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REVENUE PERFORMANCE, ANALYSIS AND FORECASTING USING TIME SERIES ANALYSIS

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Abstract
In any economy, tax analysis and revenue forecasting are of paramount importance for informing sound economic and fiscal policies. This paper is particularly relevant for Nigeria as it aims to identify significant variables affecting tax revenue and improve planning and policy outcomes. Despite its importance, tax revenue generation in Nigeria faces persistent challenges, necessitating accurate forecasting tools to enhance decision-making. The paper forecast the tax revenue (TR) of Nigeria for the fiscal year 2023–2024 using three different time series techniques. The study employed the autoregressive model with seasonal dummies (AR), the autoregressive integrated moving average model (ARIMA), and the vector auto-regression (VAR) model. Annual data from 1990 to 2023 was used, with a forecasting focus on the July–December 2024 period. For the forecasting of total tax revenue, key components such as petroleum profit tax (PPT), company income tax (CIT), value-added tax (VAT), and tertiary education tax (EDT) were analyzed. The results revealed that the ARIMA model produced the most accurate forecast for the 2023–24 fiscal year, estimating revenue at N3, 279.88 billion, which closely aligns with the government's target of N3, 521 billion for the Federal Inland Revenue Service. This study recommended that the government should introduce new tax reforms and broaden the tax net.

1.0 Introduction

Taxation is not a popular terminology for individuals and business organizations, but it is a vital instrument for collecting revenues for government expenditures. As the collection of taxation increases, it allows the government to conceive maximum developmental projects for the public interest and to improve the basic infrastructure of health, education, and the quality of life of the common people. Taxation. Tax is a mandatory, non-refundable

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remittance made to the government for products and services intermittently. It is normally paid by private businesses and consumers to the government (Agunbiade & Idebi, 2020). The collection of taxation is now, a burning issue in Nigeria; therefore, the government is trying to document the whole economy, especially bringing services and agricultural sectors, and individual people into the tax net. Direct and indirect taxation is an imperative question in the context of Nigeria because more than 60% of tax revenue is being collected through indirect taxes (Aamir *et al.,* 2021).

According to the Federal Inland Revenue Service (FIRS), the total tax revenue collection for the fiscal year (F.Y.) 2019-2022 was N26, 843.20 trillion. According to the Federal Inland Revenue Service (FIRS), the tax to G.D.P. ratio is a burning question in the Nigerian context because it is very low, between 6% and 9.7% for the last ten years (FIRS, 2021–22). The ratio was reviewed in 2021 while considering revenues from other revenue-generating agencies and resulted in 10.86% as the TAX-to-GDP ratio. The ratio is also considered to be low compared to the other African countries, while African's average is 16.5% Tax-to-GDP ratio. However, the FIRS has set a target of an 18% tax to G.D.P. ratio for Nigeria for the next three years (FIRS, 2023). Adolph Wagner was not a believer in taking an individualistic approach to solving an issue; before an appropriate solution could be found, he believed that each economic issue needed to be analyzed in the context of its social and political environment (Etim et al., 2021).

2.0 Methods

2.1 Sources and Methods of Data Collection

The data that was used in this study are secondary data, which are annual figures covering the period 1990-2023. The secondary data will be collected from the Federal Inland Revenue Service (FIRS); the selection period is based on the availability of the data and the relevance of the study.

2.2 Model Specification

As explained earlier, we shall use time series data for the period from 1990 to 2023 and forecast the total tax revenue (TR) for Nigeria by taking its four components PPT, CIT, VAT and EDT. The proposed methods to be employed for the forecasting of total revenue are autoregressive (AR), autoregressive integrated moving average (ARIMA), and the vector auto-regression (VAR) model for the forecasting of T.R. These three forecasting methods are considered for the short-run forecasting; meanwhile, the variables' causal relationship will be tested through the Granger causality test.

