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Application of Multivariate Time Series Analysis to Modelling of Total Tax Revenue and Some of Its Components

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Abstract: *The study applies Multivariate Time Series analysis to model Total Tax revenue and some of its components, examining the dynamic relationships between various tax revenue streams. Using a Vector Autoregressive (VAR) framework, the analysis fits the VAR model and also explores the interactions and causal relationships between different Tax components, such as P.A.Y.E, Stamp Duties, Direct Assessment, Road Taxes as well as Other Taxes. The findings provide insights into the complex dynamics of tax revenue generation, informing policy decisions and forecasting strategies for sustainable revenue mobilization. The findings placed P.A.Y.E on a high premium as one of tax components not only as a good predictive factor to total tax revenue and other tax components in this work, but as a major driver of the economy in Nigeria. The evidence of this is shown in the granger causality test where, at 5% critical value of F level of significance, with 2 and 77 degrees of freedom gives, 3.316 causing the null hypothesis H_0 to be rejected.*

Keywords: vector autoregression (VAR), causality, bayesian informationakaike information criteria

INTRODUCTION

In Nigeria, taxation has been in existence even before the coming of the colonial men or the British. Taxation can be defined as the system of imposing a compulsory levy on all income, goods, services and properties of individuals, partnership, trustees, executorships and companies by the government (Samuel and Simon, 2011). Income tax is one of the major sources of revenue to all government. In Nigeria, it is a factor to be reckoned with in Federal Government's budget the taxes so collected come back to the taxpayer in form of services. This has over the years encouraged or discouraged some activities in the private sector; though, this depends on whether the policy of the government is towards discouraging or encouraging such companies (Ola, 1999). Taxation is recognized as a very important tool for national

development and growth in most societies. It has viewed as a major vehicle for long term development of infrastructures of the state.

Taxation is known globally as a very strong and powerful weapon of fiscal policy and as such government of nations put structures in place to maximize revenue accruable from its various tax components. The structure of tax should be such that it is broader enough to generate revenue to finance government expenditure and various other programmers of government. The growth and development of any nation is predicated upon the availability of funds as well as other human and material resources. Economic growth can be achieved by four important determinants namely: human resources, national resources, capital formation and technological development (Dwivedi, 2004). Efficient use of these resources will help to speed up the political, economic and social activities in the country. The revenue needed is not always available, and so a potent and certain source of revenue from a well-structured tax system will obviously create the required revenue for realizing the set objectives. Nigeria being predominantly a mono-product economy, at present generates the bulk of her revenue from the sale of oil. Oil companies are also made to pay the stipulated tax while other sectors (non-oil sector) are barely harnessed. This abnormal dependence on oil for the revenue of government is generating tension in government circles since the fortunes of oil have been on the decline following global oil crisis. Furthermore, the revenue potentials of the informal sector of the economy have also not been properly identified and harnessed. If this important sector, which has been lying idle, is assisted by the relevant government authorities, the revenue from it would add up to increase the overall revenue of the government. The inclusion of the informal sector, through a broader tax system, will help to stimulate economic growth and development, create employment and stabilize the economy. (Yunusa, 2003). Tax is a compulsory payment made by individuals and organizations to the government by predetermined criteria for which no direct or specific benefit is received by the taxpayer. (Olatunji, 2009). The imposition of taxes often helps to regulate the production and consumption of goods and services; helps protect infant industry and curb inflation. Tax is a compulsory payment, backed by laws and paid according to a predetermined rate. The provision of basic amenities to the citizens is financed mainly from government revenue of which taxes ought to contribute significantly. When social amenities are provided to the taxpayers, it encourages voluntary compliance, stimulate business activities that in turn pay taxes and provide revenue to the government. Other services government renders/provides include maintenance of law and order, defence against external aggression, regulation of trade and business to ensure social and economic maintenance. Despite these, the economic effect of tax appears to still be at the micro levels. Tax serves as an incentive to work when the marginal rate of tax is low and vice versa.

Seward (2008) hold a divergent viewed, reflected in their endogenous growth theories. They argue that government policy, for example, level of taxation and tax composition can affect economic growth. This implies that direct government intervention may induce economic growth. However, taxation is a toll by government in designing various aspects of economic growth framework and policies. Vartia, L. (2008) states five possible mechanisms taxes as instrument of fiscal policy affects economic growth. First, taxes can inhibit investment rate through such taxes as corporate and personal income, capital gain taxes. Second, taxes can slow down growth in labor supply by distorting labor-leisure choice in favor of leisure. Third, tax policy can affect productivity growth through its discouraging effect on research and

development expenditures. Tax receipts and inflation rates have a substantial impact on the economic development of a region. To that end, the government needs to consider policies that can affect both of them, such as monetary policy and fiscal policy. Monetary policy aims to stabilize the economy through regulating the money supply. While the fiscal policy concerns the regulation of government expenditure as well as government revenue (tax) to direct the economy of a country. Thus, forecasting of tax revenue and inflation rate is needed as one of the considerations of policy decision making, which may affect economic development. The link between tax revenue and economic growth has long been a source of contention in public finance and macroeconomics. However, many questions remain unanswered, and the empirical link between taxes and growth appears to be far more complex than theoretical findings suggest. Das, S. (2017) found that taxation has a strong adverse effect on economic growth. In contrast, Daoud (2017) found that changes in taxation have no effect on economic growth in their study. In its most basic form, tax is a monetary payment made by the public to the government in exchange for services provided indirectly to the public by the government. It is also seen as a required payment given by people and organizations to fulfil government expenses. Taxation is critical in a developing country like South Africa for promoting long-term growth and poverty reduction. Governments, according to Hakim (2020), use taxes to increase the state's economic and productive efficiency by monitoring and fully exploiting economic resources.

