

## Nigeria's External Reserves: A Time Series Approach

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### ABSTRACT

A nation's economy can withstand shocks and increase confidence by using its external (foreign) reserves. Therefore, external reserves are significant to the extent that they aid in maintaining economic stability in the nation. The study looked into Nigeria's external reserves using time series technique. It made use of monthly data on Nigeria's external reserves from January 1990 to August 2021, which were sourced from the Central Bank of Nigeria (CBN) bulletin. The aim of the study was to investigate the external reserve pattern of Nigeria and fit a suitable time series model to the data. The Box-Jenkins methodology was utilized, encompassing four distinct stages: identification, estimation, diagnostics, and forecasting. The data was determined to be non-stationary at the initial level and displayed an upward trend. Upon initial analysis with diagnostic economic tools, it was discovered that the data consistently maintained a state of equilibrium, that is, at first difference. Additionally, model diagnostic checking showed that Autoregressive Integrated Moving Average, ARIMA (4, 1, 4) was the most suitable optimal model, and as such, it was used to forecast for the following four years. As a result, the projected figures showed that Nigeria's external reserves will keep rising gradually. Legislative actions that will facilitate improved external reserve management and accumulation are therefore recommended for the government to take.

**Keywords:** External Reserves, Box-Jenkins, Stationarity, Forecast.

### 1.0 INTRODUCTION

External reserves are defined as "official public sector foreign assets that are readily available to and controlled by the monetary authorities for direct financing of payment imbalances and regulating the magnitude of such imbalances through intervention in the exchange market to affect the currency exchange rate and/or for other purposes" (CBN, 2007). External reserves are also referred to as international reserves, foreign reserves, or foreign exchange reserves. According to this definition, foreign currency and securities held by the general public, such as those held by banks and corporations, are not considered to be part of external reserves; instead, they comprise the monetary authority's international reserve assets. To protect against a potential financial crisis, external reserves are required (Mendoza, 2004). Additionally, central banks are thought to be able to manipulate the value of their national reserves by using them as a store of assets (Nugee, 2000).

The country's economy depends heavily on its international reserves to meet its financial needs for the balance of payments, avoid manipulation of the exchange market that could lead to a depreciation of the value of the currency, and preserve public trust in the national currency. International currencies, gold reserves, and other assets denominated in foreign currencies are included in the external reserves (IMF, 2016). In particular, external reserves are crucial for safeguarding against potential financial difficulties.

The government's ability to closely monitor a nation's external reserves is crucial for maintaining stability against financial challenges. A country with highly reserved external reserves will have an economy that is more resilient to financial crises. This was confirmed by an empirical study conducted by Allegret and Audrey (2018). Consequently, the influx of foreign capital will be volatile. The confidence of the internal community is well-established in the nation's policies and creditworthiness, according to Yuguda (2003), Soludo (2005), and Nda (2006). Similarly, a country's confidence in its ability to meet international debt servicing obligations and, consequently, raise its credit rating is guaranteed to domestic borrowers through its foreign reserves (Humphries, 1990).

Act No. 41 (CBN, 1991) gave the CBN custody and management of Nigeria's external reserve. Traditionally, nations maintain foreign exchange reserves in foreign currencies by heavily intervening in foreign exchange markets in order to preserve a desired exchange rate policy. Foreign exchange market stability, exchange rate stability, exchange rate targeting, creditworthiness, transactions buffer, and emergencies like natural disasters are the main justifications for a nation to maintain external reserves (Archer & Halliday, 1998 and Humphries, 1990). These factors ensure that the reserves are readily available to finance day-to-day official transactions and provide adequate liquidity to meet unforeseen needs, all while earning returns within the set tolerable

risk limits. As various economies look for alternative approaches to safeguard their economies against financial instability and promote economic growth, the external reserve holding has attracted significant attention on a global scale. Despite the associated costs, the majority of countries in the world—including Nigeria—have amassed foreign reserves. This accumulation over the past few decades has sparked debate among academics, pundits, and development planners about the potential impact of these reserves on an economy's ability to grow.