The generalized equation form of the test is as follows:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{i=1}^{n} \alpha \Delta y_t + e_t \qquad (2.1)$$

$$y_t = y_{t-1} + \mu_t \qquad (2.2)$$

Then the A.R. (p) model is said to be a stationary model with lag operator notation and can be expressed as follows:

$$\varphi(L) y_t = \mu_t$$

$$y_t = \varphi(L)^{-1} \mu_t \qquad 2.3$$

The other characteristics of the A.R. (p) model are the variance and the mean of the A.R. (1) process, and can be expressed as follows:

$$E(y_t) = \frac{\mu}{1-\varphi_1}, var = \frac{\sigma^2}{(1-\varphi_1^2)} \qquad (2.4)$$

The equation of the stationary A.R.M.A. (p, q) process can be described as a sequence of random variables (X_t). The equation can be written as follows:

$$X_t = \Psi_1 X_{t-1} - L - \Psi_p X_{t-p} = Z_t = \varphi_1 Z_{t-1} + L + \varphi_q Z_{t-q} \quad (2.5)$$

In Equation (3.7), 'Z_t' is denoted for the sequences of uncorrelated random variables, which have zero mean and constant variance, and can be shown as follows:

$$\{Z_t\} \sim WN\ (0, \sigma^2), \quad (2.6)$$

Hence, the A.R.I.M.A. (p, d, q) processes satisfy the following form of a differential equation:

$$\Psi * (\mathrm{B}) \equiv\ X_t \Psi(\mathrm{B})(1 - \mathrm{B})^d X_t = \theta(B) Z_t, \{Z_t\} \sim WN\ (0, \sigma^2), \quad (2.7)$$

In equation (2.7), the 'X' process is known as the A.R.I.M.A. (p, d, q) procedure, if 'd' has a property of non-negative integers, such as, $(1-B)^d$, then 'X' will be known as a causal A.R.M.A. (p, q) method.
Where: $\phi(z)$ and $\theta(z)$ are known as the polynomials of p and q degrees correspondingly; moreover, $\phi(z) \neq 0$ for $|z| \leq 1$. Since the $\phi*$ (z) having a '0' of order'd' with z = 1.
The mathematical expressions for the three techniques are given as follows:

$$MAE = \frac{\sum_{i=1}^{n} |x_i - \hat{x}_i|}{n} \quad (2.8)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \hat{x}_i)^2}{n}} \quad (2.9)$$

$$MAPE = \frac{\sum_{i=1}^{n} \left| \frac{x_i - \hat{x}_i}{x_i} \right|}{n} x\ 100\% \quad (2.10)$$

Hence, for this study, the most reliable error measurement is the root mean square error (RMSE) thus,

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \hat{x}_i)^2}{n}} \quad (2.11)$$

VECM instead of a VAR on differenced variables, VECM gives long-run structural relations plus information on adjustment. VECM is as follows:

$$\Delta y_{t-1} = \Pi y_{t-1} + \theta_{t-1} \Delta y_{t-1} + \cdots + \theta_{p-1} \Delta y_{p-1} + G_t + \varepsilon_t \quad (2.12)$$

Estimation of VECMs of the form:

$$\Delta Z_t = \gamma \Delta Z_{t-1} + \beta e_{t-1} + e_t \quad (2.13)$$

Is discussed in many texts: see (Banerjee *et al*. 1993; Hamilton, 1994; and Johansen 1995), and routines are available in most econometrics' packages.
The maximum likelihood estimates are obtained in the following way.
Consider (3.21) written as

$$\Delta Z_t = \sum_{i=1}^{m-1} \gamma \Delta Z_{t-1} + \beta \delta^T Z_{t-1} + e_t \quad (2.14)$$

The first step is to estimate (3.15) under the restriction $\beta \delta^T = 0$ As this is simply a *VAR* (m-1) in ΔZ_t. OLS estimation will yield the set of residuals $\hat{e}$ from which is calculated the sample covariance matrix

$$S_r = T^{-1} \sum_{t=1}^{T} \hat{v} \hat{v}_t^T \quad (2.15)$$

The second step is to estimate the multivariate regression

$$\Delta Z_{t-1} = k + \sum_{t=1}^{m-1} \bar{\omega}_t\, \Delta Z_{t-1} + \mu_t \quad (2.16)$$