The primary goal of taxation is to fund public expenditures and redistribute wealth, which translates to funding the country's development. The best way to design a tax system depends on a variety of factors and varies from country to country. It is critical to understand how different taxes distort and harm economic growth in order to design effective tax systems. According to various studies, raising consumption taxes while lowering labour and capital taxes can stimulate the economy's growth forces. Multivariate time series analysis is used when one wants to model and explain the interactions and co-movements among a group of macroeconomic indicators. It has more than a one-time-dependent variable; each variable depends not only on its past values but also on other variables which are used for forecasting future values. The multivariate view is central in economics, where single variables are traditionally viewed in the context of relationships to other variables. In forecasting and even in economics, multivariate models are convenient in modelling interesting interdependencies and achieving a better fit within a given data or economic indicator. Most of the multivariate time series models have a good comparative advantage in forecasting future values. (Usoro 2021). In this research, the interest is to study the relation of total taxes revenue and some of its component variables (PAYE, Direct assessment, Road taxes, Stamp duties, other taxes and MDA's revenue) in Akwa Ibom State with different classes of multivariate time series models for the period (2014 - 2023). Usoro and Ekong (2022) fit Multivariate Autoregressive Conditional Heteroscedasticity model and Multivariate Generalized Autoregressive Conditional Heteroscedasticity Models (MARCH and MGARCH) respectively to crude oil quantity and price volatilities.

Several empirical studies have been conducted on the impact of taxes on economic growth. Engen and Skinner (1996) in their study of taxation and economic growth using the United States of America (USA) economy, large sample of countries and the use of evidence from micro level studies of labor supply, investment demand and productivity growth find modest

effects among variables of study in the order of 0.2 to 0.3% points difference in growth rates in response to a major tax reform. They concluded that such small effects may have a large cumulative impact on living standards. The other direct taxes- capital gains and stamp duties also had the same signs as the petroleum profit tax, however, in his study, all direct taxes positively and significantly affect Nigeria's GDP.

Arnold, *et-al* (2011) conducted a study titled "Tax policy for Economic Recovery and Growth" and found that short term recovery requires increase in demand while long term growth requires increase in supply. As short-term tax concessions can be hard to reverse, this implies that policies to alleviate the crisis compromise long run growth.

Olalekan and Irewole (2019) investigating the impact of tax reform and economic growth of Nigeria using time series data from 1994 to 2009, utilizing petroleum profit tax, company income tax, value added tax, education tax, personal income tax and customs and excise duties as proxy for tax reforms and Gross Domestic Product (GDP) as proxy for economic growth explained that there exists a positive relationship between tax revenue and economic growth. They explained that 54% variation in economic growth (GDP) was attributed to change in tax revenue and that there exists long-run equilibrium relationship between the variables of study. In a study by Olusola, (2011) on tax revenue generation and economic development of Nigeria from 1981 to 2007 using multiple regression and correlation analysis, it was found that there exists significant relationship between gross domestic product, the proxy for economic development and the dependent variable and the various tax components selected for the studies as independent variables. The results reveal that 99 percent of changes in the total GDP was influenced by changes in the independent variables of PPT, CIT, Customs and excise duties and VAT. The study by Ajayi (2019) on tax revenue and economic development in Nigeria applying least squares regression analysis found that tax revenue stimulates economic growth through infrastructural development but that tax revenue has no independent effect on growth through infrastructural development and foreign direct investments. Another study by Owolabi and Okwu (2011) on the causal link between petroleum income and Nigerian economic growth using time series data from the year 2000 to 2009 involving simple regression model to analyse the data found significant positive relationship between the variables studied at 0.05 level of significance. They suggested that an increase in petroleum income in the form of increasing petroleum profits tax and oil royalties would result in an increase in the value of goods and services produced in the economy improves economic growth. The study does not indicate a unit root test on the time series data which span a period of 10years. Therefore, the discrepancies associated with time series data may not be adjusted for in the empirical analyses conducted. In a similar study, Poulson and Kaplan (2008) examined the effect of petroleum profits tax on Nigeria economy for the period 1970 to 2010 and concluded that petroleum profits tax has a significant effect on the economic growth of Nigeria within the study period with adjusted R2 value of 86.3%. They employed multiple regression and correlation analyses in the study using time series data collected. Their variables of study were Gross Domestic Profit (GDP), Petroleum Profits Tax (PPT), inflation and exchange rate. Jones *et al* (2014) applying Autoregressive Distributed Log (ARDL)/Bound Test General-to-Specific Approach to Co-Integration to assess the long-run equilibrium relationship between tax revenue and economic growth in Nigeria (1986-2012) found that total tax has significant effect on economic growth with about 73.4% of the total variations in the Real Gross Domestic Product (RGDP)

explained by aggregate changes in all the tax revenue components in the model. The study, however, identified no significant causal link between Petroleum Profit Tax (PPT) and economic growth in Nigeria both on the short and long runs equilibrium position. Their study collaborated the Central Bank of Nigeria (CBN) report that the industrial output fell by 2.2 percent due mainly to the poor performance of the oil sector. Also, they posited that the mean value of the percentage point growth of PPT was -9.36% during the period of their study and that the bane of the poor performance could be attributable to the unstable growth rate in the oil and gas sector, allusion of fiscal indiscipline, corruption and financial mismanagement in the oil sector of the Nigeria economy.