Aluko (2007) made the crucial observation that the external reserve has a significant or favorable impact on the nation's economy. As a result, investors have access to more capital, and job seekers have more employment options; this raises output and encourages consumption. Crude oil is one of the primary sources of foreign exchange and has been the "back bone" of Nigeria's economy since the 1970s, providing the country's GDP with the strength it needs to survive. As a result, the World Bank (2014) confirmed that, in the unlikely event that oil prices rose, certain dependent oil products would be vulnerable.

It is impossible to overstate how crucial external reserves are to any nation. It can be defined as the official foreign assets held by the Central Bank of a nation. Nigeria's reserve position at any given moment reflects the conditions that are present in the global oil market (George, 2007). Over the years, Nigeria's foreign reserve holdings have varied in size. Based on the aforementioned, we believe that discussions about external reserves have typically centred around the concept, nature, sources, size, foreign exchange disbursement, and months during which such reserves could be used to finance imports. With this in mind, the study aims to provide solutions to the issues of inadequate infrastructure and social service development and underutilization of Nigeria's vast external reserves.

Hence, this study investigated Nigeria's external reserve pattern between 1990 and 2021, fitted external reserves data with a suitable time series model and forecasted Nigeria's foreign reserves for the ensuing four years.

## 2.0 LITERATURE REVIEW

Many researchers have put forth various models for external reserves based on time series techniques. Here are a handful of the academics:

Adejumo, et al. (2023), using time series approach modeled the Nigeria external reserves for data extracted for a 30-year period from the archives of the CBN bulletin from 1990 - 2019. They employed the Augmented Dickey Fuller (ADF) test unit root tests and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test to determine the stationarity of the data. They fitted

an Autoregressive Integrated Moving Average (ARIMA) model to the data and made predictions having adopted Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQIC) to determine the best model. Their result showed that the Nigeria external reserve exhibited an upward trend and showed non-stationarity. With the help of Model diagnostic tools, they found and fitted ARIMA (2, 1, 7) model as the appropriate optimal model and employed same to make forecasted for five subsequent years. Lastly, their model forecast revealed that the Nigeria external reserves maintained an upward trend.

Additionally, Ajao, et al. (2019) in empirically examining the Nigeria external reserves from 1960 – 2018 by means of Box-Jenkins ARIMA models found that ARIMA (1, 1, 2) was the most appropriate model selected based on the AIC and Log likelihood values.

Chukwuemeka (2023) considered the effect of Nigeria's external reserves on her economic growth used a longitudinal data spanning 40 years from 1981 – 2020 obtained from the Central Bank of Nigeria Statistical bulletin. They applied the Autoregressive Distributed Lag (ARDL) bounds testing approach for co-integrated variables and to explore the stated objectives in the study. Their results showed that the estimated short run coefficient of the exchange rate at current period and two lags before exhibited a negative and significant impact on Nigeria's economic growth and exchange rate at a period lag impacted economic growth positively and significantly. However, their long run result revealed that while exchange rate and inflation rate both have insignificant negative effect on economic growth, external reserves' effect was positive and also insignificant. They therefore recommended implementing a suitable macroeconomic policy to stabilise prices and consequently enhance external reserves.

In an article titled "A Comparison of Forecast Behaviour of four Time Series Models on Nigeria's external Reserves", Bolarinwa et al. (2022) compared decomposition, Holt-Winters, ARIMA and Artificial Neural Network (ANN) models for forecast accuracy and similarity on Nigeria's external reserves. Fitted adequate ARIMA model is ARIMA (1, 1, 1) while ANN (12, 7, 1) possessing minimum Mean Absolute Error (MAE) of six ANN models fitted was chosen for forecasting. Holt-Winters model utilized parameter values 0.9, 0.3 and 0.3 for level, trend and season respectively. The parameters were selected such that MAE was minimal. Based on forecast Mean Square Error of twelve out-of-sample forecasts, ARIMA performed best, followed by Holt-Winters and then, decomposition. ANN performed worst. Fitted ARIMA suggests an increasing trend for the series. The article

observed that for Nigeria’s external reserves to attain high levels of the past, there must be improved governance, security and infrastructure.