And use the OLS residuals $\hat{\mu}_t$ to calculate the covariance matrices

$$S_{11} = T^{-1} \sum_{t=1}^{T} \hat{\mu}_t \, \hat{v}_t^T \tag{2.17}$$

$$S_{10} = T^{-1} \sum_{t=1}^{T} \hat{\mu}_t \, \hat{v}_t^T = S_{01} \tag{2.18}$$

3.0 Results

3.1 Graphical representation of stationarity

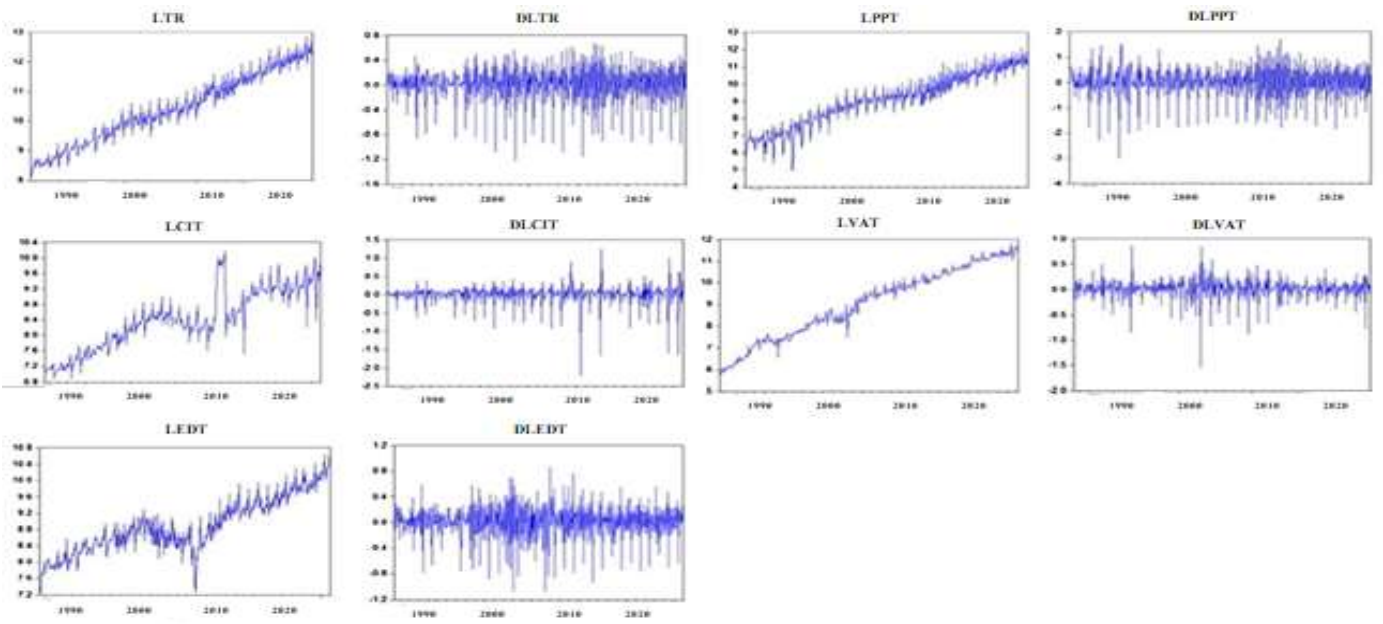

Figure 3.1: Stationary and non-stationary graphs of series.

As exhibited by Figure 3.1, all the data series are non-stationary at the level, but at the first difference time series of all the five (5) variables became stationary. Hence, this is also a confirmation of the A.D.F. test result that series are integrated of order one or I(1).

3.2 Revenue Forecasting for A.R. Model with Seasonal Dummies

Table 3.1: Forecasted Values of Total Revenue using A.R. Model.

Period/Variables	Petroleum Profit Tax	Value-Added Tax	Company Income Tax	Tertiary Education Tax	Total Revenues
Jan-17	102.56	102.00	19.68	41.04	265.28
Feb-17	88.17	97.79	19.12	38.81	243.90
Mar-17	133.43	112.54	21.26	45.28	312.51
Apr-17	105.59	111.18	22.18	43.31	282.26
May-17	119.41	123.00	23.09	46.88	312.38
Jun-17	256.03	151.34	27.94	63.00	498.30

Note: Naira in billions.