Roger *et al.,* (2017), Investigated Revenue Generation and Engagement of Tax Consultants in Lagos State, Nigeria. The challenge was to examine revenue generation of Lagos state with an emphasis on the use of Tax Monitory Agents (TAMA) in the light of tax evasion as well as activities of some unscrupulous tax officials. The study concluded by stating that tax evasion and avoidance is imminent and of course has a significant relationship with revenue generation of Lagos State; hence the researchers state that tax evasion and avoidance reduce revenue inflow. The study recommended that use of tax consultants in Lagos State yield positive result but their activities should be monitored, commissions on collections should be paid promptly as well. The study also recommends for continuous tax education right from early education as well as in religious gathering in Lagos State.

Taxation is known globally as a very strong and powerful weapon of fiscal policy and as such, government of nations put structures in place to maximize revenue accruable from its various tax components. Many researchers around the world based their findings on effect of taxation on nation's economy but limited findings on modelling tax revenue and its components. The lack of accurate forecasting and modelling of total taxes revenue and its components and the limited understanding of the relationships between total taxes revenue and its components hinders effective budgeting, resource allocation and economic decision making. For example, Anyafo (1996) conducted a study on the effects of taxes on Nigeria's GDP/Economic Growth from 1981 to 1996 and found that company's income tax positively and significantly affects GDP just as customs and excise duties. It is against this background that the study tends to investigate some components that contributes to the total tax revenue and causal relationship between total tax revenue and its components. Our main concern as regards this research is to use Multivariate Time Series (V.A.R) to model Total Tax revenue and its components Using a Vector Autoregressive (VAR) framework, the analysis will explore the interactions and causal relationships between different Tax components, such as P.A.Y.E, Stamp Duties, Direct Assessment, Road Taxes as well as Other Taxes.

METHODOLOGY

In this research, the model in Multivariate time series analysis to used is Vector Autoregressive Model (VAR). to fit Total Tax revenue and its Components. A multivariate time series consists of multiple single series referred to as components, which adopts the basic concept of vectors and matrices in its analysis (Tsay, 2005). It extends many of the ideas of a univariate time series analysis to a system of equations. This study uses monthly recorded data collected from a secondary source. The data was obtained from Akwa Ibom State Internal Revenue Service. It comprises of the Total Tax Revenue, and some of its component variables P.A.Y.E, Direct

assessment, Road taxes, Stamp duties, and MDA's revenue and it covers for the period of 7 years from 2017 to 2023. The variables considered in this study are Total Tax Revenue (Y_{1t}), P.A.Y.E (Y_{2t}), Direct Assessment (Y_{3t}), Road Taxes (Y_{4t}), Stamp Duties (Y_{5t}) and Other Taxes Revenue (Y_{6t}).

The Vector Autoregressive Models (VAR)

Let the general Vector Autoregressive Models be presented in a matrix form below:

$$\begin{pmatrix} Y_{1t} \\ Y_{2t} \\ . \\ . \\ . \\ Y_{mt} \end{pmatrix} = \begin{pmatrix} \rho_1 \\ \rho_2 \\ . \\ . \\ . \\ \rho_m \end{pmatrix} + \begin{pmatrix} \varphi_{1.11} & \varphi_{1.12} & . & . & . & \varphi_{1.1n} \\ \varphi_{1.21} & \varphi_{1.22} & . & . & . & \varphi_{1.2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \varphi_{1.m1} & \varphi_{1.m1} & . & . & . & \varphi_{p.mn} \end{pmatrix} \begin{pmatrix} Y_{1t-1} \\ Y_{2t-1} \\ . \\ . \\ . \\ Y_{nt-1} \end{pmatrix}$$

$$+ \begin{pmatrix} \varphi_{2.11} & \varphi_{2.12} & . & . & . & \varphi_{2.1n} \\ \varphi_{2.21} & \varphi_{2.22} & . & . & . & \varphi_{2.2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \varphi_{2.m1} & \varphi_{2.m2} & . & . & . & \varphi_{2.mn} \end{pmatrix} \begin{pmatrix} Y_{1t-2} \\ Y_{2t-2} \\ . \\ . \\ . \\ Y_{nt-2} \end{pmatrix} + \cdots$$

$$+ \begin{pmatrix} \varphi_{p.11} & \varphi_{p.12} & . & . & . & \varphi_{p.1n} \\ \varphi_{p.21} & \varphi_{p.22} & . & . & . & \varphi_{p.2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \varphi_{p.m1} & \varphi_{p.m2} & . & . & . & \varphi_{p.mn} \end{pmatrix} \begin{pmatrix} Y_{1t-p} \\ Y_{2t-p} \\ . \\ . \\ . \\ Y_{nt-p} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ . \\ . \\ . \\ \epsilon_{mt} \end{pmatrix} \quad (1)$$

The above matrix presentation is an alternative and better representation of matrices of the predictor lag variables with their associated parameter of Vector Autoregressive Lag Models (VARL), Usoro (2019).