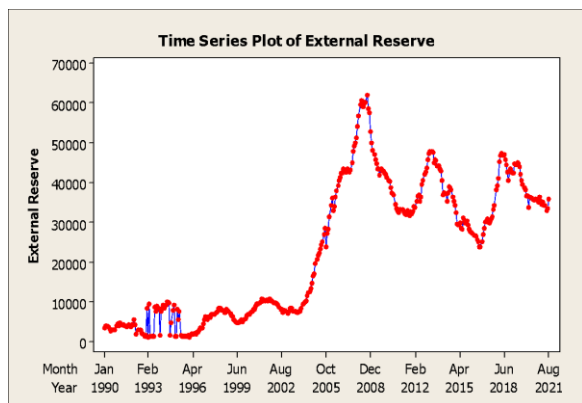
Bolarinwa et al. (2022), adopted the Box and Jenkins ARIMA approach to model the Nigeria’s external reserves (\$m) and found that the ARIMA (1, 1, 1) was appropriate and used to forecasts for 24 months beginning from January 2020 to December 2023. They observed that moving the external reserves to high levels requires improved governance, security and infrastructure. Lastly, Okenegwu (2019) built a fit and consistent Box-Jenkins model for the Nigeria’s external reserves which spanned 34 years from January 1981 to December 2014. The study found ARIMA (4, 1, 0) model with the least AIC and Bayesian Information Criterion (BIC) statistics as the most suitable and therefore proposed the model for forecasting the indicator in the future.

**3.0 MATERIALS AND METHODS.**

This study used a time series approach to analyze the state of Nigeria’s external reserves using information (data) taken from the CBN bulletin for the months of January 1990 through August 2021. Its primary time series model used the Box-Jenkins approach which involved these four stages—identification, estimation, diagnostic and forecasting. In order to achieve stationarity, the data were transformed (differenced) after which the Box-Jenkins approach was applied. Plots of the results of Autocorrelation and Partial Autocorrelation Function (ACF and PACF) were shown at various lags in order to help identify the best model for the series. In the meantime, the Box-Jenkins ARIMA model underwent diagnostic testing before being employed for future projections.

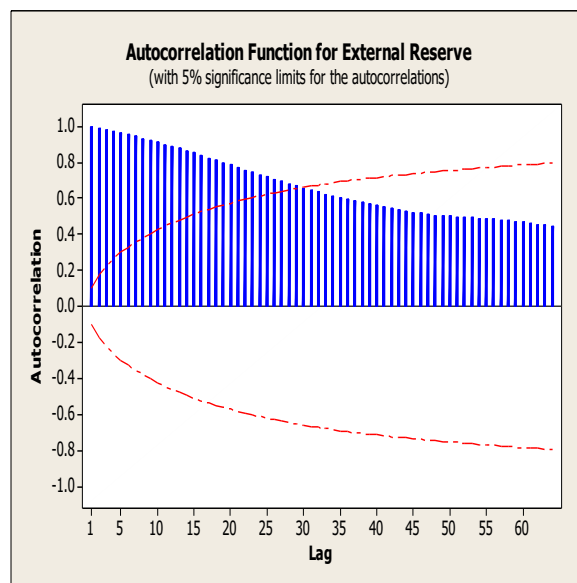
**4.0 RESULTS**

This section includes the data analysis and interpretation of the results.

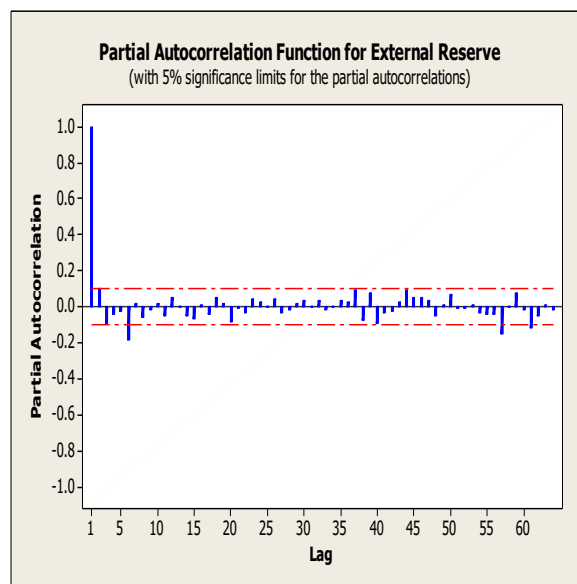


**Fig. 1: Time plot of Nigeria External Reserves from January 1990 to August 2021.**

The time plot presented in Fig. 1 clearly shows an increasing reserve. Additionally, it demonstrates that the data are not stable over time and are not stationary at their initial level. The reserve showed oscillation for the first seven years (1990–1996), increased steadily for the next seven years (1997–2003), dipped in 2003, and increased progressively from 2004 to 2008, when it dipped until 2012. However, it increased for the two consecutive years, from 2012 to 2014, and then dropped gradually for another four years, from 2014 to 2017. From 2017 to 2019, there was an increase, and declined from 2020 to 2021.