The autoregressive of order two with seasonal dummies are estimated to components of total revenue (T.R.), such as: Petroleum Profit Tax (PPT), company income tax (CIT), value added tax (VAT), and tertiary education tax (EDT). By using this model, the variables are forecasted for 6 months, that is from January 2024 to June 2024;

the root mean square error (R.M.S.E.) is calculated as 0.3215. As seen in Table 3.1 above, the total of all these forecast values (January–June 2024) for total revenues (T.R.) is presented. The total forecast and actual value for FY-2023–24 is ₦48330.95 billion. The actual revenue of ₦1468.32 billion for the last half of F.Y.-2023–24 (July–December 2023) was taken from the Federal Inland Revenue Service of Nigeria. The total forecast revenue of ₦1914.63 billion for the last six months of FY-2023–24 (January–June 2024) has been forecasted through the autoregressive seasonal dummies model.

3.3 Revenue Forecasting for the ARIMA Model

Table 3.2: Forecasted Values of Total Revenue using the ARIMA Model.

Period/Variables	PPT	CIT	VAT	EDT	TR
Jan-24	80.44	93.03	14.81	37.01	225.28
Feb-24	86.21	98.24	18.57	34.61	237.63
Mar-24	144.43	106.52	20.10	44.55	315.60
Apr-24	90.38	110.61	14.39	38.30	253.68
May-24	111.49	118.95	23.05	38.42	291.91
Jun-24	235.17	158.10	34.42	55.74	483.44

Note: Naira in billions.

The autoregressive integrated moving average (ARIMA) model is used for forecasting purposes by taking four components of total revenue (T.R.), such as: petroleum profit tax (PPT), company income tax (CIT), value added tax (VAT), and tertiary education tax (EDT). Using this model, the variables forecast a total revenue of ₦1807.54 billion for the first 6 months of F.Y.-2023–24 that is from January 2024 to June 2024; the root mean square error (R.M.S.E.) is calculated as 0.2235.

The first half (January–June 2024) forecast values of total revenues (T.R.) are presented in Table 4.2.4. The total forecast value for FY-2023–24 is ₦3279.88 billion, which is less than the Federal Inland Revenue Service (FIRS) target set by the government of Nigeria of ₦3521 billion. Therefore, the results of our study forecast the shortfall of ₦241.12 billion as estimated by using the ARIMA model.

3.4 Granger Causality Test

Table 3.3: Pairwise Granger Causality Test.

Null Hypothesis:	Obs.	F-Statistic	Prob.
Lags: 1			
D.(L PPT) does not Granger cause D.(LCIT)	376	1.9811	0.1601
D. (LCIT) does not Granger cause D. (LPPT)		7.1027	0.0080
D.(LVAT) does not Granger cause D.(LCIT)	376	0.8322	0.3622
D.(LCIT) does not Granger cause D.(LVAT)		5.0356	0.0254
D.(LEDT) does not Granger cause D.(LCIT)	376	1.9759	0.1607
D.(LCIT) does not Granger cause D.(LEDT)		0.3796	0.5382
Lags: 2			
D.(LPPT) does not Granger cause D.(LCIT)	375	2.8017	0.0620
D. (LCIT) does not Granger cause D. (LPPT)		4.0440	0.0183
D.(LVAT) does not Granger cause D.(LCIT)	375	14.2482	0.0000
D.(LCIT) does not Granger cause D.(LVAT)		3.6550	0.0268
D.(LEDT) does not Granger cause D.(LCIT)	375	3.0473	0.0487
D.(LCIT) does not Granger cause D.(EDT)		0.6193	0.5389

Source: Minitab version 16.

Before applying the vector auto-regression (VAR) model, it is better to determine if the direction of the variables, which are used in the VAR model, have any causal relationship or not. The Granger causality test applied between the pairs of LTR with LPPT, LCIT and LVAT in the difference form using lag 1 and lag 2. The results are given in Table 4.2.5, which shows that at lag 2, LPPT and LCIT have a two-way causal relationship, whereas VAT has a one-way causal relationship to LTR. This means that we can apply VAR, and the results obtained through VAR may be better than other models, which are used in this study.