By expansion,

$$Y_{1t} = \rho_1 + \varphi_{1.11}Y_{1t-1} + \varphi_{1.12}Y_{2t-1} + \cdots + \varphi_{1.1n}Y_{nt-1} + \varphi_{2.11}Y_{1t-2} + \varphi_{2.12}Y_{2t-2} + \cdots + \varphi_{2.1n}Y_{nt-2} + \cdots + \varphi_{p.11}Y_{1t-p} + \varphi_{p.12}Y_{2t-p} + \cdots + \varphi_{p.1n}Y_{nt-p} + \epsilon_{1t} \quad (2)$$

$$Y_{2t} = \rho_2 + \varphi_{1.21}Y_{1t-1} + \varphi_{1.22}Y_{2t-1} + \cdots + \varphi_{1.2n}Y_{nt-1} + \varphi_{2.21}Y_{1t-2} + \varphi_{2.22}Y_{2t-2} + \cdots + \varphi_{2.2n}Y_{nt-2} + \cdots + \varphi_{p.21}Y_{1t-p} + \varphi_{p.22}Y_{2t-p} + \cdots + \varphi_{p.2n}Y_{nt-p} +$$

$$\epsilon_{2t} \qquad (3)$$

$$\vdots \qquad \vdots$$

$$Y_{mt} = \rho_m + \varphi_{1.m1}Y_{1t-1} + \varphi_{1.m2}Y_{2t-1} + \cdots + \varphi_{1.mn}Y_{nt-1} + \varphi_{2.m1}Y_{1t-2} + \varphi_{2.m2}Y_{2t-2} + \cdots + \varphi_{2.mn}Y_{nt-2} + \cdots + \varphi_{p.m1}Y_{1t-p} + \varphi_{p.m2}Y_{2t-p} + \cdots + \varphi_{p.mn}Y_{nt-p} + \epsilon_{mt} \qquad (4)$$

$$Y_{jt} = \rho_j + \sum_{i=1}^{p}\sum_{k=1}^{n} \varphi_{i.jk}\, Y_{kt-i} + \epsilon_{jt} \qquad (5)$$

Granger Causality Test

Given two-time variables say Y_{it} and Y_{jt}, Granger causality investigates the proposition that Y_{it} causes Y_{jt} or Y_{jt} causes Y_{it}, on the assumption that the information relevant for the prediction of each macroeconomic time variable is contained in the associated variable. If Y_{it} granger causes Y_{jt} then the changes in Y_{it} should precede changes in Y_{jt} in a regression of Y_{it} on Y_{jt} including their past /lagged values. Then we can say Y_{it} granger causes Y_{jt} ($Y_{it} \rightarrow Y_{jt}$) and vice versa.

Statement of Hypothesis:

H_{01}: Y_{it} *does not cause* Y_{jt} ($Y_{it} \rightarrow \mathrm{Y_{jt}}$ *is not significant*)

H_{11}: Y_{it} *cause* Y_{jt} $\left(Y_{it} \rightarrow \mathrm{Y_{jt}}\ is\ significant\right), for\ i \neq j$

H_{02}: Y_{jt} *does not cause* Y_{it} ($Y_{jt} \rightarrow \mathrm{Y_{it}}$ *is not significant*)

H_{12}: Y_{jt} *cause* Y_{it} $\left(Y_{jt} \rightarrow \mathrm{Y_{it}}\ is\ significant\right), for\ j \neq i$

F – Statistics

In the granger causality test, the F statistics are used to test for the level of significance.

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR/(n-k)} \qquad (8)$$

Equation (7) above follows f distribution with m and (n-k) degree of freedom. RSSR is the residual sum of squares in the restricted regression, RSSUR is the residual sum of squares in the unrestricted regression, m is the number of lags in $Y_{1t}, X_{1t}, X_{2t}, X_{3t}, X_{4t}, X_{5t}$, terms and k is the number of parameters estimated in the unrestricted regression.

Decision Rule:

Reject the null hypothesis if the computed "*F*" is greater than $F_{m,n-k}$ at $\propto$ % level of significance, otherwise, accept the null hypothesis.

RESULTS

Numerical Verification for VAR Model.

$$\hat{Y}_{1t} = 0.489Y_{1t-1} + 0.306Y_{1t-2} - 0.089Y_{2t-1} - 0.143Y_{2t-2} - 9.6Y_{3t-1} + 34.5Y_{3t-2} - 2.73Y_{4t-1} + 19.67Y_{4t-2} + 0.44Y_{5t-1} + 0.65Y_{5t-2} - 0.537Y_{6t-1} - 0.479Y_{6t-2}$$

Table 4.1: VAR estimates of Total Tax Revenue (Y_{1t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
$\boldsymbol{Y_{1t-1}}$	0.489	0.432	1.20	0.234
$\boldsymbol{Y_{1t-2}}$	0.306	0.419	0.36	0.717
$\boldsymbol{Y_{2t-1}}$	-0.089	0.468	-0.75	0.457
$\boldsymbol{Y_{2t-2}}$	-0.143	0.435	-0.37	0.716
$\boldsymbol{Y_{3t-1}}$	-9.6	20.7	-1.18	0.243
$\boldsymbol{Y_{3t-2}}$	34.5	20.9	0.64	0.527
$\boldsymbol{Y_{4t-1}}$	-2.73	7.31	-0.83	0.041
$\boldsymbol{Y_{4t-2}}$	19.67	7.22	2.06	0.432
$\boldsymbol{Y_{5t-1}}$	0.44	1.13	-0.16	0.876
$\boldsymbol{Y_{5t-2}}$	0.65	1.22	0.11	0.916
$\boldsymbol{Y_{6t-1}}$	-0.537	0.463	-1.16	0.251
$\boldsymbol{Y_{6t-2}}$	-0.479	0.436	-0.72	0.476