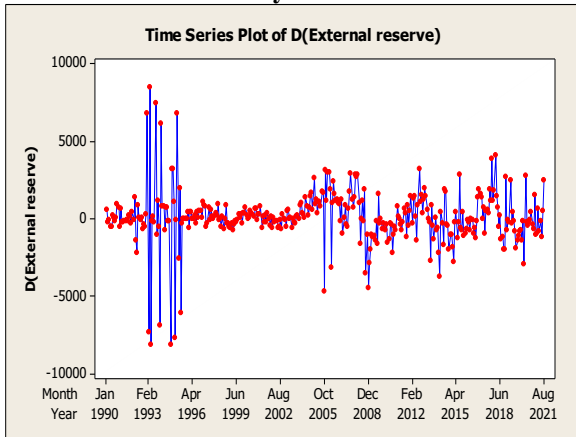
**Fig. 2: The autocorrelation function (ACF) plots of the external reserves from January 1990 to August 2021**



**Fig. 3: The partial autocorrelation function (PACF) plots of external reserve from January 1990 to August 2021.**

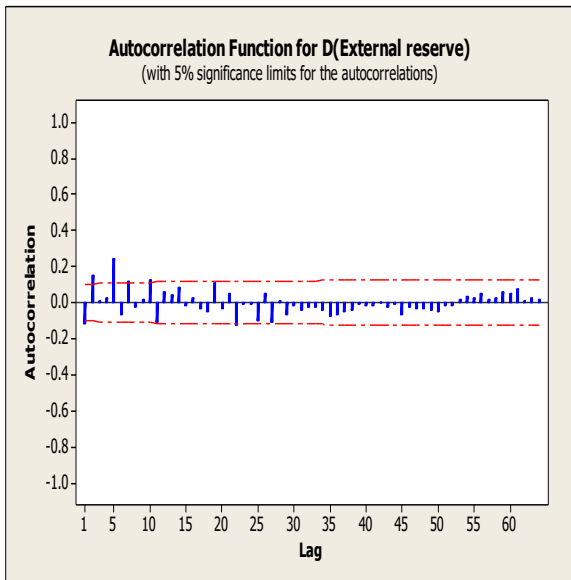
In Fig. 2, the Autocorrelation function plot (ACF) plots demonstrate that the data are not stationary at the original level as the lag spikes are slowly diminishing, while the PACF plots (Fig. 3) first-lag spike is roughly equal to one (1).

**4.1: Test for Stationarity**

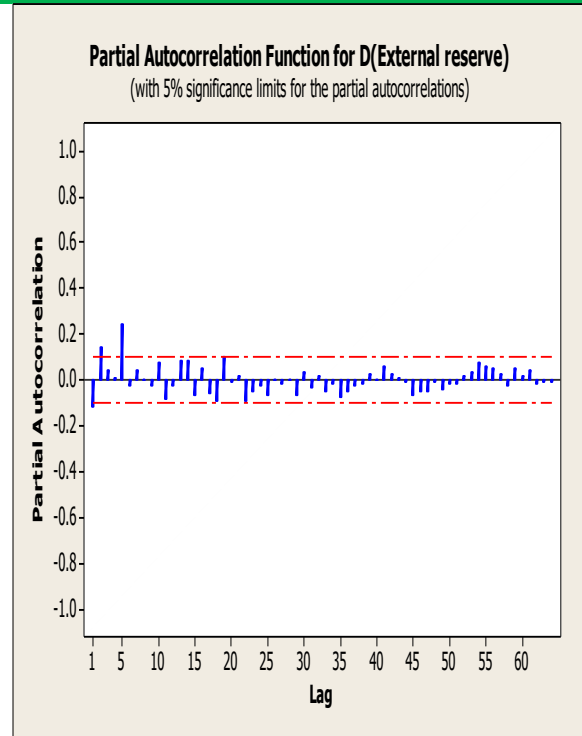


**Fig. 4: Time plots at first difference of Nigeria External reserve from January 1990 to August 2021.**

Fig. 4 shows the time plot of the first difference data. It also indicates that the data is now stable over time (as the mean and the variance were constant), demonstrating that the data is stationary since the trend in the series has vanished.