3.5 Vector Auto-regression Model (VAR)

Table 3.4: Forecast values of total tax revenue using the VAR model.

Period/Variable	Total Revenues
Jan-24 Feb-24 Mar-24 Apr-24 May-24 Jun-24	229.94 250.06 311.37 260.41 286.91 501.89

Note: Naira in billions

VAR of the order D.(LTR), D.(LPPT), D.(LVAT) and D.(LEDT) is estimated using the lags 1 to 7 and 9 to 14 with seasonal dummies as exogenous variables. Lags are selected by applying the V.A.R. lag exclusion Wald test. Then, the forecast values are obtained from January 2024 to June 2024, which is ₦1840.60 billion, as shown in Table 4.2.6, with R.M.S.E. 0.2354. Thus, the total revenues forecasted for F.Y.-2023–24 are ₦3312.92 billion. According to the Federal Inland Revenue Service (FIRS), the actual total revenue collected in first half of the fiscal year (July–December 2023) was ₦1468.32 billion.

3.6 Total revenue forecasting error

Table 3.5: Total revenue forecasting error

Models/Forecasting Error	RMSE	MAE	MAPE
A.R. model with seasonal dummies	0.3215	0.3127	69.23%
ARIMA Model	0.2235	0.2128	38.75%
VAR Model	0.2354	0.2245	45.85%

Source: Minitab Results.

Therefore, the results of our study forecast the shortfall of ₦208.08 billion as estimated by using the VAR model against the total budgeted revenue for F.Y.-2023–24.

Since the RMSE, MAE, and MAPE of the ARIMA model is minimal for the ARIMA model as shown by Table 4.2.7 among the other two time series models, which are used to forecast the total revenues for Nigeria, we can say that the forecast value of total revenues for Nigeria for F.Y.-2023–24 is ₦3279.88 billion, which is less than the Federal Inland Revenue Service (FIRS) target set by the government of Nigeria of ₦3521 billion. Therefore, the results of our study forecast a shortfall of ₦241.12 billion as estimated by using the ARIMA model.

3.7 Johansen Co-integration Technique

Table 3.6: Unrestricted Co-integration Rank Test (Trace).

Hypothesized		Trace	0.05	
No. of C.E.(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.0549	35.7515	47.8561	0.4090
at most 1	0.0300	15.0302	29.7971	0.7781
at most 2	0.0104	3.8645	15.4947	0.9142
at most 3	0.0001	0.0223	3.8415	0.8812

Note: trace test indicates no co-integration at the 0.05 level.

Source: authors' calculations.

* denotes rejection of the hypothesis at the 0.05 level.

***MacKinnon-Haug-Michelis (1999)* p-*values.*

Table 3.7: Unrestricted co-integration rank test (maximum eigenvalue).

Hypothesized No. of C.E.(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.0549	20.7213	27.5843	0.2934
1 at most 2 at most 3	0.0300	11.1656	21.1316	0.6307
	0.0104	3.8422	14.2646	0.8756
	0.0001	0.0223	3.8415	0.8812

Note: max-eigenvalue test indicates no co-integration at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level.

**mackinnon-haug-michelis (1999) *p*-values. Source: authors' calculations.

We employed a test for cointegration, and for this purpose we employed the Johansen co-integration approach. The outcomes of Tables 3.7 and 3.8 exhibited that there is no evidence of a long-run relationship among the variables because both the Max-eigenvalues and the Trace statistic values are less than the critical values; thus, it is established that there is only short run association existing amongst the variables. Therefore, the short-run association has already been estimated in the three forecasting models discussed earlier.