The estimated values of Y_{1t} showed that Y_{4t-1} is significant as shown in Table 4.1 above

$$\hat{Y}_{2t} = -0.049Y_{1t-1} + 0.230Y_{1t-2} + 0.304Y_{2t-1} + 0.023Y_{2t-2} - 19.5Y_{3t-1} + 22.1Y_{3t-2} - 5.62Y_{4t-1} + 16.90Y_{4t-2} - 0.119Y_{5t-1} + 1.131Y_{5t-2} + 0.128Y_{6t-1} - 0.381Y_{6t-2}$$

Table 4.2: VAR estimates of P.A.Y.E (Y_{2t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
Y_{1t-1}	-0.049	0.307	-0.16	0.874
Y_{1t-2}	0.230	0.295	0.78	0.438
Y_{2t-1}	0.304	0.326	0.93	0.353
Y_{2t-2}	0.023	0.309	0.07	0.941
Y_{3t-1}	-19.5	14.2	-1.37	0.174
Y_{3t-2}	22.1	13.7	1.61	0.112
Y_{4t-1}	-5.62	5.12	-1.10	0.277
Y_{4t-2}	16.90	4.97	3.40	0.001
Y_{5t-1}	-0.119	0.708	-0.15	0.660
Y_{5t-2}	1.131	0.853	1.33	0.189
Y_{6t-1}	0.128	0.329	0.39	0.698
Y_{6t-2}	-0.381	0.306	-1.24	0.218

The estimated values of Y_{2t} showed that Y_{4t-2} is significant as shown in Table 4.2 above

$$\hat{Y}_{3t} = -0.00069Y_{1t-1} - 0.00068Y_{1t-2} + 0.00086Y_{2t-1} + 0.00150Y_{2t-2} + 0.417Y_{3t-1} + 0.168Y_{3t-2}0.0391Y_{4t-1} - 0.0325Y_{4t-2} + 0.00428Y_{5t-1} + 0.0116Y_{5t-2} - 0.00098Y_{6t-1} + 0.00421Y_{6t-2}$$

Table 4.3: VAR estimates of Direct Assessment (Y_{3t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
Y_{1t-1}	-0.000089	0.00226	-0.39	0.695
Y_{1t-2}	-0.00068	0.00217	-0.31	0.755
Y_{2t-1}	0.0008	0.00240	-0.36	0.720
Y_{2t-2}	0.0015	0.00228	0.66	0.513
Y_{3t-1}	0.417	0.105	3.98	0.000
Y_{3t-2}	0.168	0.101	1.67	0.100

Y_{4t-1}	0.0391	0.0377	1.09	0.304
Y_{4t-2}	-0.0325	0.0366	-0.89	0.377
Y_{5t-1}	0.00428	0.00578	0.74	0.461
Y_{5t-2}	0.01160	0.00629	1.85	0.069
Y_{6t-1}	0.00098	0.0024	-0.41	0.686
Y_{6t-2}	0.0042	0.0022	1.86	0.067

The estimated values of Y_{3t} showed that Y_{1t-1} is significant as shown in Table 4.3 above

$$\hat{Y}_{4t} = -0.01120Y_{1t-1} + 0.01160Y_{1t-2} + 0.01410Y_{2t-1} - 0.00191Y_{2t-2} + 0.059Y_{3t-1} - 0.303Y_{3t-2} + 0.237Y_{4t-1} + 0.120Y_{4t-2} + 0.0042Y_{5t-1} + 0.0127Y_{5t-2} + 0.01302Y_{6t-1} - 0.01075Y_{6t-2}$$

Table 4.4: VAR estimates of Road Taxes (Y_{4t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
Y_{1t-1}	-0.0112	0.00639	-1.75	0.084
Y_{1t-2}	0.01160	0.00614	1.89	0.063
Y_{2t-1}	0.01410	0.00678	2.08	0.041
Y_{2t-2}	-0.00191	0.00644	-0.30	0.767
Y_{3t-1}	0.059	0.239	0.20	0.841
Y_{3t-2}	-0.303	0.286	-1.06	0.292
Y_{4t-1}	0.237	0.107	2.22	0.029
Y_{4t-2}	0.120	0.104	1.16	0.252
Y_{5t-1}	0.0042	0.0163	0.26	0.796
Y_{5t-2}	0.0127	0.178	0.72	0.476
Y_{6t-1}	0.01302	0.00685	1.90	0.062
Y_{6t-2}	-0.01075	0.00638	-1.68	0.097

The estimated values of Y_{4t} showed that Y_{1t-1} *and* Y_{4t-1} are significant as shown in Table 4.4. above

$$\widehat{Y}_{5t} = -0.0221Y_{1t-1} - 0.009Y_{1t-2} + 0.0667Y_{2t-1} - 0.0092Y_{2t-2} + 1.68Y_{3t-1} + 0.98Y_{3t-2} + 0.226Y_{4t-1} + 0.422Y_{4t-2} + 0.598Y_{5t-1} + 0.055Y_{5t-2} - 0.0151Y_{6t-1} - 0.0171Y_{6t-2}$$