**Fig. 5: ACF plots at first difference of Nigeria External reserve from January 1990 to August 2021.**



**Fig. 6: PACF plots at first difference of Nigeria External reserve from January 1990 to August 2021.**

The Partial Autocorrelation function plot (Fig. 6) with a significant spike at lag 1, suggests an Autoregressive model of order 1, and the three significant spikes in the Autocorrelation plot (Figure 5), confirm a Moving Average of order 3 i.e. MA (3). This implies that the process is stationary.

**4.2: Model Identification**

Due to the iterative nature of the model fitting process, we attempt AR (1), AR (2), or AR (3) for MA (1) until the optimal model for the data is obtained.

**4.3: Model Estimation**

In the fitted model, parameters that deviate significantly from zero are kept, and parameters that do not vary significantly from zero are removed. Thus, using the plot of the partial correlogram as a basis, the appropriate parameter estimated was an ARIMA (4, 1, 4). Table 1 below displays the outcome, which confirms all of the parameters, with the exception of the constant, have p-values that are significantly smaller than 0.05.

Table 2 shows that the Box-Pierce Chi-Square p-values are non-significant ( $p > 0.05$ ), suggesting that the model fits the data well and that the residuals appear to be uncorrelated.

**Table 1: Result of the Estimated Parameter of ARIMA (4, 1, 4)**

Type	Coefficient	Std Error	T-Test	P-value
AR1	-1.9449	0.3070	-6.3300	0.0000
AR2	-1.7798	0.4060	-4.3800	0.0000
AR3	-0.7355	0.2726	-2.7000	0.0070
AR4	-0.1223	0.0669	-1.8300	0.0680
MA1	-0.8904	0.3062	-2.9100	0.0040
MA2	0.0588	0.1058	0.5600	0.5790
MA3	0.9000	0.1072	8.3900	0.0000
MA4	0.5078	0.2408	2.1100	0.0360
Constant	-0.9600	36.6100	-0.0300	0.9790

The estimated model is

$$\begin{aligned}
 Y_t &= -0.96 - 1.9449y_{t-1} - 1.7798y_{t-2} - 0.7355y_{t-3} \\
 &- 0.1223y_{t-4} + 0.8904\varepsilon_{t-1} - 0.0588\varepsilon_{t-2} - 0.9000\varepsilon_{t-3} \\
 &- 0.5078\varepsilon_{t-4} \quad (4.1)
 \end{aligned}$$

This model reveals that the predicted monthly Nigeria External Reserves (NER) is made up of  $-0.96$  minus  $1.9449$  of the NER that occurs in previous month minus  $1.7798$  of the NER that occurs in second previous month minus  $0.7355$  of the NER that occurs in third previous month minus  $0.1223$  of the NER that occurs in fourth previous month plus  $0.8904$  of some random shock in previous month minus  $0.0588$  of some random shock in second previous month minus  $0.9000$  of some random shock in third previous month minus  $0.5078$  of some random shock in fourth previous month.