3.8 Actual and Forecast Tax Revenue (January 2024–June 2024)

Table 3.8: Actual and Forecast Values of Tax Revenue (January 2017–June 2017)

Forecast Tax Revenue (January 23–June 24)	PPT	CIT	VAT	EDT	TR
AR model	805.19	697.85	133.27	278.32	1914.63
ARIMA model	748.12	685.45	125.34	248.63	1807.54
VAR model	–	–	–	–	1840.58
Actual tax Revenue (Jan'24–June'24)	751.70	745.82	113.14	278.04	1888.71
Difference b/w Actual & Forecasted (Jan'24–June'24)	PPT	CIT	VAT	EDT	TR
AR model	−53.49	47.97	−20.13	−0.28	−25.92
ARIMA model	3.58	60.37	−12.2	29.41	81.17
VAR model	–	–	–	–	48.13

Source: Minitab result and Federal Inland Revenue Service report 2023–24.

The outcomes of Table 3.8 exhibited the actual and forecast tax revenue (January 2024–June 2024) values of the AR model with seasonal dummies, the ARIMA model and the VAR model. The individual components of the actual total tax revenue and total tax revenue values are depicted in Table 3.8. The results show that the AR model with seasonal dummies is closer to the forecast values as far as the total revenue is concerned; however, the actual values of direct tax revenue are the best forecast values as compared to other models. The wide variation is observed in the petroleum profit tax and company income tax, most probably the reason behind the unexpected increase of petroleum profit tax and company income tax in Q4 2024.

4.0 Discussion

The summary statistics of all the variables under study show the mean, maximum, minimum and standard deviations of all variables. The skewness, kurtosis and Jarque-bera statistics of all variables do not fully indicate the true nature of the data series since the probability value of the Jarque-bera statistics of all the series are shown to be less than the acceptable 0.05 for TR, PPT, CIT, VAT and EDT, indicating non-normality of the series. These average values were used in the determination of the contribution of each form of tax revenue and domestic debt to tax revenue. Their respective minimum and maximum values are equally shown, indicating variations over the years for the respective series. This is further shown in the trends of tax revenue and each of the independent variables provided. Autoregressive of order two with seasonal dummies are estimated to components of Total Revenue (T.R.) variables are forecasted for a total of 6 months, that is, from January 2024 to June 2024; the root mean square error (R.M.S.E.) is calculated as 0.3215. The total forecast and actual value for FY-2023–24 is ₦4833.95 billion. The actual revenue of ₦1468.32 billion for the first half of F.Y.-2023–2024 (January–June 2023) was taken from the Federal Inland Revenue Service of Nigeria. The total forecast revenue of ₦1914.63 billion for the last six months of FY-2023–2024 (July–December 2024) has been forecasted through the autoregressive seasonal dummies model. The Autoregressive Integrated Moving Average (ARIMA) Model was used for forecasting purposes by taking four components of the total revenue (T.R.) using this model. The variables forecast a total revenue of ₦1807.54 billion for the first 6 months of F.Y.-2023–24 that is from January 2024 to June 2024; the root mean square error (R.M.S.E.) was calculated as 0.2235. The second half (July–December 2024) forecast values of Total Revenues (T.R.) value for FY-2023–24 is ₦3279.88 billion, which is less than the Federal Inland Revenue Service (FIRS) target set by the government of Nigeria is ₦3521 billion. Therefore, the results of our study forecast the shortfall of ₦241.12 billion as estimated by using the ARIMA model. Since the RMSE, MAE, and MAPE of the ARIMA model is minimal for the ARIMA model among the other two time series models, which are used to forecast the total revenues for Nigeria, we can say that the forecast value of total revenues for Nigeria for F.Y.-2023–24 is ₦3279.88 billion, which is less than the Federal Inland Revenue Service (FIRS) target set by the government of Nigeria of ₦3521 billion. Therefore, the results of our study forecast a shortfall of ₦241.12 billion as estimated by using the ARIMA model.

5.0 Conclusion

The results of the study demonstrated the effectiveness of three different time series models, moreover, the precise results of forecasting, Total Tax Revenue for the F.Y.-2023–2024, which lay down the foundations for proper policy-making by the government of Nigeria. The results revealed that among these models, the A.R.I.M.A. model gives better-forecast values for the total tax revenues of Nigeria,

6.0 Recommendations

Conceptual Recommendations: The government should introduce new tax reforms and broaden the tax net.

Methodological Recommendations: There should be a more effective supervision of tax revenue by the tax regulatory authorities such as the Federal Ministry of Finance.

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