Table 4.5: VAR estimates of Stamp Duties (Y_{5t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
$\boldsymbol{Y_{1t-1}}$	-0.0221	0.0537	-0.41	0.682
$\boldsymbol{Y_{1t-2}}$	-0.0009	0.0515	-0.02	0.986
$\boldsymbol{Y_{2t-1}}$	0.06667	0.0569	1.17	0.245
$\boldsymbol{Y_{2t-2}}$	-0.0092	0.0541	-0.17	0.866
$\boldsymbol{Y_{3t-1}}$	1.68	2.48	-0.68	0.501
$\boldsymbol{Y_{3t-2}}$	0.98	2.40	0.41	0.684
$\boldsymbol{Y_{4t-1}}$	0.226	0.896	0.25	0.802
$\boldsymbol{Y_{4t-2}}$	0.422	0.870	0.48	0.629
$\boldsymbol{Y_{5t-1}}$	0.598	0.137	4.36	0.000
$\boldsymbol{Y_{5t-2}}$	0.055	0.149	0.37	0.714
$\boldsymbol{Y_{6t-1}}$	-0.0151	0.0575	-0.26	0.794
$\boldsymbol{Y_{6t-2}}$	-0.0171	0.0536	-0.32	0.750

The estimated values of Y_{5t} showed that Y_{5t-1} is significant as shown in Table 4.5 above

$$\widehat{Y}_{6t} = 0.012Y_{1t-1} - 0.029Y_{1t-2} - 0.038Y_{2t-1} - 0.045Y_{2t-2} + 6.6Y_{3t-1} + 19.4Y_{3t-2} + 2.34Y_{4t-1} + 1.90Y_{4t-2} + 0.471Y_{5t-1} - 0.063Y_{5t-2} - 0.130Y_{6t-1} - 0.022Y_{6t-2}$$

Table 4.6: VAR estimates of Other Taxes (Y_{6t})

Term	Coefficient	SE Coefficient	T-Value	P-Value
$\boldsymbol{Y_{1t-1}}$	0.012	0.280	0.04	0.966
$\boldsymbol{Y_{1t-2}}$	-0.029	0.269	-0.11	0.915

$\boldsymbol{Y_{2t-1}}$	-0.038	0.297	-0.13	0.900
$\boldsymbol{Y_{2t-2}}$	-0.045	0.282	-0.16	0.874
$\boldsymbol{Y_{3t-1}}$	6.6	12.9	0.51	0.614
$\boldsymbol{Y_{3t-2}}$	19.4	12.5	1.55	0.125
$\boldsymbol{Y_{4t-1}}$	2.34	4.67	0.50	0.618
$\boldsymbol{Y_{4t-2}}$	1.90	4.53	0.42	0.677
$\boldsymbol{Y_{5t-1}}$	0.471	0.715	0.66	0.512
$\boldsymbol{Y_{5t-2}}$	-0.063	0.778	-0.08	0.936
$\boldsymbol{Y_{6t-1}}$	-0.130	0.300	-0.43	0.665
$\boldsymbol{Y_{6t-2}}$	-0.022	0.279	-0.08	0.937

The estimated values of Y_{6t} showed that Y_{3t-1} is significant as shown in Table 4.6

Numerical Presentation of Granger Causality Test

Case 1:

H_{01}: Total Tax Revenue does not granger cause P.A.Y.E ($Y_{1t} \not\rightarrow Y_{2t}$).

H_{11}: Total Tax Revenue granger cause P.A.Y.E ($Y_{1t} \rightarrow Y_{2t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{1t} = 0.1729Y_{1t-1} + 0.0882Y_{1t-2} + 1.089\boldsymbol{Y_{2t}}$$

The unrestricted regression equation is given by;

$$\hat{Y}_{1t} = 0.124Y_{1t-1} + 0.076Y_{1t-2} + 0.090Y_{2t-1} + 0.017Y_{2t-2} + 1.080\boldsymbol{Y_{2t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(0.00393 - 0.00347)/2}{0.00347\ /(82-5)}$$

$$F = \frac{0.00023}{0.00012}$$

$$F = 1.92$$

F computed value is 1.92.

The critical F – value at 5% level of significance with 2 and 77 degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, which implies that Total Tax Revenue does not granger cause P.A.Y.E

CASE 2

H_{01}: P.A.Y. E does not granger cause Total Tax Revenue ($Y_{2t} \not\rightarrow Y_{1t}$).

H_{11}: P.A.Y.E granger cause Total Tax Revenue ($Y_{2t} \rightarrow Y_{1t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{2t} = 0.0351Y_{2t-1} + 0.1396Y_{2t-2} + 0.5132\boldsymbol{Y_{1t}}$$

The unrestricted regression equation is given by;

$$\hat{Y}_{2t} = 0.0038Y_{1t-1} + 0.0248Y_{1t-2} + 0.027Y_{2t-1} + 0.112Y_{2t-2} + 0.5097\boldsymbol{Y_{1t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(0.029 - 0.018)/4}{0.018\ /(82-5)}$$

$$F = 4.58$$

F computed value is 4.58.

The critical F – value at 5% level of significance with 2 and 77 degrees of freedom is 3.316. Hence the null hypothesis H_0 is rejected, which implies that P.A.Y.E granger cause Total Tax Revenue.

CASE 3

H_{01}: Total tax Revenue does not granger cause Direct Assessment ($Y_{1t} \not\rightarrow Y_{3t}$).

H_{11}: Total tax Revenue granger cause Direct Assessment ($Y_{1t} \rightarrow Y_{3t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{1t} = 0.418Y_{1t-1} + 0.276Y_{1t-2} + 0.254\boldsymbol{Y_{3t}}$$

The unrestricted regression equation is given by;

$$\hat{Y}_{1t} = 0.126Y_{1t-1} + 0.015Y_{1t-2} + 0.041Y_{3t-1} + 0.038Y_{3t-2} + 0.457\boldsymbol{Y_{3t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(0.041 - 0.024)/2}{0.024\ /(82-5)}$$

$$F = 10.63$$

F computed value is 10.63.