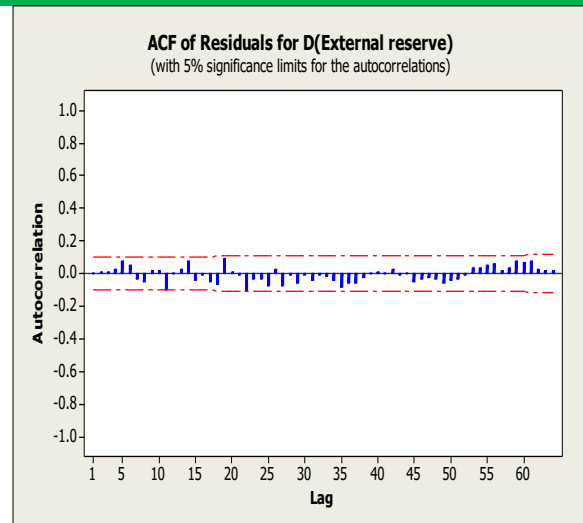
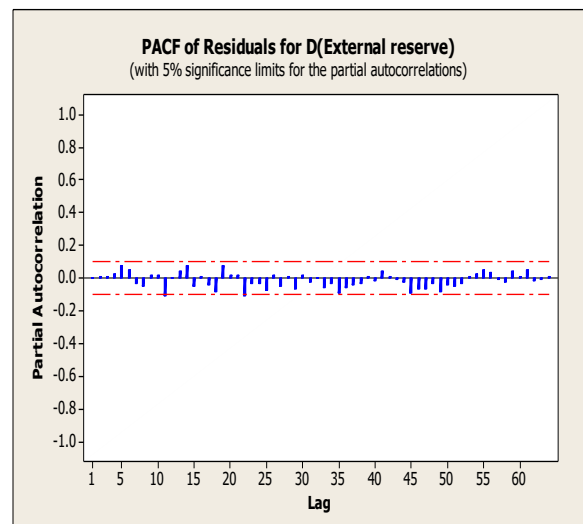
#### 4.4: Model Diagnostic Checking

To ensure that the model is adequate, tests for Auto correlation and Partial auto correlation were applied to the residual.

**Table 2: Modified Box-Pierce (Ljung-Box) Chi-Square Statistic**

Lag	12	24	36	48
Chi-Square	9.3	23.8	35.4	39.7
df	3	15	27	39
P-value	0.026	0.068	0.128	0.438

The results in Table 2 indicate that the Box-Pierce Chi-Square p-values are non-significant ( $p > 0.05$ ) indicating that the model fits the data well and the residuals appeared to be uncorrelated.

**Fig. 7: Residual ACF plot of the best ARIMA model****Fig. 8: Residual PACF plot of the best ARIMA model**

In the meantime, Fig. 7 and 8 showed that ACF and PACF plots of the results are within their two standard error limits. Hence, the residuals are white noise model classified as ARIMA (0, 0, 0) that constitute:

- No AR part since  $y_t$  does not depend of  $y_{t-1}$ ;
- There is no differencing involved;
- No MA part since  $y_t$  does not depend on  $\varepsilon_{t-1}$ . Hence, the model is efficient or a good fit.

Therefore, we can say we produced an adequate model for forecasting future values of this series. However, we are uncertain how well this model will perform past the period of 4 years, because this is the interval for which it was tested.

#### 4.5: Forecasting

An output sample forecast for the subsequent four years was created after the ARIMA (4, 1, 4) model was confirmed adequate and sufficient as diagnostic tests.

**Table 3: Result for the forecast of the Nigeria External Reserve for the next four years**

Date	Forecast	95% CI.	
		Lower	Upper
Dec., 2021	35827.46	29389.75	42265.17
Jan., 2022	36379.01	28977.96	43780.05
Feb., 2022	36138.25	27705.98	44570.52
Mar., 2022	36549.68	27246.82	45852.55
Apr., 2022	36741.28	26471.73	47010.84
May, 2022	36628.63	25459.46	47797.81
Jun., 2022	37040.41	25046.47	49034.35
Jul., 2022	36993.19	24129.96	49856.42
Aug., 2022	37067.68	23433.49	50701.88
Sep., 2022	37339.83	22949.14	51730.53
Oct., 2022	37239.94	22099.18	52380.70
Nov., 2022	37438.51	21620.98	53256.04
Dec., 2022	37552.45	21049.83	54055.06
Jan., 2023	37521.43	20368.33	54674.53
Feb., 2023	37740.66	19974.54	55506.79
Mar., 2023	37756.43	19372.11	56140.75
Apr., 2023	37823.77	18860.78	56786.77
May, 2023	37991.67	18462.07	57521.27
Jun., 2023	37987.72	17898.25	58077.18
Jul., 2023	38119.98	17501.08	58738.88
Aug., 2023	38219.61	17072.70	59366.51
Sep., 2023	38248.48	16589.26	59907.69
Oct., 2023	38394.62	16240.77	60548.46
Nov., 2023	38449.22	15802.07	61096.37
Dec., 2023	38524.11	15401.47	61646.74
Jan., 2024	38648.57	15058.45	62238.70
Feb., 2024	38692.97	14640.68	62745.26
Mar., 2024	38798.82	14299.08	63298.56
Apr., 2024	38892.18	13948.50	63835.87
May, 2024	38950.84	13571.90	64329.78
Jun., 2024	39064.16	13259.75	64868.56
July., 2024	39136.25	12909.47	65363.03
Aug., 2024	39215.96	12576.34	65855.57
Sep., 2024	39319.93	12273.25	66366.60
Oct., 2024	39386.61	11937.30	66835.93
Nov., 2024	39480.94	11637.26	67324.62
Dec., 2024	39570.69	11336.36	67805.02
Jan., 2025	39643.50	11024.15	68262.85
Feb., 2025	39741.73	10743.54	68739.93
Mar., 2025	39821.45	10447.71	69195.18
Apr., 2025	39903.86	10160.47	69647.26
May, 2025	39998.10	9889.41	70106.78



