>
<td>p = 2</td>
<td>62.59</td>
<td>62.59</td>
<td>57.67</td>
<td>56.41</td>
<td>56.68</td>
<td>58.76</td>
</tr>
<tr>
<td>p = 3</td>
<td>61.06</td>
<td>58.75</td>
<td>58.79</td>
<td>56.59</td>
<td>57.06</td>
<td>56.80</td>
</tr>
<tr>
<td>p = 4</td>
<td>58.32</td>
<td>59.35</td>
<td>58.46</td>
<td>-</td>
<td>57.41</td>
<td>-</td>
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<tr>
<td>p = 5</td>
<td>58.30</td>
<td>58.65</td>
<td>57.49</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Author’s computation and XLSTAT Output

Table 4. The Akaike’s information criteria values of estimated ARIMA models

Akaike’s information criteria (AIC)

<table>
<thead>
<tr>
<th></th>
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<th>q = 3</th>
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<tr>
<td>p = 0</td>
<td>-</td>
<td>902.98</td>
<td>902.29</td>
<td>900.19</td>
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<td>896.52</td>
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<td>p = 1</td>
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<td>902.93</td>
<td>903.18</td>
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<td>898.23</td>
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<tr>
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<td>903.05</td>
<td>904.00</td>
<td>899.15</td>
<td>894.81</td>
<td>-</td>
<td>897.93</td>
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<td>p = 3</td>
<td>900.96</td>
<td>897.72</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>p = 5</td>
<td>898.00</td>
<td>899.77</td>
<td>899.12</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Author’s computation and XLSTAT Output

Table 5. The estimated parameters of the selected best ARIMA model

<table>
<thead>
<tr>
<th>Type</th>
<th>Coef.</th>
<th>SE Coef.</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.1510</td>
<td>-5.09</td>
<td>0.0000</td>
</tr>
<tr>
<td>AR 2</td>
<td>-0.5936</td>
<td>0.1482</td>
<td>-4.01</td>
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</tr>
<tr>
<td>MA 1</td>
<td>-0.8807</td>
<td>0.1476</td>
<td>-5.97</td>
<td>0.0000</td>
</tr>
<tr>
<td>MA 2</td>
<td>-0.8565</td>
<td>0.1320</td>
<td>-6.49</td>
<td>0.0000</td>
</tr>
<tr>
<td>MA 3</td>
<td>-0.3931</td>
<td>0.0872</td>
<td>-4.51</td>
<td>0.0000</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.0340</td>
<td>2.0700</td>
<td>-0.50</td>
<td>0.6180</td>
</tr>
</tbody>
</table>

Source: Author’s computation and XLSTAT Output

Fig. 3. PACF for the residuals of ARIMA (2,0,3) model

Source: Author’s computation and XLSTAT Output
Table 6. Ljung-box Q* statistic test for the residuals of ARIMA (2,0,3) model

<table>
<thead>
<tr>
<th>Lag</th>
<th>12</th>
<th>24</th>
<th>36</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>4.7</td>
<td>11.0</td>
<td>18.7</td>
<td>25.6</td>
</tr>
<tr>
<td>DF</td>
<td>6</td>
<td>18</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.578</td>
<td>0.894</td>
<td>0.946</td>
<td>0.978</td>
</tr>
</tbody>
</table>

Source: Author’s computation and XLSTAT Output

Fig. 4. ACF for the residuals of ARIMA (2,0,3) model
Source: Author’s computation and XLSTAT Output

Fig. 5. 12 Month ahead forecast of NSE stock market returns using ARIMA (2,0,3) model
Source: Author’s computation and XLSTAT Output

5. DISCUSSION OF RESULTS

This research study focused on ARIMA modeling of monthly stock market returns of the Nigerian Stock Exchange for the period ranging from January, 2008 to September, 2018. Data used for this work were obtained from the Statistical Bulletin of the Central Bank of Nigeria. Results
were obtained from analyzing the data; the descriptive analysis showed that an average monthly stock market return was a loss of -0.3952%. While, standard deviation from the mean for was 7.9049%, this shows the market riskiness. Distribution of the monthly stock market return is negatively skewed to the left. The kurtosis value of 4.8761 means that the curve of the monthly stock market returns is leptokurtic in nature.

In addition, the Augmented Dickey Fuller test for unit root was carried out on the monthly stock market returns to assess for stationarity. The series of the variable were stationary at significance level of 0.05. Consequently, several ARIMA (p, d, q) models were applied to the series, with maximum p = q = 5 to select the ARIMA (p, d, q) that fits the series using the Mean Squared Error (MSE) and Akaike’s Information Criterion (AIC). ARIMA (2,0,3) model best fitted the monthly stock market returns of the Nigerian Stock Exchange with minimum MSE of 56.41 and minimum AIC of 894.81.

Furthermore, the model adequacy of ARIMA (2, 0, 3) was evaluated using the Ljung-Box Q Statistic test on residuals, partial autocorrelation function (PACF) and autocorrelation function (ACF) of the residuals as well. The Ljung-Box Q Statistic test on residuals from ARIMA (2, 0, 3) at different lags showed the residual values are not significantly different from zero. Therefore, the residuals are white noise. The spikes of PACF and ACF were within the 5% significance limit showing equally that the residuals are white noise.

Additionally, the 12 month ahead forecast of the monthly stock market returns of the NSE using ARIMA (2, 0, 3) showed a market with an unstable monthly stock market return. The last quarter forecast of the year, 2018 showed an upward trend movement, while first 9 months of the year, 2019 shall experience an unstable monthly stock market returns. Therefore, investors are advised to weigh the risks before venturing into the market to invest.

6. CONCLUSION

This study focused on modeling monthly stock market returns from the Nigerian Stock Exchange for the period of January, 2008 to September, 2018 using an ARIMA (p,d,q) model. Consequently, ARIMA (2, 0, 3) model was selected to be the best fit model from other competing ARIMA (p,d,q) models. The selected model was found to be adequate for short-term forecast of the monthly stock market returns from NSE. The forecast from the market showed a future bearish market to persist and investor are advised to weigh the risks before investing. Therefore, the Nigerian government should promote policies that will create confidence in the economy thereby attracting potential investors into the economy and stock market.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES


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