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is rejected, which implies that Total tax Revenue does not granger cause Direct Assessment

CASE 4

H_{01}: Direct Assessment does not granger cause Total Tax Revenue ($Y_{3t} \not\rightarrow Y_{1t}$).

H_{11}: Direct Assessment granger cause Total Tax Revenue ($Y_{3t} \rightarrow Y_{1t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{3t} = 0.142Y_{3t-1} + 0.084Y_{3t-2} + 0.0042\boldsymbol{Y_{1t}}$$

The unrestricted regression equation is given by;

$$\widehat{Y}_{3t} = 0.234Y_{1t-1} + 0.065Y_{1t-2} + 0.010Y_{3t-1} + 0.018Y_{3t-2} + 0.126\boldsymbol{Y_{1t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

$$F = \frac{(0.0064 - 0.0051)/2}{0.0051\ /(82-5)}$$

$$F = 3.82$$

F computed value is 3.82.

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is rejected, which signifies that Direct Assessment does not granger cause Total Tax Revenue

CASE 5

H_{01}: Total Tax Revenue does not granger cause Road Taxes ($Y_{1t} \not\rightarrow Y_{4t}$).

H_{11}: Total Tax Revenue granger cause Road Taxes ($Y_{1t} \rightarrow Y_{4t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\widehat{Y}_{1t} = 0.184Y_{1t-1} + 0.081Y_{1t-2} + 0.001\boldsymbol{Y_{4t}}$$

The unrestricted regression equation is given by;

$$\widehat{Y}_{1t} = 0.015Y_{1t-1} + 0.024Y_{1t-2} + 0.090Y_{4t-1} + 0.017Y_{4t-2} + 0.042\boldsymbol{Y_{4t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

$$F = \frac{(0.0728 - 0.0701)/2}{0.0701\ /(82-5)}$$

$$F = 1.15$$

F computed value is 1.15.

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, which implies that Total Tax revenue does not granger cause Road Taxes.

CASE 6

H_{01}: Road Taxes does not granger cause Total Tax Revenue ($Y_{4t} \not\rightarrow Y_{1t}$).

H_{11}: Road Taxes granger cause Total Tax Revenue ($Y_{4t} \rightarrow Y_{1t}$).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\widehat{Y}_{4t} = 0.1278Y_{4t-1} + 0.0882Y_{4t-2} + 0.035\boldsymbol{Y_{1t}}$$

The unrestricted regression equation is given by;

$$\widehat{Y}_{4t} = 0.026Y_{1t-1} + 0.084Y_{1t-2} + 0.070Y_{4t-1} + 0.016Y_{4t-2} + 0.064\boldsymbol{Y_{1t}}$$

Therefore, the F-calculated value is given by,
Therefore, the F-calculated value is given by,

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

$$F = \frac{(0.0074 - 0.0066)/2}{0.0066\ /(82-5)}$$

$$F = 1.8$$

F computed value is 1.8.
The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, that Road Taxes does not granger cause Total Tax Revenue.

CASE 7

H_{01}: Total Tax Revenue does not granger cause Stamp Duties (Y_{1t} ↲ Y_{5t}).
H_{11}: Total Tax Revenue granger cause Stamp Duties (Y_{1t} → Y_{5t}).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{1t} = 0.203Y_{1t-1} + 0.066Y_{1t-2} + 0.034\boldsymbol{Y_{5t}}$$

The unrestricted regression equation is given by;

$$\hat{Y}_{1t} = 0.236Y_{1t-1} + 0.010Y_{1t-2} + 0.022Y_{5t-1} + 0.018Y_{5t-2} + 0.105\boldsymbol{Y_{5t}}$$

Therefore, the F-calculated value is given by,
Therefore, the F-calculated value is given by,

$$F = \frac{(0.036 - 0.022)/2}{0.022\ /(82-5)}$$

$$F = 9.5$$

F computed value is 9.5.
The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is rejected, which means Total Tax Revenue granger cause Stamp Duties.

CASE 8

H_{01}: Stamp Duties does not granger cause Total Tax Revenue (Y_{5t} ↲ Y_{1t}).
H_{11}: Stamp Duties granger cause Total Tax Revenue (Y_{5t} → Y_{1t}).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n-k)}$$

The restricted regression equation is given by;

$$\hat{Y}_{5t} = 0.082Y_{5t-1} + 0.632Y_{5t-2} + 0.041\boldsymbol{Y_{1t}}$$

The unrestricted regression equation is given by;

$$\hat{Y}_{5t} = 0.142Y_{1t-1} + 0.67Y_{1t-2} + 0.005Y_{5t-1} + 0.015Y_{5t-2} + 0.026\boldsymbol{Y_{1t}}$$

Therefore, the F-calculated value is given by,
Therefore, the F-calculated value is given by,

$$F = \frac{(0.035 - 0.034)/2}{0.034\ /(82 - 5)}$$

$F = 0.441$

F computed value is 0.441.

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, that Stamp Duties does not granger cause Total Tax Revenue

CASE 9

H_{01}: Total Tax Revenue does not granger cause Other Taxes Revenue (Y_{1t} ↲ Y_{6t}).