Jun., 2025	40075.00	9604.70	70545.30
Jul., 2025	40164.30	9337.66	70990.95
Aug., 2025	40252.05	9072.40	71431.70
Sep., 2025	40331.56	8802.95	71860.17
Oct., 2025	40422.88	8549.61	72296.16
Nov., 2025	40505.90	8290.97	72720.83
Dec., 2025	40589.79	8037.27	73142.32

Table 3 showed that for the anticipated period, the Nigeria External Reserve will rise gradually.

## 5.0 DISCUSSION

The study analyzed Nigeria's external reserves from January 1990 to August 2021 using the Box-Jenkins ARIMA methodology. The data exhibited non-stationarity at its initial level but later achieved stationarity after first-order differencing. The ARIMA (4, 1, 4) model was identified as the optimal fit, with diagnostic tests confirming its adequacy, as residuals were uncorrelated and followed a white noise pattern. The model's parameters were significant, and forecasts for December 2021 to December 2025 predicted a gradual increase in Nigeria's external reserves, with 95% confidence intervals provided. The findings align with prior research, such as Adejumo et al (2023), which also noted an upward trend, but differ from Okenegwu (2019), who proposed an ARIMA (4, 1, 0) model. The study emphasized the importance of proper reserve management to sustain economic stability and recommended legislative measures to enhance accumulation and governance. The results underscore the resilience of Nigeria's external reserves despite fluctuations, particularly linked to global oil market dynamics. The research contributes to the field by introducing a Moving Average (MA) component, distinguishing it from earlier studies. In general, the study provides a robust framework for policy makers to plan economic strategies, leveraging the forecasted growth in external reserves. The upward trend indicates potential economic resilience, provided effective management practices are maintained. The ARIMA (4, 1, 4) model's accuracy was validated through rigorous diagnostic checks, ensuring reliability for short-term projection. The study highlights the critical role of external reserves in mitigating financial instability and supporting Nigeria's economic growth. The findings reinforce the need for proactive measures to optimize reserve utilization and sustain long-term economic benefits.

## 6.0 CONCLUSION

Following a diagnostic process, the study concluded that the Nigeria External Reserve is an upward trending series and that, after adjusting for diagnostic errors, the ARIMA (4, 1, 4) model best fits the Nigeria External Reserve among other models. Lastly, the study concluded that the Nigeria External Reserve forecast, made using the fitted model, for a four-year period (December 2021 to December 2025) showed

that, with proper management, the Nigeria External Reserve will continue to grow steadily for the years projected, which will help economic policy makers plan ahead. Based on the study's findings, the government is advised to implement legislative measures that will support better management and accumulation of foreign reserves. During this competitive time, the government should take the necessary steps to contract the economy. This study only looks at the stationarity and forecast of the Nigerian external reserve using time series techniques from January 1990 to August 2021. ARIMA (4, 1, 4) was found to be the best model and was used for four years of prediction. To keep an eye on Nigeria's external reserves, additional research could look at years prior to 1990 as well as the current year and project future years.

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