H_{11}: Total Tax Revenue granger cause Other Taxes Revenue (Y_{1t} → Y_{6t}).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n - k)}$$

The restricted regression equation is given by;

$$\widehat{Y}_{1t} = 0.032Y_{1t-1} + 0.028Y_{1t-2} + 0.006\boldsymbol{Y_{6t}}$$

The unrestricted regression equation is given by;

$$\widehat{Y}_{1t} = 0.240Y_{1t-1} + 0.084Y_{1t-2} + 0.070Y_{6t-1} + 0.026Y_{6t-2} + 0.543\boldsymbol{Y_{6\,t}}$$

Therefore, the F-calculated value is given by,

Therefore, the F-calculated value is given by,

$$F = \frac{(0.0715 - 0.0621)/2}{0.0621\ /(82 - 5)}$$

$F = 2.27$

F computed value is 2.27

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, that Total Tax Revenue does not granger cause Other Taxes Revenue.

CASE 10

H_{01}: Other Taxes Revenue does not granger cause Total Tax Revenue (Y_{6t} ↲ Y_{1t}).

H_{11}: Other Taxes Revenue granger cause Total Tax Revenue (Y_{6t} → Y_{1t}).

$$F = \frac{(RSSR - RSSUR)/m}{RSSUR\ /(n - k)}$$

The restricted regression equation is given by;

$$\widehat{Y}_{6t} = 0.082Y_{6t-1} + 0.175Y_{6t-2} + 0.032\boldsymbol{Y_{1t}}$$

The unrestricted regression equation is given by;

$$\widehat{Y}_{6t} = 0.421Y_{1t-1} + 0.067Y_{1t-2} + 0.024Y_{6t-1} + 0.071Y_{6t-2} + 0.008\boldsymbol{Y_{1t}}$$

Therefore, the F-calculated value is given by,

$$F = \frac{(0.041 - 0.034)/2}{0.034\ /(35 - 5)}$$

$F = 3.08$

F computed value is 3.08.

The critical F – value at 5% level of significance with m and (n – k) degree of freedom is 3.316. Hence the null hypothesis H_0 is accepted, which shows that Other Taxes Revenue does not granger cause Total Tax Revenue.

Results

The analysis revealed significant contributions of at least two tax components to each component in the VAR. As shown in tables 4.1 – 4.4, P.A.Y.E (Y_{2t}) and Direct Assessment (Y_{3t}) contributed significantly to Total Tax Revenue .(Y_{1t}); Total Tax Revenue (Y_{1t}) and Road Taxes(Y_{3t}) contributed significantly to P.A.Y.E (Y_{2t}); as well as P.A.Y.E (Y_{2t}) Stamp Duties (Y_{4t}) to Direct Assessment (Y_{3t}) and finally, Total Tax Revenue (Y_{1t}) and other taxes (Y_{5t}) to Stamp Duties (Y_{4t}). VAR estimates in tables 4.1 – 4.6 showed a few significant parameters. The general observation from the study has it that each component has contributed significantly to at least two components as evident in the results. The need for Granger Causality test was to investigate the predictive capacity to each other in a pair of two macroeconomic variables.
The F-Statistic which involved Residual Sum of Squares Restricted (RSSR) and Residual Sum of Squares Unrestricted (RSSUR) revealed that P.A.Y.E granger cause Total tax revenue ($Y_{2t} \rightarrow Y_{1t}$) , Total Tax Revenue and Other Taxes has a bi-directional causality with each other ($Y_{1t} \rightleftarrows Y_{6t}$), and Total Tax Revenue granger cause Road Taxes ($Y_{1t} \rightarrow Y_{4t}$). Notwithstanding the outcome in the granger causality tests, every component has been revealed to have a significant contribution to one or two components under study.

CONCLUSION

Modelling of Multivariate time series data of total tax revenue and its was the main focus of this project. There is no gain saying the fact that changes in the amount accrued to the state from the federation account at any given time have multiplier effects on different economic sectors. Hence the need for internally generated revenue through tax.

The findings placed P.A.Y.E and Stamp Duties on a high premium as one of tax components not only as a good predictive factor to total tax revenue and other tax components in this work, but as a major driver of the economy in Nigeria. The increase in P.A.Y.E and Stamp Duties revenue generated has been a significant success story and has brought many benefits to Nigerian economy. P.A.Y.E and Stamp Duties are usually, in most developing countries, a rational policy for expanded foreign exchange earnings in tax industry. Though, there is need for other components that will encourage tax industry and in order to enhance economic growth in this sector. In an economy like Nigeria, the intrinsic value of tax does not lie in easing tax, but in enabling growth and development by empowering the residents and transform them into more productive human capital so as to pay their taxes. Since economic growth is principally a function of variation in some macroeconomic fundamentals, there is need for deregulation polices on privatization and commercialization on inefficient and unproductive sectors of the economy be made a core policy, as this will bring about a revolutionary change in such sectors. But on recent times, tax revenue has contributed to the GDP of the country as a result of the recent electronic and virtual transactions recently introduced by FIRS

Emphasis for diversification of the Nigerian economy which has become a major challenge, concern and discourse by Nigerian government and stakeholders should still gain prominent priority and remain policy trust of government towards making every economic sector a major driver of sustainable economic development in Nigeria. The government should also strengthen its efforts aimed at increasing the rate at which tax are being paid by citizens by providing adequate

facilities for those responsible for the work to carry out their work without fear or favors, this would help in increasing the GDP of the country.

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